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Synthesis and Characterization of $Zn_{0.5}Co_{0.5}Fe_2O_4$ Nanoparticles for Gas Sensing Applications

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In this study, $Zn_{0.5}Co_{0.5}Fe_2O_4$ nanoparticles were synthesized by solution combustion method. The solution combustion method is a convenient, chief, environment friendly, and capable for the synthesis of high-quality nanomaterials. As prepared $Zn_{0.5}Co_{0.5}Fe_2O_4$ were annealed at 800 °C. The electrical, thermal, structural, magnetic, morphological and gas sensing properties of the synthesised materials has been studied in details. The spinel crystal structure was confirmed from X-ray diffraction, with average crystalline size of 37 nm. The elemental compositions in the synthesized powder were estimated using EDX spectra. The magnetic nature of the material was confirmed from vibrating sample magnetometer (VSM), conducted at room temperature with highest applied field of 15 KOe and it shows ferromagnetic behaviour. The nearly spherical particles shapes were observed from TEM and FESEM images. The fabricated thick films of the synthesised material were exposed to various gases like NH_3, Cl_2, H_2, CO_2 and LPG at different temperatures. It was observed that the gas sensing responses depends on their operating temperature. Additionally, the sensor has a quick response time and a speedy recovery time. The gas sensing results demonstrated that $Zn_{0.5}Co_{0.5}Fe_2O_4$ is a novel gas sensor material with good sensitivity and selectivity to LPG compared to other gases. The probable LPG gas sensing mechanism is schematically represented in this paper. This study provides, $Zn_{0.5}Co_{0.5}Fe_2O_4$ synthesised using low-cost solution combustion technique has a great potential in future gas sensing fields.
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Nanocrystalline spinel ferrites possess behaviour of both magnetic materials and electrical insulators. These ferrites are chemically and thermally stable materials. It is the class of complex oxide with the general formula AB_2O_4.These materials are very important due to their technological and biomedical applications including high-quality filters, radio frequency circuits, recording devices, ferrofluids, catalysis, targeted drug delivery, chemical sensors etc.[1–4] Among these ferrites,cobalt based ferrites has a great potential in such applications due to its outstanding properties like strong anisotropy, high saturation magnetization, high coercivity,better mechanical hardness and chemical stability.[5,6] Inaddition, the electrical, magnetic, optical properties and their performances can be tuned by varying particle size and by doping with a wide range of transition metal cations like Zn^{2+}, Ni^{2+}, and Mn^{2+}, since nanoparticles have different properties from their own bulk material.[7–11]

Gas detection is becoming an integral part of life for safety and environmental protection. It has many applications including fermentation control in the food industry, diagnostics and patient monitoring, domestic use to detect combustible gases etc.[12–15] It was revealed that introducing a few additives into the basic materials, surface activation of thick films can increase the material's gas sensing performances. The detection of Liquefied Petroleum Gas (LPG) is a very important because it is frequently utilised in residential and commercial applications. The LPG includes propane (5%–10%), butane (70%–80%), propylene, butylene, ethylene, and methane (1%–5%).[16] There are some well-known materials used for the making of LPG sensors, that includes Cu-ZnO,[17] graphene oxide@Fe_2O_3,[18] Ru-SnO_2,[19] spinel $NiFe_2O_4$,[20] $ZnCo_2O_4$,[21] Cr_2O_3-modified ZnO thick film,[22] $CuFe_2O_4$,[23] $ZnGa_2O_4$/graphene,[24] MgO@CeO_2,[25] SnO_2–ZnO nanocomposites etc.[26] In this study our aim to synthesis $Zn_{0.5}Co_{0.5}Fe_2O_4$ nanoparticles by effective solution combustion method for LPG gas sensing. There are many methods are reported for the synthesis of spinel oxides, which includes solid-state synthesis (mechanical milling/alloying), wet chemical routes: coprecipitation,[27] sol–gel method,[28] hydrothermal/solvothermal synthesis,[29] reverse micelles,[30] Template,[31] Mechanical milling,[32] Solid phase,[33] Combustion,[34,35] Microwave combustion,[36] Microwave hydrothermal,[37] Pechini method,[38] electrochemical synthesis,[39] solid-state reaction technique and others.

In the present study, we have synthesised $Zn_{0.5}Co_{0.5}Fe_2O_4$ nanoparticles by an effective solution combustion method to measure gas sensing performance of different gases at various temperatures. The structural, electrical, morphological, compositional, thermal and magnetic properties of the synthesised powder were studied in details.

Experimental

Powder preparation.—The $Zn_{0.5}Co_{0.5}Fe_2O_4$ nanoparticleswere prepared using a solution Combustion method. Iron nitrate nonahydrate [$Fe(NO_3)_3 9H_2O$], zinc nitrate hexahydrate [$Zn(NO_3)_2 6H_2O$] and cobalt nitrate hexahydrate [$Co(NO_3)_2 6H_2O$] were used in stiochometric amounts. The urea is used as an organic fuel, during burning, it served as a platform for redox reactions. Initially Iron nitrate nonahydrate, zinc nitrate hexahydrate, cobalt nitrate hexahydrate and urea are taken in the 1:1:1:4 stoichiometric amount and homogenous paste was made. The resultant paste was kept on hot plate at a temperature of 80 °C to get thick gel. After that temperature of the hot plate increases up to 180 °C for auto combustion. The obtained powder was annealed at 800 °C for 4 h, which turns into a black colour shining powder. The schematic of synthesised nanopowder is as shown in Fig. 1. The details are described elsewhere.[40,41]

Powder, thixotropic paste and thick film preparation.—The prepared $Zn_{0.5}Co_{0.5}Fe_2O_4$ powder was ground in amortar and pestleto ensure adequately fine particle size. The resultant powder was annealed at 800 °C for 4 h in a furnace and then cooled it naturally. After cooling it was re-grinded again. The slurry of thixotropic paste was prepared by combining annealed $Zn_{0.5}Co_{0.5}Fe_2O_4$ fine powder, binder ethyl cellulose, butyl carbitol acetate, butyl cellulose and turpineol. The glass plates were initially cleaned with distilled water and acetone. Then it was dried in hot air

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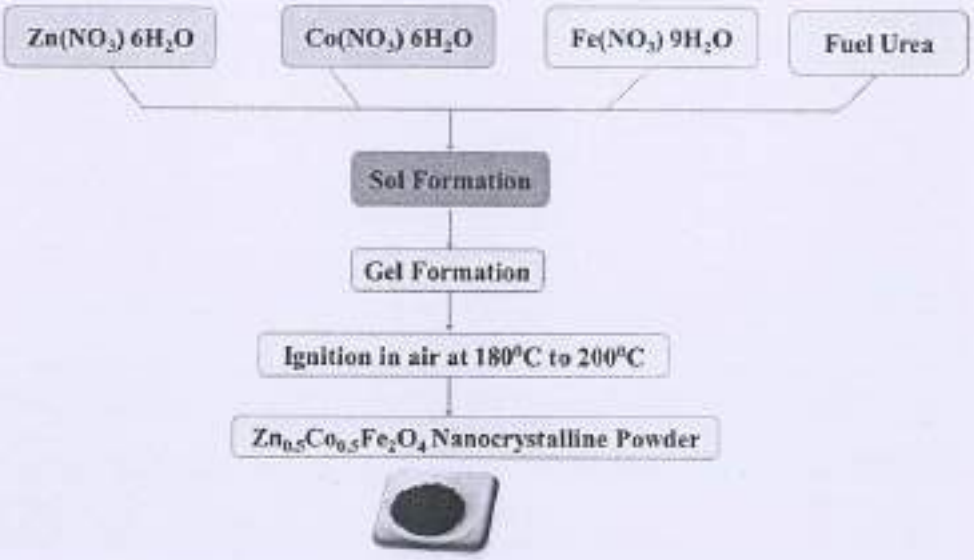


Figure 1. Schematic of $Zn_{0.5}Co_{0.5}Fe_2O_4$ powder synthesis.

for 5 min. The thixotropic paste was screen printed on a glass substrate. The resultant films were annealed at 500 °C for 24 h. The aluminium contacts were made by the vacuum evaporation techniques for electrical measurements.

Thickness measurement (talystep method).—The thicknesses of the films were measured using talystep profile method and it was in the range from 25 to 35 μm.

Fabrication and analysis of gas sensors.—The gas sensing performance of the synthesized $Zn_{0.5}Co_{0.5}Fe_2O_4$ thick film was carried out in a "static gas-sensing system." The system consists of base plate with controlled heater, inlet-outlet valves, and electrical feeds. Cr–Al thermocouple was used to measure operating temperature of the substrate. The required gas concentration inside the static system was achieved by injecting known volume of test gas using a gas-injecting syringe. A constant voltage was applied to the sensors and current was measured by digital Pico-ammeter. The air was allowed to pass into the glass dome after every gases exposure cycle.[42]

Results and Discussion

Thermogravimetry-differential thermal analysis (TG-DTA).—TGA system measures weight loss of materials as a function of temperature. TG-DTA spectra have been recorded in 30 °C to 1000 °C temperature range. When the reactants were heated at 180 °C, the reaction was carried out according to the procedure shown in Eqs. 1 and 2 and getting the final product $Zn_{0.5}Co_{0.5}Fe_2O_4$ nanopowder.

$$2CO(NH_2)_2 + (3/2)O_2 \rightarrow N_2\uparrow + 2CO_2\uparrow + H_2O\uparrow + 2NH_3\uparrow \quad [1]$$

$$Zn(NO_3)_2.6H_2O + Co(NO_3)_2.6H_2O + Fe(NO_3)_6.9H_2O + CO(NH_2)_2 \rightarrow$$

$$ZnCoFe_2O_4 + CO_2\uparrow + 26H_2O\uparrow + 15N_2\uparrow + 23O_2\uparrow \quad [2]$$

The recorded TGA curve for thermal decomposition of $Zn_{0.5}Co_{0.5}Fe_2O_4$ is shown in Fig. 2. The TGA curve shows total weight loss was only 0.2% in the temperature range from 25 °C to 1000 °C, indicating almost thermally stable material. This weight loss was due to dehydrogenation, decarboxylation and denitration from the material. No significant weight loss was observed after 800 °C confirming the complete phase formation of the $Zn_{0.5}Co_{0.5}Fe_2O_4$

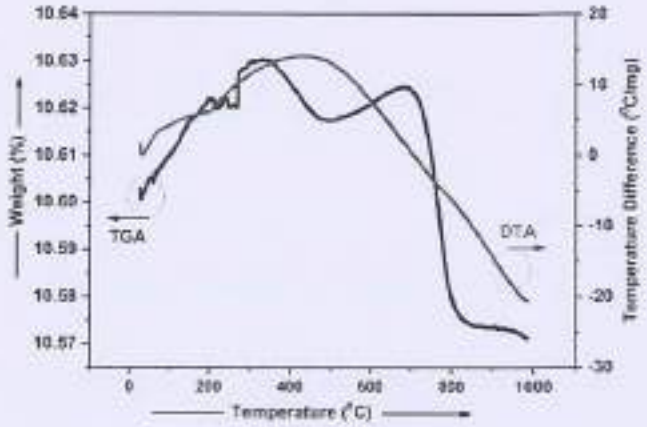


Figure 2. TG-DTA curve of as synthesized $Zn_{0.5}Co_{0.5}Fe_2O_4$ powder.

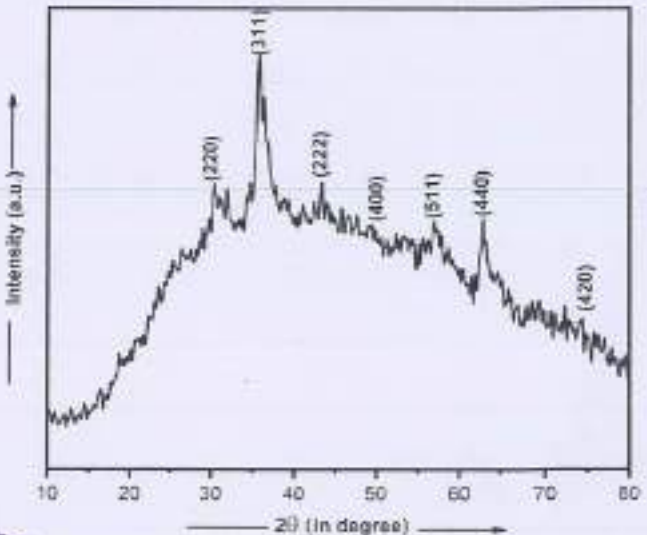


Figure 3. XRD pattern of $Zn_{0.5}Co_{0.5}Fe_2O_4$ annealed at 800 °C.

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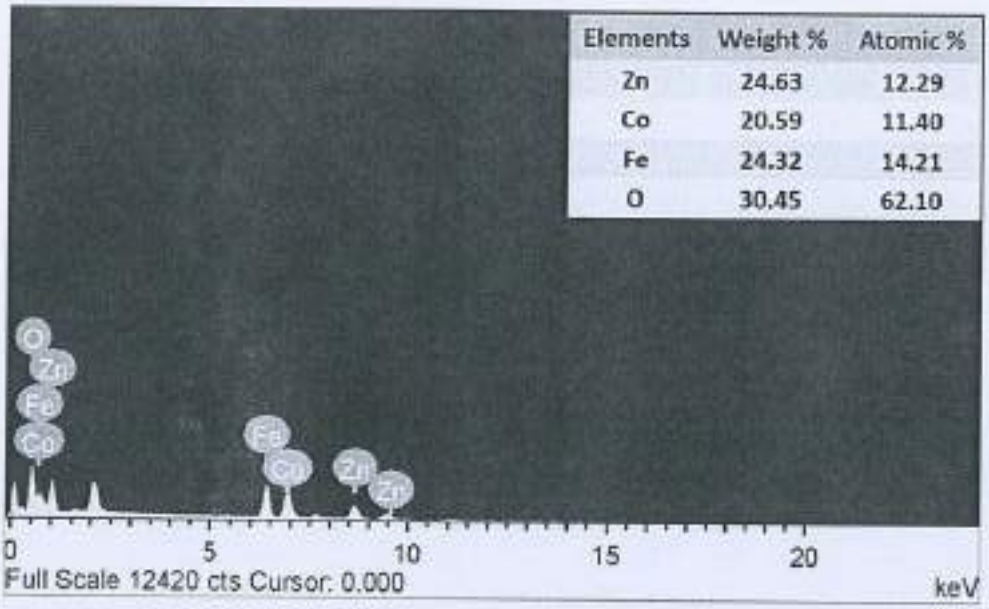


Figure 4. EDX pattern of $Zn_{0.5}Co_{0.5}Fe_2O_4$ Powder annealed at 800 °C.

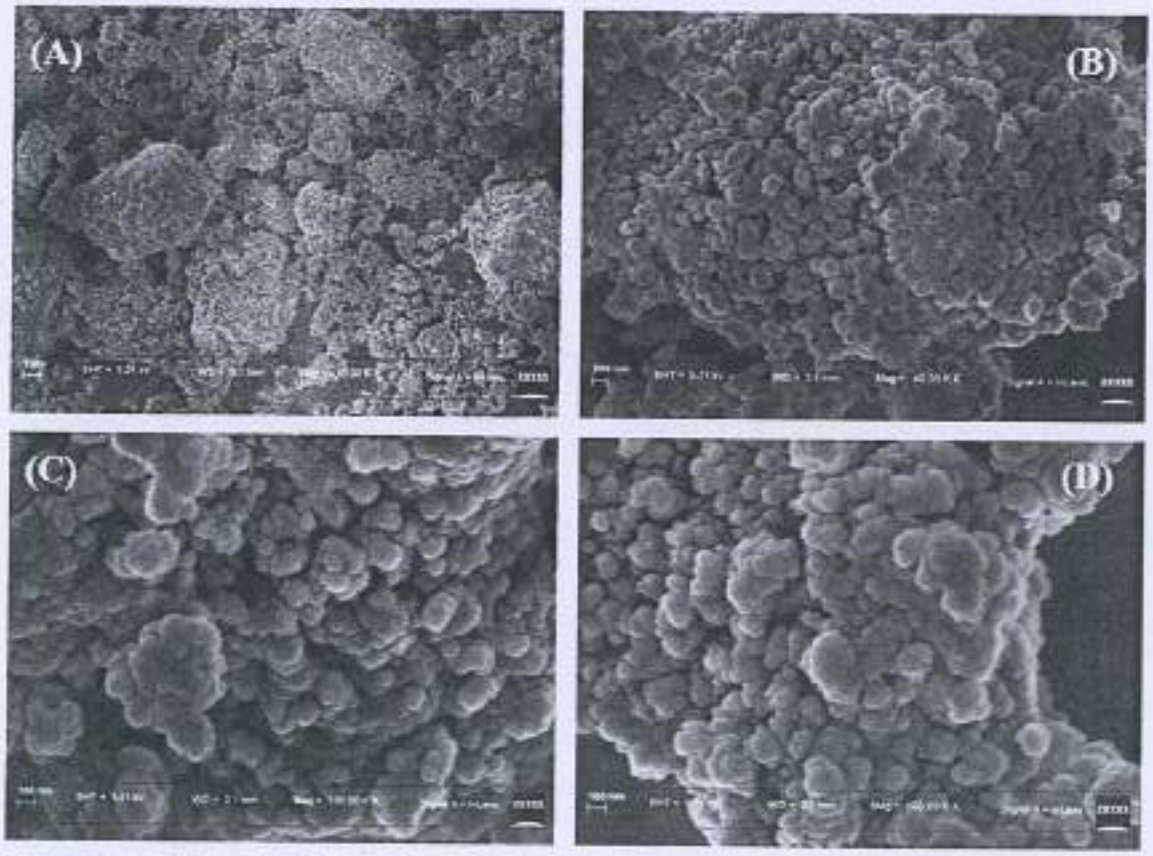


Figure 5. SEM images of annealed $Zn_{0.5}Co_{0.5}Fe_2O_4$ powder: (A), (B) low resolution and (C), (D) high resolution.

sample. So the prepared sample was annealed at 800 °C. The broad exothermic peak observed at 440 °C shows the formation of ferrites.

X-ray diffraction (XRD) analysis.—Figure 3 presents XRD spectra of $Zn_{0.5}Co_{0.5}Fe_2O_4$ powder annealed at 800 °C temperature. The reflecting planes (220), (311), (222), (400), (511), (440) and (422) of single phase $Zn_{0.5}Co_{0.5}Fe_2O_4$ ferrites are detected from X-ray diffraction pattern. The crystalline size was estimated using Debye–Scherrer equation by considering FWHM of most intense (311) diffraction peak and it is 37 nm. The observed inter planer distance (d) and (hkl) values are equivalent with JCPDS data of card number 65-3107. As seen from XRD Spectra, there is no other impurity peaks were observed, confirming the spinel structure of Co-Zn mixed Fe_2O_4 ferrite.

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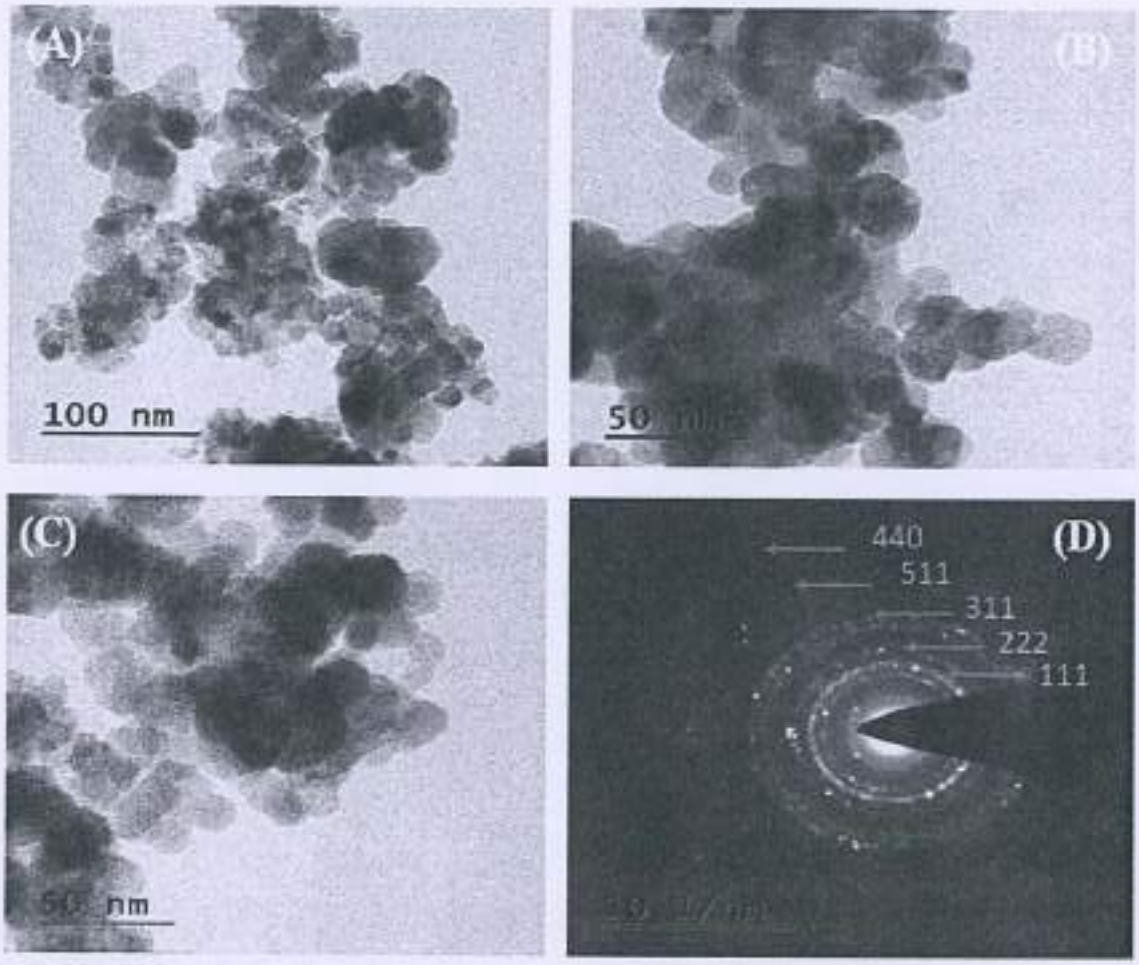


Figure 6. (A), (B), (C) TEM images$Zn_{0.5}Co_{0.5}Fe_2O_4$. (D) SAED patterns of the $Zn_{0.5}Co_{0.5}Fe_2O_4$ annealed at 800 °C.

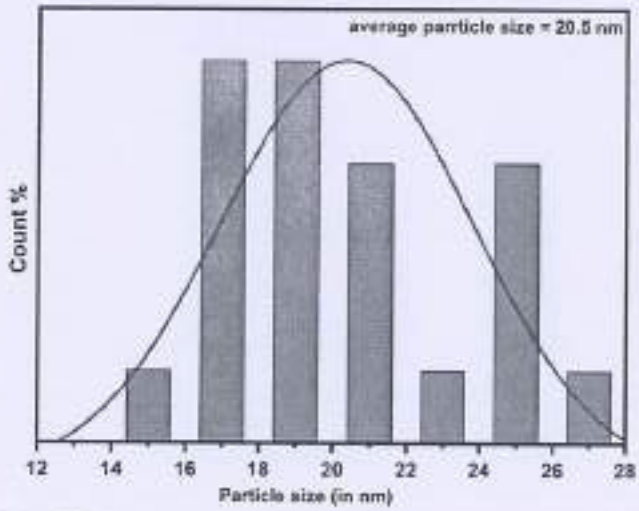


Figure 7. The average particle size distribution.

Energy dispersive X-ray (EDX) analysis.—EDX investigations were carried out to find out the elemental compositions in the prepared material. The Fig. 4 shows the EDX analysis of $Zn_{0.5}Co_{0.5}Fe_2O_4$ powder. The figure shows the presence of Co, Zn and Fe and O in the material. The weight % and atomic % of Zn, Co and Fe are in equivalent with the initial mixture used for the synthesis. It is interesting to note that the preparation condition completely favours the formation of mixed ferrites.

Scanning electron microscope (SEM) analysis.—The SEM technique was used to observe the morphology of the annealed $Zn_{0.5}Co_{0.5}Fe_2O_4$ powder. The SEM images of Figs. 5A–5D seems like bubbles as micro agglomeration with extremely fine particles. These particles appear nearly uniform spherical structural morphology with somewhat agglomerate. From the SEM micrographs, the average particle size was found in the range of 10.00–30.00 nm. The average particle size estimated from SEM and Debye-Scherre formula are well matched.

Transmission electron microscopy (TEM) analysis.—Figures 6A–6C shows TEM images of the synthesised $Zn_{0.5}Co_{0.5}Fe_2O_4$ nanoparticles. TEM images show uniform distribution of nearly spherical ferrite particles. Particle agglomeration occurs because of magneto-static interactions between the nanoparticles. The morphology and size of the particles are affected by the annealing temperature. The Fig. 6D shows SAED pattern of well-formed lattice fringes very close to the XRD results. The SAED pattern confirms a polycrystalline nature of $Zn_{0.5}Co_{0.5}Fe_2O_4$.

The average particle size of synthesised material was estimated using ImageJ software. The estimated average particle size is 20.5 nm as shown in Fig. 7, which is equivalent with the XRD measurements.

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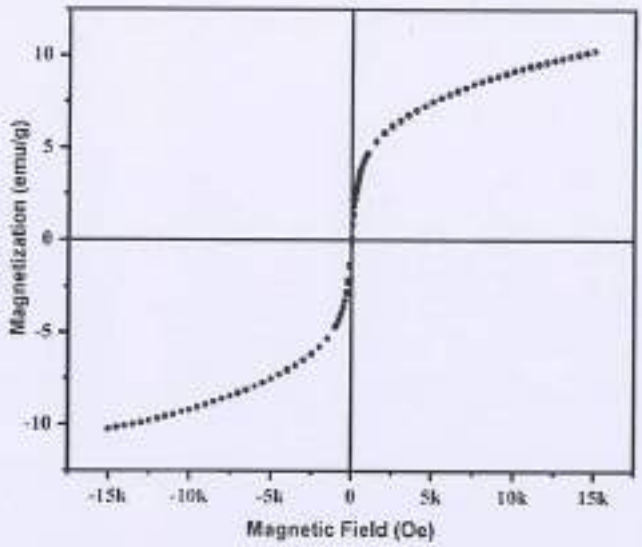


Figure 8. VSM analysis of annealed $Zn_{0.5}Co_{0.5}Fe_2O_4$ nanoparticles.

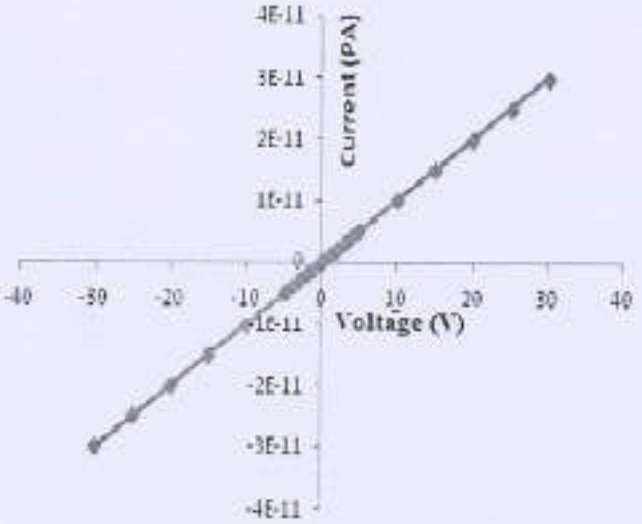


Figure 9. I–V characteristics of nanocrystalline $Zn_{0.5}Co_{0.5}Fe_2O_4$ thick film.

Vibrating-sample magnetometry (VSM) analysis.—Figure 8 shows M–H curve of $Zn_{0.5}Co_{0.5}Fe_2O_4$ samples. The VSM measurement was conducted at room temperature with highest applied field is 15000 oersted (Oe). The magnetic parameters including saturation magnetization (Ms), coercivity (Hc), and remanent magnetization (Mr) was estimated from M–H loop. The estimated value of saturation magnetization, coercivity and remanent magnetization was 10.88 emu g^{-1}, 0.05 Oe and 3.24 emu g^{-1} respectively. The changes in saturation magnetization, coercivity and remanent magnetization are due to the influence of the cationic stoichiometry and their occupancy in the specific (A− and B−) sites. The Value of Ms is smaller than that of bulk materials due to finite size effect.[43] The lack of hysteresis, low coercivity and remanance and the nonattainment of even at high magnetic fields indicating characteristics of ferro magnetization.

Surface area measurement.—BET surface area was measured by nitrogen adsorption method at 200 °C on a Benchman Coulter SA 3100 plus instrument. The BET test shows that the specific surface area of the synthesised powder was approximately 2.8 $m^2 g^{-1}$.

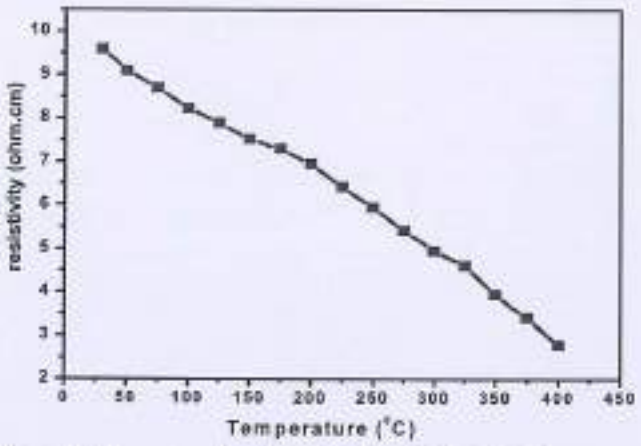


Figure 10. Temperature dependent resistivity of $Zn_{0.5}Co_{0.5}Fe_2O_4$.

Electrical properties of the sensors.—I–V characteristics.—The current passing through the sample was measured by applying voltage across to the sample. Figure 9 presents the I–V characteristics of the $Zn_{0.5}Co_{0.5}Fe_2O_4$ films measured at room temperature. From Fig. 9, I–V curve is linear in nature; hence sliver contacts fabricated on the film were ohmic in nature. The operating voltage was in the range 1–30 V. Increasing current with voltage indicating the material is highly crystalline.

Electrical resistivity measurement.—The DC temperature dependent electrical resistivity of the film was measured using two probe method. The aluminium (Al) electrodes 0.05 cm apart was fabricated by thermal evaporation using a suitable mask. The silver paste was fixed on Al for good electrical contact. The film is hated and its corresponding temperature was measured using Chromal–Alumel thermocouple. The applied voltage was measured with Meco-801 digital multimeter, while current flowing through sample was confirmed from a sensitive four-digit Pico ammeter (Model Roorkee DPM 111). From the resistivity measurements the synthesised material is showing semiconducting in nature and it is due to large oxygen deficiency in the sample. Figure 10 shows the resistivity decreases with temperature, indicates a negative temperature coefficient of resistance and the semiconducting nature of the material.

Sensing performance of sensor.—Gas response, selectivity response and recovery time:.—The specificity (selectivity) is the ability of a sensor to respond to a certain gas in the presence of different gases. The response time (RST) is the time requires for a sensor to attain the 90% of maximum increases in conductance on exposure to the target gas. Recovery time (RCT) is the time taken to get back 90% of the original conductance in air. The relative response (S) is given by Eq. 3.[44]

$$\text{relative response}(S) = \frac{\text{Conductance in sample gas}(G_g) - \text{Conductance in air}(G_a)}{\text{Conductance in air}(G_a)} \quad [3]$$

Sensing performance of $Zn_{0.5}Co_{0.5}Fe_2O_4$ thick films.—Gas response and operating temperature.—Figure 11 presents the gas response as a function of operating temperature. The temperature dependent gas response was observed in case of $Zn_{0.5}Co_{0.5}Fe_2O_4$ sensor. From Fig. 11, it was observed that sensor shows good responds to Cl_2, LPG and H_2 at 300 °C and NH_3 and CO_2 at 250 °C. Thus the sensor could be used to sense LPG, NH_3, Cl_2, H_2, and CO_2 just by varying the operating temperature. This is the best feature of this sensor.

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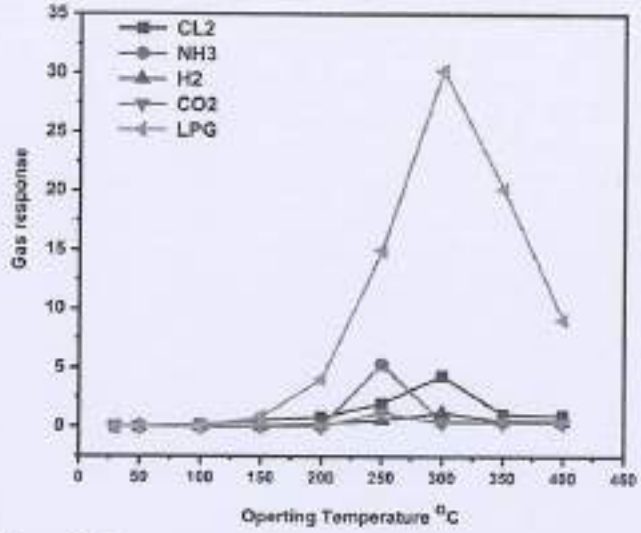


Figure 11. Gas responses as a function of operating temperatures.

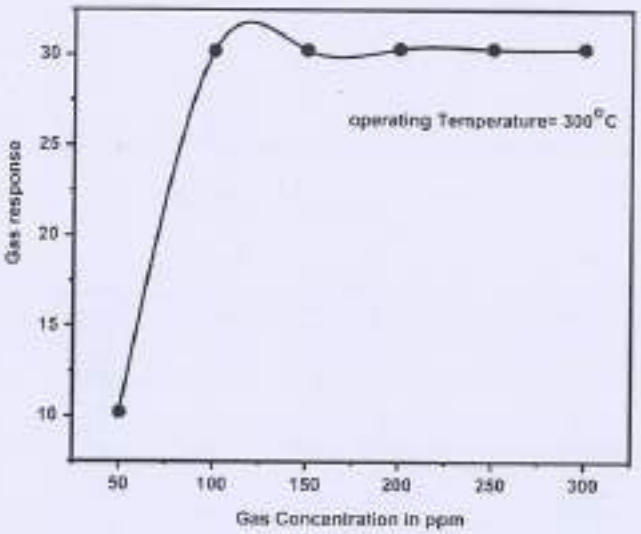


Figure 12. Variation of gas response with gas concentration.

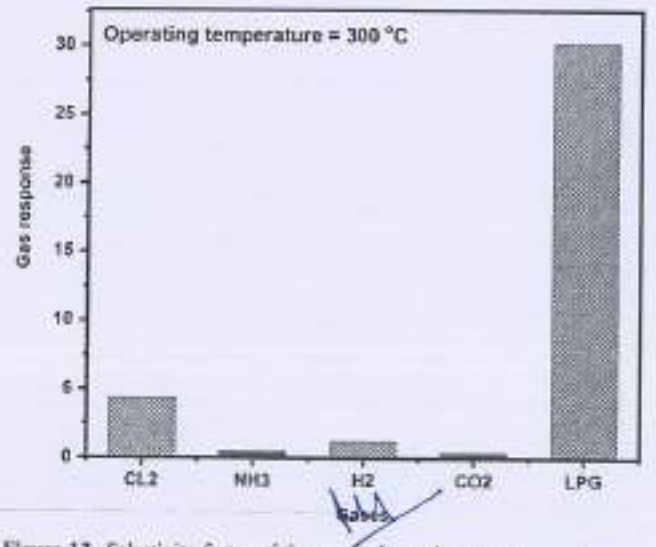


Figure 13. Selectivity factor of the sensor for various gases.

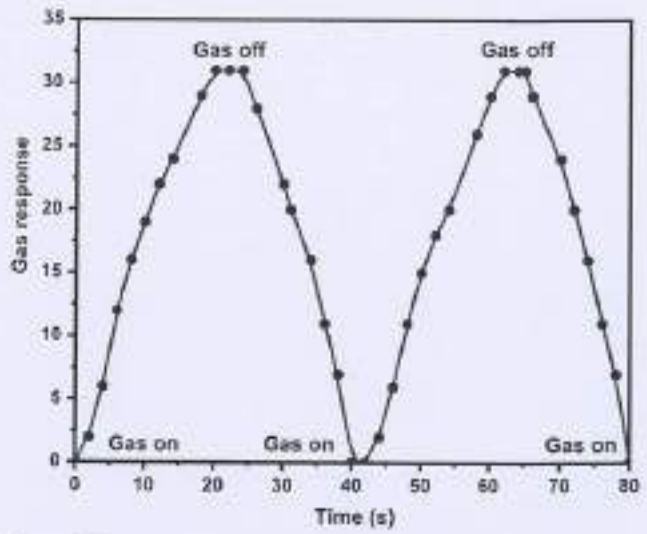


Figure 14. Response and recovery time of $Zn_{0.5}Co_{0.5}Fe_2O_4$ sample.

Gas response and gas concentration.—The Fig. 12 indicates gas response for LPG as a function of gas concentration. Initially the gas response increases with gas concentration up to 100 ppm, after that it saturates. It is because, the 100 ppm gas is sufficient to measure whole gas response. At lower gas concentration, gas molecules adsorb on the surface of the film which acts as active centres of gas response. As gas concentration increases active centres also enhances and when gas molecule completely cover the surface of film the saturation condition attains.

Selectivity.—Figure 13 shows gas response of $Zn_{0.5}Co_{0.5}Fe_2O_4$ film with respect to different gases. It is observed that synthesised sample showing the maximum response to LPG among all other gases.

Response and recovery of the sensor.—Figure 14 shows the response and recovery time of $Zn_{0.5}Co_{0.5}Fe_2O_4$ thick film for LPG. It was observed that the material has 22 s response time whereas 40 s recovery time. Thus the $Zn_{0.5}Co_{0.5}Fe_2O_4$ has quick response and fast recovery to LPG. Moreover, to illustrate the significance of this study, we have compared the present study with the earlier studies reported in literature by considering materials, operating temperature, sensitivity and concentrations for gas sensing applications [45-53] (Table I)

LPG sensing mechanism.—The nanostructured spinel $Zn_{0.5}Co_{0.5}Fe_2O_4$ was used to sense LPG. The adsorption and desorption of oxygen from LPG on the surface of material is typically responsible for their sensing properties. The resistance of $Zn_{0.5}Co_{0.5}Fe_2O_4$ sensor changes when it contacts with the amount of chemisorbed oxygen present in the LPG. The chemisorbed oxygen rapidly covers the oxide surface of a material, even at low oxygen partial pressures and even at temperatures as high as 300 °C.[54] The oxygen has an ability to absorb on $Co_{0.5}Zn_{0.5}Fe_2O_4$surface at operational temperatures and remove electrons from its conduction band.The following processes can be used to explain this phenomenon.[54,55]

$$O_2(gas) \leftrightarrow O_2(ads)$$

$$O_2(ads) + e^- \leftrightarrow O_2^-$$

Discussion.—The gas sensing is related with conductivity of the materials and conductivity is related to adsorption of oxygen (atmospheric oxygen/the lattice or interstitial oxygen) with the test

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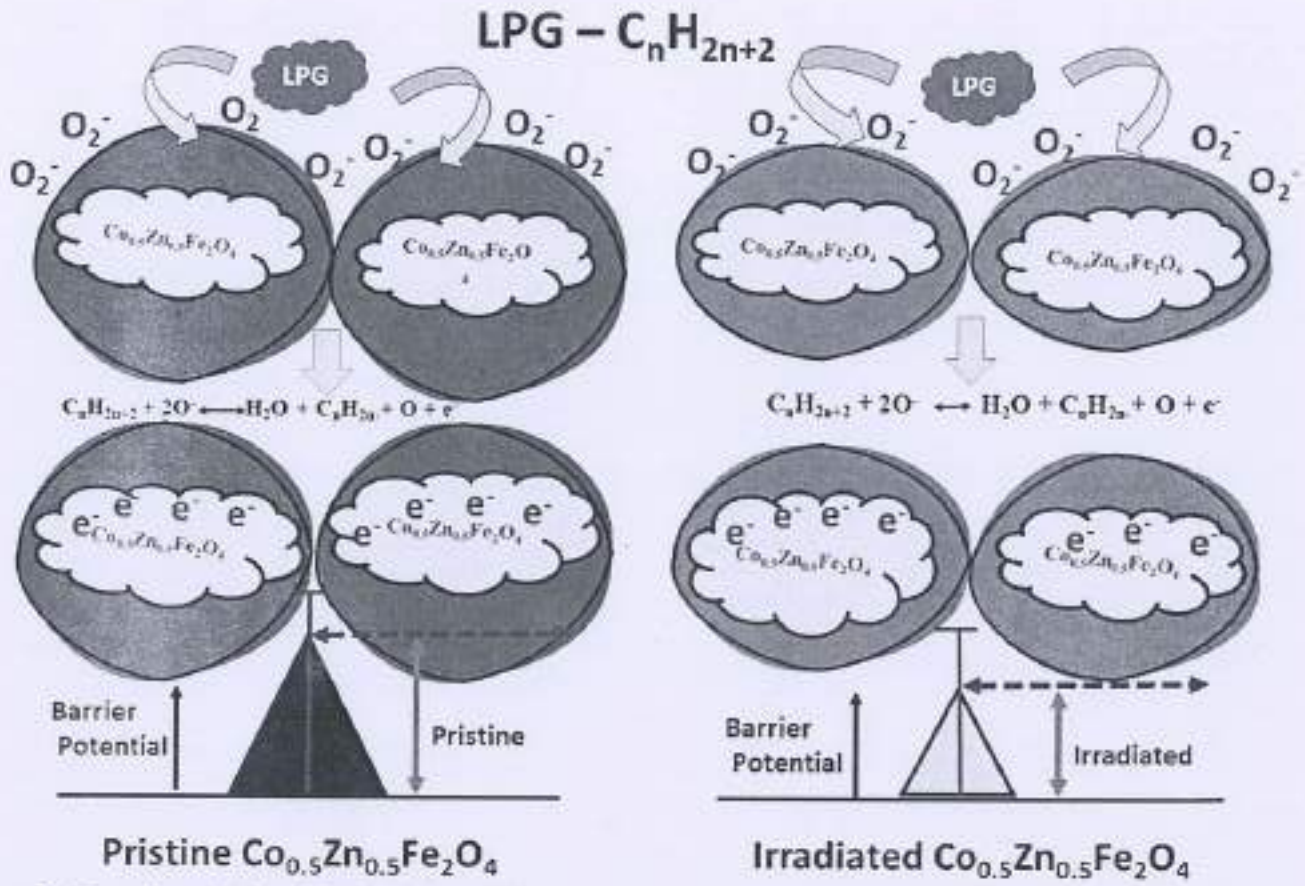


Figure 15. Gas sensing mechanism of $Zn_{0.5}Co_{0.5}Fe_2O_4$ at 300 °C.

Table I. Comparison of earlier studies reported for LPG sensor and present study.

Material	Topt* (°C)	Sensitivity	Concentration/ PPM	References
TiO_2	425	35.8	0.08 vol%	45
ZnO–CuO	400	3.8025	1000	46
Co–SnO_2	350	35	1600	47
ZnO–Cu	500	0.9	400	48
ZnO–Al	325	89	1 vol%	49
SnO_2	350	30	1000	50
Al–Ni–SnO_2	300	16	600	51
$BiFeO_3$–Mn	250	7.2	1000	52
$Zn_{0.5}Co_{0.5}Fe_2O_4$	300	30.30	100	Present work

gas. The atmospheric oxygen adsorbs on the film in the form of superoxide. At higher temperatures, adsorbed oxygen captures the electron from conduction band of the material and there is fall in conductivity as follow:

$$O_{2(air)} + 2e^-_{(cond.band)} \rightarrow 2O^-_{(film\ surface)}$$

In case of LPG gas, The LPG gas molecules react with adsorbed oxygen on film surface and it gets oxidized with releasing free electrons as follows:

$$C_4H_{10(gas)} + 13O^-_{(filmsurface)} \rightarrow 4CO_{2(gas)} + 5H_2O_{(gas)} + 13e^-_{(cond.band)}$$

The generated free electron enhances the conductivity of film rapidly. The $Zn_{0.5}Co_{0.5}Fe_2O_4$ sense LPG gas based on the surface-controlled phenomena, or LPG molecules adsorb on the surface of $Zn_{0.5}Co_{0.5}Fe_2O_4$film and interact with pre-adsorbed oxygen molecules as shown in Fig. 15.[56]

Conclusions

Nanocrystalline $Zn_{0.5}Co_{0.5}Fe_2O_4$ has been successfully synthesized using solution combustion method. This work provides the solution combustion method is a novel method for the synthesis of other metal oxides. The electrical, magnetic, structural, thermal and gas sensing properties of $Zn_{0.5}Co_{0.5}Fe_2O_4$ has been studied in

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details. The cobalt, zinc, iron, and oxygen were detected from EDX study. The synthesised material shows the characteristics of ferro magnetization. XRD study confirms the spinel structure of $Zn_{0.5}Co_{0.5}Fe_2O_4$ ferrite. The synthesised material is showing good performance and good selectivity for LPG at 300 °C among all other tested gases. The material showed very rapid response time (~22 s) and recovery time (~40 s) for LPG. Thus, the $Zn_{0.5}Co_{0.5}Fe_2O_4$ has the potential for manufacturing a temperature dependent gas sensor.

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Synthesis, study and characterization of spinel $CoFe_2O_4$ for the ethanol gas-sensing applications

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ABSTRACT

Nanocrystalline spinel structured $CoFe_2O_4$ was synthesized by a solution combustion method using a urea as fuel. The solution combustion process is a convenient, chief, environment friendly, and capable for the synthesis of quality nanomaterials. The prepared material was annealed to the temperature of 600 °C for four hours in an air. The structural, optical, morphological, compositional, magnetic, thermal and electrical properties of annealed nanocrystalline $CoFe_2O_4$ powder have been studied in detail. The sensor was constructed from nanocrystalline $CoFe_2O_4$ powder and their gas detection properties were examined for ethanol, ammonia, acetone, hydrogen, LPG and carbon dioxide. The gas-sensing measurements showed that, the $CoFe_2O_4$ material responds differently to the gases at different temperatures and it exhibits high sensitivity, good selectivity, rapid response and recovery capability for the ethanol gas compared to other test gases. The probable ethanol gas-sensing mechanism is schematically represented in this paper. This study provides, $CoFe_2O_4$ synthesized using solution combustion method has a huge potential in future gas-sensing fields.

1 Introduction

Nano-crystalline magnetic materials have been widely studied due to their significant electric and magnetic properties and their potential applications in a many fields such as: data storage, ferrofluid technology, magnetocaloric cooling, medical diagnosis, recording systems, microwave devices, gas sensors, drug delivery etc. [1]. Among the ferrites, cobalt ferrite ($CoFe_2O_4$) has received the most significance due to its outstanding chemical stability, high mechanical stiffness, high coercivity, moderate saturation magnetization and strong cubic magnetic anisotropy. These extraordinary properties of $CoFe_2O_4$ makes it an attractive candidate for many commercial electronic applications, including audiotapes, high-density digital recording media, and magnetic fluids [2–9]. The physical, chemical, electrical, optical and magnetic properties are highly influenced by the kind and size of their nanoscale particles. Comparing these materials to their bulk counterparts revealed significant changes in their magnetic characteristics. Several chromate compounds have been synthesized for various applications, for example, $MgCr_2O_4$ for humidity sensor [10–12]. The $CoFe_2O_4$

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ferrite has a cubic-spinel structure and represents a well-known and significant class of iron oxide materials. [13].

Many methods have been reported for the synthesis of cobalt ferrite nanoparticles. These includes polyol method [14], solid state method [15], citrate-gel method [16], co-precipitation [17], sol–gel auto-combustion method [18], hydrothermal process [19], wet chemical route [20], electro-spinning combined with sol–gel technology [21], combustion, laser deposition, thermal decomposition method [22],micro emulsions [23], forced hydrolysis in a polyol medium [24], mechanical alloying [25], solvothermal approach [26], anew on-aqueous route [27], reverse micelles method [28],etc.

Nowadays, strict environmental policies are being implemented to limit emissions and harmful pollutants. Thus to monitor this, demands of chemical sensors are constantly increasing. Among solid state chemical sensors, metal oxide semiconductor (MOS) sensors are the widely utilized because of their many benefits including their compact size, low cost, low power consumption, online operation, and excellent compatibility with microelectronic processing. The MOS sensors are sensitive to environmental conditions.

In this study, we have synthesized $CoFe_2O_4$ nanoparticles using a solution combustion method. One of our goals is to synthesis $CoFe_2O_4$ nanoparticles which has gas sensing capabilities and other is to synthesis it from energy saving and low-cost generic synthesis technique. We discovered that solution combustion method is practical, environmentally benign, affordable and effective for producing $CoFe_2O_4$ nanoparticles with grain size of 41 nm. Moreover, the thick film of $CoFe_2O_4$ showed excellent gas-sensing capabilities for ethanol gas.

2 Experimental details

2.1 Sample preparation

The $CoFe_2O_4$ nanoparticles were synthesized by solution Combustion method. The cobalt nitrate nonahydrate [$Co(NO_3)_3 9H_2O$, Alfa Aesar, 99%], Iron nitrate hexahydrate [$Fe(NO_3)_2 6H_2O$, Sigma-Aldrich, 98%], urea (CH_4N_2O, Alfa Aesar, 99%) and distilled water were used for the synthesis of $CoFe_2O_4$nanoparticles. First, cobalt nitrate nonahydrate, Iron nitrate hexahydrate and urea were dissolved in 150 ml distilled water. The stoichiometric amounts of cobalt nitrate nonahydrate, Iron nitrate hexahydrate and urea was taken 1:1:4 to create a homogeneous solution. The urea is an organic fuel that provides a platform for redox reactions which occurs during the flaming. The solution was continuously stirred and heated to 80 °C on a hot plate until gel formed. The hot plate is then heated to 200 °C for the burning the gel in self-propagating combustion, forming a loose powder. Then this loose powder was grinded and annealed at 600 °C for 4 h in a furnace. This resulting product was then allowed to cool at room temperature. The details of which have been explained elsewhere [29]. Figure 1 represents the flow chart of synthesised $CoFe_2O_4$ nanoparticles using solution combustion method.

2.2 Powder, paste and thick film preparation

To obtain sufficiently fine powder, synthesized $CoFe_2O_4$ powder was grinded in a mortar and pestle. The grinded powder was annealed at 600°Cfor 4 h in air and after annealing resulting powder was grinded again. A thixotropic paste was prepared by mixing the fine powder $CoFe_2O_4$ with a solution of ethyl cellulose (temporary binder) in a heavy organic mixture of butyl carbitol acetate, butyl cellulose and terpineol. The thixotropic paste is screen printed on the glass substrate in the desired pattern. The film was heated at 500 °C for 24 h. The electrical contacts were made on the film by thermal evaporation techniques for electrical measurements.

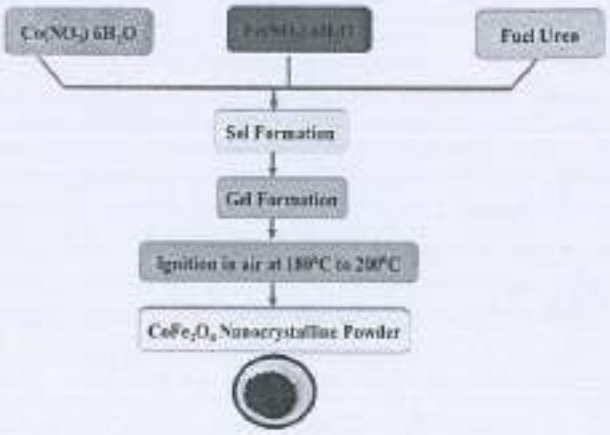


Fig. 1 Flow chart of synthesis of $CoFe_2O_4$ nanoparticles using solution combustion method

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2.3 Thickness measurement (talystep method)

The film thickness was measured using talystep profile meter and it was observed in the range of 30 to 35 μm. There reproducibility of film thickness was achieved by maintaining the proper rheology and thixotropy of the paste.

2.4 Fabrication and analysis of gas sensors

The gas sensing performance of the synthesized $CoFe_2O_4$ sample was examined using a "static gas-sensing system", particulars of which have been explained elsewhere [30].

3 Materials characterization

The structural, thermal, opto-electrical, magnetic and surface morphological properties of $CoFe_2O_4$ nanoparticles were studied via different characterization technique. The Thermogravimetry–differential thermal analysis (TG–DTA) carried out using thermal analyser (SDT Q600 V 20.9 Build 20). The structural properties of synthesised material was confirmed from X-ray diffraction pattern obtained from X-ray diffractometer (PW-3710) with Cu K_α line ($\lambda = 1.54°A$). Fourier transform infrared (FTIR) spectra of $CoFe_2O_4$were recorded using FTIR spectrophotometer (JASCO, 6100-type A) in the range of 400–4000 cm^{-1}. The absorbance spectra and optical band gap energy of the $CoFe_2O_4$ was estimated using a LAMBDA 750 (Perkin Elmer) UV–VIS NIR Sspectrophotometer in the range 200–800 nm. The morphological and compositional analysis was carried out by scanning electron microscope (SEM) (JEOL JED 2300) coupled with energy-dispersive spectrometer (JEOL 6360 LA). Transmission electron micrographs and selected area electron diffraction (SAED) patterns were obtained by means of a transmission electron microscope (TEM) operating at 200 kV. A vibrating sample magnetometer (VSM) was used to measure the magnetic properties of the $CoFe_2O_4$ nanoparticles at room temperature using VSM-Microsesse EZ-9. To measure electrical properties, the aluminum electrodes were deposited on the film by thermal evaporation techniques using a suitable mask. The silver paste was fixed on aluminum contacts for conductivity measurement. The gas-sensing performances were carried out using different gases on homemade gas sensing machine [31].

4 Result and discussion

4.1 Thermal analysis

Thermal analysis of $CoFe_2O_4$ nanoparticles were carried out in static air with temperatures increased from 35 °C to 800 °C. Figure 2 shows the TGA and DTA curves of the synthesised material. The thermal analysis helps to ensure annealing temperature required for ferrite formation. A continuous weight loss was observed from the TGA curve till 585 °C. After 585 °C there are no further significant weight loss were observed, which confirms the complete phase formation of the $CoFe_2O_4$ sample. Hence the as prepared sample was annealed at 600 °C. The total 2.158 mg weight loss was observed. The observed weight loss is due to desorption of water, decomposition of organic templates and crystallization of the final product. In DTA curve a small weak endothermic peak was observed nearly at 50 °C, which can be attributed to the exclusion of water from the gel. The broad exothermic peak observed at 490 °C is attributed due to the decomposition of nitrates and initiates the formation of cobalt ferrite crystallization [32]. The weight loss observed at these temperatures is 0.071 mg and 2.428 mg, respectively.

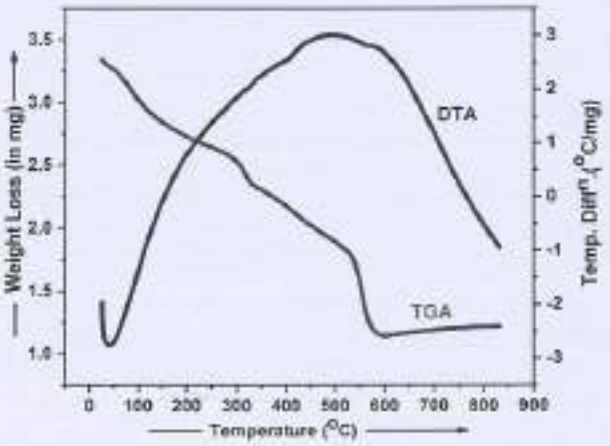


Fig. 2 TGA and DTA curves of synthesized $CoFe_2O_4$ nanoparticles at atmospheric pressure

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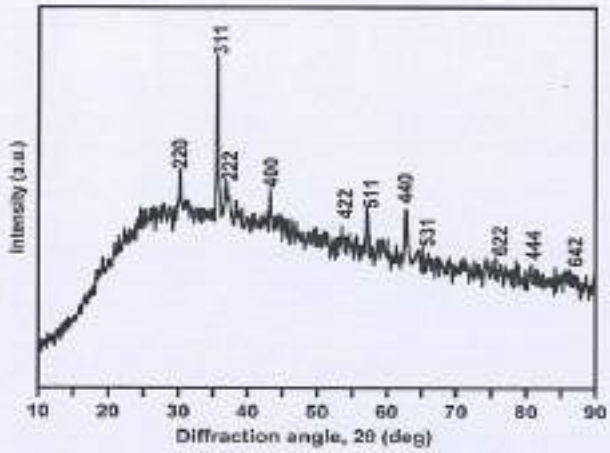


Fig. 3 XRD pattern of $CoFe_2O_4$ nanoparticles annealed at 600 °C

Table 1 Indexed X-ray diffraction pattern of $CoFe_2O_4$

Sr. no	2θ in degree	Inter planer spacing (observed) (A°)	Inter planer spacing (calculated) (A°)	[hkl]
1.	30.22	2.968	2.8070	220
2.	35.06	2.531	2.9470	311
3.	36.07	2.424	2.5110	222
4.	43.22	2.099	2.005	400
5.	53.48	1.713	1.830	422
6.	57.16	1.615	1.699	511
7.	62.72	1.483	1.499	440
8.	65.12	1.419	1.397	531
9.	75.66	1.265	1.235	622
10.	78.48	1.211	1.210	444
11.	86.18	1.121	1.123	642

4.2 X-ray diffraction (XRD) analysis

Figure 3 presents XRD pattern of the $CoFe_2O_4$ sample annealed at 600 °C for 4 h in an air. The diffraction peaks observed at 2θ is equal to, 30.22°, 35.06°, 36.07°, 43.22°, 53.48°, 57.16°, 62.72°, 65.12°, 75.66°, 78.48° and 86.18° shows the formation of $CoFe_2O_4$ spinel structure. There are no extra diffraction peaks observed in XRD pattern, shows single phase of $CoFe_2O_4$ were formed. The calculated lattice parameter a = 8.392 A° is in good agreement with the reported value for spinel $CoFe_2O_4$ (a = 8.392, JCPDS # 22–1086).

The crystallite size was estimated from the basic Scherrer equation [1],

$$D = \frac{K\lambda}{\beta cos\theta} \tag{1}$$

where D is the average crystallite size, λ is the x-ray wavelength, β is the width of the X-ray peak on the 2Θ axis, normally measured as full width at half maximum (FWHM). Θ is the Bragg angle, and K is the so-called Scherrer constant. K depends on the crystallite shape and the size distribution, indices of the diffraction line, and the actual definition used for β whether FWHM or integral breadth [2]. K can have values anywhere from 0.62 and 2.08. The calculated crystalline size was 41 nm by taking K = 0.9, the accuracy of Eq. 1 was discussed elsewhere [33–35]. The calculated and observed XRD parameters of $CoFe_2O_4$sample are shown in Table 1.

As we know that the crystallite size estimated from Scherrer equation gives only the lower bound to the crystallite size. In this work, the crystallite size (D) value calculated from Scherrer's equationis compared with the 'D' values obtained from the Williamson–Hall analysis and TEM analysis.

4.2.1 *Estimation of crystallite size (D) and lattice strain (ε) from Williamson–Hall analysis:*

In XRD, the peak broadening is due to the instrumental broadening, broadening due to crystallite size and lattice strain present in the material. The line broadening due to crystalline size and lattice strain is given by

$$\beta = \frac{N\lambda}{Dcos\theta} + 4\varepsilon tan\theta \tag{2}$$

where, λ is the X-ray wavelength, θ the Bragg angle, D the crystallite size, ε the lattice strain and N the Scherrer constant [36, 37].

To separate the line broadening, a quantitative analysis can be carried out using a plot by the Williamson–Hall method

$$\beta cos\theta = \frac{N\lambda}{D} + 4\varepsilon sin\theta \tag{3}$$

Here, we assumed isotropic nature of the crystal, where strain to be uniform in all crystallographic directions.

The Fig. 4 shows the plot of (β_{hkl}cosθ) versus (4sinθ) for the calculation of crystallite size and lattice strain present in the material. The linear fitting made to the plot using 'Origin 2018' software. The lattice strain present in the material and crystallite size can be

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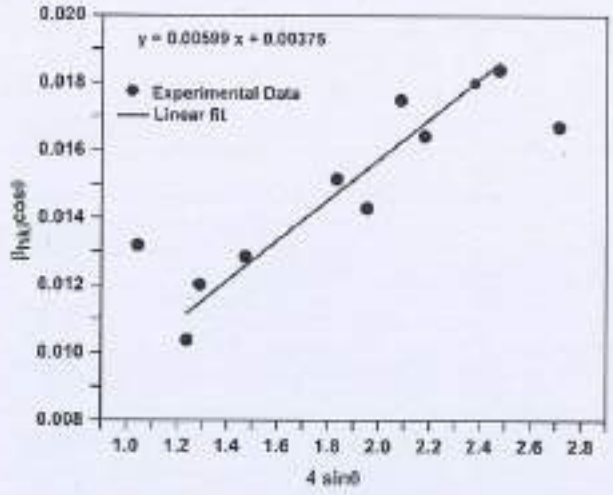


Fig. 4 Williamson–Hall analysis of $CoFe_2O_4$ nanoparticles annealed at 600 °C

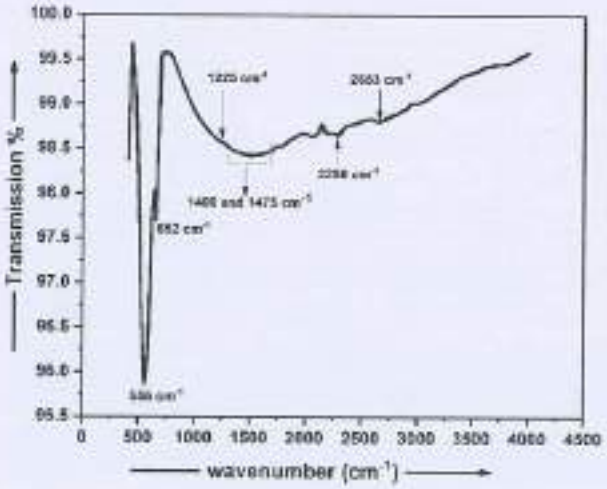


Fig. 5 FTIR spectrum of the synthesized $CoFe_2O_4$ nanoparticles

calculated from the slope and intercept of the linear fit made to the plot in Fig. 4.The calculated values of crystallite size and lattice strain present in the material are 38.60 nm and 5.99×10^{-3}, respectively.

4.3 FT-IR analysis

The FTIR spectrum of $CoFe_2O_4$ nanoparticles synthesised by solution combustion method is shown in Fig. 5. The FTIR study is used to observe whether organic molecules with functional groups are present around the nanoparticles (NPs) and to identify the vibrational modes of the metal–oxygen bonds for spinel structure. Figure 5 shows major absorption bands observed nearly around 570–670 cm^{-1} are due to the stretching vibrations of Fe^{3+}- $O_2^{-2}$and vibrations of octahedral group complex of Co-O_2, indicating the existence of spinel ferrite. The spectrum shows the absence of O–H stretching vibrations of the peak observer around at 3430 cm^{-1} and 2927 cm^{-1}, indicating the absence of water molecules [38]. The small hump at 1225 cm^{-1} corresponds to C–O vibration. The absorption bands at 1400 $cm^{-1}$and 1475 cm^{-1}corresponds to the COO^{-1}symmetric and asymmetric stretching vibrations [39]. The asymmetrical and symmetrical stretching of CH_2 groups, which are characteristics of the hydrocarbon chain of the active surfactants, can be assigned to the bands at 2286–2653 cm^{-1}.

4.4 Energy-dispersive X-ray (EDX) spectroscopy analysis

The elemental compositions was analysed using EDX. From Fig. 6, it shows that the presence of cobalt, iron and oxygen in the powder. In this study we had annealed the sample at 600 °C for 4 h to eradicate the organic molecules around nanoparticle's surface. This enabled it to remove impurities from the sample.

4.5 Filed emission-scanning electron microscopy (FE-SEM) analysis

Figure 7 (a, b) shows the morphology of the $CoFe_2O_4$ sample synthesized using solution combustion method examined using FE-SEM. The agglomeration of cobalt ferrite nanostructures were observed in the FE-SEM image. It is also reveals that the samples surface exhibit well defined crystalline nanostructures of irregular shapes with soft agglomeration. The particle size determined by FESEM micrographs is about 12–35 nm, which is well agreement with the particle size calculated from Scherrer's equation.

4.6 Transmission electron microscopy (TEM) analysis

TEM analysis and selected area electron diffraction (SAED) pattern were performed to determine the microstructure of $CoFe_2O_4$ powder. The Fig. 8 (a,b,c) shows the TEM images of $CoFe_2O_4$ nanoparticles synthesised using solution combustion method. From TEM images, it is observed that most of the $CoFe_2O_4$

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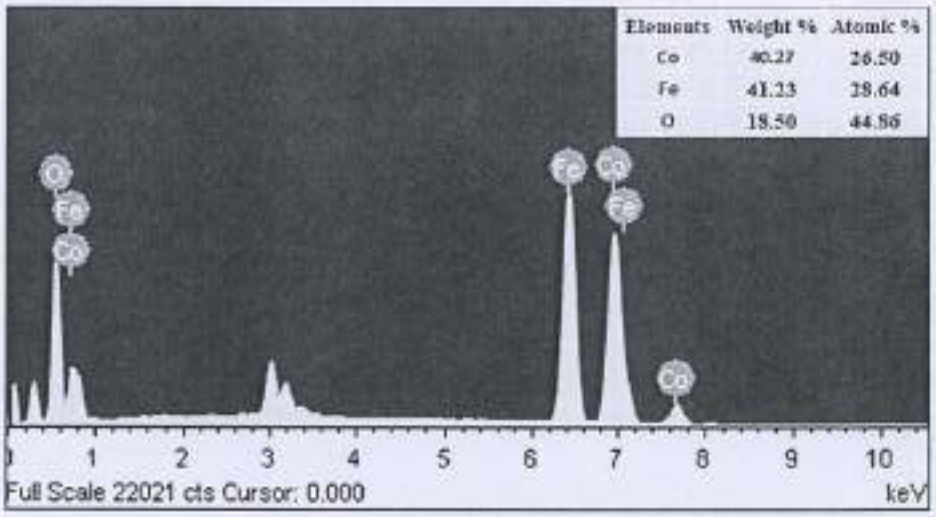


Fig. 6 EDX pattern of nanocrystalline $CoFe_2O_4$material. Inset shows the quantitative analysis of the same

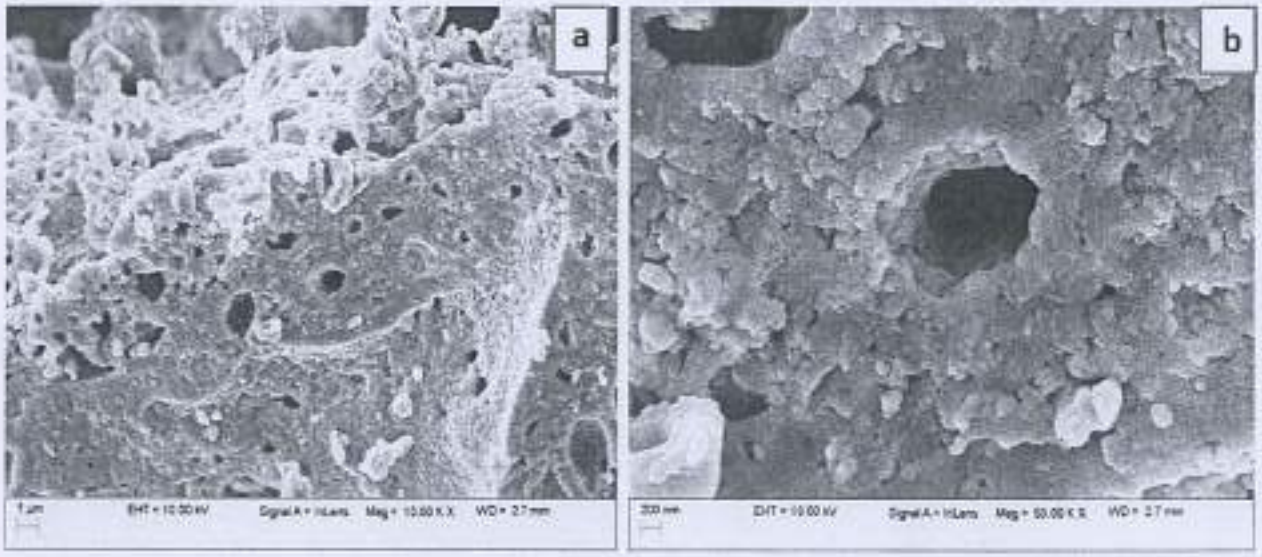


Fig. 7 FE-SEM images $CoFe_2O_4$ sample annealed at 600 °C

particles are irregular in shapes with little agglomerations of the particles. Figure 8d shows the SAED pattern of $CoFe_2O_4$ powder and it shows the synthesised material is polycrystalline in nature. The six most prominent concentric diffraction rings starting from the centre is corresponds to (111), (220), (311), (400), (511) and (440) plane, which is corresponds to cubic spinel of $CoFe_2O_4$ and it is consistent with XRD analysis (Fig. 9).

The average particle size was estimated from j viewer software and it was found 41.50 nm. The average particle size estimated from XRD, TEM, FE-SEM and Williamson–Hall plot are found nearly equal.

4.7 UV–visible spectroscopy analysis

Figure 10 shows the UV–Visible absorption spectrum of $CoFe_2O_4$nanoparticles. The remarkable absorption

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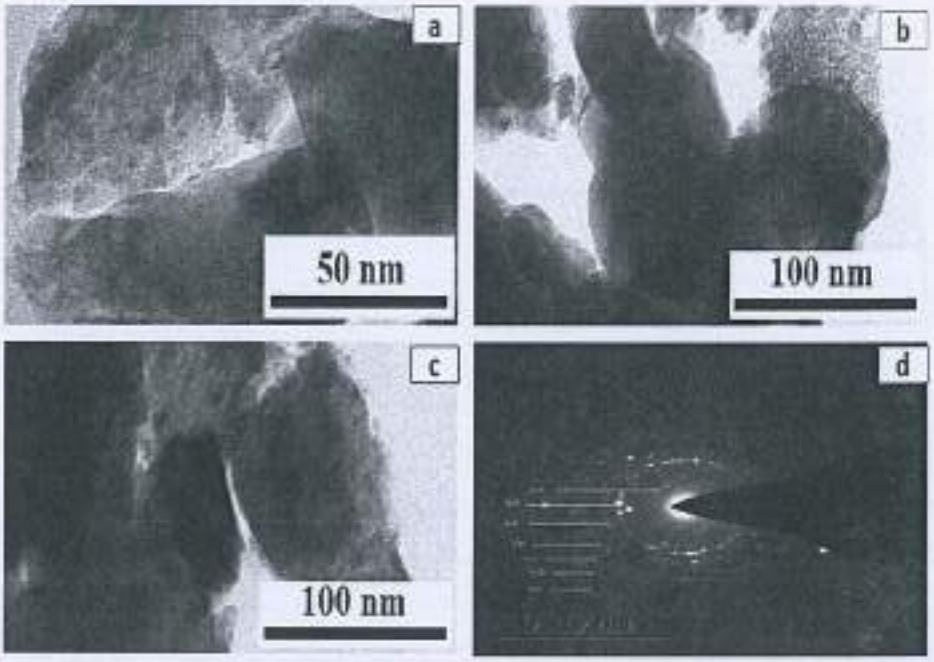


Fig. 8 TEM images of $CoFe_2O_4$ nanoparticles synthesised by solution combustion method

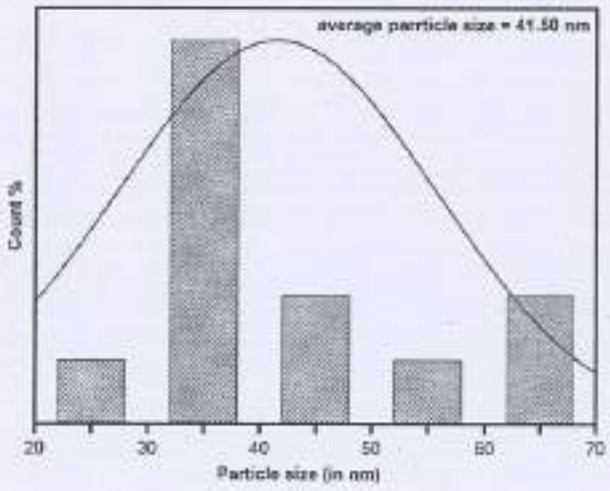


Fig. 9 Average particle size distribution using j viewer software

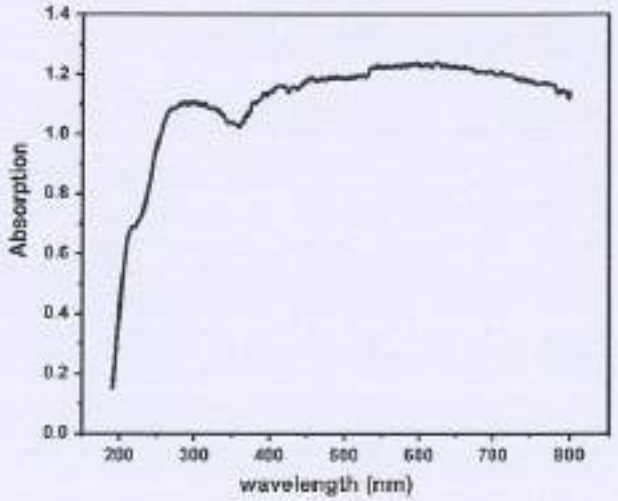


Fig. 10 UV–Visible absorption spectra of $CoFe_2O_4$ nanoparticles

in the sample is due to its black colour. The absorption spectrum shows the absorption peak of $CoFe_2O_4$ nanoparticles is found around at 305 nm. As the colour of the photocatalyst changes from golden yellow to dark brown, the increase in absorption in visible light should affect the photo catalytic ability of the composite [40].

The energy band gap of $CoFe_2O_4$ nanoparticles estimated by Tauc's relation

$$(\alpha h\upsilon) = A(h\upsilon - E_g)^n \quad (4)$$

where α: absorption coefficient, υ: frequency of light, h: Planck's constant, A and n are constants, n = 0.5 and 2 for a direct and indirect band-gap semiconductor respectively [41]. The Fig. 11 shows the plots of $(\alpha h\upsilon)^2$ verses $h\upsilon$ for $CoFe_2O_4$ nanoparticles. The energy band gap values of the $CoFe_2O_4$ nanoparticles can be found

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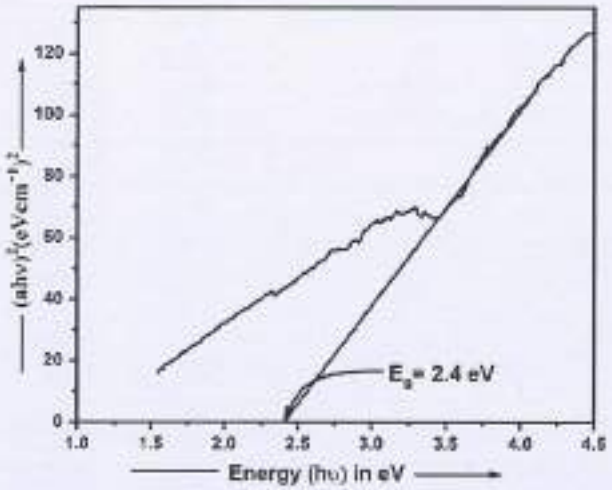


Fig. 11 Plot of $(\alpha h\upsilon)^2$ versus energy (hυ)

by extrapolating the linear part of the plot to $(\alpha h\nu)^2 = 0$ and it is found to be 1.38 eV.

5 VSM analysis

Figure 12 shows the hysteresis loop of $CoFe_2O_4$ sample annealed at 600°C. The vibrating sample magnetometer (VSM) was conducted at room temperature with highest applied field is 15,000 oersted (Oe). The magnetic parameters including saturation magnetization (Ms), coercivity (Hc), and remanent magnetization (Mr) was estimated from hysteresis loop. The estimated value of saturation magnetization, coercivity and remanent magnetization was 84.71 emu/g, 1220Oe and 35.70 emu/g, respectively. The value of Ms is very close to bulk. The higher value of Ms is due to well crystalline behaviour of $CoFe_2O_4$ sample annealed at 600 °C. During the annealing there are enhancement of rearrangement of the cation distribution takes places in which interchange of Co^{2+} and Fe^{3+} ions from octahedral to tetrahedral sites and vice versa. The observed saturation magnetization (Ms) for the sample after annealing at 600 °C agrees well with the values that have been published. The samples were largely crystalline after annealing at 600 °C, as seen by the XRD pattern. As a result, the lattice can contain a significant amount of crystal defects, dislocations, and lattice strain. This will cause a significant reduction of magnetic moment within the particles. This surface effect becomes less significant if the annealing temperature is above 600 °C. Thus, from VSM study it is clear that synthesised material is showing ferromagnetic behaviour of the material [42].

6 Electrical properties of the sensors

6.1 I-V characteristics

Figure 13 depicts the I–V characteristics of the nanocrystalline $CoFe_2O_4$ films at room temperature. The Fig. 13 shows that the sliver contacts fabricated on the film were ohmic in nature. The voltage was applied in the range 1–30 V. The current increases

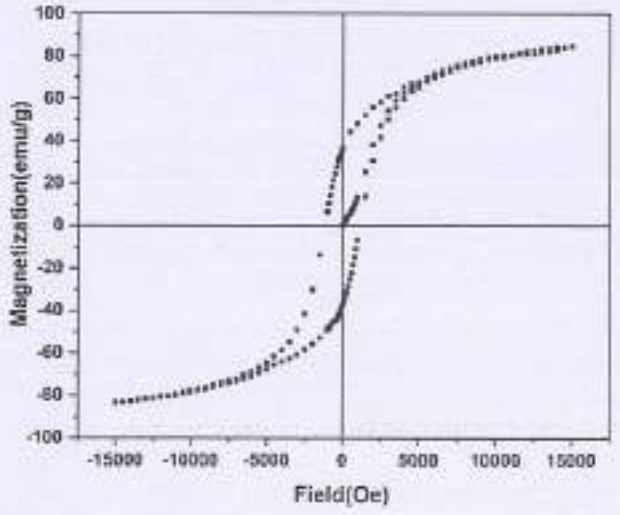


Fig. 12 Hysteresis curves of$CoFe_2O_4$ annealed at 600 °C

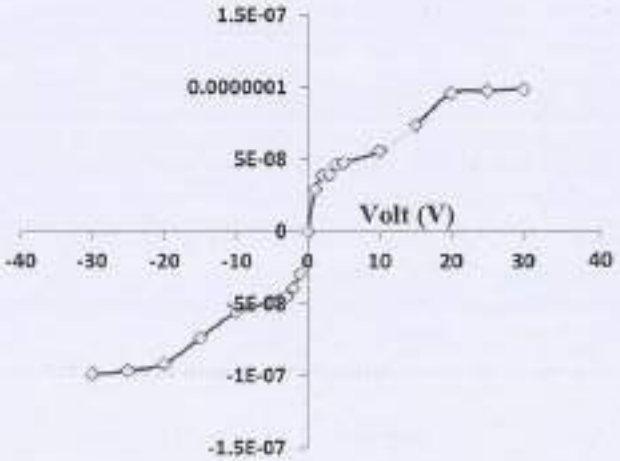


Fig. 13 I-V characteristics of nanocrystalline $CoFe_2O_4$ film

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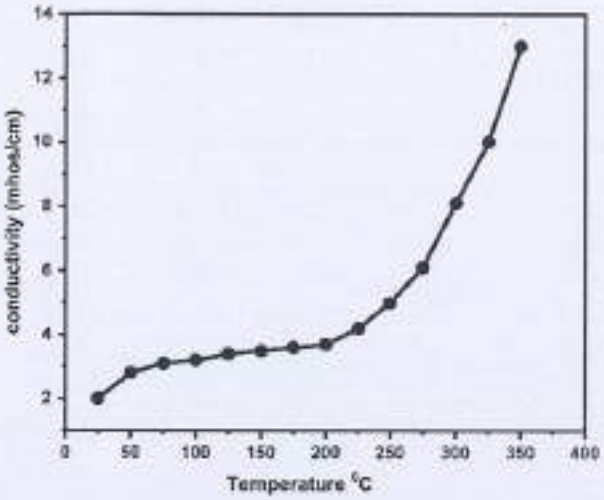


Fig. 14 Conductivity–temperature profiles of nanocrystalline $CoFe_2O_4$ thick film

with the applied voltage. The increase in current with applied voltage is due to less recombination rate and well crystalline of material.

6.2 Electrical conductivity measurement

The variation of electrical conductivity with temperature is shown in Fig. 14. The electrical conductivity $CoFe_2O_4$ nanoparticles increase with temperature enhances from 25 °C to 350 °C in air ambient. The semiconducting structure of $CoFe_2O_4$ nanoparticles is responsible for the increase in conductivity. The large oxygen deficiency in $CoFe_2O_4$ may be the cause of its semiconductivity. At higher operating temperatures, the substance will absorb the oxygen species ($O_2^- \rightarrow 2O^- \rightarrow O^{2-}$).

7 Sensing performance of sensor

7.1 Gas response, selectivity and recovery time

The Eq. 5 defines the relative response (S) to a target gas

$$S = \frac{G_g - G_a}{G_a} \quad (5)$$

where, G_a and G_g are the conductance in air and sample gas, respectively. The selectivity is the capability of a sensor to react to a certain gas in the existence of different gases. Response time (RST) and Recovery time (RCT) have been discussed elsewhere [43].

7.2 Sensing performance of $CoFe_2O_4$ thick films

7.2.1 Gas response and operating temperature

Figure 15 depicts the variation of 100 ppm gas responses with operating temperature. The $CoFe_2O_4$ thick film sensor was observed to be a temperature dependents gas sensor. The Fig. 15 shows that the sensor has better responds to ethanol gas at 250°C, NH_3 gas at 300°C, acetone gas at 50°C, H_2 gas at 150°C, CO_2 gas at 100°C and LPG gas at 150°C. Thus the sensitivity of such gases is temperature dependent. The same sensors could be used to identify these gases, just by varying the operating temperature. This is the most advantageous characteristic of this sensor.

7.2.2 Selectivity factor of $CoFe_2O_4$ thick film sensor for various gases

From Fig. 16, it is observed that the $CoFe_2O_4$ thick film gives highest response to ethanol vapours (100 ppm) at 250 °C. The sensor confirmed maximum selectivity for ethanol against all other tested gases: NH_3, Acetone, H_2, LPG, and CO_2.

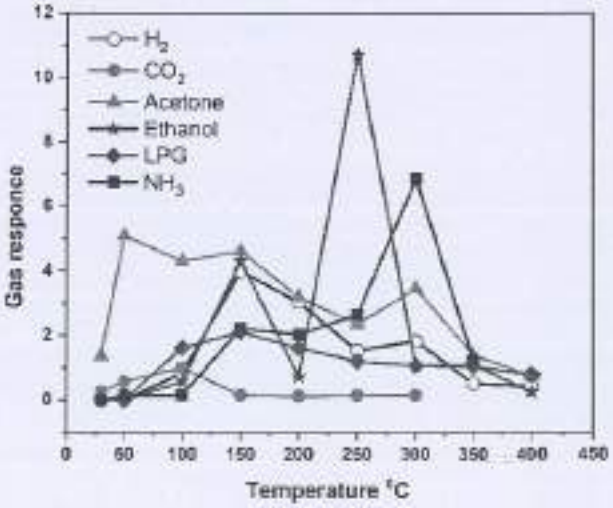


Fig. 15 Variation of different gas responses with operating temperatures

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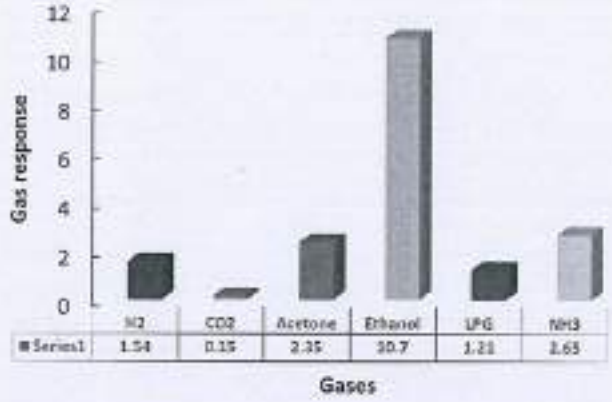


Fig. 16 Selectivity factor of the sensor for various gases

7.2.3 Active region of sensor

Figure 17 shows how the ethanol gas concentrations respond to $CoFe_2O_4$ thick film. It clearly indicates that the gas response increases linearly with gas concentration up to 400 ppm, after that gas response is coming toward the saturations. As gas concentration increases, the surface of the film is covered by the monolayer of gas molecules increases i.e. the surface-active areas of the film increases; hence there was an enhancing gas response. As the surface active layer is completely covered by gas molecules the saturation condition attains. Thus in this case, the sensor's active region could be as high as 400 ppm.

7.2.4 Response and recovery time

Figure 18 presents the response and recovery time of $CoFe_2O_4$ thick film sensor. The response for 400 ppm ethanol was quick (11 s), as compared to the recovery was (40 s). Faster gas oxidation may have attributed to the quick response. The surface reaction products in significant quantity yet elevated the volatility explain its rapid response and rapid recovery to its initial chemical status. Moreover to illustrate the significance of this study, we have compared the present study with the earlier studies reported in literatures by considering materials, gas concentrations, operating temperatures and gas-sensing responses for gas-sensing applications [47–52] (Table 2).

7.3 Discussion

When the thick film of $CoFe_2O_4$ sample exposed to ethanol vapours, the electronic conductivity of the semiconducting material changes. Electron transfer occurs between the semiconducting surface and the substances that adsorb ethanol gas molecules come into proximity to the surface of a thick film. On the surface of the thick layer, molecules of oxygen from the atmosphere are adsorbed. They accomplish this by capturing electrons from the conduction band in the thick film material as the electrical conductivity decreases.

$$O_{2(air)} + 4e^- \rightarrow 2O^{2-}{}_{(film\ surface)}.$$

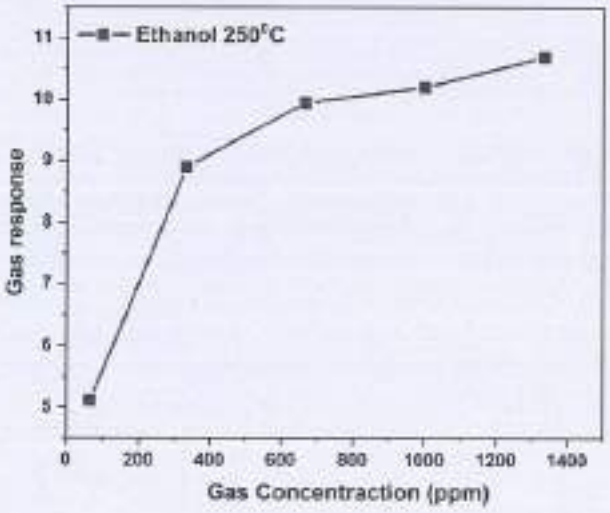


Fig. 17 Variation of gas response with gas concentration

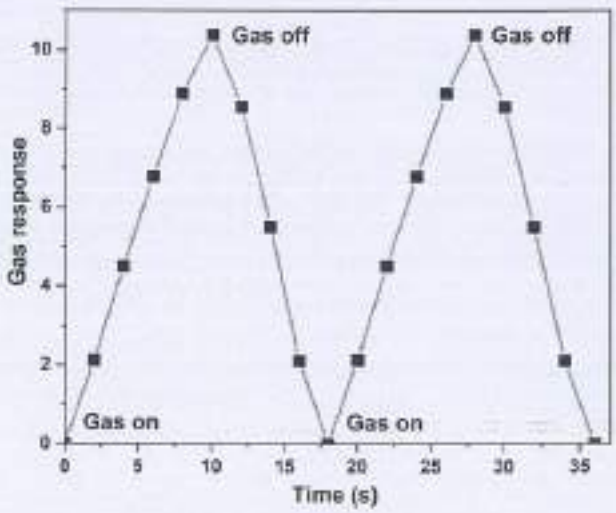


Fig. 18 Response and recovery of $CoFe_2O_4$ sample

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Table 2 Comparison of ethanol gas sensing response from different literature work and present study

Sensing material	Ethanol concentration	Operating temperature	Gas sensing response	References
$CuFe_2O_4$	1000 ppm	332 °C	7.5%	[47]
$Zn_{0.6}Mn_{0.4}Fe_2O_4$	200 ppm	300 °C	0.97%	[48]
$ZnFe_2O_4$	50 ppm	390 °C	3.66%	[49]
Branch ZnO/NiO	50 ppm	400 °C	6.7%	[50]
Fe doped NiO	200 ppm	320 °C	21%	[51]
3D flower NiO	400 ppm	300 °C	34%	[52]
$CoFe_2O_4$	100 ppm	250 °C	10.7	Present work

All samples were found to be oxygen deficient because the $CoFe_2O_4$ and O in the sample were not in an appropriate stoichiometric proportion. The absorption of surrounding molecular oxygen reduces this shortage (though to a lesser amount).This helps in decreasing the film's electronic conductivity. after a series of intermediate steps, ethanol molecules are oxidised by the oxygen ions that have been adsorbed upon exposure, producing CO_2 and H_2O.As a result, oxygen is transformed into electrically neutral atoms that are trapped behind the film's surface's negative charges (electrons).The trapped electrons could jump into the $CoFe_2O_4$ conduction band with the appropriate amount of energy released during the decomposition of ethanol molecules to increase the conductivity of the thick $CoFe_2O_4$ sheet.

The $CoFe_2O_4$ conductance modifications formed the basis for the gas-sensing system. The oxygen released on the surface of the material changed the conductivity of the $CoFe_2O_4$-based sensor. The particle size, specific area, and operating temperature of the sensor were utilised for determining the amount of oxygen on the surface of the material. As the air increased in temperature, the oxygen adsorbed on $CoFe_2O_4$'s surface went through the following reactions.

$$O_{2(gas)} \rightarrow O_{2(ads)} \rightarrow O_{2(ads)}^{-} \rightarrow 2O_{(ads)}^{-} \rightarrow 2O_{(ads)}^{2-}$$

Oxygen species absorbing electrons from the substrate were responsible for changes in whole or electron concentration in $CoFe_2O_4$ materials. Oxygen adsorbed on $CoFe_2O_4$'s surface reacted with reducing gases, and the oxygen's trapped electrons returned to the material, producing variations in $CoFe_2O_4$ conductance. Notwithstanding the fact that the sensors had the same response type (n-type or p-type) to reducing gases, the responses were also influenced by the amount of thickness of the thick film value. The value may have produced an influence on the quantity of active sites on the surface of the $CoFe_2O_4$ material that could absorb oxygen and reducing gases [44, 45]

The ethanol sensing mechanism of this $CoFe_2O_4$thick film-based gas sensor can be described as follows:

$$CH_3CH_2OH_{ads} + 6O_{ads}^{-} \rightarrow 2CO_2 + 3H_2O + 6e^{-}$$

An n-type conduction mechanism is demonstrated here. As a result, a single molecule of ethanol undergoes oxidation and emits twelve electrons into the conduction band, increasing the conductivity of the sensor. As the operating temperature increases, a huge number of ethanol molecules oxidise, producing many electrons. As a result, conductivity increases exponentially. Therefore, the gas response increases as the operating temperature increases. At higher operating temperatures, the response falls off as the oxygen adsorbates and migrates from the sensor's surface. Furthermore, due to intrinsic thermal excitation, the carrier concentration rises as the temperature rises while the Debye length decreases. The Fig. 19 [46] may be one of the factors leading to a lower gas response at very high temperatures.

8 Conclusions

The formation of $CoFe_2O_4$ spinel nanoferrites by solution combustion method is confirmed by XRD. The FE-SEM images show the synthesized material was porous nanostructures. The presence of the elemental compositions in the synthesized material was confirmed from EDX spectrum. TEM investigation of the spinel ferrites has confirmed their nanocrystallinity and phase purity. The average crystallite size estimated from XRD, TEM, FE-SEM and Williamson–Hall

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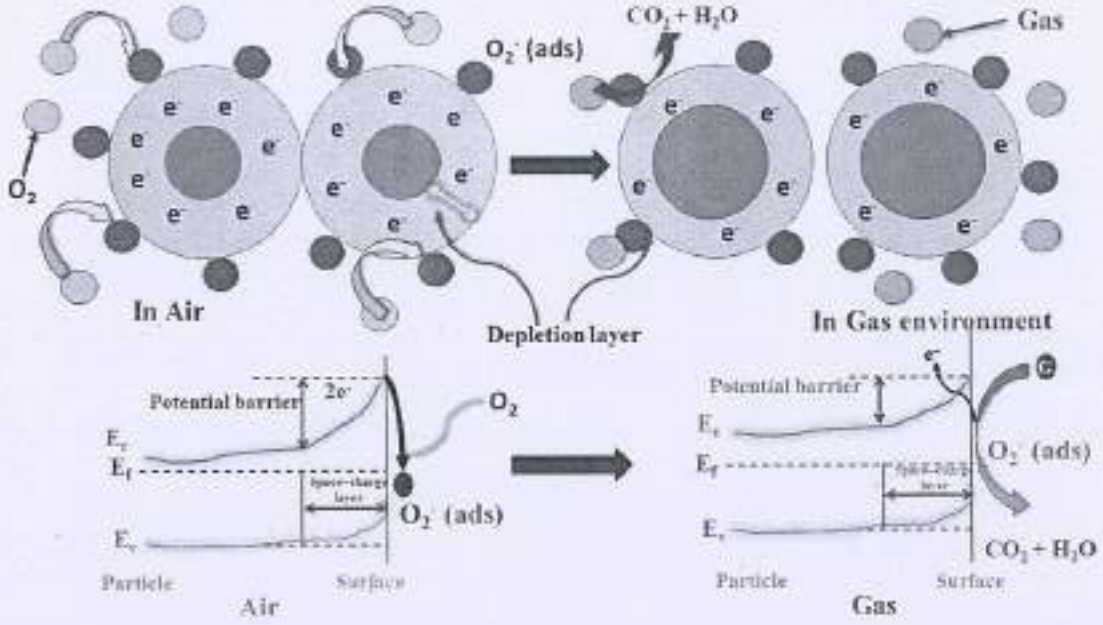


Fig. 19 Schematic diagram of all kinds of $CoFe_2O_4$thick films exposed to air and ethanol gas

plot are found nearly equal. The VSM measurement shows their compositions are inherently ferromagnetic. The $CoFe_2O_4$ sensor shows temperature dependent gas sensitivity for ethanol, ammonia, acetone, hydrogen, LPG and carbon dioxide. The $CoFe_2O_4$ seemed excellent and responded to ethanol gas optimum at a temperature of 250 °C when tested with ethanol gas, the sensor responded within (~ 11 s) and recovered within (~ 40 s). The sensors showed good selectivity to a specific gas against other reducing gases at a specific temperature. The sensor exhibits high ethanol selectivity against NH_3, acetone, H_2, LPG, and CO_2.

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Author contributions

R. D.P: investigation, writing—original draft, conceptualization, writing—review and editing. S. V. B: conceptualization, methodology, validation, formal analysis, writing—original draft, visualization, methodology, investigation, writing—review and editing. M. M. K: conceptualization, resources, writing—review and editing. S. B. S: conceptualization, methodology, formal analysis, supervision.

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Data availability

Data Available on request from the authors.

Declarations

Conflict of interest The authors declare that there is no conflict of interest.

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Combustion synthesis of spinel structured $NiCo_2O_4$ nanostructures: An efficient material for gas sensing and supercapacitor electrode applications

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ABSTRACT

Nanostructured spinel $NiCo_2O_4$ powder has been effectively synthesized using the solution combustion technique. The synthesized material was annealed at 500 °C and further utilised for gas sensing and energy storage applications. The thermal, structural, optical, electrical, magnetic and morphological properties of synthesized material were investigated in detail. The annealed synthesized $NiCo_2O_4$ powder was tested for the electrochemical studies with galvanostatic charge-discharge (GCD), cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS) and cyclic stabilitytests for the supercapacitor electrode applications. The specific capacitance (CS), energy density (E) and power density (P) of the synthesized materials were estimated from the GCD plot and it was 730 F/g, 16.22 $WhKg^{-1}$ and 398.71 Wkg^{-1} respectively at the current densities 2 A/g. The fabricated electrode from $NiCo_2O_4$ powder had an initial retention of capacitance value is 92.23 % after 5000 cycles. The synthesized material was further tested with different gases detection at various temperatures. The fabricated $NiCo_2O_4$ sensor was used for the estimation of gas sensing properties of acetone, carbon dioxide, ammonia and ethanol gases at various working temperatures. The gas-detection measurements illustrate that the $NiCo_2O_4$ material reacts differently to various gases at different temperatures and observes maximum sensitivity, superior selectivity, quick response and recovery ability for the ammonia gas as compared with other test gases. The feasible NH_3 gas detection mechanism is pictorially presented in this manuscript. The present works conclude that nanostructured spinel $NiCo_2O_4$ is the promising material in the high performance electrode material for supercapacitor applications and ammonia gas sensing application.

1. Introduction

Due to wide applications in categories like agriculture, automotive, food processing, and fertilizer manufacturing, ammonia has become a common air pollutant. Ammonia exposure in the surroundings can lead to a several health problems, including skin conditions, heart attacks, lung diseases, and permanent blindness. As a result, keeping an eye on the amount of ammonia in the surroundings is crucial. Ammonia has been detected using a variety of techniques, such as mass spectrometry, optical detectors, catalytic

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detectors, mass spectrometry sensors etc. The majority of ammonia sensors main shortcomings are their expensive price and/or low selectivity [1]. Thus the materials showing the ammonia gas sensing capabilities have a wide scope in the field of gas sensing. The nickel cobaltite ($NiCo_2O_4$) is a promising material for the gas sensing applications.

Energy conversion and energy storage have becomes an integral part of life. The improvement of energy storage tools with rapid charging, slow discharging, environmentally friendly, high energy, long lifetime, good cycling stability, high output power and low cost are necessary to resolve the energy related crisis [2]. Nowadays batteries, fuel cells, supercapacitors etc. has been extensively used to store energy. Among them, supercapacitors have gaining much attention due to their outstanding properties like high energy storing capacity, long life span, desirable charging discharging rates, excellent reversibility etc. [3]. The performance of supercapacitors widely depends on electrode materials [4]. The nanostructured materials used for the fabrication of supercapacitor electrodes have much attention because they show higher energy density and larger specific area than the respective bulk materials [5]. The materials including carbon based [6], conducting polymers [7], metal oxides etc. [8] were utilised to fabricate supercapacitor electrodes. Among these, a metal oxide shows excellent properties for energy storage applications. There are many spinel type binary metal oxide (AB_2O_4, B=Co, Fe, Mn, Mo etc.) materials utilised for supercapacitor electrodes. The spinel structures are thermodynamically stable with high conductivity. The $NiCo_2O_4$ is the p-type semiconductor and it is extensively used for the supercapacitor electrode due to its outstanding properties like rich ion exchange capability, better electronic conductivity, inexpensive, non-toxicity, abundant resources etc. [9–12]. Due to these remarkable properties, Nickel Cobaltite ($NiCo_2O_4$) has recently received a lot of interest in many filed including, electrocatalysis, lithium-ion batteries, photo catalysis, Chemical sensors [13], optoelectronic devices [14], high performance electrode materials for supercapacitor etc. [15–17]. The size, shape, and surface morphologies of nanostructured oxide materials have an important effect on their electrochemical, opto-electrical, magnetic, and catalytic capabilities than their respective bulk materials [18–22]. Nowadays supercapacitors have potential in energy storage applications, because of its desirable features like crucial charge-discharge speed, maximum power density, extended cycle life span, environmental friendliness etc. compared with other energy storage devices [23–26]. In the cubical spinel structure of $NiCo_2O_4$, the Ni ions present at the octahedral sites and the Co ions are dispersed between tetrahedral and octahedral positions [27].

In recent years, the use of semiconductors as gas-sensitive devices has received wide spread attention due to their high responsiveness, short response times, easy fabrication, handling, and portable applications [27,28]. The $NiCo_2O_4$ was widely used for many gas sensing applications like ozone, NOx, acetone etc. [29,30]. Generally, Many techniques have been listed for the production of $NiCo_2O_4$ nanoparticles such as hydrothermal technique [31], solution combustion synthesis [32], co-precipitation method [33], citrate precursor method [34], solvothermal method [35], chemical bath deposition technique [36], ange peel extract and fruit juice can provide green reducing, capping, and stabilizing agents synthesis [37], Desert gourd plant juice assisted synthesis scheme for the synthesis of $NiCo_2O_4$ nanostructures [38], Hydrothermal synthesis of $NiCo_2O_4$ nanostructures using grape fruit juice [39] etc. have

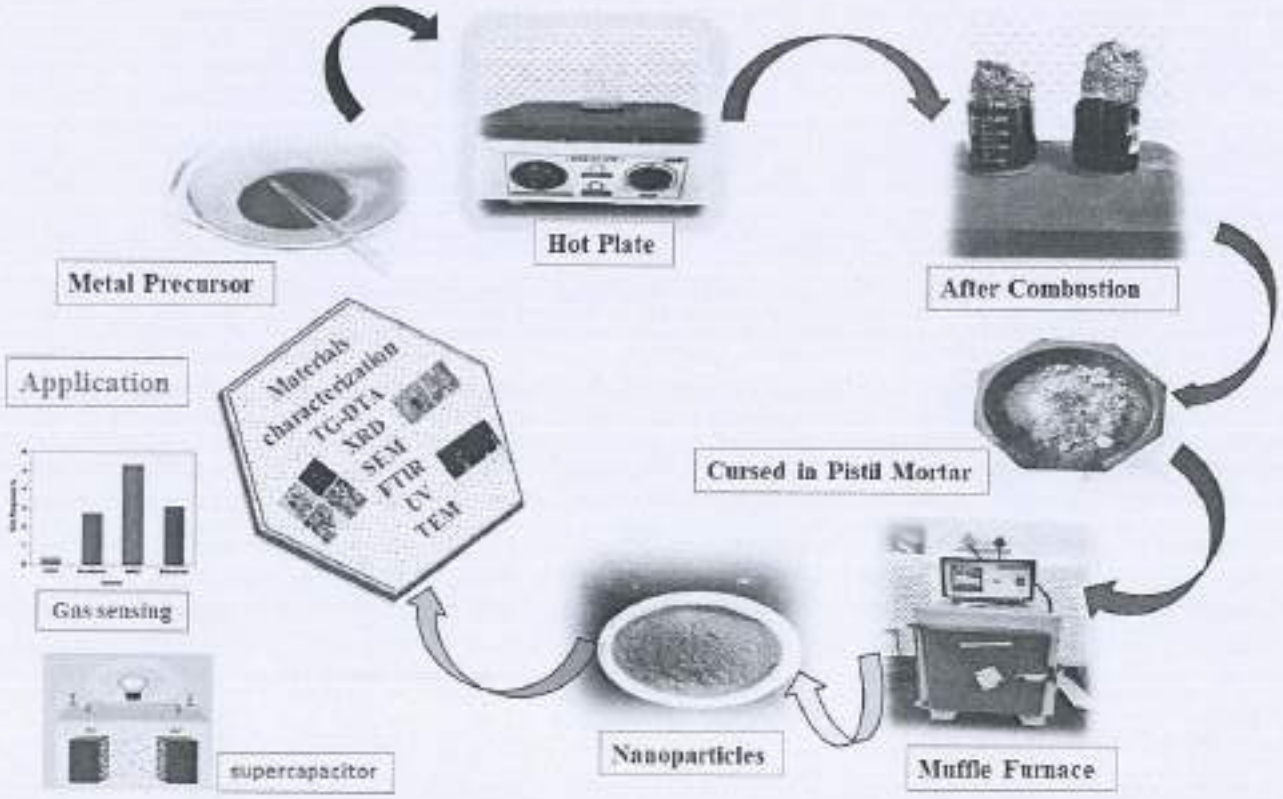


Fig. 1. Schematic for the preparation of $NiCo_2O_4$.

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been developed to synthesize $NiCo_2O_4$. This work focuses on the synthesis of $NiCo_2O_4$ by solution combustion technique for the supercapacitor electrode and gas sensing applications.

2. Experimental details

2.1. Synthesis procedure of $NiCo_2O_4$ nanostructures

The $NiCo_2O_4$ nanoparticles were formed by using solution Combustion techniques. The nickel nitrate nonahydrate [$Ni(NO_3)_3 9H_2O$, Alfa Aesar, 99 %], cobalt nitrate hexahydrate [$Co(NO_3)_2 6H_2O$, Sigma-Aldrich, 98 %], urea (CH_4N_2O, Alfa Aesar, 99 %), distilled water etc. were utilised for the formation of $NiCo_2O_4$ nanostructures. The homogeneous solution was prepared by dissolving nickel nitrate nonahydrate, cobalt nitrate hexahydrate and urea in stoichiometric amounts as1:1:4 in150 ml of distilled water. Urea is an organic fuel, which gives a channel to process redox reactions while combustion. The resultant solution was stirred continuously at a temperature of 80 °C on a hot plate till a gel formed. As the gel formed, the temperature of the hot plate is enhanced to 200 °C, causing the gel to burn in a self-propagating manner and turns into a loose powder. The obtained powder was grinded and then placed in a furnace at 500 °C for 4 h. The final product was allowed to cool naturally. The Details are described elsewhere [40,41]. Fig. 1 represents the schematics of $NiCo_2O_4$ nanoparticles synthesis by the solution combustion method.

2.2. Thick film fabrication

The synthesized materials were grinded in an agate pastel-mortar to get desired fine particle size. The grinded powder was annealed at 500 °C for 12 h in a furnace and after annealing the powder was grinded again. The resultant grinded powder was transformed into a thixotropic paste by mixing $NiCo_2O_4$ grinded powder with a temporary binder as ethyl cellulose, and organic solvents as abutyl cellulose, butyl carbitol acetate and turpineol. A paste was obtained by using 75 % inorganic solvent and 25 % of organic solvent. The resultant paste was deposited on the glass substrate using the doctor blade method to obtain thick films [42]. The obtained films were annealed at a temperature of 500 °C for one day.

2.3. Thickness measurement

The talystep method was utilised, to measure the thickness of the film and which is in the range of 30–35 μm. The repeatability of film thickness was attained by keeping proper thixotropy andrheology of paste.

2.4. Materials characterization

The different characterization techniques were employed for the detailed study of thermal, structural, opto-electrical, magnetic and morphological properties. The bonding configurations and elemental compositions are also studied in detail. The thermal properties were studied using TG-DTA with a thermal analyser (SDT Q600 V 20.9 Build 20). The X-ray diffraction pattern was used to confirm the structural properties of $NiCo_2O_4$ using an X-ray diffractometer (PW-3710, Cu K_α line, $\lambda = 1.54$ A°). The bonding configurations in the synthesized material were confirmed from FTIR spectra (JASCO, 6100-type A) in the range of 400–4000 cm^{-1}. The optical properties of $NiCo_2O_4$ were estimated from UV–Visible spectrophotometer in the range 200–800 nm (LAMBDA750, PerkinElmer). The morphological and compositional studies were confirmed by scanning electron microscope (SEM) (JEOL JED 2300) coupled with an energy dispersive spectrometer (JEOL 6360 LA). Transmission electron micrographs and selected area electron diffraction (SAED) patterns were obtained using a transmission electron microscope (TEM) operating at 200 kV. The magnetic properties of synthesized

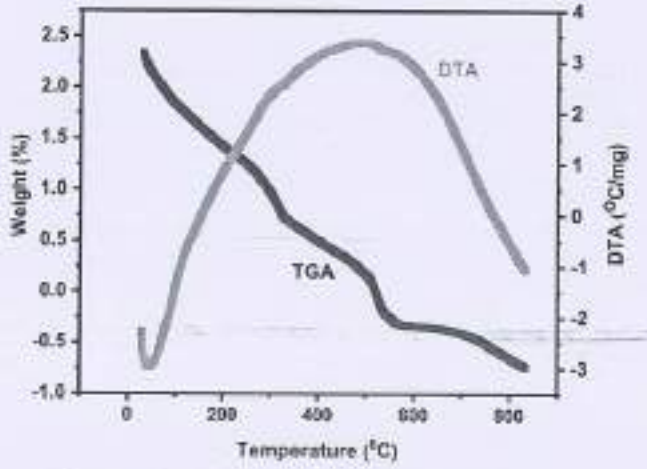


Fig. 2. Combined TGA and DTA plots of $NiCo_2O_4$ powder.

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material were confirmed from the VSM study at room temperature using VSM-Microsesse EZ-9. The electrical measurements of films were carried out by making aluminium contacts on films by thermal evaporation technique. The gas sensing performances were carried out using different test gases at various temperatures on a homemade gas sensing device. The X-ray photo-electron spectra (XPS) were recorded using a VSW ESCA instrument with an Al Kα source.

3. Result and discussion

3.1. Thermal analysis

Thermogravimetric and differential thermal analysis (TG-DTA) measurements of as-combusted $NiCo_2O_4$ composition were carried out from room temperature to 800 °C at a heating rate 10 °C/min. To examine the possible temperature of decomposition and phase formation of $NiCo_2O_4$ composition, TG-DTA studies were carried out. Fig. 2 shows the TG-DTA curve of $NiCo_2O_4$ composition by varying temperature from 30 °C to 800 °C.The analysis of TGA plot was divided into three steps of temperature ranges from 30 °C to 200 °C, 201 °C to 400 °C and 401 °C to800 °C. In the first step of temperature ranges from 30 °C to 200 °C, there is the dehydration of absorbed water. The minute endothermic effect was observed at 50 °C, with very small amounts of weight loss of 0.3 % and is associated with the exhaust of atmospheric gases sorbed with solvents. The subsequent weight losses were observed with temperature. In the second stage, the weight loss observed in TGA is related to the evaporation of residual of carbon-containing compounds and citric acid. In the last stage, weight loss was observed due to the decomposition of residual nitrates of $[Ni(NO_3)_3{\cdot}6H_2O]$, $[Co(NO_3)_3{\cdot}6H_2O]$ starting materials. The distinctly sudden weight loss was observed nearly at 550 °C, because of decompositions of the formed $NiCo_2O_4$ and oxygen released. A total 3% weight was observed while increasing temperature from 30 °C–800 °C. The decomposition has been completed around 500 °C, hence we have selected 500 °C as the annealing temperature for $NiCo_2O_4$ system. The broad exothermic peaks nearly at 475 °C were observed in the DTA plot having a temperature range 30 °C to 800 °C. The XRD analysis further confirms the phase formation of synthesized $NiCo_2O_4$.

3.2. X-ray diffraction (XRD) analysis

The phase formation and crystal structure of synthesized $NiCo_2O_4$ powder annealing at 500 °C temperatures were confirmed from XRD pattern. The XRD pattern of $NiCo_2O_4$ powder is depicted in Fig. 3. The diffraction peaks located at two theta equal to 31.25°, 37.06°, 43.14°, 59.42°, 62.68°,65.68°,75.06°,78.58° and 86.22°, correspond to the (220), (311), (400), (422), (511), (440), (531), (444), and (551) crystal planes of spinel $NiCo_2O_4$ respectively. The XRD patterns of $NiCo_2O_4$ are in good conformity with JCPDS card number 20–0781. The XRD pattern shows no other impurity peaks, indicating that the synthesized product is pure spinel structure with good crystalline. The crystallite size of synthesized powder was estimated from the Scherrer equation,

$$d_{x\text{-}ray} = \frac{0.943 * \lambda}{\beta \cos \Theta} \tag{1}$$

where $d_{x\text{-}ray}$, λ, Θ and β are the average crystallite size, wavelength of X-ray, Bragg angle and full width at half maximum (FWHM) respectively. The sharp diffraction peaks, which indicates the nanocrystalline nature of synthesized $NiCo_2O_4$ powder. The $d_{x\text{-}ray}$ estimated from Scherre's formula is found to be 57 nm.

The $d_{x\text{-}ray}$ calculated from equation (1) gives only the lower bound to the crystallite size. In the present work $d_{x\text{-}ray}$ calculated from

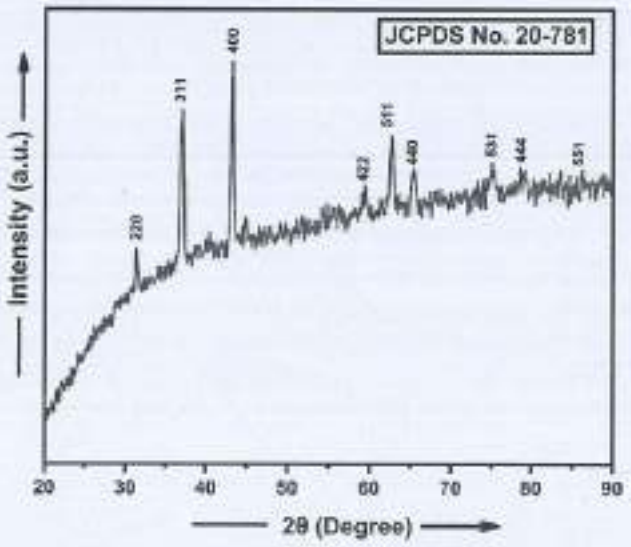


Fig. 3. X-ray diffraction patterns of the synthesized $NiCo_2O_4$ nanoparticles.

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equation (1) match with crystallite size values estimated from the Williamson–Hall analysis and TEM study.

3.2.1. Williamson–Hall (W–H) analysis for the estimation of crystallite size ($d_{x\text{-}ray}$) and lattice strain (e)

The peak broadening observed in the XRD pattern is due to lattice strain present in the sample, crystallite size and instrumental broadening. The line broadening due to the crystalline size ($d_{x\text{-}ray}$) and lattice strain (e) is given by

$$\beta = \frac{N * \lambda}{d_{x-ray} * \cos\theta} + 4e\tan\Theta \tag{2}$$

where, λ, θ, $d_{x\text{-}ray}$, e and N are the wavelength of X-ray, Bragg angle, crystallite size, lattice strain and Scherrer constant respectively [43,44].

In order to split the line broadening, a quantitative investigation performed using a graph by the W–H method

$$\beta\cos\theta = \frac{N\lambda}{D} + 4e\sin\Theta \tag{3}$$

here we assumed isotropic nature of the material in which uniform strain in all crystallographic directions [45,46].

To estimate crystallite size and lattice strain present in the material, ($\beta_{hkl}\cos\theta$) was plotted against (4sinθ) and linear fitting to the experimental data was performed in the origin 2018 software. The slope and intercept of Fig. 4 was used to estimate lattice strain and crystallite size present in the synthesized material. The estimated values of the '$d_{x\text{-}ray}$' and 'e' are the 53.61 nm and 3.3 × 10^{-3} respectively.

3.3. FTIR analysis

Fig. 5 depicts the FTIR spectrum of the synthesized $NiCo_2O_4$ sample. The observed sharp peaks nearly at 558 cm^{-1} and 656 cm^{-1} are corresponds to the Ni–O and Co–O stretching vibrations at octahedral and tetrahedral sites respectively and shows formation of the spinel $NiCo_2O_4$ nanostructure [47,48]. The peak at 2922 cm^{-1} is assigned bending vibration of H_2O molecules. The band observed nearly at 410 cm^{-1} & 490 cm^{-1} was due to Ni–O stretching vibration mode [49,50]. The absorption band observed at 432 cm^{-1} corresponds to Ni–O antisymmetric stretching vibrations. The absorption peaks centred at 1601 cm^{-1}, 1605 cm^{-1}, 1390 cm^{-1},1382 cm^{-1} are ascribed to the stretching vibration of residual H_2O in the sample [51,52]. The broad band's nearly at 1378 cm^{-1} and 1619 cm^{-1} are corresponds to the existence of NO_3^- anions and the bending modes of H_2O molecules. The peak observed at nearly at 2358 cm^{-1} corresponds to the CO_2 vibrant by environmental [53]. The small hump nearly at 2927 cm^{-1} is assigned to the N–H characteristic bond present in aromatic amines [54]. The observed peak at 2639 cm^{-1} assigned to the OH functional groups with H-bond. The peak centred at 3734 cm^{-1} can correspond to OH bonding and the occurrence of a peak at 2070 cm^{-1} confirms the vibrations of H_2O molecules [55].

3.4. UV–visible spectroscopy analysis

Fig. 6 presents the absorbance spectra of $NiCo_2O_4$ powder synthesized using the solution combustion method. The absorption peak observed nearly at 362 nm is because of the surface Plasmon's of nanoparticles. The absorption peak observed above 400 nm is due to the coupling of Plasmon modes of the neighbouring particle [56].

The band gap energy of $NiCo_2O_4$ nanoparticles estimated by Tauc's relation

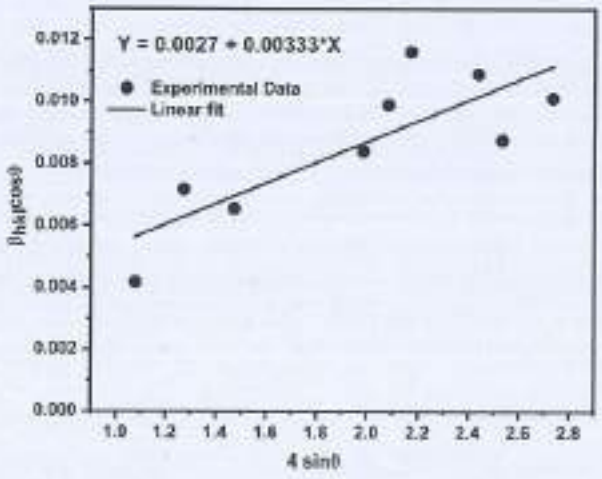


Fig. 4. Williamson-Hall analysis of $NiCo_2O_4$ nanoparticles.

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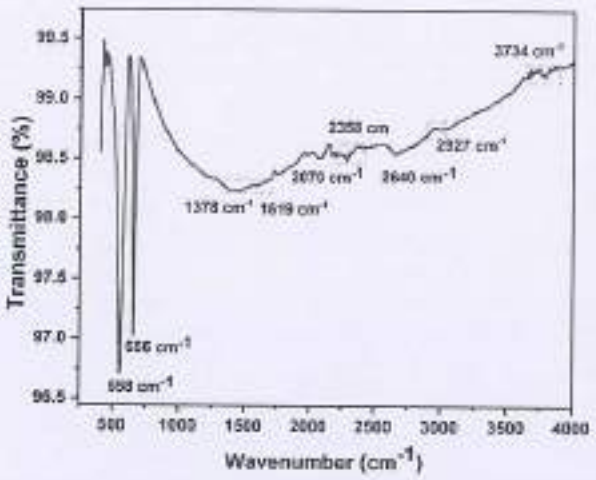


Fig. 5. FTIR spectrum of $NiCo_2O_4$ nanoparticles.

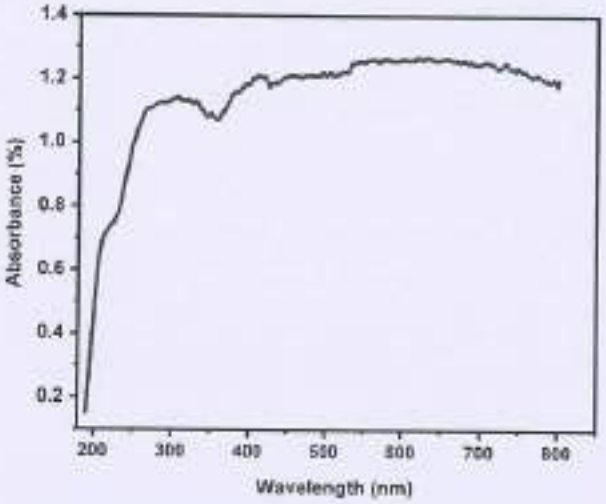


Fig. 6. UV–Vis absorption spectrum of $NiCo_2O_4$ nanoparticle.

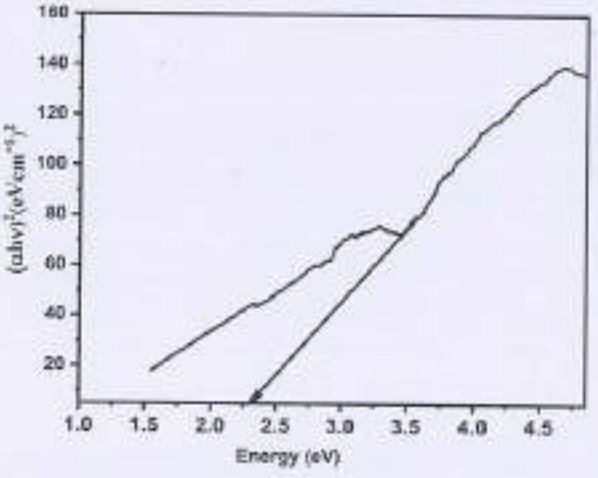


Fig. 7. Taus's plot of the synthesized $NiCo_2O_4$ sample.

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$$(\alpha h\upsilon) = A\left(h\upsilon - E_g\right)^n \quad (4)$$

where α, υ and h are the absorption coefficient, frequency of light and Planck's constant respectively. The A and n are constants, n = 2 and 0.5 for indirect and direct band-gap semiconductor respectively [57]. The plots of $(\alpha h\upsilon)^2$ verses hυ for $NiCo_2O_4$ nanoparticles is presented in Fig. 7. The E_g values of the $NiCo_2O_4$ nanoparticles can be found by extrapolating the linear part of the plot to $(\alpha h\nu)^2 = 0$ and it is found to be 2.38 ev.

3.5. EDAX analysis

The elemental compositions of synthesized $NiCo_2O_4$ are included in Fig. 8. The Ni, Co, and O signals were observed from the EDAX spectrum and atomic percentages of Ni, Co and O are 26.02%, 29.41%, and 44.56%, indicating the development of the $NiCo_2O_4$ composite structure and being appropriate with the XRD results.

3.6. FESEM study

FESEM with EDX measurements was carried out to evaluate the sample morphology and elemental compositions. Fig. 9 (a & b) presents the FESEM images of $NiCo_2O_4$ synthesized using the combustion process. Fig. 9 (a & b) shows, $NiCo_2O_4$ is composed of a hexagonal structure that is randomly ordered and coexists with good distribution. Due to the emission of gas molecules through the breakdown of nickel-cobalt precursors, pores structure can be observed. These characteristics enable the electrolyte to enter electroactive materials and increase specific capacitance. In contrast, Fig. 9a displays the $NiCo_2O_4$ FESEM images, which show loosely packed aggregated spherical nanoparticles. As shown in Fig. 9 a-b the aggregated nanoparticles were put collectively into a bundle-like form.

3.7. TEM analysis

The TEM micro-structural features of two distinct $NiCo_2O_4$ nanostructures are depicted in Fig. 10 (a, b, c &d). The hexagonal nanostructures were observed in Fig. 10 a–c and are in well agreement with FESEM. Fig. 10 a–c demonstrates how bundle-like structures made of nanoparticles can extend up to several micrometers in length. The spinel structure of $NiCo_2O_4$ nanostructures are well matched with selected area electron diffraction (SAED) patterns (Fig. 10d) are indexed to the 111, 220, 311, 400, 511, 440, and 533 planes. These findings support the XRD observation.

The average particle size was measured using jviewer software and it was found 54 nm. The average particle size estimated from XRD, TEM, FE-SEM and Williamson–Hall plot are well matched. Fig. 11 represents the average particle distribution of the synthesized $NiCo_2O_4$ material.

3.8. Magnetic properties

In addition, a vibration sample magnetometer Fig. 12 was used to characterize the magnetic properties of synthesized $NiCo_2O_4$ nanostructures at room temperature. It is believed that a material's structure, morphology, and geometry have a significant impact on its magnetic characteristics. The M-H curve of $NiCo_2O_4$ shows a sign of a ferromagnetic material, however due to surface spins; the saturation magnetization is not clearly visible at the highest applied field (15 kOe). The calculated value of saturation magnetization, coercivity and remanent magnetization was 4.96 emu g^{-1}, 0.05 Oe and 0.18 emu g^{-1} respectively. Due to the presence of an

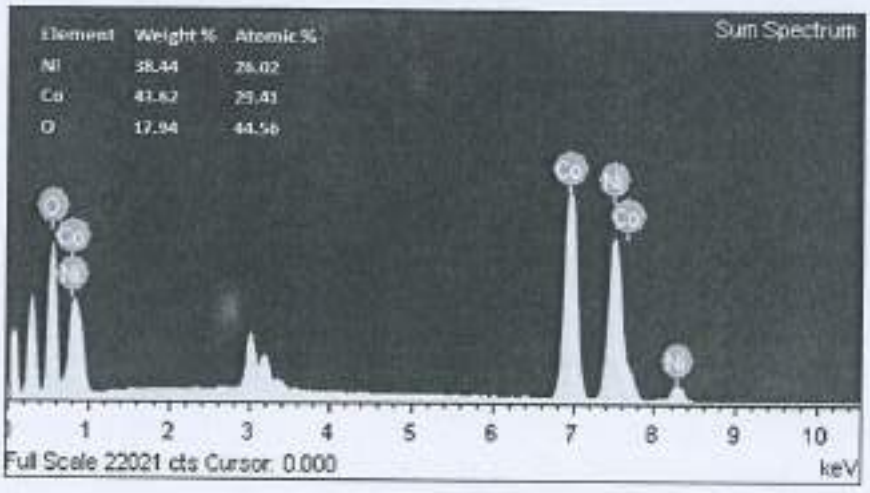


Fig. 8. EDX images of $NiCo_2O_4$ nanostructures.

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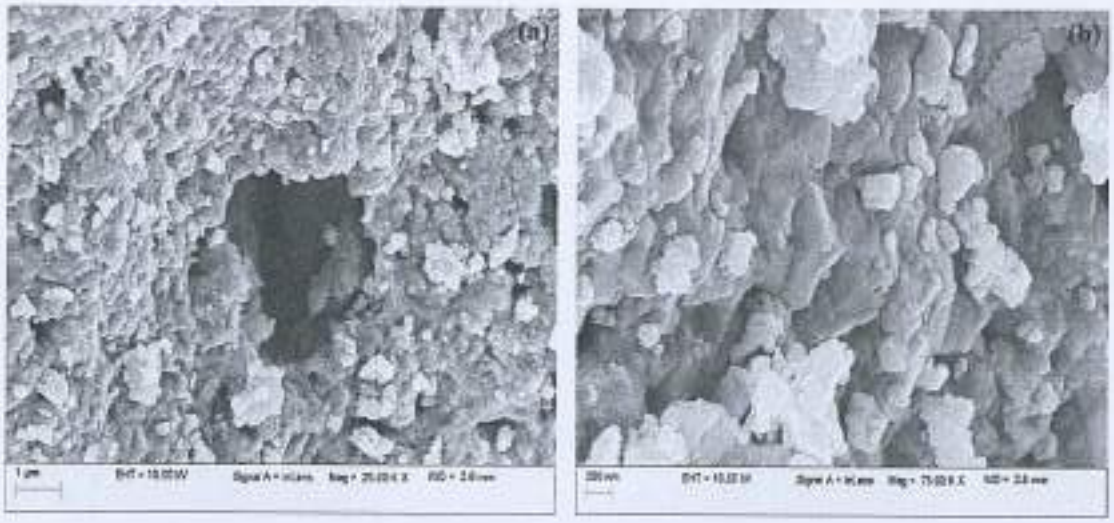


Fig. 9. FESEM images (a, b) of $NiCo_2O_4$ synthesized at temperatures of 500 °C.

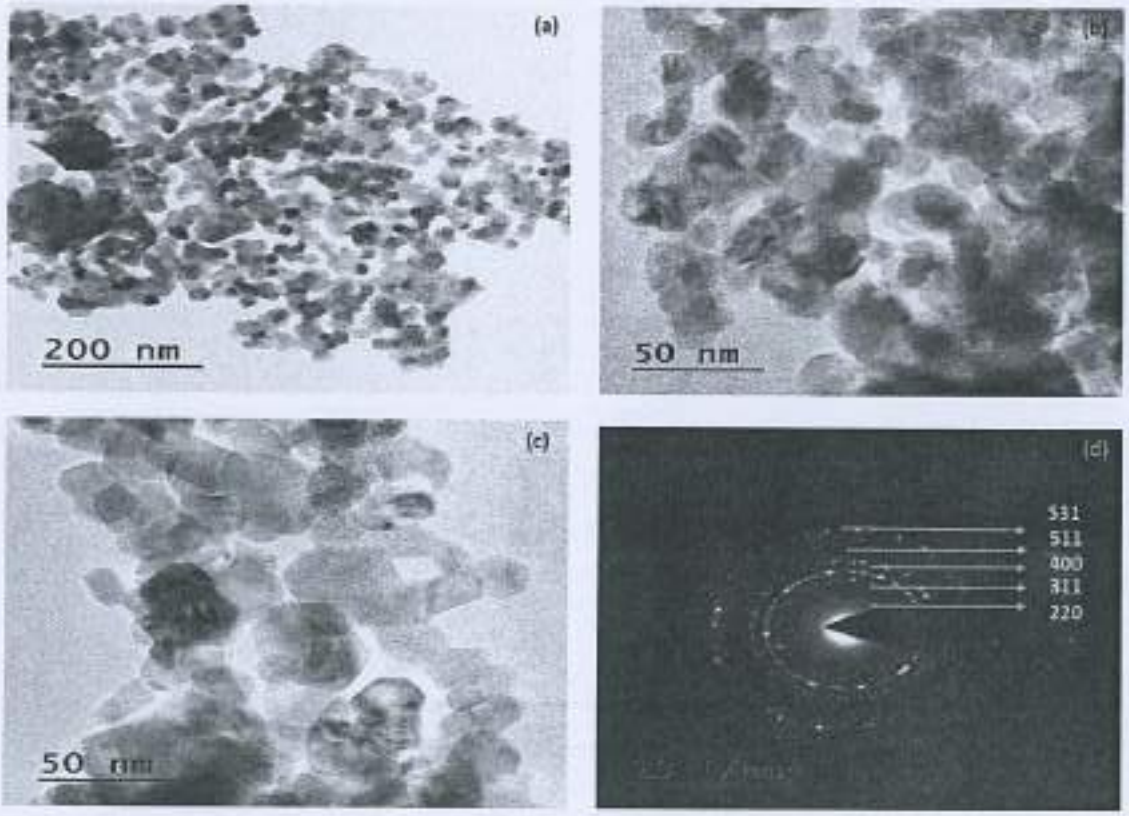


Fig. 10. a–c TEM, 10-d selected-area electron diffraction (SAED) pattern of the $NiCo_2O_4$ nanostructures.

uncompensated spin system on the surface of the nanoparticles and the effect of spin canting, $NiCo_2O_4$ with low remanent magnetization displays mild ferromagnetic behaviour [58]. The magnetic property investigation showed that the $NiCo_2O_4$ nanostructures exhibit ferromagnetic behaviors and can be applied to the creation of magnetic storage devices.

3.9. Electrical conductivity measurement

The electrical conductivity as a function of temperature is shown in Fig. 13. The electrical conductivity of $NiCo_2O_4$ nanoparticles enhances with temperature in air ambient. The enhancement of conductivity with temperature is due to semiconducting nature of

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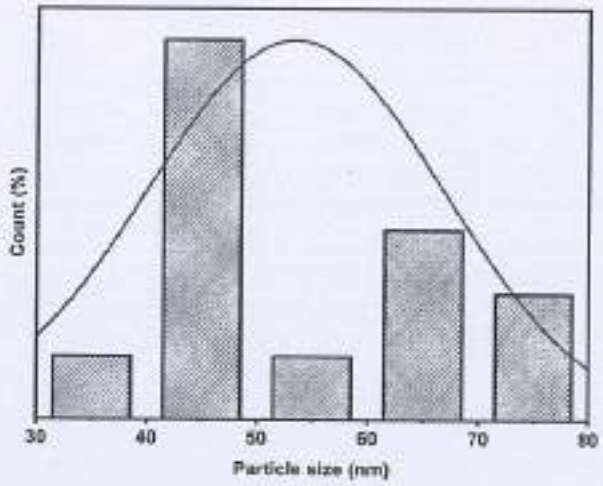


Fig. 11. particle size distribution histogram of $NiCo_2O_4$ nanoparticles.

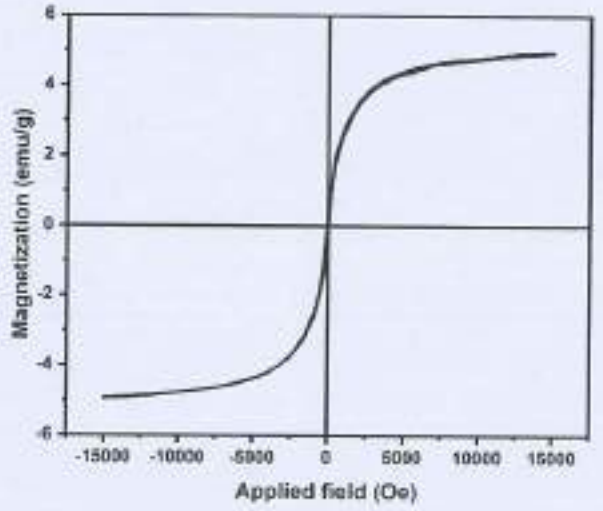


Fig. 12. Magnetization as a function of applied field.

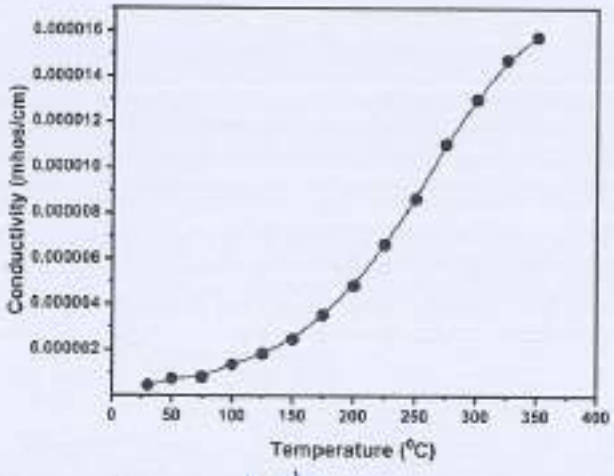


Fig. 13. Temperature dependent conductivity of nanocrystalline $NiCo_2O_4$ thick film.

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synthesized $NiCo_2O_4$ nanoparticles and it is due to large oxygen deficiency in $NiCo_2O_4$. At higher temperatures, the material will absorb the oxygen species ($O_2 \rightarrow 2O^- \rightarrow O^{2-}$).

3.10. BET surface area measurement

The surface area of synthesized $NiCo_2O_4$ powder was measured by nitrogen adsorption-desorption isotherms on automatic St 1 on NOVA touch 1LX instrument. The estimated specific surfacearea of the synthesized material was the 28.37 m^2/g.

3.11. X-ray photoelectron spectroscopy (XPS) analysis

The formation of $NiCo_2O_4$ was further confirmed by X-ray photoelectron spectroscopy (XPS) measurements. Fig. 14a represents the wide scan of $NiCo_2O_4$ material synthesized using the solution combustion method. The wide scan of XPS shows the presence of Ni, Co and O. Fig. 14b–14(d) show typical narrow scan deconvoluted XPS spectra of the Ni (2p), Co (1s), and oxygen O (1s) electron state, respectively. The deconvoluted peaks in the Ni (2p) show two major peaks observed nearly at 855.80 eV and 873.30 eV, corresponding to the Ni ($2p_{3/2}$) and Ni (2p) states respectively. The deconvoluted spectra of the Co (2p) show two major peaks nearly at 779.90 eV and 795.10 eV corresponding to the Co($2p_{3/2}$) and Co($2p_{1/2}$) and shakeup satellite peaks are also observed. Fig. 14 (d) shows the deconvoluted peak of O (1s). The deconvoluted O (1s) peak shows three main peaks located at 529.50 eV, 531.20 eV, and 532.35 eV, which shows the presence of O in the synthesized material. The peak positions observed at 529.30 eV, 531.20 eV and 532.35 eV are corresponding to lattice oxygen, H_2O oxygen vacancy and Ni–O and Co–O bonding respectively [10].

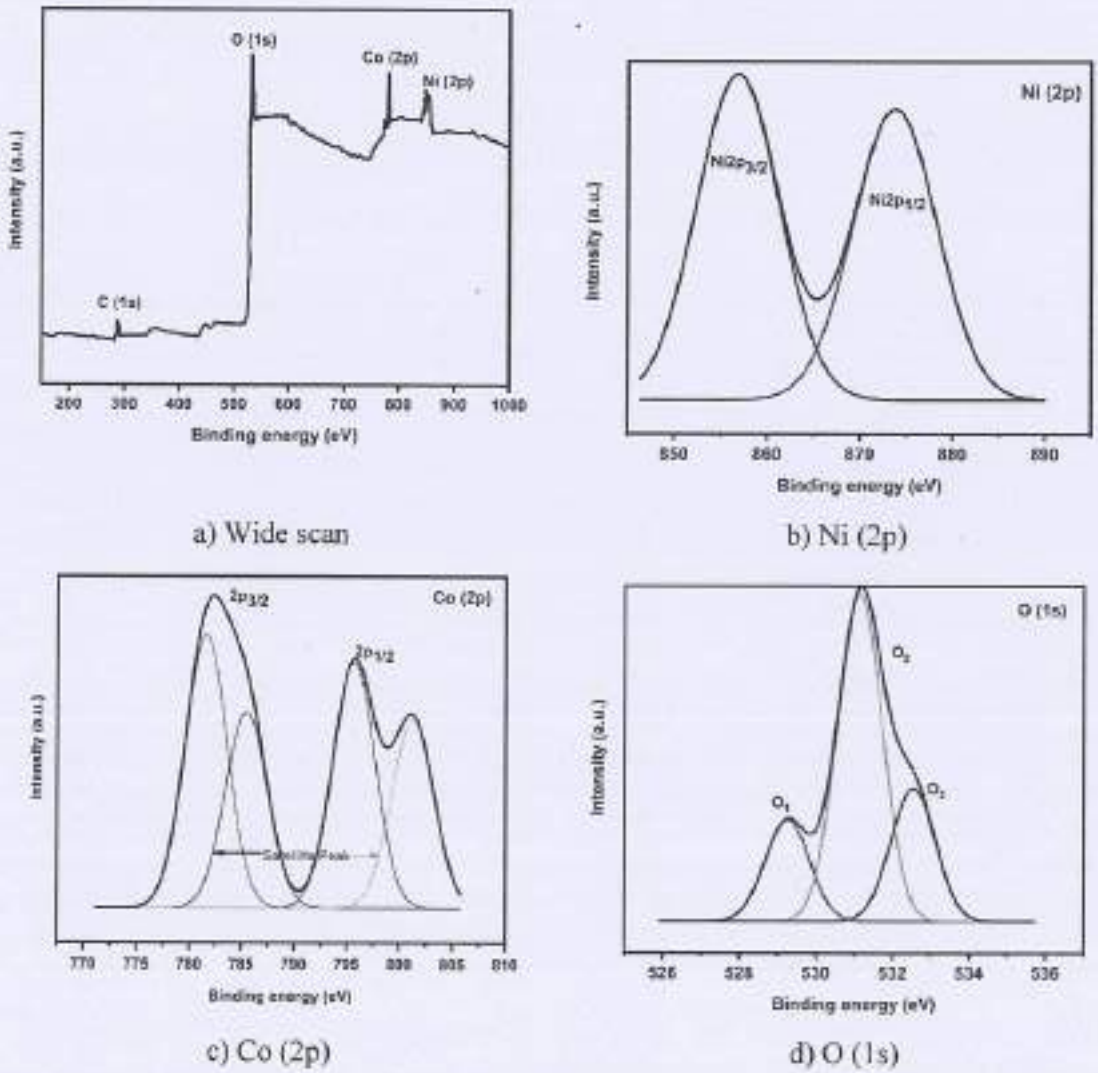


Fig. 14. Typical XPS spectra for $NiCo_2O_4$ synthesized using solution combustion method (a) wide scan, (b) deconvoluted XPS spectra of Ni (2p) (c) deconvoluted XPS spectra of Co (2p) (d) deconvoluted XPS spectra of O (1s).

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4. Electrochemical studies

4.1. Electrode preparation

To measure the electrochemical performance of synthesized material, the electrode was constructed by making a slurry of synthesized powder of $NiCo_2O_4$ (80.00 wt%), activated carbon (10 wt%) as a conducting additive and Polyvinyl difluoride (10 wt%) as a binder in N-Methyl Pyrrolidone solvent. The homogeneous mixture was obtained by grinding the slurry adequately in the mortar pestle. The resultant slurry was layered on a carbon paper substrate (1 cm × 1 cm area) using the doctor blade technique, after that it was dried at 160 °C for 12 h in a hot air oven to eradicate solvent. The mass of the sample deposited on carbon paper was estimated usingthe weight difference method.

4.2. Electrochemical studies

Herein, supercapacitive performance of synthesized material has been investigated using a potentiostat (MetrohmAutolab: PGSTAT302N model) with three electrode configurations in 2 M KOH electrolyte solution. The concentration of electrolyte is playing an important role in electrochemical performance of supercapacitors. Generally, the ionic conductivity of the electrolyte can be decreased if the concentration is too low or too high. The maximum specific capacitance was observed at 2 M of KOH electrolyte [59, 60]. The Platinum foil and Hg/HgO works as counter and reference electrode whereas synthesized material coated on carbon paper acts as working electrode. In two electrode system working and counter electrode was utilised for electrochemical performance measurement. The three-electrode system offers greater precision, control, and versatility in electrochemical performance measurement compared to the simpler two-electrode configuration. The cyclic voltammetry (CV), galvanostatic charge-discharge (GCD), and electrochemical impedance spectroscopy (EIS) measurements of the $NiCo_2O_4$ sample annealed at 500 °C was carried out to measure supercapacitive performance of $NiCo_2O_4$ powder as supercapacitor electrode materials. The EIS measurements werestudied on the same potentiostat with three-electrode cell configurations under open circuit voltage with amplitude of 10 mV between applied frequency sweeps from 1 MHz to 0.1 Hz.

4.3. Cyclic voltammetry (CV)

The specific capacitance (CS in F/g) and energy density (E in $WhKg^{-1}$) of the $NiCo_2O_4$sample electrode was estimated from CV measurements from equations (5) and (6).

$$CS = \frac{1}{ms\Delta V}\int I(V)dV \tag{5}$$

$$E_{cs} = \frac{1}{2}C_p * \Delta V^2 \tag{6}$$

where m is the mass of synthesized powder deposited on carbon substrate (m = 25 mg), I is the response current (in A), ∫ I(V) dV area under the current-voltage (CV) curve, s is the scan rate (in mVs^{-1}) and ΔV is operating potential windows (in volt).

Cyclic Voltammetry (CV) measurements of the prepared material were carried out in the potential range of 0.0 V–0.6 V at different scan rates is presented in Fig. 15. As the scan rate enhances from 5 mV/s to 100 mV/s the nature of CV curves almost remains identical, indicating the outstanding electrode capabilities and ideal supercapacitor behaviour [61]. The CV measurements showing as scan rate

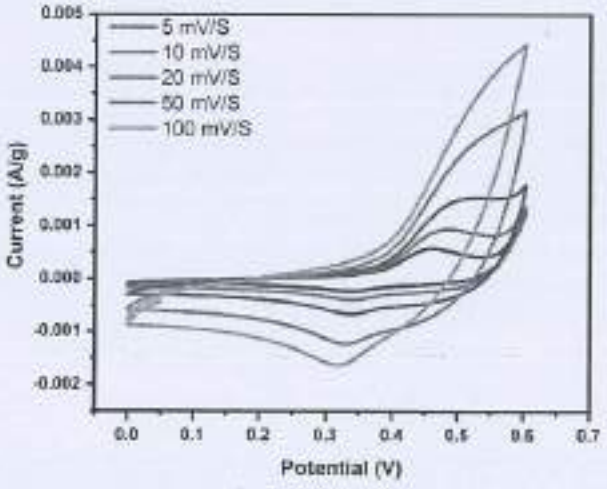


Fig. 15. CV measurements of the $NiCo_2O_4$ powder at different scan rates.

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increase, the area of the CV curve enhances indicating the behaviour of an ideal capacitor. As scan rate increases from 5 mV/s to 100 mV/s the CS reduces, because the KOH electrolyte ions cannot be totally accessible to interior surface of $NiCo_2O_4$ electrode because of the reduced diffusion time and only the outer active surface of the electrode is utilised for charge storage. The CS depends on surface morphology, electro-active sites, type of electrolyte, oxidation and reduction potential of metal ions in active materials, surface area, etc. Fig. 15 indicates, the oxidation and reduction peaks are shifted towards higher and lower potential respectively, shows fast-redox reactions at the electrolyte and $NiCo_2O_4$electrode interfaces [62]. Fig. 16 shows the specific capacitance as a function of scan rate and it shows CS enhances with decrease in scan rates. The calculated values of CS and E from cyclic voltammetry study at lower scan rate are 762 F/g and 16.88 $WhKg^{-1}$ respectively.

4.4. Galvanostatic charge-discharge (GCD) analysis

The charge storage capacity of synthesized material was confirmed from GCD cycles within the potential range of 0.0–0.6 V at various current densities 0.25A/gm, 0.5 A/gm and 1A/gm in 2 M KOH electrolyte. The nonlinearity in the discharging curves of $NiCo_2O_4$ electrode indicating pseudocapacitor behaviour [63]. Fig. 17 represents the Galvanostatic charge-discharge (GCD) plots of $NiCo_2O_4$ powder at various current densities. The specific capacitance CS (F/g), energy density E ($WhKg^{-1}$) and power density P (WKg^{-1}) can also be calculated from the GCD plot using the following equation.

$$CS = \frac{I * t_d}{m * \Delta V} \tag{7}$$

$$E = \frac{1}{2} C_s * \Delta V^2 \tag{8}$$

$$P = \frac{E}{t_d} \tag{9}$$

where I is the response current (A), m is the mass of active material (kg), ΔV is the potential window (V), and t_d is the discharge time (h). The calculated value of CS, E and P are 730 F/g, 16.17 $WhKg^{-1}$ and 398.71 Wkg^{-1} respectively at lower current density. The CV potential window is typically broader than the GCD potential window because CV involves scanning the potential over a wide range to observe the full redox behaviour, whereas GCD operates within a narrower potential range to ensure safe and controlled charge and discharge processes [64].

The cyclic stability is one more significant requirement to check performance of supercapacitor. In this work the cyclic stability for the $NiCo_2O_4$ supercapacitor electrode were carried out by repeating CV measurements between 0 V and 0.6 V at the scanrate of 50 mV/s for 5000 cycles. Fig. 18 indicates the $NiCo_2O_4$ electrode has excellent cyclic stability and overall capacitance retention is 92.23%.

The electrochemical properties of synthesized $NiCo_2O_4$ electrode further analysed using electrochemical impedance spectroscopy (EIS) in the frequency range of 0.1 MHz to 0.1 Hz. The Nyquist plot before and after stability of $NiCo_2O_4$ electrode is presented in Fig. 19 [65]. The slanting line in Fig. 19 confirms the ideal supercapacitor nature. The Nyquist plot is fitted to an equivalent electronic circuit using Zview software, as shown in the inset of Fig. 19. The estimated values interfacial charge transfer resistance (R_{ct})between electrolyte and electrode is 3.53 Ω and the internal resistance (Rs) of the electrode material is 9.03 Ω. The minute semicircle arc in high frequency region indicates excellent electrical conductivity andsmall charge transfer resistance of the electrode materials. Thus from Nyquist plot shows $NiCo_2O_4$ has a excellent electrical conductance with high specific capacitance.

We also compare the current work with other studies published in the literature on the use of supercapacitor electrodes to specify the significance of this work in Table 1.

5. Gas sensing study

5.1. Measurement of gas response, selectivity, response and recovery time

The relative response (S) of the test gas is expressed in equation (10), where 'Ga' and 'Gg' are the conductance in air and target gas respectively.

$$S = \frac{G_g - G_a}{G_a} \tag{10}$$

The capacity of a sensor to react with one gas when other gases are present is known as selectivity (see Table 2). Recovery time (RCT) is the amount of time necessary to restore 90% of the maximum conductance in air, whereas response time (RST) is the amount of time essential for a sensor to reach 90% of the maximum rise in conductance following exposure of the sensor surface to a test gas [72].

5.2. Gas detection performance of $NiCo_2O_4$ thick films

5.2.1. Gas response

Fig. 20 depicts the 25 ppm of different gases responses as a function of operating temperature. The temperature dependent gas

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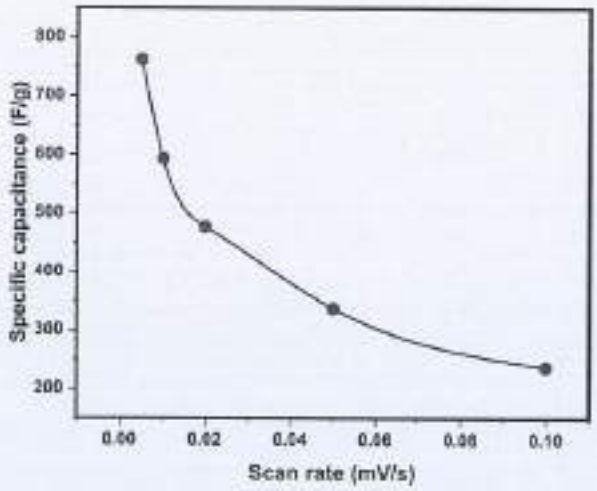


Fig. 16. The variation of specific capacitance with respect to scan rate.

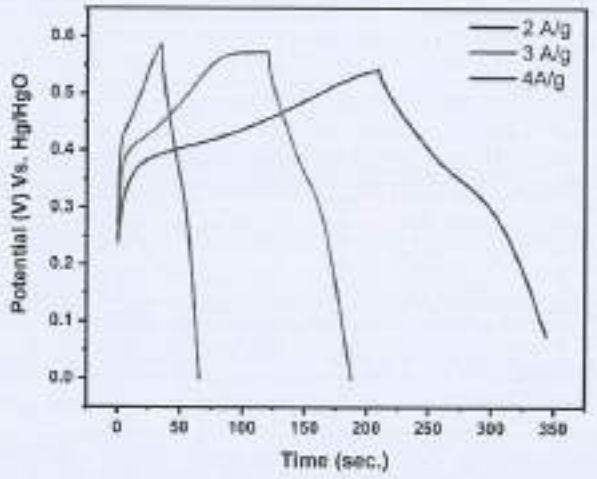


Fig. 17. GCD curves $NiCo_2O_4$ powder at different current densities.

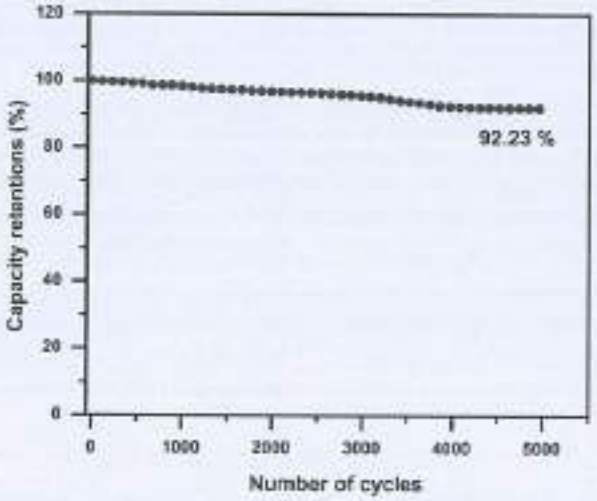


Fig. 18. Capacity retentions over the cycle number for $NiCo_2O_4$ electrode.

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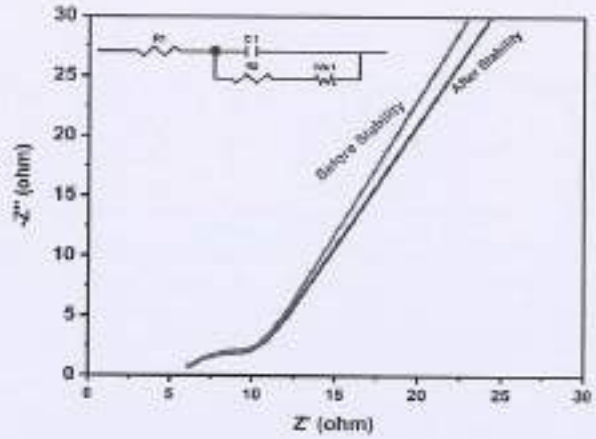


Fig. 19. The impedance plot (Nyquist plot) of $NiCo_2O_4$ samples.

Table 1
Comparison of supercapacitive performance of present work with other published work.

Sr. no.	Material	Method of synthesis	Electrolyte	Potential Window V	Specific capacitance (F/g)	Reference
1	$Zn_{1-x}Co_xMn_{1-x}Fe_xCrO$	Sol-gel auto combustion	2.0 M KOH	0.0 to 0.6	286	[66]
2.	Nickel sulfide/reduced graphene oxide	Solution combustion Method	6.0 M KOH	0.0 To 0.4	305	[67]
3.	$NiFe_2O_4$	Chemical oxidation	0.1 M HCl	0.0 to 0.45	266	[68]
4.	$NiCo_2O_4$	Sol-gel	2.0 M KOH	0.0 to 0.6	319.36	[69]
5.	$CuCoFe_2O_4$	Sol-gel	1.0 M KOH	−1.0 to 1.0	221.00	[70]
6.	Carbon-modified Fe_3O_4	Chemical oxidation	6.0 M KOH	−0.8 to 0.3	274	[71]
7.	$NiCo_2O_4$	auto combustion	2.0 M KOH	0.0 to 0.6	762	Present work

Table 2
Comparison of ammonia gas sensing response from different literature work and present study.

Sr. no.	Sensing Material	ammonia Concentration	Operating Temperature	Gas Sensing Response	Refs.
1.	CuO activated ZnO films	100 ppm	R. T.	12 %	[76]
2.	ZnOnanofibers decorated with styrene sulfonate	100 ppm	R.T.	4%	[77]
3.	ZnO films doped RuO_2	1000	250	78	[78]
4.	V_2O_5	35	R. T.	2.4	[79]
5.	Te–V_2O_5	5	R.T.	−0.9	[80]
6.	$NiCo_2O_4$	25	35	5.35	This work

sensing performance was observed for $NiCo_2O_4$ sensor. The $NiCo_2O_4$ sensor responds better to ammonia gas at 35 °C, ethanol gas at 55 °C, acetone gas at 45 °C, carbon dioxide gas at 55 °C. Thus we can use same sensor for the detection of these different gases just by changing the temperature and this is the major characteristics of the $NiCo_2O_4$ sensor.

Fig. 21 shows that the response of the $NiCo_2O_4$ film grows steadily as the gas concentration is increased till 25 ppm, at which point reaches its maximum and saturates. As the gas concentration enhances the active centres on the surface of the film enhances and causes to increases sensitivity. It would be expected that with lower gas concentrations, an unimolecular layer of gas molecules would emerge on the surface, interacting with the surface more actively and producing bigger responses. At the higher gas concentration (−25 ppm), there would be multiple layers of gas molecules on the sensor's surface, causing the gas response to become saturated.

5.2.2. *Selectivity factor of $NiCo_2O_4$ thick film sensor for various gases*

Fig. 22 shows that, the $NiCo_2O_4$ sensor gives maximum response to ammonia at 35 °C. The sensor confirmed maximum selectivity for NH_3, compared with all other tested gases: ethanol Acetone, and carbon dioxide.

5.2.3. *Response and recovery of sensors*

A sample that is extremely sensitive to NH_3 is shown in Fig. 23 in its dynamic response. The sensor responded to NH_3 gas

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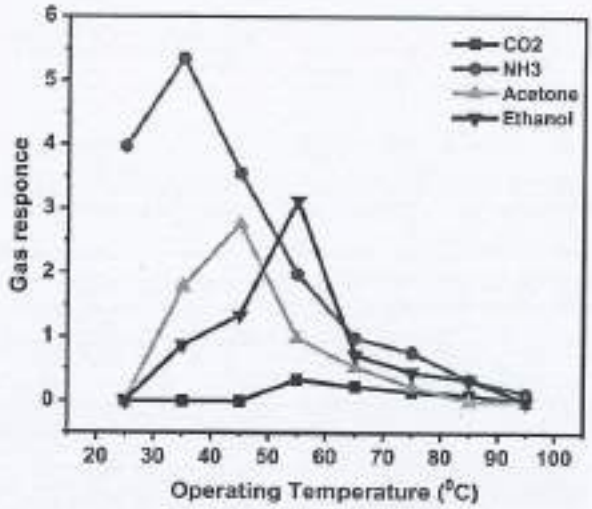


Fig. 20. Gases response with operating temperatures.

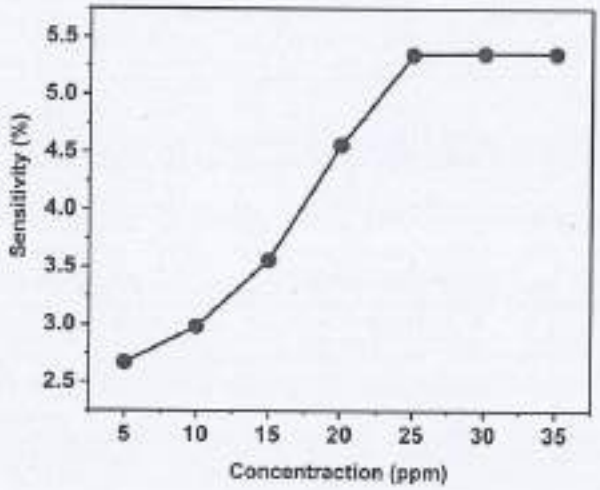


Fig. 21. Variation of gas response with gas concentration.

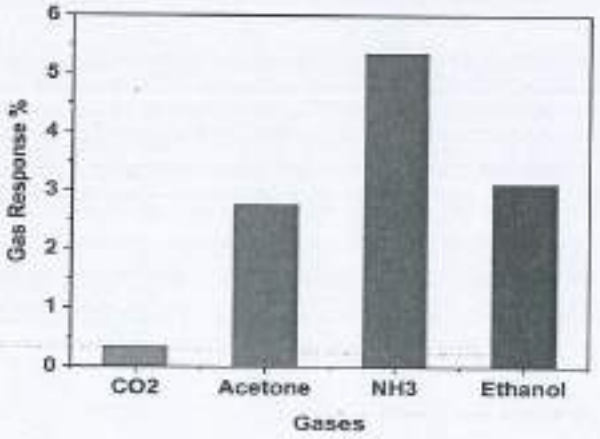


Fig. 22. Selectivity factor of the sensor for various gases.

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quicklyabout (−5 s) and recovered quickly about (−50 s). The key features of this sensor are its quick reaction time and quick recovery.

6. Discussion

The general explanation for gas sensing mechanism is based on the change in conductance caused by either the direct reactivity of lattice or interstitial oxygen with test gases, or the adsorption of ambient oxygen at a higher temperature on the surface. In the first the circumstances, test gases are mostly detected when ambient oxygen adsorbs on the surface by removing electrons from the conduction band to generate superoxide or peroxides.

The room temperature selective ammonia response of the sensor can be explained by surface reaction mechanisms. It is commonly known that the thick layer of $NiCo_2O_4$ is made up of the greatest number of grains dispersed over its surface. The resistance of the sensor was found to significantly drop when exposed to ammonia [73]. This phenomenon might be attributed to either the surface interaction of ammonia with physisorbed H_2O or proton conductivity via NH^{4+}cations. Solid bases like $NiCo_2O_4$ may produce solid acidity when exposed to $NiCo_2O_4$. The formation of NH^{4+}cations, which make up the proton conductivity and significantly reduce resistance, is a result of the solid acidity on the sensor surface. As a result, the barrier height between the grains of $NiCo_2O_4$ would be reduced.

$$NH_{3(g)} + H_2O_{(Surface)} RT \rightarrow NH_4OH_{(g)}$$

The surface reaction produces ammonium hydroxide, or NH_4OH, which is a volatile substance. The rapid reaction and quick recovery of the sensor can be explained by the high volatility of NH_4OH.

7. Gas-sensing mechanism

Sensing mechanisms of for $NiCo_2O_4$ thick film is shown in Fig. 24. $NiCo_2O_4$ is a well-known n-type semiconductor material. Temperature affects the adsorption–desorption gas sensing process. The figure illustrates how film resistance rises in conjunction with the possible barrier height in air. Both the electrical resistance and the potential barrier height drop when the sensor is in contact with the target gas. Oxygen molecules adsorb on the sensor surface when it is exposed to ambient air due to intermolecular forces; as a result, oxygen species like O^{2-}, O_2^-, O_2 and O^{2-}can be transferred from the surface [74]. The reactions can be shown asfollows:

$$O_2 + e^- \rightarrow O_2^- \text{ (ads)}$$

$$O_2^-(\text{ads}) + e^- \rightarrow O^-(\text{ads})$$

These equations illustrate how the oxidation of reducing gas at the surface will happen when exposed to ammonia:

$$2NH_3 + 3O^{-2} \rightarrow 3H_2O + N_2 + 3e^-,$$

$$2NH_3 + 3O^{2-} \rightarrow 3H_2O + N_2 + 6e^-.$$

Ammonia oxidation induces $NiCo_2O_4$ to lose its oxygen ions and lowers its barrier height, which increases conductivity [75]. We also compare the current work with other studies published in the literature on the use of gas sensing applications to specify the significance of this work in Table 2.

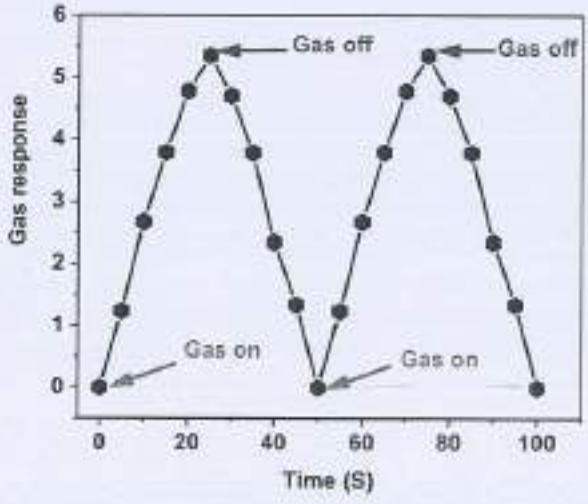


Fig. 23. Response and recovery of $NiCo_2O_4$ sample.

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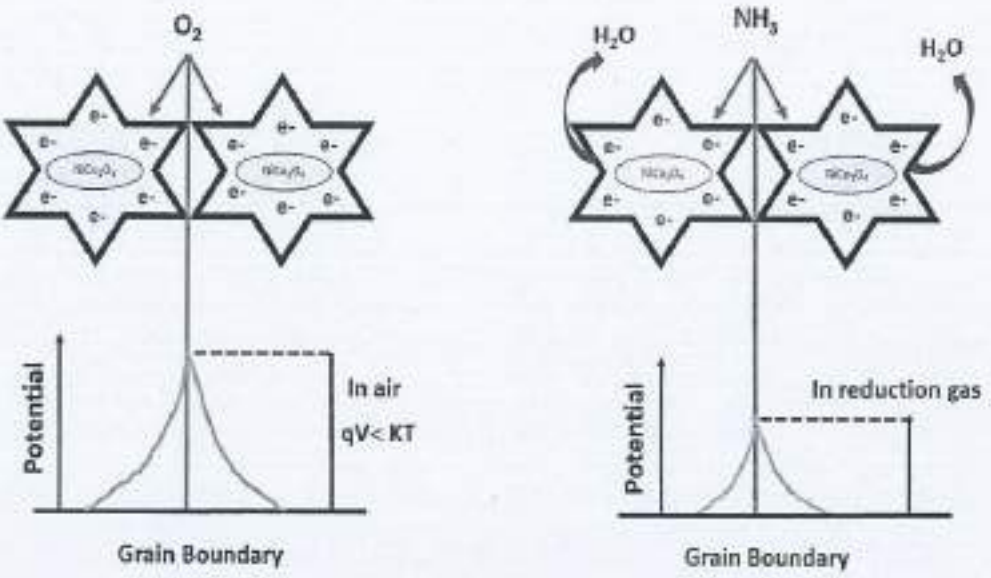


Fig. 24. Gas sensing mechanism for $NiCo_2O_4$ thick film in air and NH_3.

8. Conclusion

Combustion $NiCo_2O_4$ porous powder material was synthesized using a simple and inexpensive approach. The FTIR study shows the different bonding configurations in the synthesized material. The porous morphology of $NiCo_2O_4$ of the composite, which can improve charge transport of ions between the electrode and electrolyte surface, were revealed by scanning electron microscopy. The spinel crystal phase of NiCo2O4 were confirmed from XRD study. The XPS studies show the formation of $NiCo_2O_4$. The particle size estimated from Scherrer's equation, W–H Plot and TEM are found to be nearly equal. Due to the simple and inexpensive approachof synthetic pathway, the $NiCo_2O_4$ is an ideal material for the supercapacitors applications. The electrochemical studies show the $NiCo_2O_4$ synthesized using solution combustion method is promising material for supercapacitor electrode with CS, E and P are 730 F/g, 16.17 $WhKg^{-1}$ and 797 Wkg^{-1} respectively from GCD curve. The synthesized $NiCo_2O_4$material is also showing superior performance and better selectivity for NH_3 at 35 °C among all othertested gases. The present study shows thesynthesized $NiCo_2O_4$ has a potential for manufacturing a temperature dependent gas sensor and supercapacitor electrode for energy storage applications.

CRediT authorship contribution statement

Reshma Prakshale: Writing – original draft, Methodology, Conceptualization. **Sachin Bangale:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Mahesh Kamble:** Writing – review & editing, Supervision, Formal analysis, Conceptualization. **Sanjay Sonawale:** Writing – review & editing, Supervision, Resources, Conceptualization.

Declaration of competing interest

The author declares that there is no conflict of interest.

Data availability

Data will be made available on request.

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A metal-free, eco-friendly protocol for the oxidative halogenation of aromatic compounds by using highly efficient and reusable graphene oxide†

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Graphene oxide (GO), a carbocatalyst, is explored for its catalytic activity in halogenation reactions of active aromatics. Potassium halides as halogen sources and oxone as a green oxidant were utilized to halogenate aromatic substrates with methanol as the solvent. The protocol yields regioselective, desired products in high to excellent yields. GO was recycled successfully for four times without loss in its catalytic activity. The metal-free and mild reaction conditions, use of greener solvent, safe halide source and high recyclability of the catalyst makes this protocol environmentally benign.

Introduction

Halogenated organic compounds are essential starting compounds and intermediates in organic synthesis. They are also frequently utilized as fundamental molecules in the fields of industrial, pharmaceutical, and material chemistry which demonstrates their importance in chemistry.[1,2] The most widely used technique for making aromatic bromides and chlorides depends on the use of poisonous and dangerous halogens, primarily Cl_2 and Br_2, which has major negative effects on the environment. Over the past few decades, a variety of powerful halogenating agents that are also operationally safe have been successfully developed to replace the use of halogens.[3–11] Many reagent systems have been reported in addition to Br_2 (with or without a catalyst), such as pyridinium tribromide,[12] KBr/sodium peroxyborate,[13] tetrabutylammonium tribromide,[14] cetyltrimethylammonium tribromide,[15] HBr/DMSO,[16] and LiBr/CAN (ceric ammonium nitrate),[17] among others. Most of these techniques use the electrophilic species Br^+, which is produced *in situ* by the interaction of bromide ion with an oxidant. Synthetic systems for oxidative chlorination have been developed but their scope and selectivity still need to be improved.[18–20] The majority of currently used techniques use metal-based homogeneous catalysts, which are frequently difficult to recover and reuse, inhibiting their application in ecologically friendly processes (Scheme 1).

As a result, the scope of these significant classes of halogenated compounds would be increased by developing a simple, effective, metal-free, and environmentally acceptable catalyst. Mesoporous carbon and carbon nanotubes are examples of carbonaceous materials employed as supports and metal-free catalysts for a variety of synthetic reactions.[21–23] Due to the intrinsic optical, electrochemical, and mechanical properties of graphene and related two-dimensional sp^2-hybridized carbon materials, there has been a significant amount of research interest.[24,25] Additionally, due of their outstanding chemical, thermal, and mechanical stabilities, great electrical conductivity, and vast surface areas, a variety of porous carbon compounds have been developed.[26–28] Significant functionalization opportunities are offered by graphene oxide (GO), oxygenated graphene sheets embedded with hydroxyl, epoxy, and carboxyl groups, and it can be treated into a variety of new materials.[29–31] In the catalysis sector, GOs have predominantly been utilized as supports for catalytically active metals.[32,33] By utilizing the substantial nucleation or stabilization sites present on the GO surface, GO nanocomposite materials have been created and proved as



2a 2b

Scheme 1 Bromination of anisole with potassium bromide.

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3a 3d

Scheme 2 Bromination of 2-napthol with potassium bromide.



4a 4b

Scheme 3 Bromination of 2-methoxynapthalene with potassium bromide.

catalytically active nanoparticles that are versatile and recyclable in a number of significant organic transformations.[31,34] The aromatic scaffold of GO, however, has lately been used as an effective carbocatalyst that might provide a green substitute for metal catalysis, taking advantage of its natural chemical characteristics. Sulphides,[35] olefins, and other hydrocarbons[36] have all been oxidized by the use of GO as an oxidant. However, GO has been employed as a solid acid for the hydration of different alkynes, the aza-Michael addition of amines to activated alkenes,[37] condensation,[38] and the ring-opening of epoxides under mild reaction conditions (Scheme 2).[39]

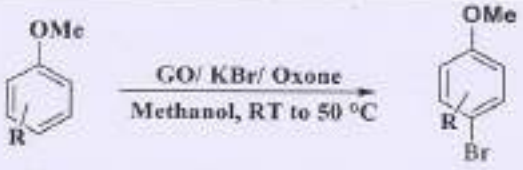
In the present study, we report on the use of oxone and GO as mild oxidants and potassium halides as a non-hazardous source of halide for the halogenation of some aromatic compounds under heterogeneous conditions. The synthesized graphene oxide is characterized by FT-IR, UV spectroscopy, XRD, TGA, SEM, TEM and Raman spectroscopy (Scheme 3).

Results and discussion

Optimization of parameters

Anisole **2a** was first reacted in methanol with graphene oxide (2 wt%), oxone as the oxidant (1 equiv.), and potassium bromide (KBr) (1 equiv.) as the bromine source. The reaction mixture was stirred at room temperature for 12 h to produce only 64% *p*-bromoanisole (Table 1, entry 1). This was done to investigate the reactivity of the oxidant. To increase the yield of product **2b**, a model reaction was conducted at various temperatures (Table 1). We found that the yield of product **2a** was significantly influenced by temperature. As the temperature raised from RT to (30)–50 °C, the product yield

Table 1 Optimization of reaction conditions



2a 2b

Entry	Parameter	Solvent/oxidant equivalents	Catalyst	Cat. Conc % (W/W)	Temp (°C)	Time (h)	Yield (%)
1		Methanol	GO	2	RT	12	64
2		Methanol	GO	2	40	12	66
3		**Methanol**	**GO**	**2**	**50**	**12**	**95**
4	**Temp. Study**	Methanol	GO	2	60	12	68
5	No catalyst	Methanol	—	—	50	12	25
6	**Catalyst loading study**	Methanol	GO	1	50	12	78
7		**Methanol**	**GO**	**2**	**50**	**12**	**95**
7.a		Methanol	GO	3	50	12	95
8		Without solvent	GO	2	50	12	NR
9		THF	GO	2	50	12	11
10	**Solvent study**	Water	GO	2	50	12	53
11		Acetonitrile	GO	2	50	12	10
12		DCM	GO	2	50	12	NR
13		**Methanol**	**GO**	**2**	**50**	**12**	**95**
14	**Oxidant equiv. study**	Without oxidant	GO	2	50	12	NR
15		0.2	GO	2	50	12	8
16		0.4	GO	2	50	12	37
17		0.6	GO	2	50	12	44
18		0.8	GO	2	50	12	85
19		1.0	GO	2	50	12	95
20		1.2	GO	2	50	12	94

Reaction conditions: anisole (4.6 mmol, 1 equiv.), GO (2 wt%), oxone (4.6 mmol), KBr (4.6 mmol), methanol (10 ml), temperature: 50 °C; GC yield, (NR – no reaction).

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Table 2 Scope of the bromination of anisole

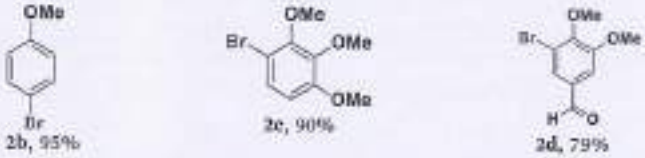
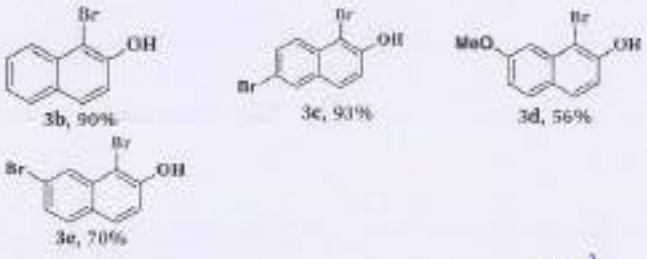


Table 4 Scope of the bromination of 2-methoxynapthalene



increased. Upon further increase in temperature (60 °C), the yield of the product reduced to 68%. This is due to formation of side products at this temperature condition. (Table 1, entries 1–4). As a result, 50 °C was determined to be the ideal temperature for the oxidative bromination reaction. Then, various polar and non-polar solvents were used to conduct this model reaction (Table 1). When the reaction was carried out in methanol, the maximum yield of product **2a** was obtained. Other solvents such as THF, water, acetonitrile, DCM and solvent free condition showed less yield as compared to methanol (Table 1 entries 8–13), and therefore methanol was chosen as the optimal solvent for oxidative bromination of anisole. We believe that methanol suits better as the solvent for this reaction as KBr has better solubility in methanol in comparison to other solvents. The measured substrate experiment was carried out at 50 °C for 12 hours without the addition of an oxidant, and we found that the desired product did not form (Table 1, entry 14). This suggests that use of the catalyst without an oxidant is not sufficient to carry out the desired bromination process. Oxone (0.2 equiv.) was added at 50 °C, and the result was an 8% yield of the desired transformation, demonstrating the crucial oxidant role for the desired product. By using 0.4, 0.6, 0.8, and 1.0 equivalent of the representative oxidant, the yield was improved by 37, 44, 85, and 95%, respectively (Table 1, entries 16–19). Additionally, control experiments were carried out at 50 °C *i.e.* in the absence of graphene oxide, which yielded only 25% of the product **2b**, respectively (Table 1, entry 5). The above results demonstrated that graphene oxide plays a crucial catalytic role in the oxidative bromination. Subsequently, the model substrates were reacted with varying amounts of graphene oxide. The yield of **2b** improved from 78 to 95% as catalyst loading was increased from 1 to 2 wt% (Table 1, entries 6–7). The higher yield can be attributed to the improved substrate–catalyst interactions, which are in charge of the improved bromination of anisole to *para*-bromoanisole *via* H-bonding. GO with improved dispersion, oxygen functionalities, and mild oxidative properties enhanced the product yield dramatically. We also carried out chlorination of anisole using potassium chloride as chlorinating agent under optimized conditions (Table 3).

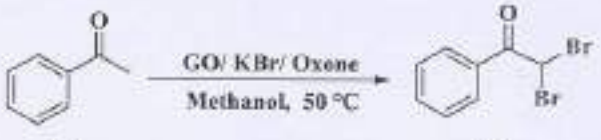
Table 3 Scope of the bromination of 2-napthol



Substrate scope

The oxidative bromination of anisole with potassium bromide in the presence of GO, oxone and methanol as the solvent at 50 °C was investigated to better understand the scope and generality of the reaction. The reaction progressed smoothly, and a high yield of the required product was produced (Table 2). The addition of ethyl acetate made it simple to separate the products from the mixture after the reaction was finished. Then, using a variety of aryl compounds, we evaluated the scope of the method by brominating a variety of aromatic substrates (Tables 2–4). Rapid monobromination of the substituted anisole provided the corresponding compounds **2b–d** (Table 2) with a single regio-isomer in excellent yields. Additionally, under the same conditions, the reaction between 2-napthol and its derivatives produced the corresponding brominated products **3b–3e** (Table 3) in excellent yields and with a significant amount of selectivity. The alpha-brominated **4b** and **4c** products were successfully produced in 75 and 90% yields, respectively, by the bromination of 2-methoxynapthalene (Table 4). The acetophenone bromination took place exclusively at the alpha position to give 2,2-dibromo-1-phenylethanone (Scheme 4 (**5b**)). Even after a 12 hour reaction with benzamide as the substrate, the reactants were recovered unchanged (Scheme 5, entry **6b**).

After gaining good results with bromination we investigated the reactivity of KCl under optimized reaction conditions with a series of anisoles (Scheme 7), 2-napthol (Scheme 6) and 2-methoxynaphthalene (Table 5). From anisole, 2-napthol, 2-methoxynaphthalene and anisole derivatives, the corresponding chlorinated products **7b–7e**, **7f** and **8b** were obtained in high yields and with regioselectivities.

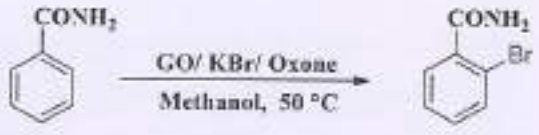


5a **5b**

Scheme 4 Bromination of acetophenone with potassium bromide.

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6a 6b

Scheme 5 Bromination of benzamide with potassium bromide.



7a 7b

Scheme 6 Chlorination of 2-napthol with potassium chloride.



8a 8b

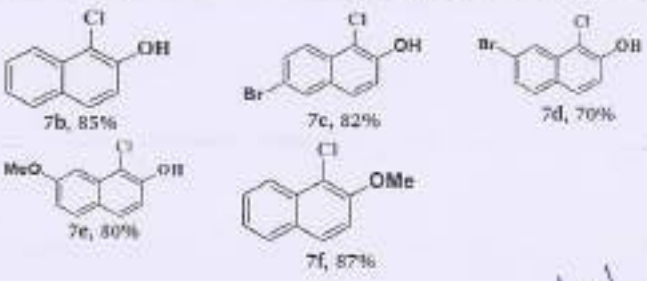
Scheme 7 Chlorination of anisole with potassium chloride.

Plausible reaction mechanism for the oxidative halogenation of aromatic compounds

A plausible mechanism[49] for the halogenation of aromatic compounds to form **2b** is depicted in Fig. 1. The reaction mechanism involves the generation of bromine radicals from oxone in the presence of GO. The bromine radicals are then used to selectively brominate the organic substrate.

The bromine radicals (Br·) abstract a hydrogen atom (H) from the organic substrate, resulting in the formation of a brominated product and a new radical (H·). This radical is then quenched by the excess oxone present in the reaction mixture, preventing further undesired side reactions. Graphene oxide acts as a catalyst and may facilitate the reaction by providing a suitable surface for the reaction to occur or by aiding in the formation of bromine radicals.

Table 5 Scope of the chlorination of arenes with potassium chloride



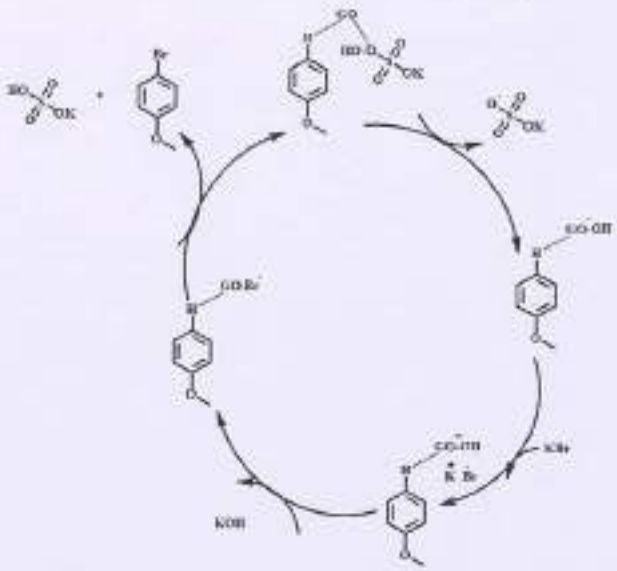


Fig. 1 Plausible reaction mechanism for the oxidative halogenation of aromatic compounds.

Recyclability study

The catalyst was recovered from the reaction mixture after filtering in order to evaluate the recyclability of the catalyst. It was then thoroughly washed with ethyl acetate, acetone, and distilled water and dried in a vacuum. The catalytic activity of the catalyst was examined for four cycles (Fig. 2). Thus, recycled and recovered graphene oxide (GO) was characterized using the following spectroscopic methods, including powder XRD, FT-IR spectroscopy, RAMAN analysis, TGA, UV-visible spectroscopy, and TEM analysis (Fig. S2a–f ESI†). These results demonstrate that the GO's catalytic activity remained unaltered even after the fourth cycle.

Conclusion

In conclusion, using graphene oxide as a metal-free carbocatalyst, we have demonstrated a simple, efficient, and

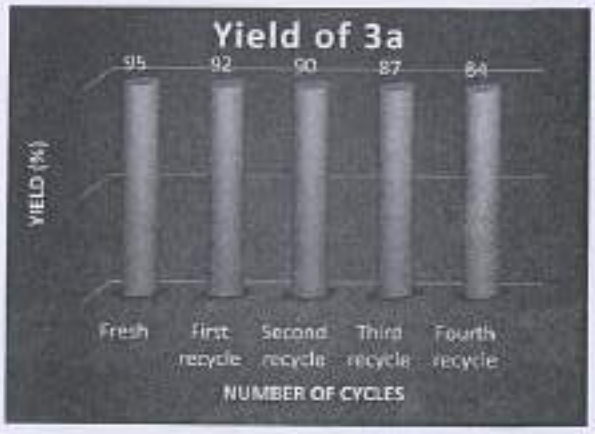


Fig. 2 Recyclability of graphene oxide.

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green approach for the oxidative halogenation of organic compounds using their potassium salts as reagents. This developed protocol is a good alternative to the traditional metal catalyst protocols owing to the fast and mild reaction conditions, good to excellent product yields, ease of usage, and ready recyclability.

Experimental

Materials and methods

All the reagents and reactants were purchased from commercial suppliers and were used without further purification. The reactions were monitored by thin-layer chromatography (TLC) using silica gel 60 GF245 precoated sheets and the components were visualized using a UV-lamp at a wavelength of 254 nm. Column chromatography was performed using silica gel (60–120 mesh). ^{1}H and ^{13}C NMR spectra were recorded using an Agilent 500 MHz spectrometer with $CDCl_3$ as the solvent (with TMS as the internal standard). The product samples were investigated using a Thermo Fisher gas chromatograph (HP 6890) equipped with an FID detector, a capillary column (TR-1), and a programmed oven with a temperature range from 50 to 200 °C and N_2 carrier gas at a flow rate of 0.5 cm^3 min^{-1}.

General procedure for the halogenation of anisole

In a 25 mL round bottom flask, 10 mg of graphene oxide was added in 10 mL of methanol and then graphene oxide is dispersed under ultrasonication. To this, a mixture of anisole **1a** (4.6 mmol), oxone (4.6 mmol) and potassium halide (KX = KBr, KCl) (4.6 mmol) was added. The reaction mixture was then stirred and heated at 60 °C until completion of the reaction (reaction progress was monitored by TLC). The reaction mixture was then cooled to room temperature and the crude reaction mass was dissolved in ethyl acetate (10 mL). To recover the catalyst, the ethyl acetate layer was centrifuged and filtered. From the residue portion, graphene oxide was separated, and the filtrate was washed with water (3 × 10 mL) and dried over anhydrous sodium sulfate. The reaction mixture was then concentrated under vacuum and purified by column chromatography using a mixture of ethyl acetate and petroleum ether as the eluting agent.

Conflicts of interest

There are no conflicts to declare.

Acknowledgements

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Solvent and Catalyst Free Acylation of Anilines with Acetic Acid

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Abstract:
Quantitative yields are produced in a short amount of time by an effective and environmentally friendly microwave-assisted approach that produces amide from amine via acylation without the need for a catalyst. Aniline and glacial acetic acid were directly combined during the synthesis of acetanilide under microwave irradiation, without the use of any catalytic agents. The reaction occurred in the frequency band of 160 MHz in 40 to 50 minutes with almost quantitative yields. We don't employ any harmful or toxic components by using the green synthesis technique.

Keywords: Green synthesis, acylation, microwave irradiation, amide, amine, aniline, acetanilide.

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1. Introduction

A new area of chemistry known as "Green chemistry" combines many tools, methods, and technologies. Creating more eco-friendly and effective products are helpful to chemists and chemical engineers in research, development, and manufacturing. These products may also have considerable financial advantages. It will soon be a necessary instrument in the study of synthetic chemistry. [3] The advent of green chemistry has altered what a solvent is used for. The mass transfer is facilitated but not dissolved by the ideal solvent. An ideal green solvent should also be cheap, easily accessible, natural, nontoxic, and have the added advantages of promoting reaction, separation, or catalyst recycling. The most crucial of the many green chemistry principles, which measures the effectiveness of chemical transformation, is maximising the atom economy. [3]

Amide compounds have drawn a lot of interest due to their wide range of applications in the pharmaceutical sector. They have typically been utilized as synthetic route protection routes. Many bioactive substances or medications have an amide functional group, and amide modifications are a crucial approach of optimization for novel chemical entities in medicinal chemistry. The foundation of proteins is made up of peptide bonds, a specific type of Amide bond found in the life sciences. Many significant materials in the chemical industry involve the structure of amides. [2]

Amide bonds are commonly formed in the following ways: the classic synthetic procedures of the acetamido group compounds are carried out by primary amino compounds under various conditions with acyl halides, acid anhydrides, esters, or acids. The acyl halides and acid anhydrides were hygroscopic, and many active acylation agents would be exothermic and produce unwanted acid during the reaction process, so they should be treated carefully, under well-cooled, anhydrous conditions in the presence of acid-tricing agents [2]. If the acylation agents used are esters and acids, the reaction may take longer and lead to lower yields due to their low chemical activity. To ensure the reactions are safe for both the environment and human health, certain chemicals that are more active, such as N, N'-dicyclohexylcarbodiimide (DCC) and N-(3-dimethylaminopropyl)-N-ethylcarbodiimide (EDC), should be added as catalysts. [2]

According to a recent study, amide bond forms account for 65% of all initial screening reactions in industrial medicinal chemistry laboratories, making them one of the most significant transformations in pharmaceutical synthesis. Amides are another significant group of intermediates that are frequently used in the production of fine chemicals, cosmetics, and food additives. However, the majority of the procedures used today to create Amides use stoichiometrically activated, harmful, and caustic substances like acid anhydrides or acyl chlorides, which have a poor atom economy and produce a lot of waste. The reaction is water-sensitive, and efficient water removal is a key component in the systems, therefore an excess of these reagents is typically required to get the best amide yields.[1]

To minimize the negative effects of amide formations on the environment, cleaner syntheses must be developed. The most appealing strategy in this regard continues to be the direct interaction of Amines with carboxylic acids. Where possible, it is best to carry out these types of reactions without catalysis; nonetheless, harsh reaction conditions must still be present in order to achieve direct amide production.[1]

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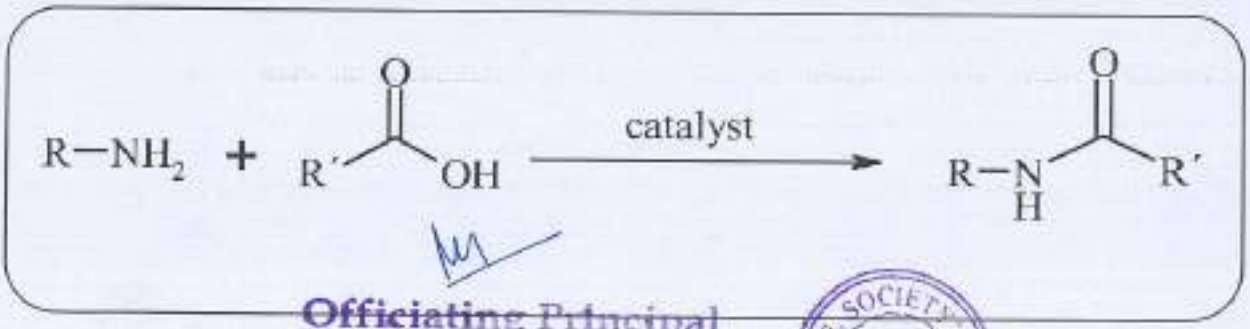
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One of the most widely utilized transformations in organic synthesis is the acylation of amines because it offers an effective and affordable way to safeguard amino and hydroxyl groups during a multistep synthesis process. Acetyl chloride and acetic anhydride are typically utilized for the amide production in the presence of an acidic or basic catalyst. Both of these reagents, nevertheless, are caustic and not often recommended for usage. Additionally, in the Lewis acid acylation of amines, the acidic environment causes the breakage of delicate functional groups like acetals and TBDMS ethers. Acylation of amines with acetic anhydride was reported for Sc(OTf)3, TMSOTf, and clays such K-10, KSF. The acylation of amines with esters also uses tetrabutylammonium salt, cyanide anion, and Cp2Sm(thf)2. One of the most essential and often employed processes in the synthesis of organic compounds is the protection of amino groups by the creation of amides, particularly acetamides.[5]

Because of their quick reaction times and high yields, microwave irradiations have been a popular method for conducting chemical syntheses in recent years. Its use in N-acylation amides was also developed, but anhydrides were required to produce the amide bonds under anhydrous circumstances, and the variety of amines were insufficient to reveal the reaction's key driving force. [1] Due to its ability to expedite a number of synthetic transformations while using less time and energy, microwave irradiation of organic processes has grown in popularity quickly. Because of their quick reaction times, selectivity, solvent-free methods, and wider reaction range, microwave aided organic syntheses are well adapted to the growing industrial demands. Under microwave irradiation, acetic acid can function by itself as an acetylating agent, although this technique only works with primary amines. [1,2]

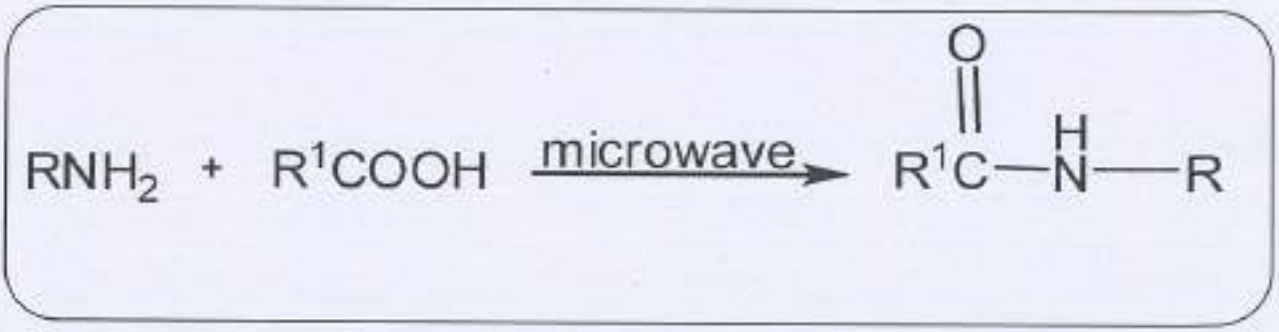
For the production of amides, a variety of greener catalytic techniques have been reported. These include using arylboronic or boronic acid derivatives, microwave irradiation, solid supported reagents (such as polymer-bound acylating agents), and N-acylation of amines with organic acids. There have been reports of several different catalysts for the acylation of amines, including solid acid catalysts, immobilized ionic liquids on mesoporous materials, and transition metal salts.[1]

Several reactions involving various catalysts have been described. Using starbon acid as a catalyst and acetic acid as the acetylating agent, one of the processes of amides by N-acylation of primary and secondary amines under microwave irradiation were reported. By introducing 2mmol of aniline, 2mmol acetic acid, and 0.1g of catalyst to a tube and microwave irradiating it at 300 watts for 1–10 minutes at 120–130°C, the conventional N-acylation of amine was carried out in this procedure. Even though the reaction was run longer and more frequently than with any other acid catalyst, the yield was quantitative (>98%) with the starbon acid catalyst.[1,3]

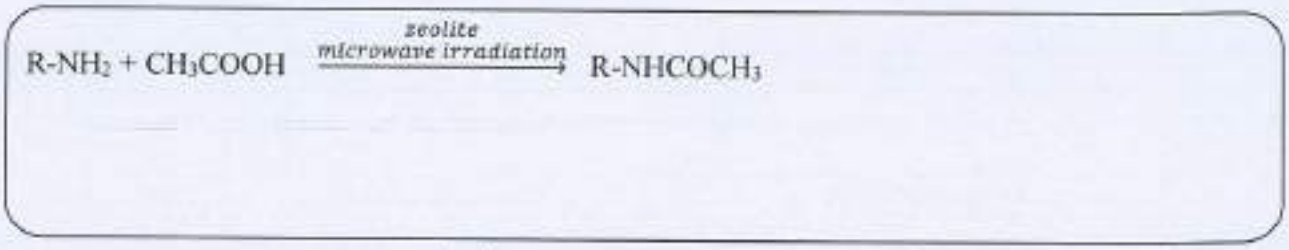


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Another article discusses the creation of an amide bond under microwave radiation using acid as the sole solvent. An N-acetylated molecule was produced in this reaction by first mixing benzyl amine and acetic acid in a microwave reaction chamber. Acetic acid served as both a catalyst and a solvent in this process. This method was mild and practical compared to the conventional amide synthesis process, taking only a few minutes as opposed to several hours, and producing excellent yields (greater than 90%). Between 90 and 95% of the main amines react with acetic acid and produce higher yields. Benzoic acid was utilized as an acylation reagent in place of acetic acid, and it produced yields that were just as high. In this process, 800 mg of benzoic acid or acetic acid was combined with 200 mg of aniline, and the mixture was microwave-irradiated at 200 watts, 50°C, for 6 to 8 minutes. The reaction mixture was added to a 1:50 solution of acetic ether and cyclohexane, then refrigerated for a while. The white crystal was obtained and dried after washing, 98% of the yield was achieved. [2]



LaY and HY have been reported to act as catalysts in the acylation of amines with acetic acid. Recent studies have shown that Gd(OTf)3 and other elements including iodine, ZnO, bromodimethyl-sulfonium bromide, lanthanide, tosylates, CoCl2.6H2O, and ZrOCl2.8H2O can help amines be acylated with acetic anhydride or acetyl chloride. There have been reports of acetic anhydride-only acylation as well. Because chemicals used in chemical synthesis may either be integrated into the finished product or produced as trash, using acetic acid instead of acetic anhydride or acetyl chloride is both economically and environmentally favourable. Zeolites, an acid catalyst, were also used to carry out the acylation process of amines. In this process, 2 mmol of aniline and 2 ml of acetic acid were combined, along with 200 mg of zeolite catalyst, and microwave irradiation at 600 watts for 30 to 40 minutes at 117 °C was utilized as the catalyst and 73% of the yield was achieved.[5]



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Amine acylation is also accomplished using Zn dust as a catalyst. In this reaction, 10ml of acetic acid and 3.3g of aniline were combined with 0.16g of catalyst. The yield was 70-80% after the reaction was cooked on a burner for 45 minutes. Zn, a harmful metal to humans and the environment, is used as a catalyst in this reaction. [3]

$$R\text{-}NH_2 + CH_3CHOOH \xrightarrow{Zn\ dust} R\text{-}NHCOCH_3$$

Although there are many techniques that can be used for this purpose, acetylation of amines is typically done in the presence of base catalysts using acetic anhydride or acetyl chloride. Tertiary amines like triethylamine or pyridine are frequently present during the process. There have also been reports of the use of catalysts such LiCl, I2, montmorillonite-K-10 or KSF, KF-Al2O3, and AlPO4. The acylation of amines with ethyl acetate has also been accomplished using the pyridine (tetrahydroborate) zinc complex. The zinc complex of 0.697g was combined with 0.093g of aniline in THF and ethyl acetate, and the reaction was refluxed for 2.5 hours; the yield was 97%.[4]

$$RR'NH \xrightarrow[THF,reflux]{(Py)Zn(BH4)2} RR'NCOCH_3$$

There is also a mention of a catalytic activity using zinc acetate. Aniline and glacial acetic acid were combined in this synthesis, and zinc acetate was used as a catalyst. Under clean conditions, zinc acetate can likewise operate as a N-acetylating agent in equimolar quantities, but the yields are lower and the reaction periods are longer.

$$R\text{-}NH_2 + CH_3COOH \xrightarrow{Zn\ acetate} RNHCOCH_3$$

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2. Experimental

Instrument used: Microwave (Ultrasonic Ltd)

Chemicals and Reagents: Aniline, glacial acetic acid and 50% ethanol. **(Merk)**

Typical procedures for acylation of aniline:

Without employing a catalyst, aniline was first added in a stoichiometric amount to glacial acetic acid to create acetanilide. Due to its excellent solubility with other organic solvents, acetic acid is used as a solvent in this procedure. 3.235g of aniline and 10ml of glacial acetic acid were combined and microwaved in a glass tube for 5 minutes at 320 MHz. The reaction had a mole ratio of (1:5). After 5 minutes, the reaction mixture was vigorously stirred and carefully poured drop by drop into a beaker with 30 cc of ice cold water. The shining product crystals were slowly separated. When the crystals first formed, they were filtered, collected, and then washed with water over the Buchner funnel. Using 50% ethanol, the product was dried and crystallized again.

Aniline, 3.3 g and 9 ml of glacial acetic acid were combined in a glass tube. The combination was heated for 5 minutes at 480 MHz in a microwave. The reaction's molar ratio was found to be (1:3). After 5 minutes, the reaction was carefully added drop by drop while being vigorously stirred into a beaker holding 30ml of ice cold water. The Buchner funnel was used to separate and filter the shining acetanilide crystals. After being cleaned with water, the crystals were dried over a sodium lamp. Later, using 50% ethanol, the dry product was recrystallized.

2.3g of aniline and 9ml of glacial acetic acid were combined in a glass tube. The combination was put inside a microwave chamber and exposed to 480 MHz radiation for 7 minutes. The reaction's molar ratio was determined to be (1:3). After 7 minutes, the reaction was vigorously stirred and gently emptied drop by drop into a beaker with 30 cc of ice water. It was possible to view the product's shining crystal as it passed through the Buchner funnel. The crystals were dried after being cleaned with water. Using 50% ethanol, the dry product was recrystallized.

3.23g of aniline and 10ml of glacial acetic acid were combined in a glass tube. The combination was put inside a microwave chamber and subjected to 480 MHz radiation for 7 minutes. The reaction's molar ratio was determined to be (1:5). After 7 minutes, the reaction was vigorously stirred and gently emptied drop by drop into a beaker with 30 cc of ice water. The product's shining crystals were visible after being filtered via the Buchner funnel. Water was used for the washings, and a sodium lamp was used to dry the product. Using 50% ethanol, the dry product was recrystallized.

Aniline (2.3g) and glacial acetic acid (9ml) were combined in a glass tube. The combination was positioned in a microwave chamber and subjected to 480 MHz radiation for 5 minutes. The reaction taken had a molar ratio of (1:3). After 5 minutes, the reaction was carefully added drop by drop while being vigorously stirred into a beaker holding 30ml of ice cold water. The product's brilliant crystals were obtained after being filtered using the Buchner funnel. Water was used for the washings, and the product was dried. The product was recrystallized using 50% ethanol after drying.

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1.32g of aniline and 8ml of glacial acetic acid were combined in a glass tube. The combination was positioned in a microwave chamber and exposed to 480 MHz radiation for 5 minutes. The reaction taken had a molar ratio of (1:10). After 5 minutes, the reaction was vigorously stirred and gently emptied out drop by drop into a beaker with 30 cc of ice water. The shining crystals of the product were obtained which was filtered over the Buchner funnel. The crystals underwent a water wash before being dried with a sodium lamp. Later, using 50% ethanol, the product was recrystallized.

Aniline 1ml and of glacial acetic acid 1ml were combined in a glass tube. The combination was positioned in a microwave chamber and exposed to 160 MHz radiation for 10 minutes. The reaction taken had a molar ratio of (1:5). After 10 minutes, the reaction was vigorously stirred and gently emptied drop by drop into a beaker with 30 cc of ice water. The product's shining crystals were created after being filtered via a Buchner funnel. After being cleaned with water, the crystals were dried with a sodium lamp. 50% ethanol was used to recrystallize the product.

A mixture of 2.04g of aniline and 3.75ml of glacial acetic acid was placed in a glass tube. The combination was heated for 20 minutes at 160 MHz using a microwave. The reaction's molar ratio was determined to be (1:3). After 20 minutes, the reaction was carefully taken out of the microwave and vigorously stirred before being gently poured drop by drop into a beaker with 30 cc of ice water. The product's shining crystals were obtained after being filtered using the Buchner funnel. The crystals were dried after being cleaned with water. Using 50% ethanol, the dry product was recrystallized.

A mixture of 2.04g of aniline and 3.75ml of glacial acetic acid was placed in a glass tube. The reaction was positioned in a microwave chamber and subjected to 160 MHz radiation for 30 minutes. The reaction's molar ratio was determined to be (1:3). After 30 minutes, the reaction mixture was carefully taken out of the microwave and vigorously stirred before being gently poured drop by drop into a beaker with 30 cc of ice water. The product's shining crystals were separated, and it was then filtered using a Buchner funnel. The crystals were totally dried after being cleaned with water. Later, using 50% ethanol, the dry product was recrystallized.

A mixture of 2.04g of aniline and 3.75 ml of glacial acetic acid was placed in a glass tube. A microwave chamber was used to irradiate the process for 40 minutes at 160 MHz. The reaction's molar ratio was determined to be (1:3). After 40 minutes, the reaction mixture was carefully taken out of the microwave and vigorously stirred before being gently poured drop by drop into a beaker with 30 cc of ice water. The product's brilliant crystals were separated, and it was then filtered using a Buchner funnel. The crystals were totally dried after being cleaned with water. Later, using 50% ethanol, the dry product was recrystallized.

2.04 grams of aniline and 3.75 milliliters of glacial acetic acid were combined in a glass tube. A microwave chamber was used to irradiate the process for 40–50 minutes at 160 MHz. The

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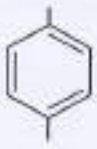
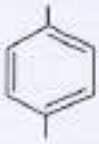
reaction's molar ratio was determined to be (1:3). After 40-50 minutes, the reaction mixture was carefully taken out of the microwave and vigorously stirred before being gently poured drop by drop into a beaker with 30 cc of ice water. The product's brilliant crystals were separated, and it was then filtered using a Buchner funnel. The crystals were totally dried after being cleaned with water. Later, using 50% ethanol, the dry product was recrystallized.

With water as a solvent:

2.04 g of aniline, 3.75 ml of glacial acetic acid, and 1 ml of water were combined in a glass tube. A microwave chamber was used to irradiate the process for 50 minutes at a frequency of 160 MHz. The reaction's molar ratio was determined to be (1:3). After 50 minutes, the reaction mixture was carefully taken out of the microwave and vigorously stirred before being gently poured drop by drop into a beaker with 30 cc of ice water. The product's brilliant crystals were separated, and it was then filtered using a Buchner funnel. The crystals were completely dried after being cleaned with water. Later, using 50% ethanol, the dried product was recrystallized.

These were the standard processes carried out with water and acetic acid as the solvent. The product is produced when aniline and acetic acid combine. Every technique involved altering the stoichiometric ratio of the reaction, influencing how much acetic acid and aniline were produced. The amount of acetic acid used in conventional methods is considerably higher than the amount of aniline utilized. To prevent any wastage, if a process is referred to as "green synthesis," then the number of chemicals used must be reduced and in an equal amount. This assignment involves reducing the amount of acetic acid and carrying out the processes. Aniline and glacial acetic acid were employed in this experiment in a ratio of 1:3. The production of acetic acid is reduced in this way.

Table no: 1 Acylation of aniline with acetic acid.

Substrate	Time (min)	Molar ratio	Yield (%)	Product
NH_2 	5	1:5	22.23	$NHCOCH_3$ 

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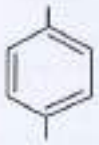
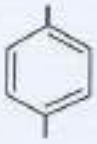
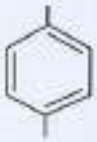
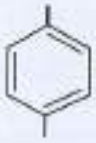
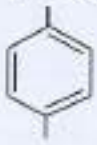
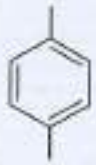
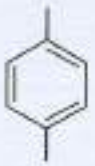
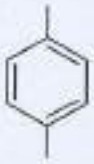
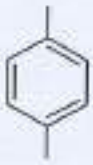
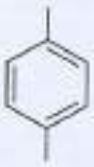
	5	1:1	10.85	
	7	1:3	30.28	
	7	1:5	37.27	
	5	1:3	20.00	

Table 2:

Substrate	Time (min)	Molar ratio	Yields (%)	Product
	5	1:10	No yield	

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NH_2 	10	1:3	50.62	$NHCOCH_3$ 
NH_2 	20	1:3	70.13	$NHCOCH_3$ 
NH_2 	30	1:3	72.09	$NHCOCH_3$ 
NH_2 	40-50	1:3	75-80	$NHCOCH_3$ 

3. Result and Discussion

From an economic and environmental perspective, using acetic acid in the acylation reaction rather than the corrosive acetyl chloride or acetic anhydride has many benefits, and the only by-product is water. The green chemistry approach was used to produce acetanilide. Re-crystallizing the synthesized materials yielded melting points that are consistent with previously reported melting points. It was discovered that the green chemistry process produced a higher yield percentage than the traditional method did.

Stereochemistry of amines:

In contrast to what would be predicted if pure p-orbitals of nitrogen were used to form bonds, the bonds to nitrogen in amines are pyramidal and have bond angles that are closer to the tetrahedral value of 109.5° than to the 90° value expected. We believe that the nitrogen in amines is best constructed with hybrid sp3-type orbitals, of which three are used for σ bond formation and the fourth is home to an electron pair that is not involved in a bond.

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Spectroscopy of amines:

NMR: The amine hydrogens are visible at concentrations between 0.5 and 5.0 ppm. The location is determined by the concentration of the sample and the degree of hydrogen bonding. Typically, the hydrogens on carbons that are directly linked to an amine range from 2.3 to 3.0 ppm. All hydrogens on non-carbon atoms will often exchange with deuteriums when D_2O is added, making these resonances dissipate. The existence of -NH can be determined by adding a few drops of D_2O and watching the signal disappear.

IR: The infrared spectrum of aniline;

Stretching vibrations: Compared to O-H absorptions, the N-H stretching absorption is less susceptible to hydrogen bonding. Free N-H absorption is seen in the 3400–3500 per cm range in both the gas phase and diluted CCl_4 solution. N-H absorptions are typically 40 to 70 times more frequent in aromatic amines. A 1600 per cm overtone for aromatic amines is thought to interact with a smaller absorption at about 3200 per cm.

Primary amines typically exhibit bending vibrations, such as strong in-plane NH_2 scissoring absorptions at 1550–1650 per cm and out-of-plane wagging at 650–900 per cm.

A primary amine like aniline was chosen for the acylation of amines because it may react with glacial acetic acid to produce the matching amide without the need for a catalyst. 40 minutes of exposure time and a maximum microwave power output of 480 MHz were chosen as the reaction parameters. Without using a catalyst, quantitative conversion of the starting material was discovered in less than 15 minutes of reaction time. The reaction parameters have to be optimized next. The yield was impacted as expected by a decrease in microwave power and time. The most crucial variables in the process were probably the duration of the microwave irradiation and the volume of solvent acetic acid. When the duration was reduced, less than a 50% yield was obtained for the majority of the reactions. The yield between 70 and 80% was achieved with concomitant increase in the amount of solvent and irradiation time to 40 to 50 minutes.

The reaction between aniline and glacial acetic acid was conducted in the absence of microwave irradiation in the presence of Zn dust as a catalyst in order to compare the efficiency of microwave irradiation with that of traditional heating. The reaction took longer than an hour to finish itself. The yield that was obtained was lower than that of the microwave reaction, which uses no catalyst at all.

Tables 1 and 2 provide comparisons of the various reactions over a range of time scales and molar ratios.

As could be seen, reaction number 10 provides the highest yield, with the reaction's molar ratio being set at 1:3. In this synthesis, 2.04g of aniline and 3.7 ml of acetic acid are utilized. At 160 MHz, the reaction is microwave-irradiated for 40 to 50 minutes. When the reaction is fully converted, the yield is between 70 and 80 percent.

6. Conclusion

In conclusion, a variety of pharmaceutical intermediates, including acetanilide, might be prepared using our effective, atom-economic, and environmentally benign methodology. We have created a process for the microwave-induced acylation of amines that is effective, quick, safe, high-yielding, and environmentally friendly. The current technique works with anilines

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and primary amines. The benefit of this approach is that no hazardous or corrosive chemicals are required to carry out the reaction. This is remarkable and increases the method's economic value. Acetic acid is used as a solvent in a 1:3 ratio to successfully create amide, and the technique was shown to be independent of the substrate combination and, more crucially, of the effective removal of water, which has been claimed to be essential to achieving high amide yields. Incorporating acetic acid into current techniques can make the facilitated acylation of amines a compelling study topic.

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अनुक्रम

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समसामायिक

विळखा : मायक्रोप्लॅस्टिक प्रदूषणाचा

सुभाष दोंदे

जगातला पहिला कृत्रिम प्लॅस्टिक-बॅकेलाइट १९०७मध्ये उत्पादित झाले, त्या सरशी आतापर्यंतची सर्वात बलस्वी मानवनिर्मित वस्तू अर्थात् प्लॅस्टिकच्या वैश्विक उद्योगाची मुहूर्तमेढ रोवली गेली. बॅकेलाइटच्या शोधाने कार, टेलिफोन, खेळणी, रेडिओ आणि अगदी आभूषणांपासून अनेक ग्राहकोपयोगी उत्पादने तयार करण्याच्या पद्धतीत आमूलाग्र क्रांती घडवून आणली. बॅकेलाइटच्या या यशाने उद्योग क्षेत्रास अनेक नवनवीन बहुउद्देशीय प्लॅस्टिक विकसित करण्यास प्रोत्साहन दिले आणि द्वितीय विश्वयुद्धानंतर प्लॅस्टिकचे उत्पादन जागतिक स्तरावर पोहोचले. १९५०पासून मागील सात दशकात प्रति दशक दुप्पट या वेगाने वाढत प्लॅस्टिकचे वैश्विक उत्पादन २०१९ साली ४६० दशलक्ष मेट्रिक टन नोंदवले गेले. आजपर्यंत विविध आकाराचे आणि पॉलिमरिक रचना असलेले प्लॅस्टिक समुद्राचे पाणी, गोडे पाणी, कृषी परिसंस्था, अन्न, पिण्याचे पाणी, जैवसृष्टी, आर्क्टिक-अंटार्क्टिक यांसारख्या दूरस्थ किंवा दुर्गम परिसंस्थेत आढळले आहे. प्लॅस्टिकचं भूतलावरील सार्वभौमत्व लक्षात घेऊन तत्कालीन भूवैज्ञानिक युग- दि प्लॅस्टिसीन या नावाने रूढ होत आहे.

कुजून मातीत मिसळणाऱ्या नैसर्गिक कचऱ्याच्या विपरित प्लॅस्टिक कचरा कायमस्वरूपी जैव अविघटनशील आहे आणि त्याचा संपूर्ण ऱ्हास होण्यासाठी अनेक शतके लागू शकतात. पण, पर्यावणातील भौतिक आणि रासायनिक आघातांमुळे झिज होऊन त्याचे रूपांतर सूक्ष्म कणात किंवा मायक्रोप्लॅस्टिकमध्ये घडते जे स्थल-कालपरत्वे वेगवेगळ्या आकृती आणि आकारमानाचे असू शकतात. पाच मिलिमीटर आकाराचे सूक्ष्मकण कुठल्याही गाळण प्रक्रियेतून बिनासायास निसटून सांडपाण्याच्या वाटे शेवटी समुद्रात पोहचतात आणि जलचरांच्या अन्न साखळीतून एक एक टप्पा वर सरकत सरते शेवटी मानवी शरिरात प्रवेशतात. मायक्रोप्लॅस्टिकचे पाच मिलिमीटरचे सूक्ष्म कण शरिरातील पेशी आवरण (प्लाज्मा मेम्ब्रेन), रुधिर-मस्तिष्क अवरोध (ब्लड-ब्रेन बॉरियर), प्लासेंटा (माता-भ्रूण संयुक्त ऊती) हे समस्त अडथळे पार करू शकतात. त्या मुळेच मानवी शरीरातील रक्तात मायक्रोप्लॅस्टिक असल्याचे आता सिद्ध झाले आहे. सूक्ष्म कणांच्या स्वरूपात प्लॅस्टिक आज चराचरात सामावले गेले आहे.

उत्पत्तीच्या आधारे वर्गीकृत केलेले प्राथमिक मायक्रोप्लॅस्टिक हे व्यावसायिक कारणासाठी जाणूनबुजून पाच मिलिमीटर किंवा त्यापेक्षा कमी आकाराचे बनवले जातात; ज्याचा वापर टूथपेस्ट जेल आणि

लेखक मुंबईस्थित किर्ती महाविद्यालयात प्राणिशास्त्राचे प्राध्यापक आहेत.
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चेहरा उजळण्यासाठीच्या स्क्रबिंग किंवा डिफोलिएटिंग फेसवॉशमधील मायक्रो-बीड्सच्या स्वरूपात केला जातो. द्वितीय मायक्रोप्लॅस्टिकचा प्रवास मोठ्या वस्तू म्हणजे पॉलीथिन, पॉली-कार्बोनेटच्या प्लास्टिक बाटल्या, कॅरी बॅग्ज, पॉलिएस्टर, नायलॉन, ॲक्रिलिकचे सिन्थेटिक कपडे, वाहनांचे टायर, मासेमारीचे जाळे, मरिन पेंट इत्यादींच्या स्वरूपात सुरू होतो. कालौघात निरनिराळ्या भौतिक- रासायनिक आघातांमुळे या वस्तूंची झिज होते आणि त्यापासून सूक्ष्म कण आणि सूक्ष्म धागे (मायक्रो-फायबर) अविरतपणे निर्माण होतात जे सांडपाणी आणि जलमार्गातून समुद्रात पोहचतात.

उच्च ऱ्हास प्रतिरोध आणि जैव-संचय या दुहेरी कारणास्तव मायक्रोप्लॅस्टिक ही पर्यावरणासाठी एक अत्यंत गंभीर समस्या आहे. त्याचबरोबर मानवी आरोग्याच्या दृष्टीनेदेखील मायक्रोप्लॅस्टिक हे एक दुहेरी संकट किंवा आरोग्य समस्या आहे असे म्हणावे लागेल. एकतर मायक्रोप्लॅस्टिकचे स्वतःचे आंतरिक रासायनिक घटक आहेत जे मानवी आरोग्याच्या दृष्टीने घातक आहेत आणि दुसरे म्हणजे मायक्रोप्लॅस्टिकचे सूक्ष्म कण चुंबकासम जलीय पर्यावरणातील इतर प्रदूषकांना जसे- कीटकनाशके, जड धातूंची संयुगे, इतर शेकडो प्रदूषक, झिनोबायोटिक्स, रोगकारक जीवाणू इत्यादींना आकर्षित करून त्यांना चिकटतात आणि त्यांचे वहन करतात. परिणामस्वरूप मानवी आरोग्यावर होणारे दुष्परिणाम हे मायक्रोप्लॅस्टिकच्या स्वतःच्या आंतरिक घटकांमुळे अधिक त्यांना चिकटलेल्या इतर विषारी प्रदूषकांचा एकत्रित परिणाम असू शकतो. या संदर्भात इस्रायलमधील तेल-अवीव विद्यापीठाच्या संशोधकांनी केलेल्या नवीन अभ्यासात असे आढळून आले आहे की, मायक्रोप्लॅस्टिकच्या सूक्ष्म कणांना सागरी पर्यावरणातील विषारी कार्बनी संयुगे चिकटल्याने त्यांची विषाक्तता किंवा विषारीपणा १० पटीने वाढतो, ज्याचे मानवी आरोग्यावर गंभीर परिणाम होऊ शकतात.

प्लॅस्टिकला विशिष्ट गुणधर्म बहाल करण्यासाठी आणि साठवण कालावधी (शेल्फ-लाईफ) वाढविण्यासाठी त्याच्या निर्मितीप्रक्रियेत प्रामुख्याने बिस्फेनॉल-ए (बीपीए), थॅलेट्स आणि इतर कार्बनी आणि कोबाल्ट, कॅडमियम, पारा, तांबे, शिसे, आर्सेनिक यांसारखे जड धातू- या अकार्बनी पदार्थांचा वापर रंगक, अग्नि किंवा ज्वाला-रोधक, भरक/ पूरक (फिलर) आणि स्थिरक (स्टॅबिलायझर) या रूपात केला जातो. बिस्फेनॉल-ए (बीपीए), थॅलेट्स ही समावेशी (ऍडिटीव्ह) रसायने संप्रेरके (हार्मोन्स) आणि त्यांना रक्तात सोडणाऱ्या अंतःस्रावी (इंडोक्राइन) ग्रंथींमध्ये बिघाड घडवून मानवी तसेच प्राण्यांच्या पुनरुत्पादन क्षमतेवर, चयापचय प्रक्रियेवर आणि मज्जासंस्थेवर अनिष्ट परिमाण घडवतात. वर उल्लेख केलेले जड धातू आणि त्यांची कार्बनी संयुगे ऑक्सीडेटीव्ह स्ट्रेसद्वारे मुक्त मूलकांची (फ्री रॅडीकल्स) निर्मिती करून आणि डीएनएच्या आणि पर्यायाने जनुकांच्या संरचना आणि कार्यात उत्परिवर्तन घडवून कर्करोग निर्माण करतात. कर्करोगाला खतपाणी घालणाऱ्या विषारी घटकांचे म्हणजेच कर्कजनचे (कार्सिनोजेनचे) मायक्रोप्लॅस्टिक हे घातक कॉकटेल आहे असे आतापर्यंतच्या संशोधनातून सिद्ध झाले आहे.

जगात सर्वाधिक प्लॅस्टिक कचरा एकट्या अमेरिकेत प्रतिवर्ष प्रति व्यक्ति सरासरी किंवा दरडोई २२१ किलोग्राम या दराने निर्माण होतो. युरोपीय देशात आणि पूर्वेकडील जपान और कोरिया देशात हेच प्रमाण अनुक्रमे ११४ आणि ६९ किलोग्राम इतके आहे. प्लॅस्टिक कचऱ्याचा पुनर्वापर करण्यासाठी त्याचे पुनर्चक्रण (रिसायक्लिंग) केले जाते. प्लॅस्टिकचे पुनर्चक्रण ही नवीन आर्थिक संधी निर्माण करणारी आणि जमिनीत गाडणे / पुरणे (लँड-फिलिंग) किंवा जाळणे या विनाशकारी प्रथांच्या तुलनेत अधिक पर्यावरण-हितैषी अशी पर्यायी प्रक्रिया आहे. एवढे असूनही वैश्विक स्तरावर फक्त ९ टक्के प्लॅस्टिक कचरा पुनर्चक्रित केला जातो. अमेरिकेत हा दर तर फक्त ५ टक्के आहे. याचा अर्थ वापरले जाणारे

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सर्वाधिक प्लॅस्टिक हे लँडफिल (जमिनीत गाडले) जाते किंवा जाळले जाते किंवा वाऱ्याने ते इतरत्र पसरते. भारतात प्रतिवर्ष ३.४ दशलक्ष मेट्रिक टन प्लॅस्टिक कचरा निर्माण होतो, त्यापैकी ३० टक्क्यांहून अधिक पुनर्चक्रित केला जातो. अमेरिकेच्या तुलनेत आणि वैश्विक पातळीवर भारतात प्लॅस्टिकचे पुनर्चक्रण अधिक प्रमाणात घडते हे निश्चितच कौतुकास्पद आहे. पण, मुळात प्लॅस्टिकची पुनर्चक्रण प्रक्रिया आणि या प्रक्रियेत निर्माण होणाऱ्या सांडपाण्याच्या विसर्गातून मायक्रोप्लॅस्टिकच्या रूपात पर्यावरणाची अधिक हानी होते याची आजवर तुरळक माहिती उपलब्ध होती.

प्लॅस्टिक उद्योगानेदेखील खूप वर्षांपासून प्लॅस्टिकच्या पुनर्चक्रण किंवा पुनर्प्रक्रियेचा एक प्रकारे दिशाभूल करणारा प्रचार केला आहे. पण, युनायटेड किंगडमसारख्या प्रगत राष्ट्रामधील एक अत्याधुनिक प्लॅस्टिक रिसायक्लिंग सुविधा दरवर्षी प्रति घनमीटर ७५ अब्ज मायक्रोप्लॅस्टिकचे सूक्ष्म कण सांडपाण्यात सोडते असे अलीकडील एका पाहणी अंती निदर्शनास आले आहे. रिसायक्लिंग केलेल्या पण गाळण (फिल्टरेशन) प्रणाली न वापरता सोडलेल्या सांडपाण्यातून प्रतिवर्षी २,९३३ मेट्रिक टन मायक्रोप्लॅस्टिक वाहून जाते आणि गाळण प्रणालीचा वापर केल्यानंतर सुद्धा १,३६६ मेट्रिक टनापर्यंत सूक्ष्म कणांचा या प्लांटच्या सांडपाण्यातून निचरा होतो असे या पाहणी अंती निदर्शनास आले आहे. उच्च उत्पन्न असलेले देश दरडोई अधिक प्लॅस्टिक कचरा निर्माण करतात; परंतु, समुद्रात पोहोचणारे बहुतांश मायक्रोप्लॅस्टिक हे निम्न ते मध्यम उत्पन्न असलेल्या देशांतील नद्यांमधून येते. याचे कारण प्लॅस्टिक कचऱ्याचे गैरव्यवस्थापन तिथे अधिक आहे, तर उच्च उत्पन्न असलेल्या देशांमध्ये कचरा व्यवस्थापन अधिक प्रभावी आहे. या पार्श्वभूमीवर जगात सर्वाधिक लोकसंख्या असलेल्या भारत आणि चीनसारख्या देशांतून प्लॅस्टिक आणि त्याचे सूक्ष्म कण किती प्रमाणात महासागर प्रदूषित करत असतील याचा विचारही आपणास सुन्न करू शकतो.

'आजचा कचरा हा उद्याचा कच्चा माल रूपी संसाधन' या तत्त्वाचा अंगिकार केलेली वर्तुळीय अर्थप्रणाली शाश्वत किंवा चिरस्थायी मानली जाते. प्लॅस्टिकचा लाखो मेट्रिक टन कचरा पुनर्चक्रण किंवा पुनर्प्रक्रिया करून पुनर्वापर करताना त्यातून निर्माण होणारे मायक्रोप्लॅस्टिक हे अत्याधुनिक गाळणप्रणालीचा वापर करून विभक्त केले जाईल-याबाबतची वैश्विक जागरूकता किंवा दक्षता ही काळाची गरज आहे. अन्यथा प्लॅस्टिक प्रदूषणाचे संकट निवारणासाठी अंमलात असलेली पुनर्चक्रण प्रक्रिया मायक्रोप्लॅस्टिकचे अत्याधिक भीषण संकट वृद्धिंगत करील.

आजमितीस कपडा उद्योगात सिंथेटिक फॅब्रिकचा (पॉलिस्टर, नायलॉन, ॲक्रेलिक आणि इतर सिंथेटिक धाग्यांपासून बनवलेले) वाटा ६० टक्के आहे. साबण किंवा वॉशिंग पावडरसह वॉशिंग मशीन किंवा ब्रशच्या घर्षणाचा एकत्रित रासायनिक आणि यांत्रिकी ताण यामुळे सिन्थेटिक कपड्यांतून मायक्रोप्लॅस्टिकचे सूक्ष्म धागे (मायक्रो-फायबर) मुक्त होतात जे अखेरीस सांडपाणी आणि विविध जलमार्गाने मजल दरमजल करत महासागरात पोहचतात. समुद्राच्या एकूण मायक्रोप्लॅस्टिक प्रदूषणात सर्वाधिक म्हणजे एकूण ३५ टक्के योगदान हे आपण वापरत असलेल्या सिन्थेटिक कपड्यांमुळे घडते.

त्या खालोखाल रस्तोरस्ती घर्षणाने वाहनांच्या टायर्समधून मायक्रोप्लास्टिक निर्माण होते. प्लॅस्टिक पॉलिमरच्या स्वरूपात वाहनांच्या प्रत्येक टायरमध्ये किमान २४ टक्के सिंथेटिक रबर असते. उष्णतेमुळे आणि रस्त्याच्या संपर्कात घर्षणामुळे टायर खराब होतात. वारा आणि पावसामुळे, टायरचे सूक्ष्म कण विविध जलमार्गातून सरते शेवटी महासागरांमध्ये मिसळतात. एका अभ्यासात असे आढळून आले आहे की, अमेरिकन लोक दरडोई सर्वाधिक टायर वापरतात आणि अमेरिकेत दरवर्षी टायर्सच्या घर्षणाने सुमारे १.८ दशलक्ष

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टन मायक्रोप्लास्टिक तयार होते. सिंथेटिक कपड्यांनंतर, महासागरांमध्ये उपस्थित असलेल्या एकूण मायक्रोप्लॅस्टिक पैकी वाहनांच्या टायर्सचा वाटा २८ टक्के आहे.

अनेक वैयक्तिक निगा आणि सौंदर्य प्रसाधनात जसे की, स्क्रबिंग एजंट, शॉवर जेल, फेस-वॉश क्रीम आणि टूथपेस्ट जेलमध्ये मायक्रोबीड्सच्या स्वरूपात इंजिनिअर्ड मायक्रोप्लॅस्टिक वापरले जाते. अमेरिकेने त्याच्या निर्मिती आणि विक्रीवर बंदी घातली आहे, परंतु उत्पादक अजूनही जागतिक स्तरावर ही उत्पादने तयार करतात आणि विकतात. मायक्रोबीड्स पॉलिथिलीन प्लॅस्टिकपासून बनवलेले असतात आणि ते एक्सफोलिएंट म्हणून काम करतात जे आरोग्य आणि सौंदर्य उत्पादनांमध्ये त्वचेला टवटवीतपणा आणण्यासाठी वापरले जातात. वैयक्तिक काळजी घेणारी वस्तू एकदा वापरल्यानंतर सांडपाण्यात मिसळली जाते. हे सूक्ष्म कण सहजपणे सांडपाणी गाळणप्रणाली किंवा संयंत्रामधून निसटून विविध जल स्रोतातून महासागरात जातात.

महासागराच्या मायक्रोप्लॅस्टिक प्रदूषणात शहरी धुळीचे २४ टक्के योगदान आहे. प्लॅस्टिकच्या एक ना अनेक वस्तूंची हवामान वा घर्षणामुळे झिज होऊन त्याचे सूक्ष्म कण शहरी धुळीत मिसळतात. 'नेचर जिओसायन्स'मध्ये प्रकाशित एका शोध निबंधान्वये दक्षिण फ्रान्समधील पायरेनीस (Pyrenees) पर्वतावर दररोज आकाशातून प्रति चौरस मीटर ३६५ मायक्रोप्लॅस्टिक सूक्ष्मकणांचा पाऊस पडतो याची नोंद झाली आहे. विशेष म्हणजे १०० किलोमीटर परिघात मायक्रोप्लॅस्टिकचे कोणतेही स्पष्ट स्रोत नव्हते. यावरून मायक्रोप्लॅस्टिक हे निव्वळ जल प्रदूषक म्हणून मर्यादित राहिले नसून त्याने वायू प्रदूषक बनून वसुंधरेचे जल-थल-वायू आणि जैव आवरण व्यापले आहे. दरवर्षी अंदाजे ८.७५ दशलक्ष मेट्रिक टन प्लॅस्टिक विविध जमीन-आधारित स्रोतांमधून आपल्या महासागरात प्रवेश करते. एकदाच वापरल्या जाणाऱ्या प्लॅस्टिकच्या पिशव्यांचे विघटन किंवा ऱ्हास होण्यासाठी कित्येक दशके लागतात. पर्लपेटचे डबे आणि पॉलीकार्बोनेट प्लॅस्टिकच्या बाटल्या पूर्ण विघटित होण्यासाठी अंदाजे ४५० वर्षे लागतील असा अंदाज आहे.

अहवाल सुचवितो की, ०.३३ ते ४.७५ मिलिमीटर आकाराचे ५.२५ ट्रिलियन मायक्रोप्लॅस्टिकचे सूक्ष्मकण सध्या जगातील महासागरामध्ये तरंगत आहेत. मुंबई स्थित केंद्रीय मत्स्य शिक्षण संस्थेतील संशोधकांच्या मते दरवर्षी २ लाख मेट्रिक टन समुद्री मासे खाणारी मुंबापुरी दररोज ५०० शिपिंग कंटेनर भरतील इतका म्हणजेच ४०८ टन प्लॅस्टिक कचरा तयार करते. लोक मुंबईच्या किनाऱ्यावर पकडलेले १०० ग्रॅम मासे खातात तेव्हा मायक्रोप्लॅस्टिकचे सुमारे ८० कण या मत्स्य आहारातून त्यांच्या शरीरात प्रवेशतात.

मायक्रोप्लॅस्टिकने आर्क्टिक-अंटार्क्टिकसह आता माउंट एव्हरेस्टसारख्या सर्वोच्च शिखरापासून सर्वाधिक खोल प्रशांत महासागरांपर्यंत संपूर्ण वसुंधरेस प्रदूषित केले आहे. अन्न-पाण्याद्वारे तसेच श्वासोच्छ्वासाद्वारे मायक्रोप्लॅस्टिकच्या सूक्ष्म कणांचे अन्न साखळीत उच्चस्थ स्थानी विराजमान मानवात जैव-विस्तारण किंवा बायो-मॅग्निफिकेशन होत आहे. अर्भकांच्या आणि प्रौढांच्या विष्ठेत ते या आधीच आढळले आहे. अलीकडे प्रथमच मानवी रक्तामध्येदेखील मायक्रोप्लॅस्टिक आढळून आले आहे, शास्त्रज्ञांनी चाचणी केलेल्या जवळजवळ ८०% लोकांमध्ये हे सूक्ष्म कण सापडले आहेत. प्लॅस्टिकच्या उत्पादन आणि वापरावर निर्बंध आणले नाहीत तर २०५०पर्यंत वस्तुमान किंवा वजनाप्रमाणे महासागरात माशांपेक्षा जास्त प्लॅस्टिकच असेल आणि जैव-अवरणातील प्रत्येक सजीवामध्ये मायक्रोप्लॅस्टिक असेल जे आपल्या येणाऱ्या पिढ्यांच्या हेल्थ-स्पॅन आणि लाईफ-स्पॅन (आयुर्मान) या दोहोंवर विपरीत परिणाम घडवतील या बाबत शंका नाही. ●

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(3·43) 2023-24

अनुक्रम

एक रेघ

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3.4.3 (2022-23)

निमित्ताने

मधुमेहाचा विळख्यातून सुटका

सुभाष दोंदे

१९२३च्या वैद्यक शास्त्रातील नोबेल पारितोषिक विजेते सर फ्रेडरिक बँटिंग यांच्या जन्मदिनी म्हणजेच -१४ नोव्हेंबरला दरवर्षी 'जागतिक मधुमेह दिन' साजरा केला जातो. १९२१ साली बँटिंग आणि त्यांचा विद्यार्थी चार्ल्स बेस्ट या द्वयींनी स्वादुपिंड ग्रंथीतून स्रवणाऱ्या आणि रक्तातील ग्लुकोजचं नियमन करणाऱ्या इन्सुलिन संप्रेरकाचा शोध लावला; ज्याने मधुमेहाचा कार्यकारणभाव आणि औषधोपचाराची मुहूर्तमेढ रोवली. मागील शंभर वर्षात मधुमेह कारणमीमांसा क्षेत्रात झालेल्या भरीव संशोधनामुळे प्रौढांना होणाऱ्या टाईप २ मधुमेहा संदर्भात एक बाब अगदी सुस्पष्ट झाली आहे आणि ती म्हणजे जीवनशैलीच्या या दीर्घकालीक व्याधीचे आहार-विहारात सकारात्मक बदल घडवून प्रतिबंधनच नव्हे तर शतप्रतिशत व्युत्क्रमण (रिव्हर्सल) करता येते. पण, अपवाद वगळले तर बहुतांश डॉक्टर्स हे औषध-गोळ्यांद्वारेच टाईप २ मधुमेहाचे तहहयात व्यवस्थापन करताना दिसतात; कारण एकतर प्रतिबंधन किंवा रिव्हर्सल द्वारे पेशंट कायमचे बरे करणे त्यांच्या हिताचे नाही आणि दुसरे असे की शोध वृत्तीचा अभाव किंवा तशी संशोधन संस्कृती इथे जोपासली न गेल्यामुळे या क्षेत्रातील नवे कल, नव्या दिशा याबद्दल ते अनभिज्ञ असणेही नाकारता येत नाही.

आज भारतासह जगभरातील एकूण मृत्यूच्या साधारणतः ७० टक्के मृत्यू हे मधुमेह, हृदय आणि रक्त वाहिन्यांचे रोग, कर्करोग, दमा आणि फुप्फसांचे रोग आणि स्मृतीभ्रंश सारख्या दीर्घकालीक असंक्रामक किंवा असंसर्गजन्य रोगाने घडत आहेत. या उपरांत करोना-१९ महामारी दरम्यान सहव्याधी किंवा सह-रुग्णता (कोमॉर्बीडीटी)ने ग्रस्त असलेल्या व्यक्ती निरोगी व्यक्तींच्या तुलनेत सर्वात अधिक प्रमाणात मृत्युमुखी पडल्याचे आपण पाहिले आहे. वर वर भिन्न वाटणाऱ्या या व्याधी समुच्चयातील मधुमेह, हृदयरोग, आणि स्मृतिभ्रंश (अल्झायमर) रोग यांची सुरुवात कुठे तरी रक्तातील अति-ग्लुकोजता (हायपर ग्लायसेमिया) आणि अति-इन्सुलिनता (हायपर इन्सुलिनिमिया) या दोहोंनी एकत्रितपणे निर्माण केलेल्या इन्सुलिन प्रतिरोधा (रेझिस्टन्स)मुळे घडते हे जवळपास सिद्ध झालं आहे. याच कारणास्तव अलिकडे वैद्यकिय क्षेत्रात हृदयरोगास 'निदान न झालेला मधुमेह' आणि स्मृतिभ्रंश (अल्झायमर) व्याधीस 'टाईप ३ मधुमेह' म्हणून संबोधले जात आहे. त्यामुळे जीवनशैलीशी निगडित हे दिर्घकालीक आजार एकमेकांशी परस्पर सह-संबंधितच नव्हे तर परस्पर आधारित आहेत.

लेखक मुंबईस्थित कीर्ती महाविद्यालयात प्राणिशास्त्राचे प्राध्यापक आहेत.
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इन्सुलिन प्रतिरोधात शरीरात इन्सुलिन अतिप्रमाणात स्रवते पण ते रक्तातील ग्लुकोजचे प्रमाण सामान्य कक्षेत ठेवण्यात अपयशी ठरते ज्याची परिणीती अति-ग्लुकोजतेमध्ये घडते.

एकमेकांना परस्पर पूरक आणि एकमेकांत वृद्धी करणाऱ्या या दुहेरी घटना मेटाबॉलीक सिंड्रोम (चयापचयी लक्षणसमूह)ला कारणीभूत ठरतात. जागतिक आरोग्य संघटनेने मेटाबॉलीक सिंड्रोमचे पाच निकष सांगितले आहेत; ज्यात

१. कंबरेचा घेर वाढणे

२. उपाशी पोटी रक्तातील साखर वाढणे

३. उपाशी पोटी रक्तातील ट्रायग्लिसेराइड (मेद) वाढणे

४. उपाशी पोटी रक्तातील हाय डेन्सिटी लायपो-प्रोटीन (एचडीएल) कोलेस्टेरॉल कमी होणे

५. रक्तदाब वाढणे इत्यादींचा समावेश होतो.

या पाच निकषांपैकी कोणतेही तीन निकष एकत्रितपणे दाखवणाऱ्या व्यक्तीला 'मेटाबॉलीक सिंड्रोम'ची बाधा झाली आहे असे समजले जाते. इन्सुलिन प्रतिरोधामुळेच मेटाबॉलिक सिन्ड्रोमची वर उल्लेखलेली एक ना अनेक लक्षणे दिसून येतात. या स्थितीत यकृता (लिव्हर)मध्ये मेद (फॅट) संचय सुरू होतो; ज्याला ड्निोबो लायपोजेनेसिस म्हणून संबोधले जाते आणि पुढे हे मेद स्वादुपिंड आणि ओटीपोटात जमू लागते त्यामुळे पोटाचा घेर वाढू लागतो. या मध्यप्रदेशीय स्थूलतेमुळे शरीर सफरचंदी आकाराचे होते. या स्थितीत रक्त दाब वाढतो आणि रक्तात घातक ट्रायग्लिसेराइड मेदाचे प्रमाण वाढते तर एचडीएल या आरोग्यदायी किंवा चांगल्या कोलेस्टेरॉलचे प्रमाण घटते.

उंची अनुरूप शारीरिक वजन आणि बॉडी मास इंडेक्स (बीएमआय) निर्देशांकाबाबत लोकांमध्ये अलिकडे बऱ्यापैकी जागृती आहे. त्यामुळे वजन कमी करायचे क्रॅश-कोर्स आणि क्रॅश-डाएटची चलती आहे. पण दुर्दैवाने आरोग्य स्थितीच्या सटीक आकलनाच्या दृष्टीने बीएमआयपेक्षा सरस आणि मध्यवर्ती स्थूलता दर्शवणाऱ्या कंबरेचे उंचीशी असलेले गुणोत्तरीय प्रमाण (वेस्ट टू हाइट रेश्यो) या कित्येक पट अधिक महत्त्वाच्या गुणोत्तर किंवा निर्देशांकाबद्दल अनभिज्ञता आहे. उत्तम आरोग्याच्या दृष्टीने सर्वसाधारणपणे उंचीच्या तुलनेत पोटाचा घेर अर्धा असावा असा नियम आहे. उदाहरणादाखल जर उंची १८० सेमी (७२ इंच) असल्यास पोटाचा घेर ९० सेमी (३६ इंच) असायला हवा. थोडक्यात वेस्ट टू हाइट रेश्यो ०.५ किंवा त्यापेक्षा कमी असावा. जस जसा हा रेश्यो वाढत जाईल तस तसा मधुमेह व्हायची आणि त्याच्या पुढे जाऊन हृदय आणि रक्त वाहिन्यांचे (कार्डिओव्हॅस्कुलर) रोग आणि त्यांनी अकाली मृत्यू होण्याची शक्यता दुणावते. बीएमआयद्वारे ओटीपोटात संचित फॅटची माहिती मिळत नाही त्यामुळे एक सारखी उंची आणि वजन असलेल्या दोन व्यक्तींचा बीएमआय एक सारखाच असू शकतो पण, त्या दोघांचे वेस्ट टू हाइट रेश्यो भिन्न असू शकतात. तेव्हा मधुमेह तसेच हृदय रोगापासून मुक्तीसाठी आणि निरामय आरोग्यप्राप्तीसाठी तहहयात वेस्ट टू हाइट रेश्यो ०.५हून कमी राखणे अत्यंत गरजेचे आहे. कंबरेचे उंचीशी असलेले आदर्शवत गुणोत्तरीय प्रमाण हे इन्सुलिन संवेदनशीलतेचे तसेच निरोगी आणि निकोप यकृताचे निदर्शक आहे असे म्हटले तर वावगे ठरू नये.

वेस्ट टू हाइट रेश्यो वाढतो कारण स्टार्चयुक्त (एकदलीय तृणधान्य, जमिनीखालील ट्युबर जसे बटाटे) पिष्टमय पदार्थांचे दीर्घकाळ अति सेवन केल्यामुळे, तसेच साखर, मध, फळांचे रस, हाय फ्रूक्टोज कॉर्न सिरप मिश्रित परिष्कृत पदार्थ यातून अति ग्लुकोज अधिक फ्रूक्टोज या शर्करांमुळे यकृतात मेद संचयीत होतो याला शास्त्रीय परिभाषेत नॉन-अल्कोहॉलिक फॅटी लिव्हर (वसामय यकृत) म्हणून संबोधले जाते. थोडक्यात शरीरांतर्गत वसामय यकृताचे शरीरबाह्य दृश्य-परिणाम म्हणजे ओटीपोटाचा घेर वाढणे किंवा पोट सुटणे असं म्हणता येईल. पोट सुटलेल्या ८० ते ९०

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टक्के लोकांना पुढे जाऊन टाईप २ मधुमेह होतो. उपाशी पोटी केलेल्या रक्त तपासणीत जर ग्लुकोज शर्करा १२६ मिलीग्रॅम प्रति शंभर मिली लिटर असेल किंवा ऑक्सिजनचं वहन करणाऱ्या हिमोग्लोबिनशी संयोग पावलेल्या ग्लुकोजचे म्हणजेच ग्लायकेटेड हिमोग्लोबीनचे प्रमाण ६.५ टक्क्यांपेक्षा अधिक असल्यास शरीरात मधुमेहाने बस्तान बांधलंय असे समजायला हरकत नाही. ग्लायकेटेड हिमोग्लोबीन (Hb-1C) चाचणी ही मागील तीन महिन्यातील रक्तातील सरासरी ग्लुकोजची पातळी दर्शवते त्यामुळे उपाशी पोटी केलेल्या रक्त तपासणीच्या आदल्या रात्री काय आहार होता? वा बाबीचा सदरहू चाचणीवर काहीही परिणाम होत नाही. ग्लायकेटेड हिमोग्लोबीन चाचणी ही मधुमेह देखरेखीच्या संदर्भात अधिक विश्वासार्ह आणि बोधक चाचणी आहे. एक सूत्र वापरून प्रतिशत ग्लायकेटेड हिमोग्लोबीनचं रूपांतरण मिलीग्रॅम ग्लूकोज प्रति शंभर मिली लिटरमध्ये करता येतं. निरामय आरोग्य स्थितीत ग्लायकेटेड हिमोग्लोबीनचं प्रमाण ५.७%हून कमी असते किंवा ते तेवढं असायला हवे. मधुमेहाच्या पूर्वावस्थेत हे प्रमाण ५.७% ते ६.४% दरम्यान वाढते आणि मधुमेहात ते ६.५% ची कक्षा ओलांडून पुढे कितीही वाढू शकते. या खेरीज उपाशी पोटी दिलेल्या रक्त नमुन्यात फास्टिंग इन्सुलिन आणि फास्टिंग ग्लुकोजची चाचणी करून त्यांच्या परस्पर गुणोत्तरीय प्रमाणाद्वारे इन्सुलिन प्रतिरोधाची पातळी तपासता येते. या गुणोत्तर प्रमाणास 'होमा-आयआर' म्हणून संबोधलं जातं.

१९७०पासून सातत्याने स्थूलता आणि मधुमेह एकमेकांच्या हातात हात घालून गुणोत्तरीय पद्धतीने जगभर वाढताना दिसत आहेत. कधी काळी सुखवस्तू आणि श्रीमंतांचे आजार म्हणून ओळखला गेलेले हे आजार आता सर्वच सामाजिक-आर्थिक स्तरात; तसेच शहरी आणि ग्रामीण भागात कुठलाही भेदभाव न ठेवता सुद्धा पसरलेले दिसत आहेत. तसेच कधी काळी प्रौढावस्थेत दिसणारे हे आजार आता कुमार वयातील मुला-मुलींमध्ये झपाट्याने वाढताना दिसत आहेत. मातांच्या अज्ञानामुळे लहान नवजात शिशू बाळसेदार आणि गुटगुटीत दिसावं या मानसिकतेतून त्यांना फॉर्मुला, सिरेलॅक, कॉमप्लॅन सारखे डबाबंद आणि पूर्वपचन केलेले परिष्कृत अन्न; टेट्रापॅकमधील फ्रुटी, पी किंवा तत्सम हाय फ्रुक्टोज कॉर्न सिरप मिश्रित फळांचे रस सारखे उष्मांक घन अन्न खाबची सवय लागली जाते. अशी मुले रडायला लागली की त्यांना कोल्ड्रिंक्स, सॉफ्ट-ड्रिंक्स, आईस्क्रीम, मिठाई, चॉकलेट, बिस्किटे, वेफर्स, नूडल्स अशा प्लास्टिक आवरणातील रेडीमेड खाद्यवस्तू किंवा फास्टफूड भरवून गप्प केले जाते. घरात शिजलेल्या नैसर्गिक पौष्टिक आहारा ऐवजी आजकालची पिढी परिष्कृत किंवा रिफाइंड खाद्य पदार्थांच्या आणि फास्ट फूडच्या आहारी गेली आहे. अशा प्रकारे पोषण मूल्ये नसलेल्या प्रोसेस्ड आणि जंक फूडमधून शर्करेचे व्यसन जडलेल्या लहान मुलांमध्ये लठ्ठपणा, मधुमेह आणि नॉन-अल्कोहॉलिक फॅटी लिव्हर आणि विशेषतः वयात आलेल्या मुलींमध्ये 'पॉलीसिस्टीक ओवॅरियन सिन्ड्रोम' या व्याधींचा प्रादुर्भाव वाढू लागला आहे.

उच्च ग्लायसेमिक इंडेक्स आणि ग्लायसेमिक लोड असलेली रिफाइंड कर्बोदके, साखर, हाय फ्रुक्टोज कॉर्न सिरपच्या जोडीला शरीरात मुक्त मूलकांची निर्मितीद्वारे ऑक्सीडेटिव्ह ताण निर्माण करणारी ओमेगा ६ फॅटी ॲसीड युक्त रिफाइंड वनस्पती तेल यांच्या घातक कॉकटेलचा वर्षानुवर्षे सातत्याने होणाऱ्या भडीमारामुळे प्रथम वसामय यकृत आणि इन्सुलिन प्रतिरोध, त्यानंतर मध्यवर्ती स्थूलता अधिक टाईप २ मधुमेह आणि सरते शेवटी हृदयरोग या क्रमाने एक ना अनेक सह-रुग्णता (कोमॉर्बीडीटीज) शरिरांतर्गत दीर्घकालीन आणि क्रायमस्वरूपी बस्तान बांधतात आणि चाचण्या, डॉक्टरी कन्सल्टेशन आणि औषधोपचार निर्मित नियमित खर्चाच्या प्रचंड आर्थिक

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अरिष्टात किंवा खायीत लोटतात.

अमेरिकेत साधारणतः पन्नासच्या दशकात हृदय रोगाने मृत्युमुखी पडण्याचे प्रमाण वाढत असताना झालेल्या पूर्वग्रहदूषित संशोधनाअंती कोलेस्टेरॉल आणि ज्या अन्न घटकात किंवा आहारात कोलेस्टेरॉल असतं त्या मांसाहारी- अंडी, मांस, दुग्धजन्य पदार्थांवर ठपका ठेवण्यात आला. अमेरिकेत बलवान शुगर लॉबीने काही संशोधक आणि राजकारणातील व्यक्तींना हाताशी धरून हे संशोधन पुरस्कृत केलं होतं. थोडक्यात पैसा आणि राजकिय वरदहस्त या दोहोंच्या बळावर या लॉबीने संशोधनाचे निकष आपल्या उद्योगानुरूप यावेत म्हणून हस्तक्षेप केला होता. अर्थात त्या काळीदेखील साखर ही आरोग्याच्या दृष्टीने घातक आहे अशा स्वरूपाचे संशोधन आणि कंठघोष करणारे मोजके संशोधक होते ज्यांना कुणी वाली नव्हता. प्राणिजन्य मेद विरुद्ध वनस्पतीजन्य साखर अशा एकतर्फी लढतीत, साखरेला क्लिन चिट आणि मोकळं रान मिळालं. कोलेस्टेरॉलला पद्धतशीरपणे खलनायक म्हणून पेश केल्याने औषध बनवणाऱ्या बहुराष्ट्रीय कंपन्यांनी त्याचे भांडवल केले आणि कोलेस्टेरॉल कमी करणारी औषधे जगभर रुग्णांच्या माथी मारली आणि मागील सहा ते सात दशकांत अब्जावधी डॉलर्स कमवले. तेव्हापासून साखर निर्धोक समजून परिष्कृत किंवा प्रक्रिया केलेल्या अन्नात साखर (सुक्रोज), हाय फ्रुक्टोज कॉर्न सिरप आणि स्टार्च असलेली कर्बोदके (उदा. मैदा) यांचा अनियंत्रित आणि मनमानी वापर होऊ लागला आणि औद्योगिक स्तरावर टेट्रापॅक किंवा प्लॅस्टिकच्या आवरणात बंद असे अगणित प्रक्रिया केलेले जंक फूड जगभरात नव्याने उदयाला आलेल्या खाद्य संस्कृतीचा भाग होऊ लागले.

हृदयरोगापासून बचाव व्हावा म्हणून त्या काळी जगभर एक 'हृदय-हितैषी फूड पिरॅमिड' स्वीकारला गेला होता; ज्याचे स्वरूप अधिक प्रमाणात कर्बोदके, मध्यम प्रमाणात प्रथिने आणि अल्प प्रमाणात वसा (मेद) असे होते. कोलेस्ट्रॉल वाढेल म्हणून तूप, लोणी, दुधावरची साय, अंडी, चरबीयुक्त मांस इत्यादी खाववास त्यामुळेच लोक आजही धजत नाहीत. पण, स्टार्चयुक्त कर्बोदके प्रचंड प्रमाणात ग्रहण करतात. मेद खाल्ल्याने मेद वाढत नाही तसेच शरीराला कोलेस्टेरॉलची गरज असते आणि त्या गरजे अनुरूप बकृत अहोरात्र कोलेस्टेरॉल बनवत असते; कारण मेंदूला खूप प्रमाणात कोलेस्टेरॉलची गरज असते. त्यामुळे मांसाहार केल्याने कोलेस्टेरॉल वाढत नाही आणि त्या उपरांत उशिरा का होईना पण कोलेस्टेरॉल हे आता हृदय रोगाची जोखीम वाढवणाऱ्या कारकांच्या यादीतून वगळले गेले आहे. खरं तर स्टार्चयुक्त कर्बोदके आणि साखर (सुक्रोज- जे ग्लुकोज आणि फ्रुक्टोजपासून बनलेलं) अति प्रमाणात ग्रहण केल्याने रक्तातील मेद वाढतं, पण याबाबत लोक अनभिज्ञ आहेत.

मागील पन्नास वर्षात सर्व फोकस कोलेस्टेरॉलवर केंद्रित झाल्याने आणि साखरेला आणि स्टार्चयुक्त पिष्टमय पदार्थांना क्लिन चिट आणि मोकळं रान मिळाल्याने स्थूलता+टाईप २ मधुमेह या सह-रुग्णतेने दीर्घकालीक महामारीचे स्वरूप धारण केले आहे. हृदय हितैषी फूड पिरॅमिड उलटा केल्यास म्हणजेच अधिक प्रमाणात नैसर्गिक मेद (फॅट), मध्यम प्रमाणात प्रथिने आणि अल्प प्रमाणात स्टार्चयुक्त कर्बोदके (उदा. एकदलीय तृणधान्य) + साखर ग्रहण केल्यास मधुमेहाचं व्युत्क्रमण (रिव्हर्सल) घडतं, पोटाचा घेर कमी होतो आणि वसामय यकृत पूर्वपदावर येऊ लागतं. असंसर्गजन्य रोगाच्या कचाट्यातून सुटका होण्यासाठी स्टार्च युक्त आणि साखर युक्त गोड पदार्थ न खाणे किंवा त्या ऐवजी तंतुमय (फायब्रस) कर्बोदके म्हणजेच जमिनीवर उगवणाऱ्या इतर भाज्या, पालेभाज्या खाणे, नैसर्गिक मेद आणि पोषक मूल्यांनी समृद्ध मांसाहार हा निरामय आरोग्यप्राप्तीचा राजमार्ग आहे असे अलीकडील अनेक संशोधन पाहणीतून सिद्ध झाले. या खेरीज मधुमेह प्रतिबंधन आणि रिव्हर्सलचे काही अनुभवातून आणि

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प्रयोगांती सिद्ध झालेले खात्रीलायक राजमार्ग असे आहेत :

१. दिवसातून भुकेच्या दोन वेळा ओळखून फक्त त्याच वेळी उदरभरण करणे. जेवताना सुरुवातीस मूठभर सुका मेवा (ड्राय फ्रुट्स), त्यानंतर एक वाटी कच्ची कोशिंबीर किंवा सॅलड, नंतर एक वाटी मोड आलेल्या कडधान्याची उसळ आणि सरते शेवटी मेन कोर्स ज्यात एकदलीय तृणधान्यापासून बनलेले भात / चपाती / भाकरीसारखी स्टार्चयुक्त कर्बोदके अगदी अत्यल्प प्रमाणात पण तंतुमय भाज्या किंवा मांसाहारी पदार्थ यथेच्छ या क्रमात जेवल्यास पोट सुद्धा भरते आणि रक्तात ग्लुकोज संथ गतीने आणि अल्प प्रमाणात वाढते. महत्त्वाचे म्हणजे जेवणाच्या दोन वेळीच इन्सुलिन स्रवण घडते. इन्सुलिन स्रवण कमीत कमी दोन वेळा घडवून त्या द्वारे इन्सुलिन प्रतिरोधाचे इन्सुलिन संवेदनशीलतेत परावर्तन घडवणे हा या आहार प्रणालीचा मुख्य गाभा आहे. डॉ. जगन्नाथ दिक्षित आहार पद्धती या नावाने ओळखली जाणारी ही सोपी, शाश्वत आणि परिणाम-अभिमुख आहार प्रणाली आहे ज्याचे जगभर असंख्य लाभार्थी आहेत.

२. औद्योगिक स्तरावर बनवलेलं रिफाइंड तेल ज्यामध्ये ओमेगा ६ हे फॅटी ॲसिड प्रचुर प्रमाणात आहे (उदा. सुर्यफुलाचे तेल) अशी तेले वर्ज्य करणे आणि त्या ऐवजी घाण्याचे किंवा कोल्ड प्रेस्ड तसेच बियांच्या तेलाऐवजी फळांचे तेल जसे खोबरेल तेल, ऑलिव्ह तेल वापरणे, त्याच सोबत प्राणिजन्य संतृप्त मेद जसे तूप, लोणी, चरबी, फॅटी फिश (मासे) इत्यादीचा आहारात समावेश करणे. ओमेगा ६ फॅटी ॲसिड हे शरीरात ऑक्सिडेशनद्वारे मुक्त मूलकांची (फ्री रॅडिकल्स) निर्मिती घडवून दाह (इंफ्लेमेशन) घडवून आणतात जे स्वतंत्रपणे दीर्घकालिक, ऱ्हासकारी (डिजनेरेटिव्ह) आजार निर्माण करतात.

३. सविराम लंघन (इंटरमिटंट फास्टिंग)- शरिर प्रकृतीनुसार जेव्हा जमेल तेव्हा उपवास (लंघन) किंवा बेगवेगळ्या प्रकारचे १६ ते १८ तासांचे इंटरमिटंट फास्ट (सविराम लंघन) करणे हे इन्सुलिन संवेदनशीलतेच्या दृष्टीने अत्यंत पूरक आणि प्रेरक आहे. उपवासाच्या काळात यकृत आणि ओटीपोटातील संग्रहित मेद वापरला जातो. उपवास काळात सर्वांत महत्त्वाचे म्हणजे शरीरात स्वभक्षण (ऑटोफॅजी) ही स्वास्थ्य-दायी प्रक्रिया कार्यान्वित होते ज्या द्वारे 'रिपेअर आणि मेन्टेनन्स' घडतं आणि मृतपेशी, पेशी अंगकांचे रिसायक्लिंग घडतं. उपवास आणि आहारातील रोजच्या आवश्यक उष्मांकाला (कॅलरीज) अर्ध्यावर आणलं तर कॅलरीज रिस्ट्रिक्शनमुळे आयुर्मान वाढतं हे प्रयोगशाळेतील प्रत्येक प्राणी प्रारूपामध्ये (मॉडेल) सिद्ध झालं आहे.

जगभरातील ११ प्रौढांपैकी एक मधुमेहग्रस्त आहे. भारतात १०.१ कोटी लोक मधुमेहग्रस्त आहेत आणि १३.६ कोटी लोक मधुमेहपूर्व अवस्थेत म्हणजेच मधुमेहा-कडेच्या मार्गावर आहेत. मधुमेहाच्या कॉम्प्लीकेशन्समध्ये हृदयविकाराचा झटका, पक्षाघात, अंधत्व येणे, मूत्रपिंड निकामी होणे आणि हात किंवा पाय कापावे लागणे ही त्याची भयावता दर्शवतात. या पार्श्वभूमीवर काटेकोरपणे भुकेच्या दोन वेळा ओळखून फक्त दोनदाच अन्न ग्रहण करणे; स्टार्चयुक्त कर्बोदकांऐवजी तंतूमय किंवा फायब्रस कर्बोदके ग्रहण करणे आणि सविराम लंघन अशा अनेक पर्यायांतून यथायोग्य पर्याय निवडून तो जीवन शैलीचा भाग बनवणे क्रमप्राप्त आहे. या पार्श्वभूमीवर औषधोपचारांद्वारे मधुमेहाचे प्रबंधन करण्याऐवजी जीवनशैली किंवा आहार-विहारातून मधुमेहाचे नैसर्गिकरित्या प्रतिबंधन आणि रिव्हर्सल करणे याबाबत जनजागृती घडणे अत्यंत आवश्यक आहे.

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कार्यालयीन वेळ

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संशोधक

"A study of the role of microfinance in socio-economic transformation with respect to Self Help Groups (SHG) in Mumbai."

Dr. Vithal Shankar Sontakke,
Associate Professor,
Department of Economics,
DES Kirti M. Doongursee College, Dadar (w), Mumbai 400028.

Abstract :

In India, microfinance has played a significant role in the nation's development. It has been a vital instrument for reducing poverty and promoting financial inclusion. It has also been crucial in generating employment and giving the less fortunate members of society access to financial services. A significant number of independent contractors and small enterprises have been established in India thanks in part to microfinance. Better livelihoods, more jobs, and easier access to financial services are the outcomes of this. Additionally, gender inequality has decreased and women's economic empowerment has increased because to microfinance.

Microfinance has increased the economic independence of female entrepreneurs by enabling them to launch their firms with small loans. Furthermore, microfinance has shown to be a useful tool for India's rural development. It has made it easier for agricultural labourers and small farmers to get loans and other financial services, allowing them to invest in better farming methods and raise their incomes. All things considered, microfinance has been a crucial instrument for India's economic growth and has helped to lower poverty and increase financial inclusion.

Key words : Microfinance, Self-help groups, Women empowerment, Gender justice, Socio-economic development.

Introduction

This study examines how SHGs have fulfilled members' credit demands while fostering an atmosphere that is favourable to the expansion and development of microbusinesses. It is necessary to reinforce its convergence with government initiatives and schemes. In order to sustain and run their own business, its members must be generally empowered in terms of better socioeconomic standing, income, mobility, and confidence-building initiatives. Women's lives have improved as a result of these grassroots initiatives because they have increased their ability to work together and make decisions both within and outside of the home. Through SHGs, indications of women's empowerment have been identified in this study.

During the Age of Enlightenment and when capitalism became the dominant economic system, women were marginalised in public discourse (Landes 1996; Smith 2005). Women were not included in everyday discourses because of the masculine character of the public domain (Habermas 1992). However, it presented a picture of a woman who, given the opportunity, is capable of accepting responsibility and may grow into a logical actor (Donovan 1992; 31).

After facing limitations prior to the mid-1900s, women began to accelerate towards new kinds of organisation in the middle of the century. Democratic traits extended from European nations to the rest of the globe, with a concentration in South Asian

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nations. Women and other marginalised groups in society have access to opportunities for social mobility and participation in the educational and social spheres.

The gender and development paradigm acknowledges women's threefold role in community management, reproduction, and production. The women in development paradigm assumes that women have been excluded from the development process and must be included to provide benefits. However, because of social prejudices, women have fewer rights in families and society as a whole, which has an impact on how effective development initiatives are (Papanek 1990; Sen 1990).

Three closely related dimensions can also be used to study the idea of empowerment: accomplishments (outcomes), resources (preconditions), and agency (process), which is key to the idea. The methods by which decisions are made and carried out are represented by agency. Achievements are the results of agency, while resources are the means by which agency is exercised (Kabeer 1999; 2005). Three perspectives of SHGs/microfinance and gender have been highlighted by Mayoux (2000): financial self-sufficiency, poverty reduction, and feminist empowerment.

Microfinance may be a more effective means of promoting social Rather than focusing only on economic empowerment, microfinance could be a more effective tool for bringing about knowledge and social empowerment through courage, skill development, leadership, confidence, and a general reduction in the feminization of poverty (Sultana; Jamal and Najaf 2017). According to Reddy (2003), the primary goals of development programmes, particularly microfinance, may be divided into three categories: (i) start programmes that generate revenue; (ii) educate women about their rights, entitlements, and legal framework; and (iii) implement measures that increase capacity. The gender and development approach emphasises that before taking any suitable action to empower women, gender analysis and the identification of strategic gender requirements are necessary.

Review of Literature :

The effect of microfinance on measures of women's empowerment is examined by Priya et al. (2019). This empirical study is being conducted in the state of Uttarakhand. The study's conclusion shows that microcredit and women's empowerment are unrelated.

In 2018, Rana and Kiran conducted a study on the role of self-help groups in women's empowerment. They came to the conclusion that microfinance programmes improved women's participation in family financial activities and increased an individual's ability to positively contribute to the advancement of their family.

In 2017, Srivastava Vijay conducted study on the key factors that influence women's empowerment in Uttarakhand. In his investigation, he used exploratory factor analysis to identify the 22 characteristics that are crucial for women's empowerment. Self-reliance, consciousness, confidence, awareness, sociopersonal aspects, knowledge, empowerment, and finances were among the notable elements taken into account.

In their evaluation of the literature, Dhanalakshami and Rajini (2013) looked at the literature on SHGs. It examined SHG history in India. The study discovered that rather than viewing women's empowerment as a process, the majority of earlier research examined it as an outcome.

According to Getamma and Bulla's (2013) research, microfinance through self-help groups has gained international recognition as a powerful tool for addressing issues of poverty and rural development. It is also expected to play a significant role in raising awareness and ultimately contribute to the growth of the country.

With a focus on social and economic empowerment, Puhazhendhi and Satyasai (2001) assessed the effectiveness of 223 SHGs operating in 11 states that represent four distinct regions of the nation. The SHG project is more well-liked in the southern region, and its advancement in other

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regions is very minimal, indicating unequal success throughout the regions. Compared to younger groups, older groups had comparatively more favourable traits, such as superior performance. Manimekalai and Rajeshwari (2001) discovered that Self-Help Groups (SHGs) had acquired leadership and organisational skills, as well as the ability to handle a range of business tasks, including obtaining funding, locating raw materials, navigating markets, and appropriately diversifying and modernising their operations.

When Puhazhendhi (1999) examined how SHGs operated, he found that they were effectively promoting social change and societal development. In a similar vein, K.C. Sharma (2001) noted that women are becoming empowered through SHGs. Their growing involvement in economic activities and decision-making at the household and societal levels contributes to the democratic, sustainable, and subsidy-free nature of the participatory rural development process. Through the spread of formal microfinance activities, modest transactional practices, and innovation, the resource poor become accountable and build durable working relationships (Adams and Pischke 1991). In general, microfinance initiatives have improved group members' coordination, although they are less sustainable in Uttar Pradesh.

The analysis of research on women's credit accessibility only shows that rural women have extremely restricted direct access to institutional credit and that this access is hampered by gender stereotypes. Nonetheless, compared to women employed in the agricultural industry, non-farming women have easier access to banks. Even male co-borrowers with female borrowers have a bigger say in who can use credit and how much they have to pay back.

Objectives of the Study :

This study's primary goal is to evaluate the contribution that SHGs make to members' improved socioeconomic standing, particularly that of women in the home and in society at large.

1. To determine the extent to which the impoverished can raise their earnings and standard of living by gaining access to suitable financial services.
2. To lower urban poverty and broaden access to financial services.
3. To make it possible for the underprivileged to engage with the formal financial system and gain from the country's economic expansion.
4. To assess how collaborative action has improved public knowledge of health, education, and development initiatives.
5. To raise the impoverished's level of financial literacy and comprehension of financial services
6. To assess their influence on the impoverished's socioeconomic advancement.
7. To evaluate how group efforts affect urban women's empowerment and how that empowerment is reflected in family decision-making.

Methodology & Plan of Work :

The city of Mumbai is the site of the field survey. Four talukas (Worli, Dharavi, Shiwree, and Wadala) were chosen out of the entire city of Mumbai. A survey was administered to sixteen SHGs for women, chosen at random from each of the four talukas. There are 120 women in the sample, all of them are residents of Mumbai. In order to conduct in-person interviews with the members arranged for social capital and microfinance initiatives, 120 women were selected. For the field survey, a random selection of SHG members was made. To gather primary data, questionnaires and interview schedules were employed. Recommendations for policy were also derived from secondary sources.

This study project is essentially analytical and descriptive in nature. The study's objectives guided the analysis of both primary and secondary data. With the aid of a standardised questionnaire, primary data was collected, and SPSS software was used for analysis.

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Interpretation :

The preceding data leads us to the conclusion that the majority of respondents established SHGs in order to encourage saving and get financial support.

Table-5 : ECONOMIC EMPOWERMENT

S. No.	Statements	No. of respondents who have strongly agree	No. of respondents who have agree	No. of respondents who have neutral	No. of respondents who have disagree	No. of respondents who have strongly disagree
1	Increases creation of personal assets	9	38	52	1	0
2	Increased in ability to support the family	6	92	2	0	0
3	Increased in access to microfinance	3	38	59	0	0
4	Increase in income	100	0	0	0	0
5	Increase ability to make decisions regarding the utilization of money / credit	84	16	0	0	0
6	Increased support during economic crisis	6	82	10	2	0
7	Increase capability of managing bank related activities	65	35	0	0	0

Source: Field Survey

Interpretation:

The table above displays the economic empowerment in the research of SHG women that were interviewed. 92% of respondents agree to assist their families after joining SHG, while 52% of respondents have a neutral opinion about the increase of personal wealth. The opinions of 59% of respondents about microfinance accessibility are unbiased. 84% of respondents strongly agreed that they could more readily select how to support their family and spend money after joining a SHG.82% of participants concur that during the financial crisis, they received more support. Sixty-five percent of members firmly agree that joining SHGs helped their bank-related activities.

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Table-6 : SOCIAL EMPOWERMENT

S.No.	Statements	Measurement Scaling				
		No. of respondents who have S.A.	No. of respondents who have A	No. of respondents who have N	No. of respondents who have D.A	No. of respondents who have S.D.A
1	Increase in Self Confidence	100	0	0	0	0
2	Increase in decision making for family	03	96	1	0	0
3	Increase in Communication skills	100	0	0	0	0
4	Increased support during social crisis in family	7	86	7	0	0
5	Increased recognition in community	4	66	28	2	0
6	Participation in community activities	3	69	28	0	0
7	Value given by family members in crucial decision	5	85	10	0	0

Source: field survey

Note: S.A. - Strongly Agree, A- Agree, D.A. - Disagree, S.D.A. - Strongly Disagree, N-Neutral

Interpretation:-

The respondent's social effect status is displayed using the table above. The data indicates that women's self-confidence and communication skills have increased to 100%. They have also shown an increase in family-related decision-making power, 86% support during social crises in the family, 85% value placed on important decisions made by family members, 69% participation in community activities, and 66% recognition in the community.

Table-7: Benefits derived from the income generating activity:

1. Monetary benefits:

Monetary benefits	No. of Respondents	Percentage
Rs. 500 to Rs. 1500	53	44.17%
Rs. 1501 to Rs. 3500	9	7.5%
Rs. 3501 & above	58	48.33%
Total	120	100%

Source: field survey

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Interpretation:-

According to the results of this study, 48% of participants had boosted their financial benefits to Rs. 3500 or more, and 44% had done so between Rs. 500 and Rs. 1500.

2. **Non-monetary benefits :**

Non-monetary benefits	No. of Respondents	Percentage
Communication ability increase	120	100%
Confidence level increase	120	100%
Respect in the society	116	96.67%
Respect in the family member's	120	100%
Increase in Household consumption pattern	108	90%

Source: field survey

Interpretation:-

The above table is a list of the non-financial rewards. It stated that 100% of respondents had improved their confidence and communication skills, had received respect from family and society, 97% had increased home product use, and 90% had boosted communication skills.

Table-8: Change on Socio – Economic Status after Joining SHGs

Socio-economic Status	Number of Respondents	Percentage
Same	19	15.83%
Increased	101	84.17%
Decreased	Nil	Nil

Source: field survey

Interpretation:-

The above table shows that 84% of respondents' socioeconomic status increased after joining SHGs, whereas 16% of respondents' socioeconomic situation remained unchanged.

Implication for Research :

Given that women make significant contributions to society, this study is helpful for women's social and economic empowerment. Women's self-help organisations in Mumbai's urban regions have a lot of potential since they fulfil two functions: they offer year-round work and they promote increased involvement in decision-making. The study draws on a Self Help Group in Mumbai that uses a range of strategies to encourage social and economic empowerment. The study looks at the different approaches these self-help groups take when it comes to women's welfare. This is significant because women may only become free via concerted, determined efforts.

Constraints in Women Empowerment :

The barriers to women's empowerment are ingrained in society, the way that unequal gender dynamics are reproduced in households, communities, marketplaces, and governments (Kumar 2018). In addition, women experience

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limited opportunities for decision-making in other aspects of life, as well as restricted access to and control over resources.

The following specific causes are to blame for the sluggish progress of women's empowerment :

1. Top-down planning, which did not rationally reinforce democratic institutions (local self-governments), is the reason why policy interventions aimed at decentralising power failed.
2. The social framework, which emphasises an abstract morality yet gives room for discrimination through its unequal behaviours, was dominated by acceptance of religious doctrines.
3. A culture of corruption that permeates the minds of those who create policy and those who carry it out, impeding the advancement of women's empowerment and emancipation.
4. Reproductive and biological variables that make women more susceptible to relying on male family members

Conclusion :

The study set out to find out how self-help organisations could enable women in the Mumbai metropolitan area to take charge of their own lives. It was discovered that after joining the self-help groups, people's social circumstances, personal growth, and economic standing had all altered. The respondent's income rose following their enrollment in the self-help groups. Long-term strengthening of women's duties requires addressing new challenges. If the right policies are put in place and non-profit organisations are involved in social mobilisation, microfinance has the potential to spread widely and take on national significance. Self-help organisations play a critical role in preserving and advancing humankind. We can draw the conclusion that the self-help groups' business endeavours are profitable. In this sense, the self-help groups in Mumbai City have been very effective in advancing women's empowerment and urban neighbourhoods.

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इतिहासाचार्य वि. का. राजवाडे मंडळ, धुळे
या संस्थेचे त्रैमासिक

।। संशोधक।।

पुरवणी अंक ५० – मार्च २०२४ (त्रैमासिक)

- शके १९४५
- वर्ष : ९२
- पुरवणी अंक : ५०

संपादक मंडळ

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- प्राचार्य डॉ. अनिल माणिक बैसाणे
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- डॉ. एस.एम.भोईर

*** प्रकाशक ***

श्री. संजय मुंदडा

कार्याध्यक्ष, इ. वि. का. राजवाडे संशोधन मंडळ, धुळे ४२४००१
दूरध्वनी (०२५६२) २३३८४८, ९४२२२८९४७१, ९४०४५७७०२०

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कार्यालयीन वेळ

सकाळी ९.३० ते १.००, सायंकाळी ४.३० ते ८.०० (रविवारी सुट्टी)

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अक्षरजुळणी : सौ. सीमा शिंत्रे, पुणे.

टीप : या नियतकालिकेतील लेखकांच्या विचारांशी मंडळ व शासन सहमत असेलच असे नाही.

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"Organic Farming: Need of an Hour"

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Abstract:

Organic matter is a very important component of soil. Fertility of the soil depends on this curb. At present, the amount of organic matter in the soil in the Maharashtra state is 0.3 to 0.5 percent. Due to changes in the physical, chemical and biological quality of the land, the productivity of the land is decreasing. To increase the fertility and productivity of the soil, the amount of organic matter should be increased to 2.5 percent. For that organic or natural fertilizers should be mixed in more quantity in the soil.

Key Words: Organic farming, natural fertilizers, worm culture, composting, Organic products, Soil health, Biomass, Biodiversity

Introduction:

The spirit of organic curb soil :

Soil, water, forest. These are important elements of the earth. Humans are harming the earth by using it. When it comes to soil or land, it is predicted that crop production will decrease by ten percent by 2050 due to soil fumes. Therefore, soil protection is becoming an important agenda. On the other hand, the problem of soil organic matter is rearing its head. To meet the growing population of the country and their food needs, the use of chemical fertilizers in agriculture increased. As a result, the amount of organic matter in the soil decreased. When Maharashtra is considered, only organic carbon content is 0.3-0.5 percent. Crops are also yielding only 30 to 50 percent of their potential. The proportion of organic matter in the soil to prevent this change Proportion should be maintained properly.

Organic matter is a very important component of the soil and the fertility of the soil depends on it. In particular, the number of microorganisms in the soil, their activity, the water holding capacity of the soil are related to organic matter. E.g. One percent of organic matter in the soil means approximately two kg of cow dung in 100 kg of soil. Organic carb is a source of all nutrients. The amount of organic matter depends on the organic matter in the soil. Organic curb works to balance soil properties. Agriculture in traditional way is related to nature. Like nature, agriculture also has a cycle. Integrated use of compost from fallen tree mulch, sawdust and waste organic matter. It is called 'organic cycle'.

The foundations of organic agriculture are the Principles of Health, Ecology, Fairness, and Care. They articulate the potential global impact of organic agriculture as well as their goal of enhancing all forms of agriculture.

Review of Literature :

Mendon et al. (2020) claim that growing organic products is a special method that manages the negative effects on consumer safety while also balancing environmental sustainability and instilling a favorable perception in the minds of consumers. According to Varkey (2020), countries, both developed and developing, are placing greater focus on agricultural production, technologies, and

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practices that are environmentally sustainable. There are several reasons why the conventional knowledge of farmers on native agricultural methods is being questioned more and more.

Magnaye's (2018) research explores the connection between small-scale organic farming and entrepreneurship, considering both the financial benefits of entrepreneurship and the environmental preservation methods of organic farming. Additionally, it aims to ascertain the skills required of an organic farmer when starting an organic farm firm, as well as how smallholder organic farming might be planned through qualitative research utilizing case studies.

However, Giovannucci (2007) states that, in general, there is strong evidence to support the idea that organic farming practices may benefit small farmers. Actually, the majority of the cases made evident a lot of direct benefits and associated externalities, therefore it makes sense to draw the conclusion that encouraging small and resource-poor farmers to use organic agricultural methods might be highly justified.

According to Yadav et al. (2013), producing enough food for India's expanding population has been the country's biggest post-independence concern. As a result, high-yielding cultivars are employed along with fertilizers and irrigation water.

Objectives:

- To study the importance of organic farming in this era.
- To study the benefits and challenges of organic farming.

Main causes of organic curb loss :

Soil consists of 45 percent chemical substances, 25 percent organic matter, 25 percent water and 25 percent air. Alkaline content in soil, lack of organic matter, adoption of mono cropping system, excessive use of chemical fertilizers, soil erosion etc. are causing deterioration of soil health. Apart from this, due to hot weather and biological activity, decomposition and burning of organic matter in the soil continues. Also, the additional use of chemical fertilizers, pesticides, water for agriculture is gradually reducing the amount of organic carbon in the soil and this amount is 0.1 to 1 percent. Soil fertility depends on the availability of 16 nutrients such as hydrogen, oxygen, carbon, nitrogen, phosphorus, potassium, calcium, magnesium, Sulphur, iron, copper, zinc, boron, chlorine etc. These nutrients help maintain farm health.

How to increase the amount of organic matter in the soil?

It is necessary to increase the amount of decaying matter lying on the ground. Mulch only takes a month to decompose on the ground, the same waste decomposes in a day in cow dung. From dung

Curb supply is high. For this, the use of organic fertilizers, cow dung, chicken manure, compost manure, crop residue mulch, leaves, branches, green manure should be increased. Rain and humidity in the Konkan can quickly turn something into a curb. When we think of Marathwada, because of the low moisture in the soil there, something can take longer to rot. Therefore, it is necessary to plan according to the weather to increase the amount of curb in the soil. Take green crops and bury them in the ground as soon as they flower. Legumes eg. When takla, tarwad, barbada flowers are started, if they are buried in the field, the amount of organic matter in the soil can be increased.

Why mix organic matter in the soil?

Organic compost is a basic ingredient for soil fertility. The amount of organic matter in the soil depends on the hot climate. If the temperature increases, the rate of decomposition of organic matter increases. Decomposition of plant and animal remains in the soil is slow in regions of low temperature. Organic carbohydrates provide food and energy to microorganisms. Microorganisms cause aggregation of soil particles into small aggregates. Earthworms, microorganisms under the soil increase the rate of water percolation in the soil, as well as the process of mineralization. Due to hot

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air and low rainfall, decomposition of organic matter is accelerated. Therefore, there is no equilibrium in the formation of organic matter. To bring this balance, organic fertilizers or fertilizers should be added to the soil in greater quantity. These fertilizers (manure, liquid manure etc.) should be given regularly to each crop. So the soil does not decrease.

Benefits of organic foods :

By reducing the density of the soil, increasing the voids in the soil particles allows air to circulate. Air, water remains in proper proportion. This increases the water holding capacity of the soil. Organic compost increases the number of microorganisms in the soil. The water carrying capacity of the soil increases. This increases the availability of nutrients. Sufficient moisture is retained in the soil and water pollution is avoided, as well as reducing damage to pests and wildlife that are beneficial to agriculture. Organic matter is essential for the survival of soil bacteria. This helps to bind the soil particles together in light soils. This improves the structure of the soil. Also, organic farming keeps water quality good. Reduces soil erosion. Unnecessary or zinc-free lime is detrimental to crop growth. Lime toxicity can be reduced by increasing the amount of organic manure.

Policy measures are adopted by the government :

Directional steps are being taken by the central and state governments to increase the fertility of the soil in the country and to give direction to organic farming. Efforts have been started to create biological/organic farming clusters in the country. In Maharashtra, Under the scheme ' Dr. Punjabrao Deshmukh Biological Mission', a program has been undertaken to develop biological/organic farming by forming 500 farmer groups in six districts of Vidarbha. The present state government has set a target of developing about 2.5 lakh hectares of land to complement the natural farming policy on the lines of the central government. Let's hope that it will help to increase the organic content of the land in the coming time in the state as a whole.

Conclusion:

Organic farming is a lifestyle. India has a rich tradition of organic farming. Indians have a great knowledge of organic farming. Since Covid-2019 the importance of the organic farming has been rising. The number of farmers opting for organic farming is on the rise. It guarantees the supply of toxin free nourish able food to the modern generations to come.

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शोधआलेख विषय:विश्वशांति एवं विकास में हिंदी भाषा का योगदान

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'भारत' की राजभाषा हिंदी है। विश्व की प्रमुख भाषा के साथ– साथ भारत की राजभाषा है। भारत में हिंदी भाषा का उपयोग प्रचुरता से किया जाता है। संवैधानिक रूप से राजभाषा है। हिन्दी भारत की राष्ट्रभाषा नहीं है क्योंकि भारत के संविधान में किसी भी भाषा को ऐसा दर्जा नहीं दिया गया है। एथनोलॉग के अनुसार, हिन्दी विश्व की तीसरी सबसे अधिकतर बोलनेवाली भाषा है। आर्थिक दृष्टिकोन के अनुसार वह विश्व की दस शक्तिशाली भाषा में से एक है। सरल और प्रभावी रूप से सम्पर्क की भाषा है। किसी भी राष्ट्र की उन्नति के लिए वहां की भाषाओं से ओतप्रोत होना भी जरूरी होता है।राष्ट्रभाषा हिंदी इसी संदर्भ में हमें एक नए पद की ओर अग्रसर कर रही है। चाहे वह आजादी से पहले का समय हो या आजादी की बात का समय। इसीलिए हमें हिंदी भाषा का ज्ञान होना बहुत आवश्यक है। किसी कार्य में सफलता प्राप्त करने के लिए परिश्रम तथा संघर्ष करना पड़ता है। हिंदी भाषा बोलने वालों की संख्या भारत में बड़ी मात्रा में पाई जाती है। हिंदी का उपयोग ज्यादातर बड़ी मात्रा में सभी स्थानों में पाया जाता है हिंदी भाषा हम सभी के लिए नई–नहीं है यदि राष्ट्र को सशक्त बनाना है तो भाषा का होना जरूरी है और अब तक हम अपने देश में हिंदी भाषा का प्रयोग करते आ रहे हैं इससे धार्मिक और सांस्कृतिक एकता बढ़ सकती है।

"संस्कृति की पहचान है हिंदी
देश का सम्मान है हिंदी .....।"

देश की स्वतंत्रता से लेकर हिंदी ने कई महत्वपूर्ण उपलब्धियां प्राप्त की है। भारत सरकार द्वारा विकास योजनाओं तथा नागरिक सेवाएं प्रदान करने में हिंदी के प्रयोग को बढ़ावा दिया जा रहा है । हिंदी तथा प्रांतीय भाषाओं के माध्यम से हम बेहतर जन सुविधाएँ लोगों तक पहुंचा सकते हैं। एक भाषा के रूप में हिंदी न सिर्फ भारत की पहचान है बल्कि यह हमारे जीवन मूल्यों, संस्कृति एवं संस्कारों की सच्ची संवाहक, संप्रेषण और परिचायक भी है। बहुत सरल, सहज और सुगम भाषा होने के साथ हिंदी विश्व की संभवतः सबसे वैज्ञानिक भाषा है जिसे दुनिया भर में समझने, बोलने और चाहने वाले लोग बहुत बड़ी संख्या में मौजूद है ।

आज जरूरत है हमारी सरकार को हिंदी का अधिक से अधिक प्रचार– प्रसार करना चाहिए। जैसे कि चीन अपनी भाषा को प्रोत्साहन देना होगा और हिंदी में उच्च स्तरीय शिक्षा के पाठ्यक्रम को क्रियान्वित करने की जरूरत है। विश्वशांति का अर्थ केवल हिंसा न होना नहीं है, बल्कि ऐसे समाजों का निर्माण है जहा सभी को यह अहसास हो कि वे आगे बढ़ सकते है और फल – फूल सकते हैं। हमे ऐसी दुनिया का निर्माण करना है जहा सभी के साथ उनकी जाति, नस्ल, धर्म की परवाह किए बिना समान

व्यवहार किया जाए। राष्ट्रों और लोगों के बीच अहिंसा, शांति और युद्ध विराम के आदर्शों को बढ़ावा देने का प्रयास करती है। साहित्य से हम यह कार्य संपन्न होता है। साहित्य का अर्थ हि हितकारक रचना है। भारत में और तो और विश्व में हिंदी भाषा ने यह स्थान प्राप्त किया है। हिंदी साहित्यकारों ने साहित्य से समाजपरिवर्तन किया है। विश्वशांति में हिंदी साहित्य का उच्च स्थान रखती है, हिंदी भाषा प्रचुरमात्रा में विश्व में भारत की पहचान बन चुकी है।

हिन्दी साहित्य में संत कबीर, मलिक जायसी,2 सूरदास, तुलसीदास आधुनिक काल के भारतेंदु से प्रयोगवाद के साहित्यकारों का योगदान रहा ही है। नई सदी के साहित्यकार भी अपना योगदान दे रहे है। हिंदी न सिर्फ भारत की पहचान है बल्कि यह हमारे जीवन मूल्यों, संस्कृति एवं संस्कारों की सच्ची संवाहक, संप्रेषण और परिचायक भी है।

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बहुत सरल, सहज और सुगम भाषा होने के कारण हिंदी विश्व की संभवतः सबसे वैज्ञानिक भाषा है जिसे दुनियाभर में समझने बोलने और चाहनेवाले लोग बहुत बड़ी संख्या में मौजूद है।

भारत एक धर्मनिरपेक्ष राष्ट्र है। वहा के विभिन राज्यों में अनेक भाषाएं बोली जाती है। हिन्दी ने हमें विश्व में एक नई पहचान दिलाई है। हिन्दी दिवस भारत में हर वर्ष '14 सितंबर' को मनाया जाता है। हिन्दी विश्व में बोली जानेवाली प्रमुख भाषाओं में से एक है। विश्व की प्राचीन, समृद्ध और सरल भाषा होने के साथ-साथ हिन्दी हमारी राष्ट्र-भाषा भी है। वह दुनियाभर में हमें सम्मान भी दिलाती है। यह भाषा है हमारे सम्मान स्वाभिमान और गर्व की। हम आपको बता दे कि हिन्दी भाषा विश्व में सबसे ज्यादा बोली जानेवाली तीसरी भाषा है। अब हमारी राष्ट्रभाषा अंतरराष्ट्रीय स्तर पर भी बहुत पसंद की जाती है। इसका एक कारण यह है कि हमारी भाषा हमारे देश की संस्कृति और संस्कारों का प्रतिबिंब है।

आज विश्व के कोने कोने से विद्यार्थी हमारी भाषा और संस्कृति को जानने के लिए हमारे देश का रुख कर रहे है। एक हिंदुस्तानी को कम से कम अपनी भाषा यानी हिन्दी तो मानी ही चाहिए, साथ ही हमें हिन्दी का सम्मान भी करना सीखना होगा।

भारत की प्राचीन भाषा संस्कृत रही है और इसी भाषा के विभिन्न कालखंडो में अलग - अलग स्वरूपों में हुए वियोजन से हिंदी का विकास हुआ है। संस्कृत भाषा से पालि, पालि से प्राकृत, प्राकृत से अपभ्रंश, अपभ्रंश से अवहट्ट, अवहट्ट से पुरानी हिंदी और पुरानी हिंदी से आधुनिक हिंदी का विकास हुआ है या पुरानी हिंदी से । मगर वर्तमान भाषाविज्ञानी इसे अपभ्रंश से ही विकसित हुआ मानते है। हिंदी को 14 सितंबर 1949 को राजभाषा का दर्जा दिया गया था। भारत में राजभाषा तथा राष्ट्रभाषा का दर्जा दोनों हिंदी को ही प्राप्त है।

देशके कई राज्यों में हिंदी अभी भी कई लोगों के लिए मातृभाषा है और ज्ञान प्रदान करते करने के माध्यम के रूप में इस्तेमाल की जानेवाली अंग्रेजी एक बड़ी बाधा बनी हुई है। यह भी कहा गया है कि संख्यात्मक और साक्षरता में मजबूत आधार कौशल सुनिश्चित करने के लिए पाठ्यक्रम उस भाषा में प्रदान किया जाना चाहिए जिसे बच्चा समझता है। संविधान को 26 जनवरी 1950 को अपनाया गया था और इसमें कहा गया था कि अनुच्छेद 343 के अनुसार देवनागरी लिपि में हिंदी और अंग्रेजी को 15 साल की अवधि के लिए संघ की आधिकारिक भाषाओं के रूप में नामित किया गया था। नतीजतन दक्षिणी राज्यों से इसका कड़ा विरोध हुआ जहां द्रविड़ भाषा बोली जाती थी ।

अगर देखा जाए तो भारतीय भाषाओं में केवल हिंदी ही एक ऐसी भाषा है जिसे राष्ट्रभाषा के रूप में अपनाया जा सकता है क्योंकि यह अधिकांश भारतीयों द्वारा बोली जाती है यह समस्त भारत में धार्मिक आर्थिक और राजनीतिक संपर्क का माध्यम के रूप में प्रयोग के लिए सक्षम है तथा इस सारे देश के लिए सीखना आवश्यक है ।हालांकि इंटरनेट के बढ़ते इस्तेमाल नहीं हिंदी भाषा के भविष्य के संबंध में भी नहीं रहे दिखाई है गूगल के अनुसार भारत में अंग्रेजी भाषा में जहां विषय वस्तु निर्माण की रफ्तार 19 फ़ीसदी है तो हिंदी के लिए यह आंकड़ा 94 फ़ीसदी है इसलिए हिंदी को नई सूचना प्रौद्योगिकी की जरूरतों के मुताबिक ढाला जाए ।

बौद्ध ग्रन्थों में बोलचाल की भाषा का शिष्ट और मानक रूप प्राप्त होता है। पालि के बाद प्राकृत भाषा का उद्भव हुआ। यह पहली ईस्वी से लेकर 500 ई. तक रही। इस भाषा में जैन साहित्य काफी मात्रा में लिखे गए थे। पहली ई. तक आते-आते यह बोलचाल की भाषा और परिवर्तित हुई तथा इसको प्राकृत की संज्ञा दी गई। उस दौर में जो बोलचाल की आम भाषा थी वह सहज ही बोली व समझी जाती थी, वह प्राकृत भाषा कहलाई ।

दरअसल, उस समय इस भाषा में क्षेत्रीय बोलियों की संख्या बहुत सारी थी, जिनमें शौरसेनी, पैशाची, ब्राचड़, मराठी, मागधी और अर्धमागधी आदि प्रमुख हैं। प्राकृत भाषा के अंतिम चरण से अपभ्रंश का विकास हुआ ऐसा माना जाता है। यह भाषा 500 ई. से 1000 ई. तक रही। अपभ्रंश के ही जो सरल और देशी भाषा शब्द थे उसे अवहट्ट कहा गया और इसी अवहट्ट से ही हिंदी का उद्भव हुआ।

ऐसा कहा जाता है कि हिंदी का जो विकास हुआ है वह अपभ्रंश से हुआ है और इस भाषा से कई आधुनिक भारतीय भाषाओं और उपभाषाओं का जन्म हुआ है, जिसमें शौरसेनी (पश्चिमी हिन्दी, राजस्थानी और गुजराती), पैशाची (लंहदा, पंजाबी), ब्राचड़ (सिन्धी), खस (पहाड़ी), महाराष्ट्री (मराठी), मागधी (बिहारी, बांग्ला, उड़िया और असमिया), और अर्ध मागधी (पूर्वी हिन्दी) शामिल है।

बता दें कि अवहट्ट नाम का जिक्र मैथिल महान कवि कोकिल विद्यापति की 'कीर्तिलता' में आता है। पूरे देश के

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भक्त कवियों ने अपनी वाणी को जन-जन तक पहुंचाने के लिए हिंदी का सहारा लिया। भारत के स्वतन्त्रता संग्राम में हिंदी और हिंदी पत्रकारिता की बहुत अहम भूमिका रही। महात्मा गांधी सहित अनेक राष्ट्रीय नेता हिन्दी को राष्ट्रभाषा के रूप में देखने लगे थे। भारत के स्वतन्त्र होने के बाद 14 सितंबर 1949 को हिन्दी को भारत की राजभाषा घोषित कर दिया गया। यह तो था हिंदी के विकास का सफरनामा।

हिंदी भाषा के विकास में यदि और जानने की कोशिश करेंगे तो हिंदी भारतीय गणराज की राजकीय और मध्य भारतीय-आर्य भाषा है। सन् 2001 की जनगणना के अनुसार, लगभग 25.79 करोड़ भारतीय हिंदी का उपयोग मातृभाषा के रूप में करते हैं, जबकि लगभग 42.20 करोड़ लोग इसकी 50 से अधिक बोलियों में से एक इस्तेमाल करते हैं। सन् 1998 के पूर्व, मातृभाषियों की संख्या की दृष्टिकोण से विश्व में सर्वाधिक बोली जाने वाली भाषाओं के जो आंकड़े मिलते थे, उनमें हिंदी को तीसरा स्थान दिया जाता था।

हिंदी विश्व की लगभग 3,000 भाषाओं में से एक है। इतना ही नहीं हिंदी आज दुनिया की सबसे बड़ी आबादी द्वारा बोली और समझे जानी वाली भाषा है। भाषाई सर्वेक्षणों के आधार पर दुनिया की आबादी का 18 प्रतिशत इसे समझता है, जबकि अन्य भाषा की बात करें तो चीनी भाषा मैंडरीन समझने वालों की संख्या 15.27 और वहीं अंग्रेजी समझने वालों की संख्या 13.85 प्रतिशत कही गई है।

हिंदी को हम भाषा की जननी, साहित्य की गरिमा, जन-जन की भाषा और राष्ट्रभाषा भी कहते हैं। ऐसे में यह कहना कतई गलत नहीं होगा कि हिंदी भविष्य की भाषा है। हां, एक बात जरूर है कि हम इस भाषा का प्रयोग वास्तविक जीवन में जरूर करते है लेकिन यह रोजगार और महत्वाकांक्षी की भाषा बनने में थोड़ी कारगर नहीं बन पाई।

इससे यह जाहिर नहीं होता कि हिंदी का विकास नहीं हुआ। उपरोक्त में कई ऐसे तथ्य हैं, जो पूर्ण रूप से साबित करते हैं कि हिन्दी का विकास कितनी तेजी से हुआ है। हमारे देश के राष्ट्रपति और प्रधानमंत्री अपना बधाई संदेश हिंदी में प्रसारित करते हैं क्योंकि हिंदी भाषा अपनत्व का बोध कराती हैभविष्य में हिंदी का वर्चस्व कम से कम दक्षिण एशिया के क्षेत्रों में तो अवश्य ही रहेगा और इसका कारण है बहुत बड़े वर्ग का हिंदी भाषा जानना। हिंदी भाषा की महत्ता का अंदाजा इसी बात से लगाया जा सकता है कि विश्व की शीर्षतम सॉफ्टवेयर कंपनी माइक्रोसॉफ्ट ने अपने उत्पादों को हिंदी में बनाना भी शुरू किया है।

एक कंपनी जो सारे विश्व में अंग्रेजी भाषा में अपने उत्पाद बेचती है, पर भारत में वह अपने सॉफ्टवेयर हिंदी में ला रही है। इतना ही नहीं, जितनी भी मोबाइल कंपनियां हैं सभी ने सारे हैंडसेट्स में भारतीय भाषाओं को भी शामिल करना शुरू कर दिया है। यह इस बात का इशारा है कि भारतीय जनमानस में हिंदी भाषा का कितना वर्चस्व है। यहां तक की सारे डिजिटल माध्यमों में हिंदी की पहुंच बढ़ी है। चाहे वह बैंक एटीएम हो या किसी सरकारी या गैरसरकारी फॉर्म या अन्य। सारे माध्यमों में हिंदी का विकास तेजी से हो रहा है।

एक बात ध्यान देने योग्य है कि अपने शैशव काल से लेकर आज तक इंटरनेट ने जो सीढ़ियां चढ़ी हैं वो अपने आप में प्रतिमान है, लेकिन जितनी प्रसिद्धि हिंदी भाषा की वेबसाइटों को मिलती है, उतनी किसी और को नहीं मिलती। इसके साथ ही यदि भारत में आप हिन्दी और अंग्रेजी समाचार चैनल की बात करेंगे तो आपको बखूबी पता चल जाएगा कि किस भाषा के चैनल की डिमांड और टीआरपी ज्यादा है।

इतना ही नहीं विकिपीडिया ने भी हिंदी की महत्ता को समझते हुए कई सारी सामग्री का सॉफ्टवेयर अनुवाद हिंदी में प्रदान करना शुरू कर दिया, जिससे हिंदी भाषी को किसी भी विषय की जानकारी सुलभ हुई।

आज के परिपेक्ष्य में हिंदी भी इंटरनेट की एक अहम लोकप्रिय भाषा बनकर उभरी है और ऐसा माना जाता है कि है जब लोग अपने विचार और लेखन हिंदी भाषा में इंटरनेट पर और ज्यादा करेंगे तो वह दिन दूर नहीं की सारी सामग्री हिंदी में भी इंटरनेट पर मिलने लगेगी।

भाषा नदी की धारा के समान चंचल होती है। यह रुकना नहीं जानती, यदि कोई भाषा को बलपूर्वक रोकना भी चाहे तो वह उसके बंधन को तोड़ आगे निकल जाती है। यही भाषा की स्वाभाविक प्रकृति और प्रवृत्ति है, चाहे कोई भी भाषा क्यों ना हो। अंत में हम यही कहना चाहेंगे की हिंदी भाषा सबसे अहम है, क्योंकि इसमें हमारा मान है।

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- हिंदी भाषा – भोलानाथ तिवारी ।
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Population, Migration and Displacement

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ABSTRACT :

The phenomenon of migration has a background as old as the history of humanity and a powerful dynamic that has a great place in the social memory of people. Migration is the long-term relocation of an individual, household or group to a new location outside the community of origin. Today the movement of people from rural to urban areas is more significant. International migration is also increasing but the numbers are smaller than the movement of people within the borders of a country.

Displacement specifically is the forced movement of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence, in particular as a result of, or in order to, avoid the effects of armed conflict, situations of generalised violence, violations of human rights or natural or human-made disasters. There have been displaced persons spread throughout history as long as there has been natural or man-made disasters, climate change, conflict, war, persecution, and political instability. According to the United Nations High Commissioner for Refugees (UNHCR), at the end of 2021 there were 89.3 million people worldwide who have forcibly had to flee their homes as a result of persecution, conflict, violence, human rights violations or events seriously disturbing public order. This includes 27.1 million refugees, 53.2 million internally displaced persons and over 4.6 million asylum seekers. Currently there are more displaced persons world-wide than there have been at any time since the end of World War 2.

Keywords: Population, Migration, Displacement, Effect of Migration, Development.

Objectives of the Research Paper :

The present Research Paper has following objectives :

1. To study detailed concept of Migration.
2. To study the relationship between displacement and migration
3. To study the displacement and its implication.
4. To study the linkages between Migration, Displacement and Development

INTRODUCTION :

Migration is defined as the movement of persons away from their place of usual residence, either across an international border or within a state. It can be viewed both with positive connotations (e.g. moving to start a new job, seeking better living conditions) or with negative connotations (e.g. escaping political oppression, conflict, violence, disaster or human rights violations). It is generally accompanied by a significant change in the cultural set up of both the migrants and the host community. According to the Migration Data Portal, at the end of 2020 there were 280.6 million migrants globally. Migration may begin internally but often crosses international boundaries, just as international migration may one day cycle back home.

RESEARCH METHODOLOGY :

The present research paper studied the impact of Population Migration and Displacement in

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Indian rural sector. The study is descriptive in nature based on the secondary data and secondary data have been collected from different sources i.e., the Reference Book, Research Paper, Journals, Website and Articles in Newspaper.

TYPES OF MIGRATION

1. Internal Migration :

"The movement of people within a State involving the establishment of a new temporary or permanent residence. Internal migration movements can be temporary or permanent and include those who have been displaced from their habitual place of residence such as internally displaced persons, as well as persons who decide to move to a new place, such as in the case of rural–urban migration. The term also covers both nationals and non nationals moving within a State, provided that they move away from their place of habitual residence."

- **Rural to Urban Migration (R-U)**: The movement of population from rural areas to the nearby towns and cities mainly in search of better livelihood and standard of living, i.e., employment, education, and recreation facilities.
- **Rural to Rural Migration (R-R)**: Mostly agricultural workers, because of marriages, and sometimes looking for land for cultivation.
- **Urban to Urban Migration (U-U)**: The relocation from one metropolitan community to the next looking for more significant compensation and another market for business potential opens doors.
- **Urban to Rural Migration (U-R)**: The movement from urban areas or cities to rural areas to get freed off the urban problems like air pollution, overcrowding, noise pollution, and returning to their native place after retirement from jobs.

2. International Migration :

The movement of persons away from their place of usual residence and across an international border to a country of which they are not nationals." As for internal migration, this can be temporary or permanent and includes those who have been displaced from their "habitual place of residence", and people who have chosen to move to a new country. It excludes movements that are due to "recreation, holiday, visits to friends and relatives, business, medical treatment or religious pilgrimage.

- **Legal Immigrants:** Legal immigrants are the individuals who moved with the lawful authority of the beneficiary country.
- **Unlawful Immigrants**: Unlawful immigrants are individuals who moved without lawful authorization.
- **Refugees:** Refugees are those who crossed a worldwide limit to get away from abuse.

REASONS FOR MIGRATION

1. Climate Migration :

The movement of a person or groups of persons who, predominantly for reasons of sudden or progressive change in the environment due to climate change, are obliged to leave their habitual place of residence, or choose to do so, either temporarily or permanently, within a State or across an international border.

2. Labour Migration :

Movement of persons from one State to another, or within their own country of residence, for the purpose of employment. This includes migrants moving within the country and across international borders.

3. Irregular Migration :

Movement of persons that takes place outside the laws, regulations, or international agreements governing the entry into or exit from the State of

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origin, transit or destination." It is generally used to "identify persons moving outside regular migration channels." These migrants may have had no other option but to use these irregular migration channels. It may include: asylum seekers, victims of trafficking, or unaccompanied migrant children.

4. Forced Migration or Displacement :

The movement of persons who have been forced or obliged to flee or leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, generalized violence, violations of human rights or natural or human-made disasters.

Effects of Migration :

Although the choice of migration may make good sense, it does cause issues for the communities where the migrants are coming from and going. Migration has an impact on the political, social, cultural, economic, and demographic sectors.

1. Economic Growth :

Both internal and international migrants' contributions are very beneficial to the areas from which they have moved. The funds are utilized for a variety of purposes, including purchasing food, paying off debt, getting married, treating illnesses, educating kids, building homes, and more. Conversely, uncontrolled migration to India's urban areas results in undesirable population density increases and overpopulation.

2. Challenges and Opportunities :

Migration can pose challenges, such as strain on local resources or competition for jobs. However, it also presents opportunities for growth and development if managed effectively through policies that address the needs of both migrants and locals.

3. Social Consequences :

By contributing ideas, technology, and life skills acquired from living in cities, migrants help bring about societal transformation in their home countries. Migration also contributes to the blending of cultures which results in diversity. However, living apart from family can cause loneliness and anonymity, which can lead people to participate in undesirable activities like drug usage and criminality.

4. Demographic Changes :

Within the working-age population, the male population from the rural areas moves to the city of metropolis leaving behind dependents in the countryside. This results in an imbalanced ratio of sexes. Without male assistance, women are forced to perform farm work in addition to household responsibilities. Also, the development of rural areas is hampered by the loss of human resources.

5. Environmental Consequences :

Migration from rural areas strains the social and physical infrastructure already in place and results in urban overpopulation. Slums and unplanned settlements grow. In certain places, over-exploitation of natural resources causes pollution and resource depletion.

6. Cultural Exchange :

Migration leads to the exchange of cultures. When people move to a new place, they bring their traditions, languages, and customs. This cultural diversity enriches the local culture and creates a melting pot of traditions.

7. Global Connections :

Migration connects different parts of the world. Families and communities maintain ties across borders, contributing to a more interconnected global society.

RELATIONSHIP TO DEVELOPMENT :

Migration and development are highly interdependent processes. Internal migration relates to people who have chosen to move from the rural to urban areas of their own country.

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International migration in the development context relates both to people who have chosen to move of their own accord, and forced migrants who can ultimately end up contributing to both their country of resettlement and possibly their country of origin if it is ever safe to return.

Development, meanwhile, is a dynamic process implying growth, advancement, empowerment and progress, with the goal of increasing human capabilities, enlarging the scope of human choices, and creating a safe and secure environment where citizens can live with dignity and equality. In the development process, it is important that people's productivity, creativity and choices are broadened, and that opportunities are created.

With internal migration a countries expands its urban areas and all the activities that are conducted in the urban set up, mainly secondary and tertiary sector activities. It contributes to the growth and development of the country itself.

International migration contributes to the growth of the country to which the migrants have moved.

There is a range of evidence about the positive impacts of migration on human development, through such avenues as increased household incomes and improved access to education and health services. There is further evidence that migration can empower traditionally disadvantaged groups, in particular women. At the same time, risks to human development are also present where migration is a reaction to threats and denial of choice, and Where regular opportunities for movement are constrained.

DISPLACEMENT :

Displacement is more than physical dislocation. It is being uprooted and dismemberment of the socio-economic webs of life with traumatic experiences. It results into a spiral of impoverishment. Displacement threatens the existence and identity of people. There is a process of dispossession in displacement. Displaced populations leave their homes in groups, usually due to a sudden impact, such as an earthquake or a flood, threat or conflict. There is usually an intention to return home.

There are two types of displacement resulting from development projects:

1) Direct displacement: It leads to actual displacement of people from their locations.
2) Indirect Displacement: It leads to a loss of livelihood.

It forced to leave the home region to which they are attached and for which they have the knowledge to make a living most effectively. This displaced populations often become impoverished. The displacement of people as a result of development projects, policies and processes, therefore, constitutes a social cost for development.

An internally displaced person is someone who is forced to leave their home but stays within their own country. They are often called refugees, even though they don't meet the legal definition. In 2010, about half of the internally displaced people and refugees were believed to be living in cities, and many of them were unlikely to ever go back to their original homes. A study conducted in 2013 found that international aid and governance had not adequately addressed the issue of long-term displacement in urban areas, as they had primarily focused on displacements in rural camps. The study argues that a new approach is needed to support those who are displaced and their host societies, which would involve human rights and development actors as well as local and national governments. The study also calls for a change in the way this issue is perceived, highlighting the resilience and resourcefulness of displaced populations, the opportunities for self-sufficiency and safety in urban areas, and the potential contributions they can make to their host societies.

Displacement and Development: The issue of internal displacement became more prominent too because of the realization that peace and reconstruction in war-torn societies depended on the effective reintegration of displaced persons.

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Many of the countries devastated by civil war—such as Mozambique, Angola and Liberia—had anywhere from one-third to three-quarters of their population forcibly uprooted. Unlike wars between nations, civil wars, particularly when they divide countries along racial, ethnic, linguistic, or religious lines, do not resolve themselves easily. When states are monopolized by or identified with one ethnic group to the 175 Development, Migration and Displacement exclusion or marginalization of others, displaced persons easily fall into a vacuum of responsibility in the state. The developmental projects like large dam, mining, power projects and nature conservations have displaced the people from their habitat which caused them to live on the margins of society such as tribes, pastoralists and subsistence agriculturalist. The local inhabitants lose their command over the resources. The plight suffered by the displaced, many are now asking: whose nation is it? Whose good is being served? Is it for the planners, administrators, implementing agencies or upper middle class or marginalized sections of the society? (Fernandes 1997) Planners and administrators invariably capitalize on and manipulate the relatively weaker socio-economic and political position of the Displaced Persons (DPs). Their numbers are underestimated. They are treated indifferently and only minimal cash compensation, if at all, is paid to them. They are rarely granted security of tenure or alternative developed land. Often after a painful and traumatic period of establishing a new lifestyle, they are again informed, they must move again to make way for yet another project. Apart from the immediate economic loss, displacement also brings about social, cultural and psychological dislocation. The physical displacement of the people leads to their uprooting from their sociocultural base which is no less pathetic than the dispossession of land. They lose their traditional mechanism of social control, and as a result social tensions increase among them (Fernandes, 1997). About 70 per cent of India's population, most of whom are tribals, primarily depends on land related work and agricultural production. Thus, land for them is a means of livelihood and the basis of socio-economic relationship. Alienation from land and displacement have threatened the livelihood of millions. People are displaced without any consultation or participation in the development process and denied their rightful share in the gains of the development project that displaces them.

TYPES OF DISPLACEMENT :

1. **Refugee Displacement:** A refugee is someone who has been forced to flee his or her country because of persecution, war or violence. A refugee has a well-founded fear of persecution for reasons of race, religion, nationality, political opinion or membership in a particular social group. Most likely, they cannot return home or are afraid to do so. War and ethnic, tribal and religious violence are leading causes of refugees fleeing their countries.
2. **Stateless Person:** Stateless persons have been described as "non-persons, unclaimed, outcasts, legal ghosts or the ultimate forgotten people". These expressions reflect the dramatic impact that statelessness can have on an individual's enjoyment of human rights and overall well-being. As such, a stateless person is someone who is not a citizen of any country, which can occur due to a variety of reasons, including sovereign, legal, technical or administrative decisions or oversights including
3. **Asylum Seeker:** An asylum seeker is someone who claims to be a refugee, but whose claim has not yet been fully evaluated. When people flee their own country and seek sanctuary in another country, they apply for asylum or the right to be recognised as a refugee and receive legal protection and material assistance. An asylum seeker must demonstrate that their fear of persecution in their home country is well-founded.

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4. **Human Smuggling**: Smuggling of migrants is defined as "the procurement, in order to obtain, directly or indirectly, a financial or other material benefit, of the illegal entry of a person into a State Party of which the person is not a national or a permanent resident"
5. **Environmental migrants**: Environmental migrants are people who are forced to leave their home region due to sudden or long-term changes to their local or regional environment. These changes compromise their well-being or livelihood, and include increased drought, desertification, sea level rise, and disruption of seasonal weather patterns such as monsoons.

CONCLUSION :

Migration has always existed, and will continue long into the future but the term "migrants" has become more politically loaded over the years, and remains a contentious point of discussion. Consistent public debate is challenging when multiple definitions exist and terminology is used interchangeably. While many individuals migrate out of choice, many others migrate out of necessity and for many they are forced to leave their home. Every migrant is a unique person protected by human rights. Some migrants may have specific vulnerabilities and, as a result, have particular rights because of who they are or what they have experienced (e.g. children, people with a disability, survivors of trafficking, stateless persons and refugees). The use of 'migrants' as a label for all should always go hand in hand with recognising and protecting the rights of each of the specific groups identified above.

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TWIN TRAILBLAZERS OF INDIAN POETRY IN ENGLISH: TORU DUTT AND SAROJINI NAIDU.

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Introduction: Indian women poets have a legacy of equality of sexes inherited from the Indian freedom struggle, Indian constitutional rights to women, introduction to Western thoughts through the spread of education, and the consequent new awareness as a result of all of these among women. The literary period between 1800 and 1900 was very turbulent and witnessed many changes. It was a phase of transition. Yet, it should not go unnoticed that Indian women were often caught between the flux of the glorified past of the country and the onslaught of modern ideas. Very often these ideas contradict the existing system and finding the middle point in the incessant new changes was a daunting task before women. Yet, to overcome the traditional barriers and express freely in the literary repertoire forms the crux of feminism in Indian literature. Thus, Indian feminism becomes a pursuit of a search for identity and a quest for the definition of self.

It is a well-observed fact that, by and large, Indian poetry in English originated in Bengal. Moreover, this poetry was largely an urban phenomenon. It has also to be noted that as English was an elite language in India, Indian poets writing in English belong to the upper class and caste. Lack of spread of English education is the major responsible factor. Two trailblazers in the early Anglo-Indian poetry are Toru Dutt and Sarojini Naidu. Being in the nascent stage the efforts of Toru Dutt and Sarojini was imitative and derivative of English poetry, which successfully gave a new direction to Indian poetry in English by writing on Indian history, myths, and legends. This phase is called the imitative phase for poets of this phase followed the poetic trends of Romantic and Victorian Poetry. The second phase of Anglican-Indian poetry is assimilative. This period starts in 1947. Self-expression was all-important to the poets of imitation and self-definition. It was accompanied by heart-searching, probing into the cultural inheritance. Toru Dutt and Sarojini Naidu mark a kind of watershed between these two phases, summarizes Jyoti Naresh in her article *Three Great Indian Women Poets: Toru Dutt, Sarojini Naidu and Kamala Das.*

Susie Tharu and K. Lalitha extol the contribution of these two poets in the Indian literary repertoire. "Even the celebrated Indo-Anglian poet Toru Dutt, whose work invariably found a place in syllabuses, was usually presented as a brilliant, but protected, upper-class child-poet, who died early of consumption. Rarely did students learn that, like her uncle Romesh Chunder Dutt was a nationalist and a passionate republican; that she was widely read in the history and literature of the French Revolution; or that she had translated speeches made in the French Chamber of Deputies around the time of the Revolution for Indian nationalist journals. Hardly ever is it mentioned, in the context of the literature classroom, that Sarojini Naidu was called the Nightingale of India as much for the rhythm and modulation of the speeches she made during the Independence movement as for her delicate verse". (Preface Pg xvi)

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Susie Tharu and K. Lalitha's above comment is in terms of feminism while to locate these two poets in the Anglo-Indian history one has to look at Makarand Paranjpe. In his essay "Introduction" to *Indian Poetry in English*, he reviews M. K. Naik's attempt of periodization against the historical and political backdrop in the latter's seminal work, *History of Indian English Literature*, to trace the development of Indian English literature from the beginning. He tries to compare and identify various movements in British literature such as Classicism, Romanticism, Victorian literature with Indian *chhayavad, pragativad, rahasyavad, adhunikta, uttaradhunikta*, etc but remains unsatisfied with any sort of classification. Hence, he suggests a combination of political and poetic ideologies to mark the phases in Indian Literature. Thus, Toru Dutt belongs to the first phase called "colonialism (1825-1900)" and Sarojini belongs to "nationalism (up to 1947)". One finds glimpses of socio-political circumstances in their poetry especially of Sarojini Naidu. Both these poets were fortunate to inherit educational backgrounds and the considerable freedom given to daughters in the family. As a result, unlike the other daughters of India, critical assumptions, historical circumstances and ideologies prevalent then, seem far from being hostile to literary productions in the case of Toru Dutt and Sarojini Naidu. '
The present chapter ventures to evaluate if the poetry of Toru Dutt and Sarojini Naidu manifest Indian value system along with feminist understanding and the factors that led to the formation of their respective selves and thereby attempts to prove that the poetry of Toru Dutt and Sarojini Naidu is deeply rooted in Indianness but there is hardly any reference to feminism. The socio-historical context is scrutinized if they play any role in the literary output of the poets. The chapter within its limited scope, cannot discuss all the aspects, hence, it confines itself only to Indian value system and elements of feminism as reflected in their writings.
While examining the poems of the twin women poets of India from the perspective of feminism and Indianness, it is pertinent to examine the status of feminism then and the reasons for the presence or absence of these two elements. Inevitably the chapter penetrates into the biographies of the two to understand the socio-political-cultural circumstances in which these two poets grew. The chapter also throws light upon how these two poets negotiated with the margins of patriarchy, religion, orthodox social norms prevalent then. It is also necessary to evaluate if these two poets have resisted sexism in their poetry. Whether to term these two poets as feminists or not depends on how feminism is defined then and now.
It is essential to reread women's writing from a feminist perspective so that it will not be lost or ignored from the male point of view. In *A Literature of Their Own*, Elaine Showalter proposes following three phases of women's writing: The 'Feminine' Phase, The 'Feminist' Phase, The 'Female' Phase. In the feminine phase, female writers tried to adhere to male values, writing as men, and usually did not enter into a debate regarding women's place in society. Female writers often employed male pseudonyms during this period. Toru Dutt and Sarojini fall in the first phase.
Toru Dutt (1856-1877): In the sphere of Indo-Anglian poetry, the Era of Indian Renaissance (1870-1900) may also be termed 'The Age of Dutts' for, the two sisters Aru Dutt and Toru Dutt and the renowned intellectual Romesh Chandra Dutt dominated the literary scene. Toru Dutt had a different order of intellect and exhibited great ability and originality in bringing Indo-Anglian poetry to a high level of poetic excellence. Her poetry exhibits pure creativity, imagination and almost flawless technical skills. In her English translations 'A sheaf Gleaned in French Fields, and in her 'Ancient Ballads and Legends of Hindustan' she almost achieved a striking success as to make one regret that our language is essentially alien to the riot of imagery and ornament which form a part of the natural texture of the oriental mind. Her early exit in 1877 at the age of

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twenty-one is a big loss but her literary achievements which were the fusion of western and eastern culture, were so remarkable that they still reverberate the poetic repertoire of Indian poetry in English.

Toru Dutt published *A Sheaf Gleaned in French Fields* (1875) featuring eight pieces by Aru Dutt. Her second volume of poems was published under the title *Ancient Ballads and Legends of Hindustan* (1882) with an introduction by Edmund Gosse. She wrote two novels, one in English Bianca, and another in French 'Le 13 Journal de Mademoiselle d' Arvers'. She also wrote short lyrics and sonnets. The high spot of Toru Dutt's literary career was her use of rich Indian heritage of myth and folklore. Her poems 'Sita' and 'Our Casuarina Tree' needs a special mention as they contain autobiographical elements. Padmini Sengupta puts it aptly,

> "Her exquisite talent, her keen observation of roots, her command of traditional meter and her return to roots- all these are reflective in her immortal poem 'Our Casuarina Tree'. It is the most revealing of Toru's verses, with its nostalgia and an 'inner vision' of sublime beauty. This poem alone can number her with the immortal English poets of her age."

Toru Dutt's deep fascination for the glorious past and ancient culture of India reflects in her *Ancient Ballads and Legends of Hindustan* (1882). She very strongly endorses Indian mythological beliefs in her poems. Along with seven non-mythological pieces, it contains nine ballads or legends in which she wrote about Savitri, Lakshman, Jogadhya Uma, *The Royal Ascetic and the Hind*, Buttoo, Dhruva ,Sindhu, Sita and Prahlad. The central characters of most of her poems are mythological personalities who can be termed as cultural icons of India. The mythical images she draws upon in *The Ancient ballads and Legends of Hindustan* stand for the Indian ideal of womanhood (Sita and Savitri), ideal brother (Lakshman), ideal pupil (Buttoo), ideal devotee (Prahlad), and ideal son (Sindhu). One can have a glimpse of her towering idealism in 'The Legend of Dhruva': "That man is truly wise Who is content with what he has and seeks Nothing beyond, but in whatever sphere Lowly or great, God placed him, works in faith...." (http://www.poetrycat.com)

In 'Savitri', Toru Dutt comes out with her true genius of depiction of love. Savitri's love is firm and unchangeable. She makes up her mind once and for all to marry Satyavan, who was destined to die within a year though Narad Muni and her parents opposed. Unfazed by Narad's fatal prediction, she calmly and patiently avows her love for Satyavan. Satyavan dies after a year and Savitri, persuades Yama, the God of Death, to revive her husband and He yields to her supplication. Savitri triumphs the Death of her husband proving true love is beyond time and destruction.

If she has a fine command of the art of lyrical balladry, her shorter poems reveal her real and creative instincts. Her exquisite talent, her keen observation of roots, her command of traditional meter and her return to roots- all this manifest eloquently in her immortal poem 'Our Casuarina Tree'. It is the most revealing of Toru's verses, with its nostalgia and an 'inner vision' of sublime beauty. This poem alone can number her with the immortal English poets of her age.

Assessing Toru Dutt following the standards of literary criticism, one finds her mainly a translator. Her few, original pieces are simple and flawless expressions that cannot claim to be of great poetic value. The only exception is her ode, 'Our Casuarina Tree'. The narrative pattern of her translations from Sanskrit is based on the style of William Wordsworth, St. Coleridge and John Keats.

Sarojini Naidu: (1879-1949): The felicity and charm of Sarojini Naidu's lyrics make her the rightful heir to Toru Dutt, whom she has recalled as a lyrical poet. Edmond Gosse praised her as,

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"The most brilliant, the most original, as well as the most correct of all the natives of Hindustan who have written in English".

Sarojini Naidu, the eldest child of the poet Varada Sundari and an ardent supporter of education, Aghorenath Chattopadhyay. She was fortunate to grow up in a household that was a center of learning and arts. It is evident through her political speeches and poetry that during her formative years her young mind was shaped as much by the rich Muslim culture of Hyderabad as by the traditional Hindu ethos of her family and the Western influences of her education. For further studies she was sent to England. She spent three years there, first at King's College in London and later at Girton College in Cambridge, and returned to Hyderabad in 1888. She married Govindaraju Naidu, a doctor and a widower ten years her senior, the same year. They bore four children between 1899 and 1903. Her contribution in setting up the All-India Women's Conference and demanding, as early as 1917, full franchise for women can't go unacknowledged. When India became independent in 1947, Sarojini Naidu was appointed governor of Uttar Pradesh, the largest state in the country.

Most of her poetry was written between 1895 and 1917. She was sixteen and published her first collection, Songs. It was 1917, when her fourth and last volume, *The Broken Wing*, including *The Temple, A Pilgrimage of Love*, came out. She published in 1905 *The Golden Threshold*, a book dedicating to Edmund Gosse, the well-known British critic. *The Bird of Fame*, her third book of poems that came out in 1912 which includes her popular poem, "Bangle-Sellers,". Her poetry is widely read and even committed to memory by people who enjoy the delicate rhythm and the luxurious imagery of her verse. However, literary critics term her work as sentimental and as offering an exotic image of India. Her poems are short, highly patterned, and most lyrical. Sarojini belongs to Romantic-Georgian tradition and it is unjust to judge her by applying the canons of neo-modernists' ideology of poetry.

Iyengar's observation well expresses her dedication to Keats dictum, " Beauty is truth, Truth Beauty ....", "She was, above all, sensitive to beauty and the beauty of living things, the beauty of holiness, the beauty of the Buddha's compassion, the beauty of Brindavan's Lord. She didn't especially seek out the bizarre the exotic, the exceptional, but her poems lack neither variety nor the flavor of actuality. Seldom did she venture out of her depth; she wasn't interested in wild experimentation; she didn't cudgel towards explosive modernity. But she had genuine poetic talent and she was a wholesome and authentic singer."

R. Tilak supports Iyengar's observations, "Lotika Basu, P. Lal, Nissim Ezekiel, and Paul Verghese have all criticized her lyrics for their romantic sentimentality, saccharine sweetness and tick-tock and precise rhythm. Her over opulent imagery, it is said, blurs the visionary focus, and the meaning is lost in a cloud of words. Such critics forget that in her lyrics there is an integration of different traditions of different levels of experience, thought and emotion."

Sarojini's poems revolve around three dominant themes: Love, Nature, Indian Spirit, and Questions of Life and Death. There are poems pulsating Indian spirit. Moreover, there are 8 poems in the category of Indian Folk Songs. Very few poems deal with patriotism though she pays tribute to her contemporary personalities. Other poems exhibit poet's fancies e.g., 'Cradle Song,' and Slumber Song for Sunalini.

Edmund Gosse could recognize in Sarojini Naidu a poetic potential and promise hence, advised her to ground her poems firmly on her native soil. Sarojini Naidu took his suggestion in all seriousness and vernacularised her themes and motifs. The poems represent India in scene and spectacle with occupations, faiths, and festivals, its legends, myth, and rituals.

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It was in the year 1920 that Sarojini Naidu opted out of literature and participated actively in the national independence movement but she never ceased to be a poet. The impact of Indian devotional poets and Sufi-mystics is evident in Sarojini Naidu's mind, but her conception of nature does not correspond to that of classical Indian poetry, where nature is treated just like the physical environment of man and not as an automatic force. Her conception of nature is a blend of Wordsworth and Indian classics. Sarojini Naidu's conception of nature reveals a spontaneous understanding of the Indian point of view though lacks a philosophical foundation. Sri Aurobindo rightly observes:

> "Her work has a real beauty. Some of her lyrical work is likely, I think, to survive among the lasting things in English literature and by these, even if they are fine rather than great, she may take her rank among the immortals".

Sarojini Naidu is firmly rooted in Indian soil, to its faiths and festivals, folk-life, culture, and rich tradition. She has succeeded in recreating the multitudinous panorama of Indian life with its variegated pageants. She discovers a strange significance in the commonest of sights and sounds, the festivals and the life of her countrymen. Every dimension of Indian life attracts her, finding its expression in a kind of poetry that is unique unto itself. According to Paul Varghese and Lotika Basu, Sarojini Naidu falsified the Indian scene by filling it with romantic characters like 'Beggars' and 'Pardah Nashins'. The Pardah Nashins and Palanquin Bearers may remind us of Rudyard Kipling's India, yet the weavers, the bangle sellers, the fishermen and the snake charmers still form the vital part of Indian folklore. The individual is believed to pass from the ritualized order and pattern of daily life to regenerative flux through the sacred continuum. The seasonal festivals of 'Vasant Panchami', 'The Festival of Serpents', 'Nariyal Purnima', 'The festival of lights, etc., appear frequently in Sarojini Naidu's poetry, both as themes and as symbolical plots of human experience. Sarojini Naidu had a strong sense of India's cultural fabric. This understanding was further enriched by a deep love of the variety and multiplicity through which the fundamental unity of India has found expression.

Patriotism has been quite strong in Sarojini Naidu since her childhood days. Love for the motherland is a passion with her, and throughout her life, she is seen struggling between two equally powerful forces in her – her craving to sing songs of beauty, love, and life and her urge to serve her countries. Some of her lyrics like 'Gift of India', 'To India', 'Anthem of Love' and her invocations to the national leaders like Gopala Krishna Gokhale, Mahatma Gandhi, and Bal Gangadhar Tilak are charged with intense patriotic feelings fully justifying the title 'Nightingale of India' lovingly conferred on her by Gandhiji. At times, it appears that she is translating people's suffering into a gesture of revolt. In this connection K.K. Mehrotra says, "One will find in her poetry again and again the announcement that she wished to serve her countrymen by her songs." Many of her poems express patriotism, hope and optimism. In her address at the Kanpur session she said, "As long as I have life, as long as blood flows through this arm of mine, I shall not leave the cause of freedom. Come, my general! Come, my soldiers! I am only a woman, only a poet. But as a woman, I give to you the weapons of faith and courage and the shield of fortitude. As a poet, I fling out the banner of song and sound the bugle call to battle."

Sarojini Naidu though not a feminist in modern or Western sense fought for the cause of Indian women, was an anti-imperialist. She proved to be a loyal wife and conscientious mother. The works that contain feministic values according to the standards set then, are The Pardah Nashin, A Song from Shiraz, The Imambura, The Prayer of Islam, Wandering Beggars, and The World Woman.

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Poems describing Hinduism are: Harvest Hymn, Suttee, Damayanti to Nala in the Hour of Exile, To a Buddha Seated on a Lotus etc. Two poems overtly idealizing typical, sacrificing Indian womanhood but covertly revealing the pathetic condition of them are Suttee and Purdah Nashin. The narrator of Sutte is a young widow who assumes herself to be flesh and her husband her soul, so finds her life worthless after her husband's death. The poem glorifies the practice of "*Sati*" ignoring the subjugation of the subalterns and Raja Ram Mohan Roy's efforts of abolition of the practice of "*Sati*".

Purdah Nashin, like Suttee is a sonnet with three stanzas dealing with the life of a woman behind the veil, "purdah". Sarojini seems to be endorsing the safety of Muslim women in purdah yet see the tears under the veil. Both the poems depict the religious practices imposed upon women under the guise of "safety". Ironically enough, the poet finds the practice of purdah as a sign of subjugation but not the practice of *Sati*. Though the poems are woman-cantered, Sarojini does not seem to take any stand and criticise these two practices despite being in the power-position.

Comparison: To compare these two prominent figures in Indo-Anglian poetry, Tou Dutt and Sarojini Naidu, one finds that the literary lineage of the duo traces to their parents, especially fathers. Through their poems, they interpreted Indian life before the Western world. Though there exists a gap of almost four decades between the active literary career of Toru Dutt and Sarojini Naidu, one finds them to be contemporaries especially in their literary outlook. If one compares them, one discovers more similarities than differences. Both of them subscribe to lofty idealism in their poetry, which bears echoes of Sanskrit and Persian poetic traditions. They are equally indebted to some of the poetic traditions of the land.

Sarojini Naidu was not gifted with descriptive power of character delineation, but in the sphere of lyrical poetry, she was endowed with lifting melody, spontaneity, and the musical flow of the verse. She has neither peers nor followers. Her genius is essentially lyrical. She is pre-eminently a poetess of love. Although her conception of love is ideal, yet her love poems are often full of ornamental verbose which we do not find in Toru Dutt's 'Savitri'. To Sarojini Naidu, physical love leads to spiritual love. In her love poems: An Indian Love Song, A Rajput Love Song, Song of Radha, the Milkmaid and in the trilogy The Temple, love is expressed as an ideal, founded on self-surrender and complete identification.

Despite her Western influences, Toru Dutt was an Indian to the core. Many passages in her *Ancient Ballads and Legends of Hindustan* bear the unmistakable stamp of Vedanta and are the best expositions of the Hindu view of life. In the poems of both Toru Dutt and Sarojini Naidu, depiction of nature occupies a large space. In Toru Dutt's poems depicting Indian legendary themes like Nature is portrayed as background for the enactment of the human drama of the sufferings of Savitri, Button and Sindhu. The poetic achievement of Toru Dutt and Sarojini Naidu is limited. Padmini Sengupta Says "Both Toru and Sarojini Naidu are simple; but the former is more natural and at the time more mature, the latter is conventional and also sings songs."The study of Sarojini Naidu's poems puts her vision in perspective and also helps trace the interlacing connections between the Indian tradition and her poetic individuality.

Conclusion: Literary achievements of Toru Dutt and Sarojini Naidu demonstrate that education and conversion in case of Toru, had in no way alienated them from their roots in Hindu society, Indian culture, and nationalism. The diction they use expresses their own Indian sensibility. Therefore, to understand and appreciate their poetry one must possess the sensitivity of the Indian environment. To appreciate their poems fully one must be well versed with the ethos and contemporary background of India that governs the poetry. The urge to express 'Indian sensibility' is continued in all the phases. Like many modern Indian writers Toru Dutt and

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Sarojini Naidu project and sustain traditional values and extol old roles and models in their presentation of women. Both of them rarely chose female characters who show exemplary courage and strength in critical situation, have feminist conviction in the modern sense of feminism. Sarojini will be ever remembered for the part she played in setting up the All-India Women's Conference and demanding, as early as 1917, a full franchise for women but there is hardly any reflection of this aspect in her literary production. Rather her poem, Suttee is found to be perpetuating, though unconsciously, the patriarchy imposed on women. Articulate and influential as she was in her political life, which is completely absent in the themes and treatment of her literary output.

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TO STUDY ON CO-CURRICULUM ACTIVITIES ON STUDENTS' SUSTAINABILITY GROWTH WITH THE HELP OF NATIONAL EDUCATION POLICY

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Abstract

The National Education Policy (NEP) 2020 is a framework that aims to revamp the education system, in India. A key aspect of the NEP 2020 is the integration of co- curriculum activities into Education with the goal of enhancing graduates' employability and make the self-sufficient and self-employed. However, it is crucial to consider the sustainability of education within higher education institutions under the NEP 2020.

This research paper intends to focus on collective strength of youth as a one family make our earth stronger and our future brighter. To assess the sustainability of education within education institutions as, per the guidelines outlined in the NEP 2020 in India. The research methodology employed for this study is qualitative focusing on exploring perspectives, experiences and insights. To gather data structured interviews are conducted involving various key stakeholders including educators, policymakers and industry experts.

Keywords: National Education Policy, Co-curricular Activities, Self-Employability

Introduction

The National Education Policy 2020 (NEP) sets forth a plan to revamp the education system, in India. The goal is to create a system that reflects values and actively contributes to the development of India, known as Bharat into a knowledge-based society that is fair and progressive. This transformation will be achieved by providing top notch education accessible to all with the aim of positioning India as a leading powerhouse, in knowledge and innovation.

Under the NEP co-curricular activities are included like sports, yoga, cultural activities, literary arts , handmade arts etc. with the help of this activities students can able to bring their interest in to their career.

The co- curricular activities enhancing skills and making students self-sufficient.

In the realm of education, the National Education Policy (NEP) 2020 presents a range of valuable perspectives and suggestions that cover various aspects of education. These suggestions and insights include;

1. Multidisciplinary and Comprehensive Education; The NEP 2020 promotes a shift, towards an approach to education allowing students to explore a range of subjects and fostering a well-rounded academic journey.
2. Institutional Autonomy; The policy emphasizes the significance of autonomy by giving education institutions more freedom, in decision making processes. This encourages innovation and the enhancement of quality.

Literature Review

L. Radha, Thiagarajar College of Engineering, India and J. Arumugam, PSG College of Technology, India Volum 11, E-ISSN: 2582-1334 published on 1st sept 2023

In their study they had discussion on benefits on aligning the National education policy (NEP) to promote sustainability development in higher education. This study also states that NEP is developing the entrepreneur skills among young students and encouraging them to become a job giver for changing the need of the world.

Pavneet Kaur 2 Prof. Abhinav Sharma , Vol-18, No-2, April - June, 2023 (UGC Care Listed Journal) ISSN: 2320-7698

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In this research paper the researchers have appreciate the NEP and its expected impact on globe but they have also underlined the challenges will come while implementing NEP in all our India. Challenges like fund, gender disparities, socioeconomic disadvantage, political indifferences, and efficient facilitators. In this study they have also stated road map to the policy implementation.

Suresh, S. P. ., & Simon, S. . (2023). Measuring Sustainable Eco centric Views of Young Entrepreneurs with NEP Scale - A Way Forward to Oman 2040 vision. *European Journal of Sustainable Development*, *12*(1), 129

In this study researchers have stated environmental aspect in the higher education. The research paper authors have shown requirement of environmental education and importance of natural resources. Especially on these 5 points researchers had major focus, those are equality of Limits to Growth, Anti-anthropocentrism, Fragility of Nature's Balance, Rejection of Exceptionalism and Possibility of an Eco-Crisis.

Objectives of Study

To Examine the Perceived Impact of co-curricular activities on self- Employability

Identify how the involvement of co-curricular activities has affected the employability of graduates, considering the alignment of their skills with industry demands and job market trends.

To exhibit Stakeholders' Perspectives on co-curricular activities Integration

Collect viewpoints from educators, and industry experts through semi-structured interviews to understand their perceptions of the benefits, requirements and necessary improvements regarding co-curricular activities within higher education.

To Analyse Transformative Leadership Strategies Promoting Diversity in Educational Institutions: Investigate the role of transformative leadership in fostering diversity within educational institutions, focusing on strategies employed by leaders to promote faculty diversity and inclusivity.

To Investigate the Relationship between Faculty Diversity and Student Performance Outcomes: Examine whether there is a correlation between faculty diversity and student performance outcomes, considering factors such as student achievement, retention rates, and graduation rates.

Research Methodology:

The subsequent analysis of these interviews employs analysis as its technique. This approach involves creating job positions, patterns and sub themes within the collected data. The research project concludes by presenting the findings in an organized manner explaining the themes and sub themes that have been identified. This provides insights, into can be sustained in co-curriculum activities education institutions following the guidelines of the NEP 2020

Thematic Analysis constitutes a form of qualitative examination, serving to dissect groupings and unveil themes that thread through the data's fabric. This technique exposes the data's intricacies through careful interpretation (Boyatzis, 1998)12. Thematic Analysis stands as the ideal approach for any study bent on unearthing insights through interpretations. This method lends a systematic touch to data scrutiny, enabling the investigator to correlate the prevalence of a theme within the broader content. This precision infuses the research with accuracy, complexity, and a heightened holistic understanding. Given that qualitative research demands a grasp of multifaceted elements and information, Thematic Analysis provides a gateway to a more comprehensive comprehension of any subject (Marks and Yardley, 2004)13. Namey et al. (2008) elaborate that Thematic Analysis transcends mere tallying of overt words or phrases; it delves into the realm of pinpointing and articulating implicit as well as explicit notions. The codes devised to encapsulate these ideas or themes subsequently find application, serving as succinct markers for later analysis of the raw data. Such analysis might encompass activities like comparing the relative prevalence of themes or subjects within a data pool, seeking patterns in code co-occurrence, or visually representing the relationships between codes14 (p.138).

Interview Questions to educators

1. How familiar you are with NEP and its provision related to co – curriculum?
2. Can you share your perspective to integrate co- curriculum in academics

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3. How are you planning to evaluate co – curriculum activities
4. Are you planning to appoint an expert to teach students?
5. On what basis you are allocating co – curriculum activities to students

Interview Questions to 1st year students

1. Would you like to study practical/ Industry related syllabus apart of traditional education?
2. Would you like to pursue any game for evaluation?
3. Do you think other activities should be part of education?
4. Do you want to turn your passion into your career?

Data Interpretation

Explanations of educator's questions

When the above questioned had been asked to educators most of them were not having clear idea about National Education Policy 2020. Every college were using their own to implement National Education policy. Even if there was a huge confusion everybody were agreed to give skilled based education to students and focusing on their passion. This policy will defiantly enhance skills and reduce the employability gap in between industry and academia. One of the important components of Nep is Co- Curriculum activities which will support students hobbies and skills and make them self-sufficient.

Explanations of student's questions

Students are one of the important factors of National Education Policy and student's opinion is required for this study. For this few questions were asked to 1st year students to understand their willingness to study something new that time most of the students were absolutely clueless but after explanation of the course students were excited to study and all were agreed to happily support co – curriculum as a subject for evaluation, initially students required guidance and information relation to Co- Curriculum but once its streamline students were so happy satisfied with this National education policy.

Conclusion

In conclusion, the thematic analysis of interview showcase willingness to implement National education policy but everyone was wanted proper guideline and structure to run a policy.

After some time students and professors understood the importance and relevance of National education policy 2020 then it was easy to accept and adapt to work with it.

As we know Co – curriculum is one of the most important elements in this policy. Initially it was really difficult to understand and implement as well. But with help of proper guideline by university it was possible to frame proper structure and run the policy. Co- curriculum is the most attractive part of this policy and more over its getting evaluate properly.

Co-curriculum is not only beneficial to score good in the mark list but its also helping students to create something by their own , Inculcate entrepreneurship skill into them and make them self-reliant.

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मानविकी एवं समाजविज्ञान की द्विभाषी शोध-पत्रिका

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STAY HOME. STAY (NOT) SAFE: VIOLENCE AGAINST WOMEN IN THE MUMBAI REGION DURING COVID-19.

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Abstract: Most crises take a toll on interpersonal relationships. This Corona pandemic caused due to the spread of Covid-19 virus too was no exception. Humans in modern times value and need personal space. This space was crunched due to the lockdown and the government's order to "Stay Home. Stay Safe"! The same order proved to be ridiculous as women were not safe at home but faced domestic violence at home. As the Covid-19 pandemic and the resultant lockdown were unprecedented the violence against women too took many shapes. Hence, data collection by government agencies and other organizations in the first place took time. It indicated that the worldwide phenomenon of increasing domestic violence also existed in India in general and Mumbai in particular. Thus, the paper attempts to prove the hypothesis that the home was not at all a haven for many women during the pandemic and there was a tremendous rise in violence against women in the Mumbai region during COVID-19. Agencies faced many restrictions due to the lockdown. The present paper examines the causes of the violence against women and the efforts taken by Governmental and non-governmental bodies to reach out to the victims. The paper also attempts to investigate the reasons why these efforts proved insufficient while suggesting certain measures. The conclusion of the present paper is based on the various reports of the NGOs working in and for the Mumbai region making this research qualitative and not quantitative.

Key Words: Mumbai, violence against women, Covid-19, home, safety

Introduction: Human History is a history of pandemics, natural calamities, and other such post-apocalyptic mishaps. Man has always fallen short of time to prepare to face the repercussions of all the contagions. Whenever such catastrophe has stricken, science has taken its own time to bell out humankind from the clutches of the Pandemic Situation. Turning the pages of the past, one can see that various infectious diseases have devoured man and have devastated the normal routine of life. In 2020, the novel corona-virus or Covid-19, often described as the great leveller, struck everywhere and everyone - rich and poor, workers and masters, irrespective of religion, colour or caste across the world. India noticed this growing threat in early 2020. By March, it was evident that the pandemic had reached India, and itsspread was rapid.

The story of the pandemic *is* not only the story of the sufferings of humans but the saga of the sufferings of women as they are doubly victims, at the hands of natural calamity and the hands of the opposite gender. The fatal corona virus can never be more harmful than man's institutional idea that he can build his domain upon the ruins of others. While quarantine is an effective infection control measure, it can lead to significant health, social, economic and psychological consequences. COVID-19 and violence against women are interrelated.

Most crises take a toll on interpersonal relationships. This pandemic too was no exception. Humans in modern times value and need personal space. This space was crunched due to the lockdown and the government's order of "Stay Home. Stay Safe"! It goes without saying, that absence makes the heart grow fonder, and familiarity breeds contempt. Too much closeness due to stay-home compulsion led to many frictions at home. "Stay Home. Stay Safe" proved to be

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ridiculous as women were not safe at home but faced domestic violence at home. It was presumed so far that women are unsafe out of the home. Hence, whenever women are attacked questions are asked such as Where was she? At what time? What was she wearing? Was she alone? All of this puts a responsibility on the individual woman for her safety. However, these questions proved redundant as she was home. The cases of violence against women were on the rise during the pandemic of Covid-19. UN report states thatone in three women experience intimate partner violence (IPV) worldwide, and the economic costs of this violence range from 1% to 4% of global GDP(Gross Domestic Product). UN has referred to the rise in violence against women during the Covid19 pandemic and accompanying lockdowns as the "Shadow Pandemic". This is a stark reminder of the scale of gender inequality and discrimination against women. The definition given by UN of the violence against women goes as: "any act of gender-based violence that results in, or is likely to result in, physical, sexual, or mental harm or suffering to women, including threats of such acts, coercion or arbitrary deprivation of liberty, whether occurring in public or in private life." (UN Women, 2020)

Literature Review: Lal (2023) in her article investigates the types and magnitudes of violence with respect to women during pandemic. Her article reiterates the UN Women's mention of the pandemic as 'parallel or shadow pandemic' given the rise in the reported cases of violence against women in different countries of the world (Lal, 2023). Women globally underwent Gender Based Violence leading to isolation, loneliness and uncertainties. This has been referred to as 'quarantine paradox' (Mittal & Singh, 2021). The fact that lockdown procedures in the majority of countries have isolated women from violent partners is one of the pandemic's negative effects on women (Chandra & Gandhi, 2020).There is a dearth of comprehensive studies estimating the relationship between violence against women(VAW) and the COVID-19 pandemic.Most of the articles are commentaries, letters, and editorials, and most of the published data derives from social media, internet, anecdotal evidence, and helpline reports. Although there are reports from civil society, states, national human rights institutions, international organizations, academia and other stakeholders in India, the study based on the Mumbai region are a few. The present paper aims at filling that gap. The paper is designed to provide a broad overview of the problem of VAW during the COVID-19 pandemic. The review of the literature underscores that there is a risein domestic violence, in the COVID-19 pandemic. One of the major delimitations of this paper is that it talks about only violence and no other problems faced by women such as food safety, health, nutrition, etc.

Causes of Domestic Violence: Domestic violence includes all types of abuse. If the definition given by law as per the Domestic Violence Act of 2005 is checked, it gives four types of abuses viz: physical, sexual, verbal and emotional and economic(Ministry of Law and Justice, 2005)

The stress of confinement, financial uncertainty, attitudes about gender roles and a desire for control during disasters all contribute to an increased risk of Interpersonal Violence (IPV) or Domestic Violence (DV). The victim is unable to seek out the customary channels of support—friends, family, relatives, doctors, or police—for assistance (Tomar & Mohanty, 2020). Many transactions went online/digital during the lockdown. Though technology proved to be a boon to many, it was a disaster for females making them all the more vulnerable. Cybercrimes increased. The cases of cyberbullying were multiplied. One of the very important reasons for the increase in GBV is that the perpetrator knew that she had nowhere to go due to the lockdown. Police were busy with pandemic-related duties. As a result, the call for help went unattended. Working women were victims of frustration as they had to balance between office work and household chores without any domestic help. Many went into depression. Though the loss of jobs added stress equally to males and females, husbands poured their frustrations on females in the house (wife, daughter and at times mother) indulging in physical violence.

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It should also be noted that the Indian lockdown caused a shadow pandemic in which violence against women increased at home and online platforms, unfortunately, the complaints regarding rape and sexual harassment decreased sharply. During quarantine, as more women were in informal jobs and got laid off, this led them to experiencing a greater impact as they became economically dependent on their male counterparts. The first lockdown, from March to May 2020, severely impacted women. Like others in cities and towns all over India, women too lost jobs, saw their savings dwindle and witnessed family and friends falling seriously sick. As the pandemic was novel so was the violence. However, what remained unforeseen was the slogan, Stay Home! Stay Safe! Would mean something entirely different for women. With family members at home all the time, women weredoubly impacted not only by economic and other losses but also by a heavier burden of housework and the ugly spectre of domestic violence looming over them. In India, data collection usually takes time. However, data gathered by government agencies and other organizations indicated that the worldwide phenomenon of increasing domestic violence also existed in India.

Nature of Violence: Home has always been conceived as a place for relaxation, leisure, learning and family support as well. It is here our basic needs are met. It also is the place where women as homemakers are expected to fulfil their roles as mothers, wives and daughters. Customary gender norms make the home a woman's primary workplace and responsibility. The home is also a closed space, a private space kept out of reach of the neighborhood and the community. Domestic violence has been something of an open secret, known but dismissed as private, to be resolved or suffered within the family and between its members. Fortunately, our laws have clearly stated domestic violence is a crime and not just a family matter to be hushed or ignored. During the Covid-19pandemic, however, domestic violence becomes multi-dimensional solely as the lockdown resulted in many women and their children locked up with their abusers. Initial data and experiences of women's rights organizations suggest that there were many more survivors of domestic violence than those who reached out for help. Women had nowhere to go and no one to whom they could turn for help. All support services were discontinued and the nodal agency for women, i.e., the police, was concentrating on patrolling and imposing COVID-19 lockdown restrictions.

Laws and services that protect and help women in distress already exist. There are government-run shelter homes, One Stop Crisis (OSC) Centres and legal aid, protection officers and so on. However, women's groups found that government services were not available during the lockdown because the services meant to address domestic violence were not considered part of essential services. People with Disabilities (PWDs), largely invisible in the country, constitute little over 2% of the total population. Many of them depend on external help to get through everyday activities. In a country with hardly any facilities for the disabled in normal circumstances, one can only imagine the difficulties PWDs faced during the lockdown. Moreover, women with disabilities are even more disadvantaged and vulnerable than their male counterparts. As the United Nations Secretary-General had said even as governments implement lockdowns, they needed to also make prevention and redress of violence a part of their national response, plans and policies. National and state governments could have responded to the rising rates of violence announced by their own women's departments through public announcements, policies, and directives(Guterres, 2020).

The National Commission for Women which receives complaints of domestic violence from across the country, recorded a more than twofold rise in gender-based violence in the national Coronavirus lockdown period. The total complaints from women rose from 116 in the first week of March to 257 in the final week. In April and May 2020, 47.2% of all cases received by NCW were of domestic violence as compared to only 20.6% of cases between January and

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March2020(Press Information Bureau, 2020).During the second wave of the pandemic, NCW received 30865 cases of which about 21.6% related to domestic violence (Pandit, 2022). Those who were addicted to substances were spending meagre savings on purchasing alcohol, for instance, leading to growing conflicts at home. Women and children were getting beaten up more, as they were the soft targets in the household (Ansari, 2021). The economic instability during the pandemic and social and cultural norms of India ignited psychological abuse against women during the pandemic. The stress of confinement, financial uncertainty, attitudes about gender roles and a desire for control during disasters all contribute to an increased risk of IPV/DV (Huq M, 2021).

Majors taken by agencies: Pre-covid studies show that 86% of women who experience domestic violence do not seek help in India. As an immediate response to rising cases of domestic violence, NCW had launched a helpline during the first wave itself (Press Information Bureau, 2020). Invisible Scars, an NGO working to help domestic violence victims launched helpline 'Mpower 1 on 1' to report domestic abuse(Roy, 2020). That proves furthermore the gravity of the situation. Akshara Foundation, a Mumbai-based NGO has published a report with the objective of documenting some of the problems survivors of domestic violence faced during the pandemic and lockdown, to describe some State & women's rights groups' interventions and put forward recommendations for immediate and long-term advocacy to be more pandemic/disaster prepared in the future. It referenced twenty Women's Rights Organizations from eleven states and interviewed thirteen of them working on the issue of violence which were active during the lockdown period and were ready to share their field experiences. According to data shared by them, there was a 2.5 times increase in cases of domestic violence registered between February 27and May 31, 2020. Activists and field workers tried to help women exposed to violence and abuse inside their homes realized that women were not even able to make a phone call to them to ask for help. Further, it states that even if they managed to reach out somehow, it was nearly impossible to intervene in any manner except telephonically because no one was allowed to step out(Akshara Foundation, 2021). Activists from the Special Cell for Women and Children, TISS, Mumbai elaborated on how strained marital relationships led to aggression against women in families during the lockdown(Special Cell for Women and Children, n.d.). Bharatiya Stree Shakti's comparative report of 2018-19 and 2021 underlines the fact of the increase in violence and the "nowhere to go" condition of the victims(Bharatiya Stree Shakti, 2022). Considering the metropolitan nature of the city with diverse social, religious and economic conditions, it goes without saying that everyone needs to chip in. No one agency can do this, it has to be the collective effort of society, of the community of young people acting for equality; the mass media projecting better role models, the police and legal system working effectively, the corporates hiring more women and keeping them safe from harassment and the family supporting their daughters".

Suggestions and Conclusions: Most women's groups have linked their economic status and financial independence to greater chances of resisting or enduring domestic violence. So, women must have that fallback and not be dependent on perpetrators for their basic needs. This is one long-term advocacy that they will need to work on during and post-pandemic. A disaster of the scale of the pandemic needs public activism as well as state intervention and collaboration between different entities to be successfully handled. In the long term, both women's rights groups and the government have to pursue their efforts to ensure the enhancement of women's capabilities and agency to resist violence. It has been established that women with some form of safety net are in a better position to challenge domestic violence. While quarantine is an effective infection control measure, it has led to significant health, social, economic and psychological consequences, study shows. COVID-19 and violence against

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women are interrelated pandemics. Health healthcare system should learn from the actual tragic scenario in order to identify creative solutions to the violence against women. The government and the health care system should learn from the actual tragic scenario to identify creative solutions to provide clinical care and forensic services for victims of violence. They should be able to face other future calamities, in which the hospitals might become inaccessible. Not only Government/ Non-governmental helplines should be active but there should be a special task force to attend to it. The role of cyber cells and Civil Society Organizations is significant.

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BEYOND BORDERS: G20'S IMPACT ON WOMEN'S EMPOWERMENT – NAVIGATING A GLOBAL PATH TO EQUALITY

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Abstract
This research explores the multifaceted relationship between the Group of Twenty (G20) and women's empowerment, delving into the global initiatives, commitments, and collaborative efforts that shape the path toward gender equality. This study scrutinizes the policies and practices employed by G20 member countries, assessing the socio-economic impact on women and identifying challenges and opportunities. Through case studies, comprehensive analysis, and a forward-looking perspective, this research article aims to provide valuable insights into how the G20 can play a transformative role in fostering a more inclusive and equitable world for women. G20 summits have taken place yearly since 2008. Among the working groups inside the G20 is Women 20 (W20), which was established in 2015 during the Turkish Presidency. W20 was founded with the intention of accelerating women's economic emancipation. Considering the shared objectives among the G20 nations, the effects of varied plans and policies for development, and initiatives carried out inside the G20 framework have resulted in a noticeable improvement in the women's socioeconomic standing. Numerous Communiqués and Declarations issued since its founding are the authentic evidence of their unwavering dedication to the economic emancipation of women. The purpose of this article is to examine the G20's pledges to gender equality among its member nations, as there is still more work to be done in promoting empowerment.

Keywords: *Women empowerment, G20, Gender equality, SDGs, W20, WeFi.*

Introduction:

India's G20 agenda is centred on the economic empowerment of women. This intergovernmental forum of the G20 promises a platform for members to collaboratively translate ideas into concrete solutions targeted at attaining substantial and sustainable gender equality, while also exploring the potential of gender transformative initiatives. Gender equality has consistently been a significant concern due to the economic, social, cultural, and political circumstances that women face worldwide. The typical issues that women encounter, both both developed and developing nations have endured for a considerable amount of time. However, women who have been successfully aiding in the promotion economic expansion of the countries, aside from sharing a diverse range of duties, playing a crucial part in raising their youngsters, as well as completing the family income, they continue to face discrimination at each level. Despite several initiatives and actions done and attempts made at various levels, the difference in health between genders, decision-making, diet, work, and education creating, and more crucially in political participation. Right from the start, it is crucial to underscore that putting an end to any and all types of discrimination against women and girls is not just a matter of fundamental human rights but is also imperative for expediting sustainable development. Hence, the empowerment of women and girls is poised to generate cascading positive effects, propelling economic growth and development. The initiative to empower women gained momentum in 1975, marked as the International Women's Year by the UN General Assembly, coinciding with the inaugural World Women Conference in Mexico. Subsequently, a

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significant advancement occurred during the 4th World Conference on Women in Beijing in 1995, ushering in a new era and revitalizing the global perspective on women's empowerment. Following the 1997 Asian financial crisis, the G20 emerged in 1999 as a coalition comprising 19 countries, along with the European Union, providing a platform for finance ministers and central bank governors to collaborate on strategic measures addressing global economic challenges. Collectively, the G20 nations account for 85 percent of the world's economy and represent two-thirds of the global population.

Since 2008, annual G20 meetings have taken place, featuring several working groups, including Women 20 (W20) introduced in 2015 during the Turkish Presidency, along with B20, T20, C20, L20, and Y20. W20's primary goal is to bolster women's economic empowerment. The issues related to women's empowerment vary based on the distinct priorities and aspirations at the country level. Given the shared interests among G20 nations, the implementation of various developmental policies, plans, and programs within the G20 framework has notably improved the socio-economic status of women. Notably, W20 and We-Fi (Women Entrepreneurs - Finance Initiative) emerge as critical initiatives, creating an enabling environment for women's empowerment and contributing to an enhanced quality of life.

In pursuit of achieving Sustainable Development Goal 5: Gender Equality, the Indian Government has implemented remarkable initiatives, including Stand-Up India, PM MUDRA Yojana, Beti Bachao Beti Padhao, and POSHAN Abhiyaan, aimed at expanding opportunities for women in entrepreneurship. The promotion of women-led enterprises has been further facilitated through Self-Help Groups, which enhance skills and encourage women's entrepreneurship. To address credit gaps and provide comprehensive financial services such as savings accounts, need-based lending, remittances services, insurance, and pensions, the government has introduced financial inclusion schemes like the Pradhan Mantri Jan Dhan Yojana (PMJDY). This effort has resulted in the establishment of over 460 million bank accounts, with women owning 56 percent of them. Notably, the average deposit into PMJDY accounts has tripled from INR 1,279 to INR 3,761 between 2015 and 2022. Similarly, the Udyam Sakhi portal has proven effective in disseminating information about government schemes, policies, and activities for women entrepreneurs, contributing to enhanced financial inclusion. Notably, the fiscal year 2022 witnessed the registration of approximately 8.59 lakh women-led MSMEs, a significant increase from the 4.9 lakh registrations in the previous fiscal year.

From its establishment, the G20 has consistently demonstrated its unwavering dedication to women's economic empowerment and addressing crucial issues through the issuance of various Communiqués and Declarations following each summit and Ministerial meetings. These official statements serve as concrete evidence of the participating countries' resolute commitment to advancing gender equality. Repeatedly, the Heads of G20 nations have emphasized their earnest commitments to enhance cooperation, highlighting the significance of the W20 as a crucial mechanism for fostering closer coordination on matters related to gender equality. This paper seeks to evaluate the G20's dedication to promoting gender equality globally, recognizing that there is substantial progress yet to be achieved. The G20 has a significant role in providing substantial momentum to women's economic empowerment and striving to diminish the gender gap in the labor force participation rate by 25 percent before 2025. Consequently, it is imperative to implement concrete strategic measures that correspond to the commitments articulated in diverse G20 forums.

Empowering women is not merely an option but an essential requirement. It involves enhancing results, investing in more robust communities, and fostering resilient economies. The Constitutional framework of India upholds the principle of gender equality, and the government consistently demonstrates dedication to advancing gender equality across various

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sectors and governance levels. Effectively addressing gender disparities requires substantial financial support. Gender budgeting emerges as a crucial strategy in this pursuit.

Research Methodology:

This research has extensively used Qualitative research design. Analyzing relevant policy documents, reports, and statements related to G20 initiatives on women's empowerment. This includes official G20 documents, national reports, and academic publications.

Women 20:

Established during the Turkish Presidency in 2015, Women 20 (W20) is a network comprising transnational women's organizations, think tanks, and associations of female entrepreneurs. Its primary goal is to advocate for women's economic empowerment within the broader G20 framework. Within the context of Sustainable Development Goal 5 (SDG-5), there is ample opportunity to integrate women into the workforce to achieve gender equality and empower all women and girls. W20 has consistently urged the G20 to adopt the '25 by 25' initiative, aiming to reduce the gender gap in the labor force participation rate, ultimately contributing to the reduction of overall poverty and inequality. Their persistent commitment involves advocating for an equal distribution of paid work and unpaid care, emphasizing the value of care and domestic work traditionally undertaken by women. Furthermore, W20 emphasizes the importance of recognizing the potential of female entrepreneurship and urges the G20 to prioritize financial inclusion for women, ensuring access to finance, credit, training, and technical support. Digital inclusion is also highlighted, with a call to eliminate the gender gap in access to information communication technologies. W20 insists on specific measures within G20 to facilitate girls' access to STEM education (science, technology, engineering, mathematics) and underscores the importance of supporting women-owned enterprises and innovation in the ICT sector. The reaffirmation underscores the necessity of implementing women-centric policies for fair, equitable, and sustainable development, thereby strengthening the W20 initiative.

Throughout the years, the G20 has actively worked towards fostering economic empowerment for women, issuing impactful declarations and communiqués and coordinating member countries' activities accordingly. Consequently, each member country holds the responsibility to formulate actionable plans ensuring gender equality within their borders. Despite the W20's call for increased efforts in monitoring gender-related issues through data sets, empirical studies, and a G20 scorecard, it appears that these measurable actions have not been fully implemented yet (Shaffner, 2018).

The Indian presidency has called on G20 leaders to honor their previous commitments outlined in the 2022 Bali Leaders' Declaration and the 2021 Rome Roadmap. It is actively working to advance global strides in gender equality and equity, encompassing various initiatives such as the development of national gender strategies and systematic progress monitoring through gender-disaggregated data collection in all member nations. With a focus on advocating for Global South countries, the Indian presidency is committed to addressing gender and development concerns for non-member nations. Priority areas include addressing climate change impacts, fostering entrepreneurship, bridging the gender digital gap, promoting grassroots leadership, and enhancing education, skill development, and labor market participation.

Recognizing the intersectionality of climate change and gender, the Indian presidency emphasizes the pivotal role of women in climate justice pursuits. It urges inclusive and gender-equitable approaches in all climate-related policies and advocates for women's active involvement in decision-making platforms for climate action. The presidency emphasizes the need for gender-responsive policymaking, including in relation to Nationally Determined Contributions (NDCs), and seeks to embed a strong gender orientation in financial

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commitments for climate action. The promotion of women's entrepreneurship is identified as a catalyst for women-centric development on a global scale. The Indian presidency underscores the influential role of women entrepreneurs in driving GDP growth, job creation, and the provision of essential goods and services. To address challenges faced by women-led enterprises, the presidency advocates for policies that tackle legal, regulatory, and societal obstacles while improving access to capital and financial services.

Efforts to broaden market access encompass public and corporate procurement, supply chain inclusion, and the adoption of innovative technologies. Initiatives include the establishment of women-focused business centers to facilitate the transition of women entrepreneurs from informal to formal status. The Indian presidency is actively working to institutionalize gender-responsive public procurement programs across G20 nations, with a goal to set national targets by 2030 for aligning public procurement practices with gender-inclusive objectives.

Addressing the gender-based digital divide is identified as a crucial challenge. Efforts are underway to halve the digital gender gap by 2030, focusing on barriers related to affordability, ski*lls, access, security, and the adoption of digital technologies by women. Special attention is ++needed to prevent gender biases in Machine Learning (ML) and Artificial Intelligence (AI). The W20 Engagement Group recommends implementing tax reductions or incentives for women-led technology startups and female entrepreneurs in tech-powered enterprises. Grassroots leadership by women is considered pivotal for women-centric development. The Indian presidency aims to empower women to assume leadership roles and catalyze societal transformation, drawing inspiration from India's success in women securing significant leadership positions in local governance structures. Recognizing education as a fundamental right, the Indian presidency aims to propel the education, skill development, and labor market involvement of women. Emphasis is placed on upskilling women in emerging sectors and STEM fields, along with ensuring access to affordable hygiene, health, and nutritional products and services. The promotion of inclusive research in health, medical devices, and pharmaceuticals is highlighted, along with efforts to adopt and enforce anti-violence legislation and workplace safety measures. Legislation for gender pay gap reporting is also being pursued across various sectors. A crucial aspect of the strategy involves augmenting funding for a "universal basic care basket" to standardize, professionalize, and formalize the care economy. This initiative aims to create a conducive environment for women's economic participation by addressing childcare, elderly care, and care for those with disabilities.

The Indian presidency calls for a renewed commitment to past UN agreements, such as the commitment by G20 donor countries to allocate 0.7 percent of GNI to support global development. Developing care infrastructure is identified as a critical component in enhancing women's economic participation across G20 countries, along with policies to protect and improve maternity and parental benefits. Indian presidency's comprehensive approach covers diverse areas, including entrepreneurship, digital inclusion, climate justice, grassroots leadership, education, healthcare, and care infrastructure, with the overarching goal of advancing gender equality and women's economic empowerment on a global scale.

India, along with 193 other UN member countries, is a signatory to the "Transforming our World: the 2030 Agenda for Sustainable Development," which was adopted by the UN in 2015. This agenda comprises 17 Sustainable Development Goals (SDGs) with 169 targets, guided by the principle of 'leaving no one behind.' While none of the G20 countries effectively practice gender equality, India played a significant role in shaping the outcome of the 2030 Agenda, particularly SDG5, which focuses on gender equality. SDG5 is an independent goal aiming to "achieve gender equality and empower all women and girls," although gender equality is integrated throughout the entire 2030 Agenda. Similar to the G20 Agenda, SDG5 outlines various targets to eliminate discrimination and violence against women, ensure women's effective participation in the workplace, provide equal opportunities for leadership, address

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reproductive and sexual health, and guarantee ownership and control over property, supported by existing laws and policies.

SDG5 recognizes that women's empowerment is a prerequisite for achieving several other SDGs, such as poverty eradication, inequality reduction, access to good health, and education for all, as well as promoting decent work and economic growth. In practice, significant gaps in development policies and investments hinder women from realizing their full potential in social, economic, and political life across most G20 countries. Government policies often lack support for informal sector activities, where a substantial female workforce is involved. The substantial contributions women make to the domestic sphere are not considered productive output and are not included in national accounts.

India's Constitution strongly mandates equality and women's rights through its Preamble, Fundamental Rights and Duties, and Directive Principles of State Policy. India is also a signatory to various UN Conventions, including the Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW), the Beijing Platform for Action, and the Convention on the Rights of the Child, affirming the nation's commitment to protecting and empowering women and girls. Laws against sex-selective abortion, child marriage, and workplace sexual harassment are implemented to safeguard women's interests. Initiatives like Beti Bachao Beti Padhao (BBBP) aim to improve the child sex ratio. The Government of India has recently finalized the Draft National Policy for Women 2017, envisioning a society where women attain their full potential and participate as equal partners in all aspects of life. In India, women constitute nearly half of the population, yet gender equality in education, health, economics, and politics remains an elusive goal for most. Despite legislative reforms and policy initiatives, gender discrimination persists as a significant social problem. Deep-rooted issues such as patriarchy, unequal distribution of wealth and resources, climate change, and unequal gender roles contribute to multiple socio-economic inequalities for women within India.

Way Ahead:

The correlation between the social and economic empowerment of women is often linked to their participation in the labor force and income. However, mere access to employment and income does not automatically enhance the socio-economic status of women or their influence in decision-making processes. A range of factors, including socio-cultural, educational, economic, and political elements, contribute to persistent gender gaps in some G20 countries. Achieving real empowerment requires robust socio-economic, political, and legal measures devoid of discriminatory policies to promote gender equality across various domains. Unfortunately, at least fifteen G20 countries still maintain discriminatory laws restricting women's involvement in the formal economic sector (Dutkiewicz & Ellis, 2018). It is crucial to eliminate such legal barriers to enable women's participation and unleash their full potential in the labor market. Decades of research on gender equality underscore the need for a specific development paradigm tailored to meet women's needs and aspirations, facilitating their active engagement in the labor force. In this context, the establishment of W20 and WeFi by the G20 represents significant initiatives offering substantial opportunities for women to assert themselves in traditionally male-dominated spheres. While the tangible results of numerous We-Fi projects initiated in the first year are yet to be fully realized, it is anticipated that subsequent projects in demand-driven countries will yield the desired outcomes.

Furthermore, the governments of G20 countries should collaborate effectively with public, private, and civil society organizations to bring about substantial improvements in the socio-economic conditions of women. It is essential to acknowledge that the achieved results so far stem from positive initiatives. Women's empowerment is an incremental process that requires time, and it involves changing the overall perception of those at the bottom of the social hierarchy.

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WOMEN EMPOWERMENT - II

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Beyond Taboos – Destigmatising Menstruation and Empowering Women: Women Empowerment and Society

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Abstract

Menstruation is often prohibited, veiled in secrecy, and shrouded in mythology in several regions of the world. Menstruation and menstrual hygiene, are becoming crucial challenges for development, human rights, and gender equality. Menstruation does, in fact, sustain mankind and ought to be embraced today and every day rather than being shrouded in shame and contempt. Despite its universality, menstrual health remains a taboo topic in many cultures and is inadequately addressed in health and educational sectors. This research paper explores the relationship between menstrual health and women's empowerment, arguing that the management of menstruation can have profound implications for the individual, community, and societal empowerment of women. The social stigmas, preconceptions, and misunderstandings that affect how women manage their periods are among the biggest obstacles. The research's conclusions are consistent with the global quiet and worries. Many girls lack biological understanding and are unaware of what happens when they begin menstruation. This paper emphasizes the importance of proper management of menstruation hygiene in empowering women and ending the cycle of stigma. It highlights how having access to clean and safe menstrual products can have a good impact on women's engagement in public life and the workforce, as well as girls' education.

Keywords: Menstrual Health; Women's Empowerment; Reproductive Rights; Gender Equality; Menstrual Hygiene Management; Menstrual Equity.

Introduction :

Only a few weeks have passed since a young 12-year-old girl in Ulhasnagar, Maharashtra, was murdered by her own brother. Why? Because there were blood stains on her clothes, her brother, who had no idea that his sister was menstruating, assumed that she was having sex. Due to her lack of knowledge and the stigma associated with menstruation and menstrual health, the child was unable to explain why there were stains on her clothes when questioned. The 30-year-old man tortured and physically abused his sister because of his misperception of how biology works. This

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incident brought to light two issues that our culture still struggle with today. First and first, women lack the fundamental information, knowledge, and awareness about the normal biological processes occurring in their bodies. Second, the patriarchal patronage acts as the protectors of women and is thus entitled to govern and punish their bodies as they see fit. Women have been held captive by patriarchal gender standards on a physical and psychological level for decades, and today's unfavourable perceptions of menstruation are a result of lack of knowledge about and stigma surrounding women's menstrual cycles. Girls are put in a position where they could experience shame and low self- esteem because of their menstrual bodies as a result of this animosity, misinformation, and lack of awareness. Around 300 million women worldwide are menstruation on any given day, and on average, a woman has her period for around seven years of her life.

Women are so silenced, given less autonomy over their bodies, and menstruation becomes associated with stigma and shame.This incident exemplifies the widespread discrimination menstruating women face in India, where the taboo surrounding menstruation has solidified the idea that they are filthy. A parallel for how the community and culture as a whole are generally against having an informed attitude and awareness of the menstrual cycle is provided by the brother's anger and violence towards his sister. The majority of the population is shaped by conventional and outdated ideology, attitudes, and beliefs. We seem to be advancing towards a "gender inclusive" future in 2023, but we are still stuck in the past. Women frequently choose to manage their periods at home due to a lack of facilities at work, school, and in public places, which prevents them from engaging in cultural, educational, social, and income-generating activities. Unsafe procedures and materials make the issue worse. Additionally, many women and girls do not have access to sanitary and safe materials. Menstrual pads are said to be dried in secluded, dark areas, yet this does not guarantee the eradication of germs. In fact, one of the main causes of infection is insufficient washing and drying of materials. Women typically dispose of used disposables in toilets and latrines that are unable to handle this waste, which causes clogging, overflowing, and pollution where they are used.

The social stigmas, prejudices, and myths that affect how women and girls manage their periods and, as a result, have an impact on their everyday lives, rank as one of the biggest obstacles for women. Religious, dietary, household, and sexual restrictions placed on women and girls during menstruation frequently result in further marginalisation or stigmatisation. And last, how many cultures view girls is influenced by how they interpret menstruation. Menstruation is frequently seen as a sign of maturity, indicating that girls have matured enough to perhaps be ready for marriage. However, having children too soon after marriage greatly raises the danger of having several pregnancies without enough time between them.

Research conducted by UNICEF found that until they reach puberty, 71% of adolescent girls in India lack understanding and access to information regarding the menstrual cycle. Menstruation is a subject that is steeped in myth and mystery, especially in rural areas. It is considered to be dirty, wicked, unclean, and unholy. Women are unable to perform basic tasks like entering their own homes, cooking, or going to the temple due to the related culture of shame and embarrassment. Due to the negative external reactions from society, it is only natural for young girls to avoid and overlook the topic of conversation when they are prevented from going about their daily lives while menstruating. In addition, 1 in 5 females leave school early due to a lack of access to sufficient sanitary pads or other period supplies. As a result, these young girls are sent down the same path as the majority of women in their community,

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which includes illiteracy, teenage marriage, and social, economic, and mental servitude. This has a tremendous detrimental impact on their future. It is a downward spiral, but it can be stopped if menstrual products are available and the correct information is made available. The lives of these girls have the potential to improve not only the lives of other women but also those of their whole community, society, and economy.

Menstrual health management encompasses more than just providing girls with sanitary napkins. Giving a girl a pad is insufficient if she doesn't understand why menstruation occurs, has to skip school while having her period, or is embarrassed to express worries about her health. Menstruating people need to understand the biological mechanisms that cause their periods, as well as a safe environment in which to understand and express their demands. Every woman who menstruates should have access to this essential right.

Impact of Myths Related to Menstruation on Women's Life

Menstruation-related taboos, which are prevalent in many societies, have an impact on girls' and women's emotional well-being, attitude, way of life, and, most significantly, health. In many less economically developed nations, a significant portion of girls stop attending school when they start their period. In addition, the monthly menstrual cycle presents challenges for female teachers. As a result, the right to privacy is compromised by the gender-discriminatory school culture, infrastructure, and lack of suitable menstruation protection options or clean, safe, and private sanitary facilities for female teachers and girls. Concerning girls and menstruation, there are additional health and hygienic considerations to take into account. Additionally, the majority of women in India, particularly in the rural hinterlands, occasionally turn to ashes, newspapers, dried leaves, and husk sand as absorbents. Girls are at danger of stigma because of the smell of menstrual blood, which may increase susceptibility to infection. Inadequate washing facilities are another issue. The latter could have serious effects on their mental health. Addressing the stigma and taboo associated with menstruation is key to empowering women and girls and promoting gender equality. Even though menstruation is a natural biological process, cultural beliefs, social norms, and misinformation have resulted in widespread negative attitudes towards it. This can lead to exclusion, discrimination, and health issues for women and girls. There are several strategies that can be employed to destigmatize menstruation and empower women:

- **Education:** Comprehensive and scientifically accurate sexual education that includes information on menstruation is fundamental. Everyone, not just women and girls, should understand the biological process of menstruation. This can help dispel myths and misinformation.
- **Open Discussions**: Encourage open, respectful conversations about menstruation. This helps break down the taboo and can improve understanding among everyone, not just those who menstruate.
- **Sanitary Products**: Access to sanitary products is often a challenge, especially in low-income communities and developing countries. By making sanitary products affordable and available, we can ensure that menstruation does not impede women and girls from carrying out their daily tasks.
- **Facilities:** Proper menstrual hygiene management requires access to clean water,

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sanitation, and private spaces. Providing these facilities can enhance the dignity and quality of life for women and girls.

- **Media representation**: Encouraging positive portrayal of menstruation in media can help normalize the process. This might include depicting menstruation in TV shows, movies, and advertisements, or writing about it in books and news articles.
- **Policies and Legal Frameworks:** Enforcing policies that ensure access to menstrual hygiene products, and provide adequate sanitary facilities in schools, workplaces, and public places is crucial. Additionally, laws that protect against discrimination based on menstruation should be enacted and enforced.
- **Community Engagement**: Engaging community leaders and influencers can help change cultural attitudes and beliefs about menstruation. This might include religious leaders, teachers, elders, celebrities, etc.
- **Menstrual Equity**: Advocating for menstrual equity – the idea that the ability to manage one's period should not be a barrier to equal opportunity – can be a powerful way to destigmatize menstruation.

Role of Men:

Encouraging men to understand and empathize with the challenges women face due to menstruation can help normalize the process. Men play an important role in destigmatizing menstruation, as they can help challenge and change negative attitudes in society.

The media is particularly important in preserving the stigma associated with periods, and it might even encourage secrecy in this area. But the picture is changing slowly. A good example are recent sanitary advertisements in India that showcase period blood as originally red over the fake blue coloured blood. Movies like Padman not just find audience but also go on to becoming commercial success. By implementing above strategies, we can create a society where menstruation is seen as a normal, natural part of life, and where all women and girls have the knowledge, resources, and support they need to manage their periods with dignity and without shame. Menstrual hygiene encompasses more than just using sanitary napkins and the proper restrooms. It is important for women to understand their bodies and to live in a setting where they may deal with their periods in secret and safety. According to research, two-thirds of all women who pass away from cervical cancer had poor menstrual hygiene.

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ECONOMIC SCOPE OF APPLICATION OF *Piper betle* L. (PAAN) FOR AESTHETIC HEALTH

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Abstract

Piper betle L. an indigenous species known for its edible leaf is cultivated on a large scale for the purpose of raw consumption. The plant is widely grown in Asian nations and is used during various occasions throughout year. Studies have suggested that the betle leaf contains many health effective biomolecules and phyto-chemicals beneficial for the health. It is commonly consumed as an aid to digestion process after having lunch or dinner. However, the aesthetic view of the leaf in various sectors may form a dosage towards the targeting effective health and also the finance by generating income through collaborative efforts at industrial levels. The research experiment is completed to analyze the bio-molecules present in the leaf of Piper betle L. and phytochemicals study with reference to health benefits and it's development in finance sectors through the application in industry. The research successfully concludes presence of health effective components and it's application stabilizing the need of an hour in current phase.

Keywords: *Health & Finance, Piper betle L., Bio-molecules.*

Introduction

Piper betle L. is the indigenous plant species originated from various Asian nations. The plant is effectively used for various aspects known for its leaf. The plant is also known to be of ethanomedicinal importance. The leaves of this plant are extremely useful for improving the digestive ability. *Piper betle* L. oil is of a prime importance useful with respect to industrial application of food and cosmetics. The plant is aromatic and effective in sense of flavoring and production of dyes too. Thus, the presence of aromatic, nutraceutical properties in the plant of *Piper betle* L. determines the eminence of the Phyto-chemical presence with respect to efficient in production of defense and acting as anti-bacterial and anti-fungal effects. The essential components of the plant support the mechanism of health effects properties as observed in the GC-MS. Throughout the whole estimation of the components through GC-MS, the components observed to be of nutraceutical importance containing the properties of anti-inflammatory, anti-cancerous (Kalita S., Kumar G *et.al.*) ability and heart disease (Prasad K., Chew L. *et.al.*). The anti-oxidant property (Aadil M., Nitesh Singh *et. al.*) of plant bio-chemical compound is of greater importance. The plants and its derived compounds (Hassine M., Zardi B., *et. al.*) useful in application of various industrial sectors. The socio-economic status of *Piper betle* L. throughout the state of West Bengal is constituting approximately around 20 lakh population involved in cultivation and harvesting. However, still a 35-70% (Mazumdar, Saikat et.al.) of the betle cultivation goes into wastage due to lack in the technology of processing industry. Hence, developing the food sector with an inclusive of *Piper betle* L. leaves in various formulations generating the aesthetic health benefits may for an opportunistic source in the for storage and processing on a large scale. The easiest way in any processing industry is semi-drying of leaves further processing of such leaves in the food sector and cosmetic sector. The longevity of betle leaves when combined with various sources increases with respect to the formulations designed food and cosmetic sector.

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The current research attempt is successfully carried out to understand the phytochemical study and targeting the experimental purpose in a food industry such as *Piper betle* green tea proving it suitable for consumption with zero addition of artificial sweeteners and artificial colours. The research attempt successfully provides a pathway towards management of *Piper betle* L. leaf which is wasted further generating the economic scope in the food industry and also in the health sector.

Materials and Method

The *Piper betle L.* leaf extract of Methanolic and Aqueous was prepared. These extracts were treated for the qualitative and Quantitative estimation for Alkaloids, Flavonoids, Tannins and Phenols. The semi-dried betle leaf (1%) mixed with triphala powder (3%) and extracted betle leaf essential oil (0.01%) were mixed and the solution was further tested for the analysis from MCGM Clinical lab approved by *fssai*.

Table 1

Sr. no.	Phytochemicals	Tests
1.	Alkaloids	Mayer's Test
		Wagner's Test
2.	Flavonoids	Alkaline Reagent Test
		Lead Acetate Test
3.	Tannins	Ferric Chloride Test
		Sodium Hydroxide Test
4.	Phenols	Ferric Chloride Test
		Ammonium Hydroxide Test

The quantitative estimation of the phytochemicals was completed through the protocols as mentioned in the book of "*Standard Methods of Biochemical Analysis*" for Alkaloids, Flavonoids, Tannins and Phenols.

Results and Discussion

The qualitative analysis of the test completed as mentioned in Table 1 is presented with its result in Table 1.1. However, the quantitative estimation of the above mentioned phyto-chemicals from Table 1 is mentioned in Table 2. The individual graphical presentation of the phyto-chemicals of Table 2 is presented in Figure 2.1, Figure 2.2, Figure 2.3 and Figure 2.4. The overall comparative study of graphical presentation of the phyto-chemicals is presented in Figure 3. Based upon the presence of phytochemicals a formulated tea extract tested from the Greater Mumbai Municipal Corporation MCGM clinical testing lab: *fssai* approved is presented in Table 3

Table 1.1

Sr. no.	Phytochemicals	Tests	Fresh Leaf		Semi-dried Leaf	
			Aq. Ext.	Met. Ext.	Aq. Ext.	Met. Ext.
1.	Alkaloids	Mayer's Test	√	√	√	√
		Wagner's Test	√	√	√	√
2.	Flavonoids	Alkaline Reagent Test	√	√	√	√
		Lead Acetate Test	√	√	√	√
3.	Tannins	Ferric Chloride Test	√	√	√	√

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4.	Phenols	Sodium Hydroxide Test	√	√	√	√
		Ferric Chloride Test	√	√	√	√
		Ammonium Hydroxide Test	√	√	√	√

Table 2

Sr. no.	Phytochemicals	Aqueous Extract (mg/gm)		Methanolic Extract (mg/gm)	
		Fresh	Semi dried	Fresh	Semi dried
1.	Alkaloids	190	540	62.8	380
2.	Flavonoids	430	440	520	610
3.	Tannins	329	619	840	718
4.	Phenols	344	303	445	432

Artificial preservative test of formulated food product
MUNICIPAL CORPORATION OF GREATER MUMBAI
Public Health Department (BMPP – 21801-2015-16-50,000)

Table 3

Sr. No.	Quality features	Name of the method of the test used	Results	Prescribe standards a) Food safety & standards (food products and food additives) Regulations, 2011 b) As per label declaration for the proprietary food. c) As per provisions of the act, rules and regulations for both the above
1.	Synthetic Food Colour	FSSAI Manual of Analysis of foods (food additives)	Not detected	Permitted as per appendix A
2.	Artificial Sweetener	FSSAI Manual of Analysis of foods (food additives)	Not detected	Permitted as per Appendix A

Opinion: The sample of tea confirms to the standards of Proprietary Food prescribed under regulation 2.12.1 of chapter 2 of food safety and standards act 2006 (Food products standards and food additives) Regulations 2011 for the parameter tested

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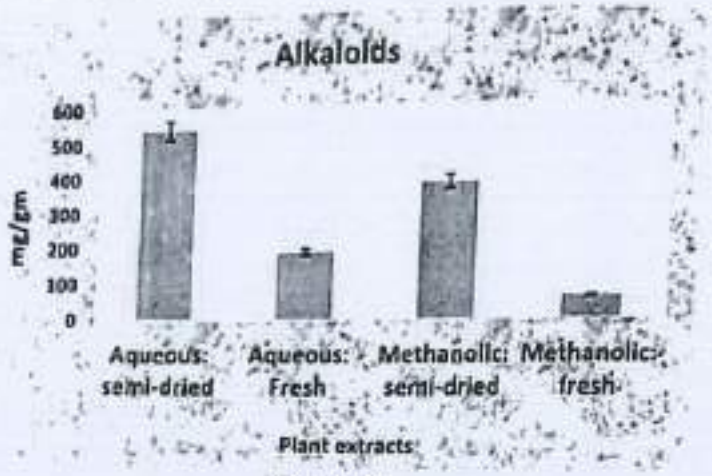


Figure 2.1

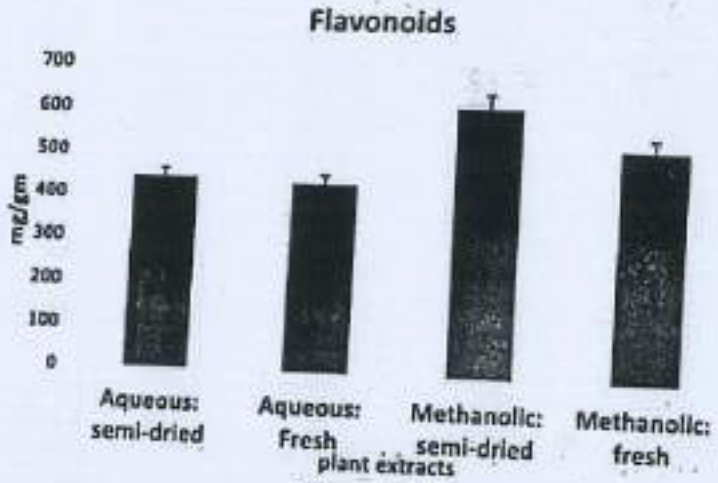


Figure 2.2

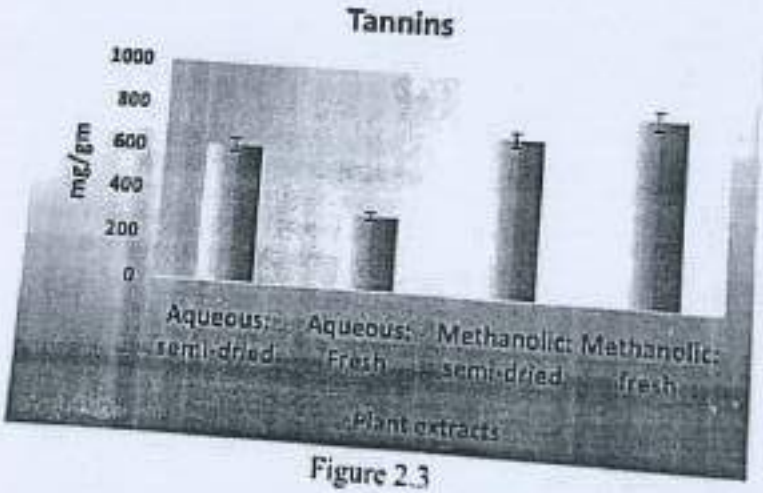


Figure 2.3

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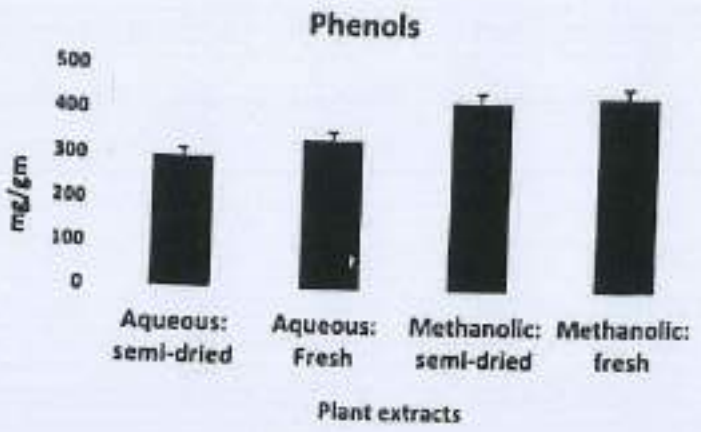


Figure 2.4

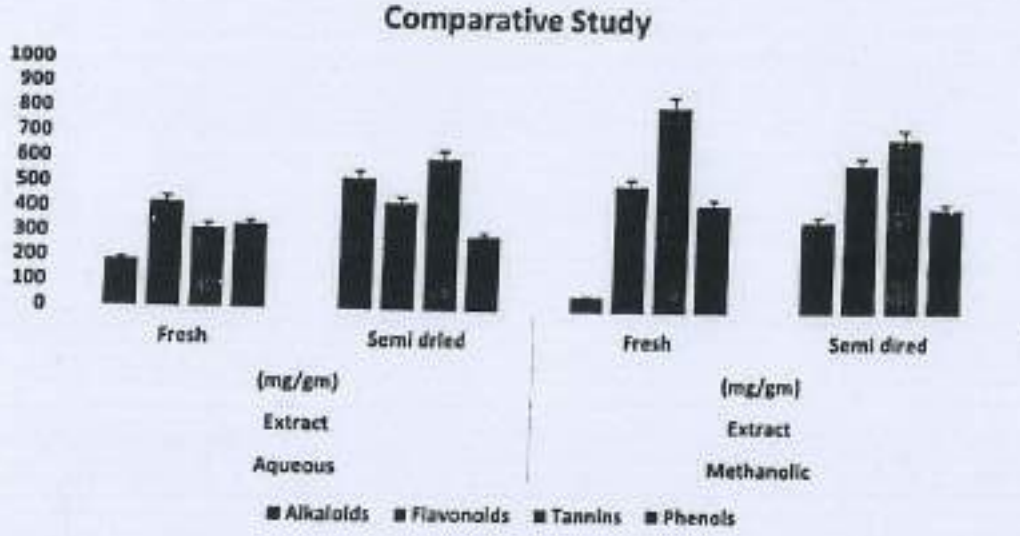


Figure 3

Table 1.1 describes the presence of phyto-chemicals such as Alkaloids, Flavonoids, Tannins and phenols which was found to be present in fresh and semi-dried leaves sample of Aqueous and methanolic solutions. Table 2 determines the amount of estimation of mg/gram of bio-chemical such as alkaloids, flavonoids, tannins and phenols in the leaf's extracts of Aqueous and Methanolic solution. The graphical presentation of Figure 2.1, Figure 2.2, Figure 2.3 and Figure 2.4 represents the individual presentation of the amount of the phyto-chemicals present in the given sample. The individual sample of graphical representation defines the amount of Flavonoids and Tannins to be greater in the methanolic solution while later with the next two components of Alkaloids and Phenols. However, the Figure 3 defines the overall comparative study of graphical presentation determining the presence of all bio-chemical estimations in the *Piper betle* L. leaf samples of Fresh and semi-dried ones. Table 3 determines that the formulated tea sample suitable for consumption when tested for its artificial sweetener and synthetic food colour from the approved *fssai* lab of MCGM.

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Conclusion

Phytochemicals such as Alkaloids, Flavonoids, Tannins and Phenols results in Tannins > Flavonoids > Phenols > Alkaloids. The number of Tannins and flavonoids are found to be greater than phenols and the alkaloids. Both these bio-chemicals are useful in industrial applications of pharmaceutical and the processing industries of various sectors. The estimation of both tannins and flavonoids are found to be greater in methanolic extracts than an aqueous extracts. Tannins are one of the plant based chemical compounds responsible for anti-inflammatory and anti-oxidant properties. Hence, the experimental analysis of *Piper betle* L. extracts for its qualitative and quantitative aspect is successfully completed leading further research experimentation in applied aspect of tea formulation to be effective in consumption for the provision of aesthetic health and a source of generating an economic scope in food sector through an easiest way of preserving the biomolecules and its effective use in the application segment.

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SUSTAINABLE FARMING PRACTICE OF MICROGREENS OF *Eleusine coracana* & *Hordeum vulgare*

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Abstract

Sustainable development practice is based on the aspect of economic, societal and environmental factors responsible for the growth of human kind. Agriculture is one of the basic need of Bharat in which a huge quantity of cultivation of monocots are followed for its seeds. Eleusine coracana (Ragi) and Hordeum vulgare (Barley) are monocot staple crop cultivated for its seeds. The seeds are consumed through various recipes added in a daily diet to gain nutritional benefits. Microgreens are delicate first leaf stage plant cultivated in 7 days from the day of sowing. Studies show microgreens to be a potent edible plant source as a whole. Apart from traditional farming practice cultivating microgreens on a large scale may benefit economy, society and environment in sustainable development methods. The research experiment is completed on the study of cultivation of Eleusine coracana and Hordeum vulgare Microgreen and it's cost effectivenes towards economical development as per the required change to incorporate in sustainable farming practice. The research experiment successfully results a key opportunity by promoting green development in the sector of aesthetic farming practice.

Keywords: *Sustainable, Eleusine coracana, Hordeum vulgare, Green Development.*

Introduction

A wide range of crops including grains, millet, legumes, oilseeds and vegetables. Ragi and barley are one of them. *Eleusine coracana* L. is cultivated in the state during the Kharif season (Singh et al., 2018) commonly known as 'Ragi'. Ragi is a type of millet. Madhur district in Uttarakhand is well known for Ragi which is one of the most important staple foods, especially for people in rural areas. The common name of ragi is finger millet, but it is known by its local name in various places. Ragi, Mandua, Nagri, Kapai, Madua etc. Ragi is widely cultivated in hilly and rainy regions. It is known as African millet because it is mainly grown in Africa and Asia regions. Originally a native plant of Highlands of Ethiopia, now the states of Maharashtra and Tamil Nadu are well known for cultivation of millet grains. It's a very nutritious food rich in calcium, fiber, protein, iron and other minerals. Cereals are easily digested and can be stored for long periods of time. Long; since insects have not been able to easily destroy it (Rani et al., 2016). It is a heat-loving crop, so it needs heat. An average temperature of 26-29°C is required for proper growth. This crop can be grown in poor to fertile soils. Mixed cropping patterns following terrace agriculture in the central Himalayas include: Making ragi. The Ministry of Agriculture classifies agricultural land into two types: Places such as Upuraon are talaus based on availability of irrigation.

Hordeum vulgare L. (Barley) grows quickly and has a cool season. Annual grains are also used as animal feed and used as a mulching to cover soil of crops to improve soil fertility (Ghanbari *et al*., 2012). It is the fifth most popular grain in the world after corn, wheat, rice, and soybean (Miralles *et al*., 2001). Total from 2013 to 2014 World barley production is 140.1 million metric tons. Barley production increased from 2012 to 2013. Bangladesh held 7000 tons of her (USDA, 2013). The main benefits of including barley in your diet today, it's because of its

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potential health benefits. Relationship between blood cholesterol and β-glucan (Behall *et al.*, 2004) glycemic index of barley (Cavallero *et al.*, 2002) has been widely reported (Pins and Kaur, 2006). Water is one of the most important elements for proper growth, balanced development and higher yields of all plants seedlings. Lack of water affects plant growth and grains yield (Hussain *et al.*, 2004; Wajid *et al.*, 2004). Cultivation practice is negatively affected by water stress in early growth stages (Baheri *et al.*, 2005). Sowing of barley seeds is carried out by scattering or sowing as a Line-seeding. Spreading method is a method of dispersing seeds. Plant in well-prepared soil and mix well with the soil. Make sure the seeds are completely covered with soil. However, cultivation practice followed for both the cereals such as *Hordeum vulgare* L. and *Eleusine coracana* is by traditional methods throughout. Hence to make effective under protected cultivation practice and open cultivation practice das a whole for both these cereals "Microgreen" plays a vital role. It is not only the effective way to improve the quality of biomass but also to produce a healthy seedling of first leaf product with high amount of nutrients and minerals.

The current research is completed to produce a sustainable approach in farming practice by cultivating micro-greens of *Eleusine coracana* and *Hordeum vulgare* L. since due to its efficacy as a nutrient packed content promoting green development by use of resourceful methodology. The result successfully provides the scope for monocots as microgreens towards all season cultivation through artificial/ closed farming practice or an open farming practice.

Material and Method

The seeds bought from the nursery of Vangani, Karjat farm house were sowed in a space of 1.5 ft. x 1 ft. of the tray. Before sowing it was treated with a normal hot water soaking for 24 hrs. After 24 hrs. Seeds were spread unevenly in the space of soilless cultivation medium coco-peat. The seeds were further germinated and allowed to grow until completion of the 7th day from the day of sowing. During sowing seeds were covered properly with a thin layer of coco-peat. The produce obtained was analyzed for its growth from the aspect of cultivation practice.

Results and Discussion

The produce obtained was calculated for its length from the tip of root to the apex of the leaf. Randomly the readings obtained from 20 microgreens of each tray were analyzed and an average readings obtained from the triplet is mentioned in a Table 1.

Table 1

SOILLESS CULTIVATION		
Sr. no.	***Eleusine coracana*** length of microgreen (cm)	***Hordeum vulgare L.*** length of microgreen (cm)
1	4	7.1
2	3.5	7.8
3	4.2	7.4
4	2	6.4
5	3	7.3
6	3.5	6.5
7	3	6.3
8	4.1	7.9
9	3.2	7.7
10	2.9	6.1
11	3	7.6

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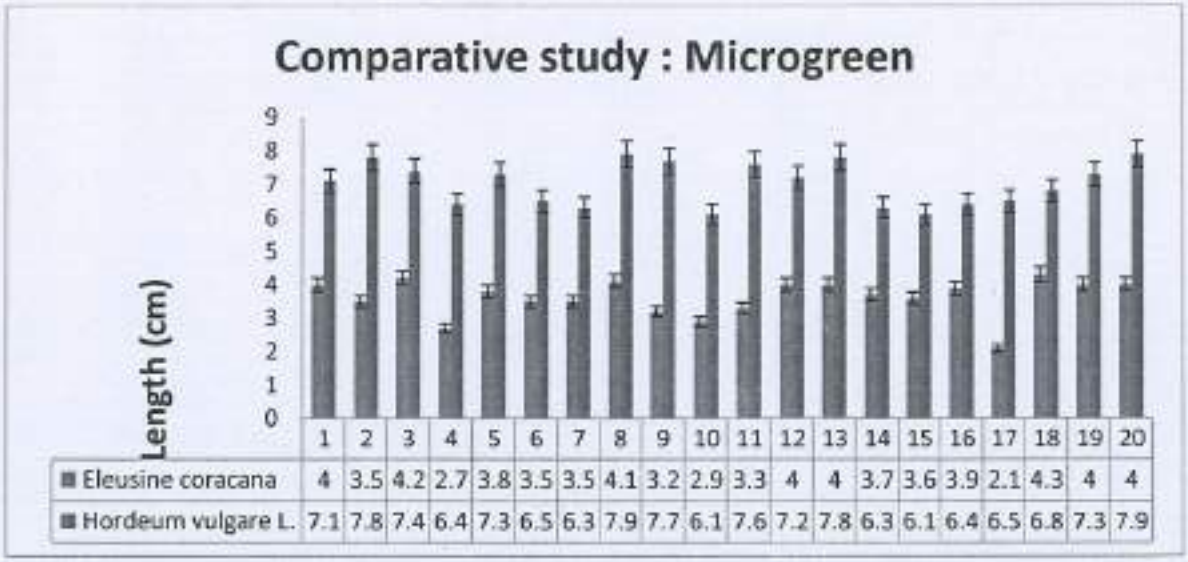
12	4	7.2
13	4	7.8
14	3.7	6.3
15	3	6.1
16	3	6.4
17	2.1	6.5
18	4.3	6.8
19	4	7.3
20	4	7.9
SUM	68.5	140.4
Mean	3.425	7.02
Median	3.5	7.15
Mode	4	7.8
Standard Deviation (Sample population)	0.671898332	0.648561161
Standard Deviation (Total population)	**22.89568441**	

Table 2

t-Test: (Unpaired) for two different sample species		
	Eleusine coracana	***Hordeum vulgare L.***
Mean	3.425	7.02
Variance	0.451447368	0.420631579
Observations	20	20
Hypothesized Mean Difference	0	
Df	38	
t Stat	-17.21614815	
P(T<=t) (α at 0.05)	**1.54503**	
t Critical (α at 0.05)	2.024394164	
P(T<=t) (α at 0.01)	**1.54503**	
t Critical (α at 0.01)	2.711557602	

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Table 3



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Eleusine coracana	4	3.5	4.2	2.7	3.8	3.5	3.5	4.1	3.2	2.9	3.3	4	4	3.7	3.6	3.9	2.1	4.3	4	4
Hordeum vulgare L.	7.1	7.8	7.4	6.4	7.3	6.5	6.3	7.9	7.7	6.1	7.6	7.2	7.8	6.3	6.1	6.4	6.5	6.8	7.3	7.9

Table 1 represents the data of the length of the microgreen for *Eleusine coracana* (Ragi) and *Hordeum vulgare* L. (Barley). The sum of the length of the microgreen of Barley (140.4 cm) is twice that of the Ragi (68.5 cm). The mean value of Barley is observed to be 7.02 while that of Ragi is 3.425; while the median observed to be 7.15 for Barley, 3.5 for Ragi and the mode found to be 7.8 in Barley and 4 in Ragi. The standard deviation within the individual sample population in Ragi was found to be 0.671 and in Barley observed to be 0.648. The Standard deviation of whole population was observed to be 22.895. Table 2 represents the data of statistical analysis of Unpaired T-test of two different samples of Microgreens highlighting the computed value to be lesser than the critical (table) value at P (T<=t) (α at 0.05) = 1.545 < 2.024394164 t Critical (α at 0.05); While at P (T<=t) (α at 0.01) 1.54503 < 2.711557602 t Critical (α at 0.01). Figure 1 represents the data set of statistical analysis of the *Eleusine coracana* and *Hordeum vulgare L.* of Table 1 showing the differences between the lengths of microgreen. A greater difference was observed in the length of microgreens between *Eleusine coracana* and *Hordeum vulgare L.*

Conclusion

The *Eleusine coracana* and *Hordeum vulgare L.* was found to be effective of 7 day's old cultivated microgreen. Both these microgreens were found to be effective Through a statistical Unpaired t-test representing a calculated value < critical value at α at 0.05; 0.01 signifying null hypothesis (H_0) to be *rejected* and alternative hypothesis (H_1) to be *accepted*. Hence, there is a significant difference between the length of the microgreens of *Eleusine coracana* and *Hordeum vulgare L.*

The cultivation practice of monocots followed by the traditional way might be optimized under controlled cultivation methodology utilizing the whole sample as an edible with its root and the first leaf initiation. The methodology promotes the green sustainable methodology in farming practice in an available space with maximum utilization to achieve production within less-span of time. With respect to the growing of microgreen; *Eleusine coracana* and *Hordeum vulgare* L. it's a cost effective method with least maintenance. However, application of these microgreens in various sectors may provide an eminent source of proper utilization towards production ability ahead for efficient management in Farming practice.

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Financial Development & Income Inequality in India: An Analysis

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ABSTRACT
Objective: The objectives of the paper are: (i) to test whether financial development has increased the incidence of income inequality in India over the period of time and (ii) to help the policymakers to design and implement programs to resolve the incidence of income inequality in the country.
Methods/Statistical Analysis: Techniques such as correlation and regression analysis are used to examine the impact of financial development on income inequality since 1990-91 to 2018-19. The analysis is done using the SPSS software.
Findings: Among various factors, only two factors such as Financial Development (M3/GDP) and Unemployment Rate (UR) are more influencing income inequality in India.

Application/ Improvements: Special financial institution like '**Education Bank**' be set up to provide education loans and other incentives. These banks should have tie up with quality education institutions and corporate world. Various scheme of 'financial accessibility' be innovated and implemented effectively to reduce the incidence of inequality. There is a need to bring the unbanked-weaker segment of population in the mainstream of the economy. An attempt should be made to increase the tax revenue by simplifying the tax structure, extending the tax net and reducing the tax rates. An effective combination of fiscal stimulus and financial inclusion may help to reduce the incidence of income inequality by helping up-till-now ignored people to come in mainstream of development and by increasing their participation rate.

Keywords: Income, Income Inequality, Financial Development, Unemployment.

I. INTRODUCTION:

Financial system, consisting of financial institutions, financial instruments, financial markets and financial services, together help to transfer financial resources from savers to various sub sectors across the regions. Hence, finance is considered as an essential condition for economic development (Kunjukunju & Mohanan, 2012).

The relative importance of each of the financial institution, financial instrument and the financial market in the financial system as a whole is referred to as '**financial structure**'. This relative importance keeps on changing with the introduction of new players in the financial system. Thus, financial structure of the country changes overtime. This change in financial structure of the country overtime is referred to as '**financial development**'.

The unequal distribution of income of the household or an individual across the various participants in an economy is called as '**income inequality**'. It shows how income is distributed unequally among individuals in a group, among groups in population or among countries (Berger & Ostry, 2011).

Income inequality is a difference in economic position of individuals within the country. It depends on earning capacity (income), consumption expenditure and wealth governed by level of income. Hence, inequality can be estimated through income, consumption expenditure and wealth. While consumption and income measure a flow of resources over time, wealth refers to a stock of resources at a given point in time (generally measured as net worth) (Himanshu, 2019).

Obtaining precise estimates of household incomes is complicated issue because, first, only few households have regular sources of income. And, there is tendency on part of people not to disclose their true income and wealth. Second, incomes are irregular in agriculture and in small businesses. Hence, considerable efforts are required to obtain estimates of revenue and expenditure before net income can be calculated. Third,

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measurement errors are generally large in agricultural incomes. Fourth, seasonal variations are much greater in agricultural incomes than in other incomes (Desai, 2010).

Between consumption and income, consumption is considered a more accurate reflection of living standard as household tend to smooth consumption flows over time. As consumption data is also easier to collect in economies with large informal sectors (Himanshu, 2019).

Income Inequality is measured in Gini Coefficient based on consumption expenditure.

The beneficial role of financial development in economic development has been well documented in economic literature. However, theories on the effect of financial development on income distribution give conflicting predictions. Accordingly, there are two different hypotheses i.e. one is '**finance-inequality widening hypothesis**' and the other is '**finance-inequality narrowing hypothesis**'.

The **finance-inequality widening hypothesis** reveals a positive association between financial development and income inequality. That is, income inequality increases with financial development. This hypothesis suggests that financial development benefits more to the rich due to their credit-worthiness to the banks and financial institutions (Clarke et al, 2006); On the other hand, the socially and economically backward poor individuals lack credit-worthiness due to insufficient collateral at their disposal. Hence, the poor find it difficult to access the financial services from the financial institutions. This makes the institutional quality weak. As a result, their opportunity of investment and improving income prospects suffers. This, in turn, gives rise to income inequality. This indicates an increase in income inequality along with financial development of the economy (Ahmed, 2017).

The **finance-inequality narrowing hypothesis** shows negative association between financial development and income inequality. It was put forward by Galor and Zeira (1993), Galor & Moav (2004) and Banerjee and Newman (1993). These authors propose that as the economy expands, financial market develops to support the growing economy with broader credit services. With this, the poor have opportunity to borrow for their human capital (the skills, knowledge and experience possessed by an individual) and upgrade their earning potentials. Hence, income inequality starts declining in the economy with financial development (Ahmed, 2017).

One can see different trends regarding level of income inequality across countries in the world. Almost all Latin American and Caribbean countries show very high levels of inequality, but considerable declines from 1990-2015. Conversely, advanced industrial economies show lower levels of inequality but rises in most, though not all. In six countries of Middle East and North Africa region, mostly falling trend is seen. In Sub-Saharan Africa, East Asia and the Pacific, the trends are more mixed. However, one can see rising trend in income inequality in some of the world's most populous countries including China, India, USA and Indonesia (together accounting for around 45% of world population) (Hasell, 2018). Widespread poverty and excessive inequality have remained as major challenges to the process of globalization, which has been underway during the last two decades (IDEA, 2002).

Income inequality (Gini Coefficient) in India has increased from 29.6 percent in 1991 to 38.1 percent in 2018 indicating that the income inequality is an important problem that needs to be tackled.

Financial development was expected to attain the objective of reduction in disparity in income among the poor and the rich. As, income inequality is one of the major challenges faced by many countries including India, possibly this study will help to improve an understanding of the problem and suggesting some effective measures, based on the study, to tackle this issue.

With this backdrop, the study attempts to examine the impact of financial development on distribution of income in India. For this purpose, we have taken various factors along with financial development to examine their impact on income distribution in India.

An Analysis:

The **aim of this study** is to examine the relationship between financial development and income inequality in India during the period of 1990-2018. This time period is chosen as India embarked on a process of economic and financial liberalization of the economy on a larger scale since 1990-91.

To examine the impact of financial development and other factors on income inequality, quantitative techniques such as correlation and regression are used.

The data required for the study is collected from secondary sources such as RBI (various issues), Handbook of Statistics on Indian Economy; UNDP (various issues); World Bank (various issues); UNESCO (2019); Govt of India (various issues), Planning Commission; Government of India (various issues), Economic Survey.

Initially, we have considered three indicators for measuring financial development in India. They are namely the Ratio of Bank Credit to Commercial sector to GDP, the Ratio of M3 to GDP and the Ratio of Bank Deposits to GDP (Table No.1).

However, the estimated correlation between these three indicators of financial development found to be very high. The estimated correlation coefficient between the Ratio of Bank Credit to Commercial Sector to GDP and

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the ratio of M3 to GDP was (r=0.96); between the Ratio of Bank Credit to Commercial sector to GDP and the Ratio of Bank Deposits to GDP was (r=0.98); and between the ratio of M3 to GDP and the ratio of Bank Deposits to GDP was (r=0.99).

Table No.2: Correlation Matrix

	Bank Credit / GDP (%)	M3/GDP (%)	Bank Deposits / GDP (%)
Bank Credit / GDP (%)	1	0.96	0.98
M3 / GDP (%)	0.96	1	0.99
Bank Deposits / GDP (%)	0.98	0.99	1

Hence, out of these three indicators, we can use any one of them for the further analysis. We use the Ratio of M3 to GDP as an indicator of financial development (Beck et al, 2000; Samargandi et al, 2015). This ratio highlights the role of intermediation played by banks in economic development (RBI,1998).

The technique of regression is used to examine how income inequality is influenced by various factors in the economy values of Gini coefficients which reflect income inequality, are based on the consumption expenditure (World Bank, 2016; UNDP {various issues}; Himanshu & Murgai, 2016; Himanshu, 2019).

Altogether there are twelve variables used in this analysis. They are Gini coefficient (GINI) for income inequality is based on the consumption expenditure, Ratio of Broad Money to GDP (M3/GDP) for financial development, Industrial Growth (IG), Service Sector Growth (SSG), Ratio of Tax to GDP (TR), Population Growth Rate (PGR), Age Dependency Ratio (ADR), Unemployment Rate (UR), Secondary School Enrollment (SSE), Inflation Rate (INF), Foreign Direct Investment (FDI) and Exports (EXP).(Table No.3).

The Gini Coefficient (GINI) is dependent variable and the rest of the variables are independent variables. The technique of regression is used to examine how income inequality is influenced by various factors in the economy.

Table No.1: Indicators of Financial Development in India
[Amt in Rs Billion]

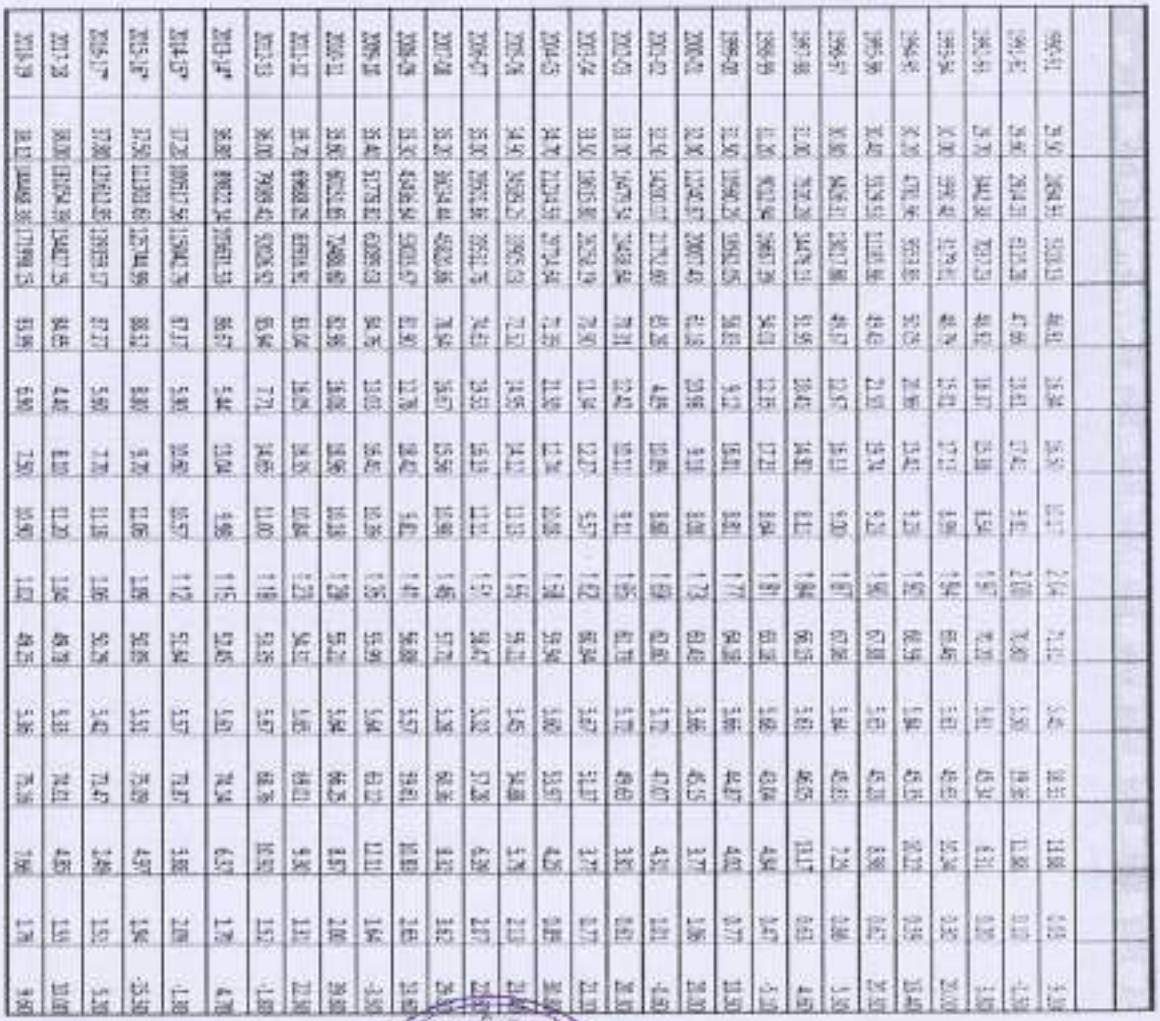
Year (1)	GDP at Factor Cost (Amt) (2)	Bank Credit to Comm Sector (Amt) (3)	M3 (Broad Money) (Amt) (4)	Bank Deposit (Amt) (5)	Ratio of Bank Credit to GDP (%) (6)	Ratio of M3 to GDP (%) (7)	Ratio of Bank Deposit to GDP (%) (8)
1990-91	5318.13	1717.69	2494.93	1593.49	32.29	46.914	29.96
1991-92	6135.28	1879.93	2924.03	1856.70	30.64	47.659	30.26
1992-93	7037.23	2201.35	3442.38	2221.11	31.28	48.917	31.56
1993-94	8179.61	2377.74	3990.48	2585.60	29.06	48.786	31.61
1994-95	9553.85	2927.23	4781.96	3099.56	30.63	50.053	32.44
1995-96	11185.86	3446.48	5529.53	3532.05	30.81	49.433	31.57
1996-97	13017.88	3763.07	6426.31	4149.89	28.9	49.365	31.87
1997-98	14476.13	4333.1	7520.28	4959.72	29.93	51.950	34.26
1998-99	16687.39	4959.9	9012.94	5966.02	29.72	54.010	35.75
1999-00	18582.05	5865.64	10560.25	6859.78	31.56	56.830	36.91
2000-01	20007.43	6792.18	12240.87	8200.66	33.94	61.182	40.98
2001-02	21752.6	7596.47	14200.07	9503.12	34.92	65.280	43.68
2002-03	23438.64	8989.81	16479.54	11105.64	38.35	70.309	47.38
2003-04	26258.19	10161.58	18618.80	12793.94	38.69	70.895	48.72

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2004-05	29714.64	12759.12	21214.59	14521.71	42.93	71.394	48.87
2005-06	33905.03	16886.81	24589.25	17444.09	49.8	72.524	51.44
2006-07	39532.76	21288.62	29501.86	21822.03	53.85	74.626	55.19
2007-08	45820.86	25789.9	36034.44	26726.30	56.28	78.642	58.32
2008-09	53035.67	30148.93	43436.64	33110.25	56.84	81.901	62.43
2009-10	61089.03	34914.09	51778.82	38472.16	57.15	84.760	62.97
2010-11	72488.6	42366.76	60151.65	45662.64	58.44	82.981	62.99
2011-12	83916.91	49923.38	69688.05	52837.52	59.49	83.044	62.96
2012-13	92026.92	56678.67	79089.42	60881.55	61.58	85.942	66.15
2013-14	103631.53	64452.96	89822.14	69916.39	62.19	86.675	67.46
2014-15	115042.79	70497.24	100517.56	77392.56	61.27	87.374	67.27
2015-16	125744.99	78030.69	111303.63	84382.94	62.05	88.515	67.1
2016-17	139359.17	84114.92	121612.85	94762.17	60.35	87.266	67.99
2017-18	154827.15	92137.16	131054.39	100557.67	59.5	84.645	64.94
2018-19	171998.15	103801.8	144468.38	110624.84	60.35	83.994	64.31

Source: (RBI 2018), Handbook of Statistics on Indian Economy

Table No.3: [Year, Gini Coefficient, M3 (Broad Money), GDP at Factor Cost etc.]



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Note: GDP at factor cost not measured after 2011-2012, therefore we have mentioned GVA at current price from 2013-14 onwards in the same column (RBI, 2018).

1- Year
2- Gini Coefficient (GINI)
3- Broad Money (M3)
4- GDP at Factor Cost (GDPFC)
5- Ratio of Broad Money (M3) to GDP-% (M3/GDP)
6- Industrial Growth- % of GDP (IG)
7- Service Sector Growth- % of GDP (SSG)
8- Ratio of Tax to GDP -% of GDP (TR)
9- Population Growth Rate- % (PGR)
10- Age Dependency Ratio - % of working population (ADR)
11- Unemployment Rate - % of labour force (UR)
12- Secondary School Enrolment - % of population (SSE)
13- Inflation – consumer price index (%) (INF)
14- Foreign Direct Investment -% of GDP (FDI)
15- Exports - % of GDP (EXP)

Sources:-
1) World Bank Indicators (2016); Himanshu & Murgai (2016); UNDP (2003, 2005, 2009 & 2016); UNESCO (2019); World Development Indicators (2019); Planning Commission (2014) & Economic Survey (2016-17; 2019-2020); Indexmundi (2019); World Data Atlas (2017); Inflation.eu (2018; 2020) World Bank, 2019; RBI Handbook of Statistics on the Indian economy 2018-19.

The multiple linear regression equation is as follows:

$$GINI = a + b_1 * M3/GDP + b_2 * IG + b_3 * SSG + b_4 * TR + b_5 * PGR + b_6 * ADR + b_7 * UR + b_8 * SSE + b_9 * INF + b_{10} * FDI + b_{11} * EXP + \varepsilon$$

where,

GINI = Gini Coefficient
M3/GDP = Ratio of Broad Money to GDP
IG = Industrial Growth
SSG= Service Sector Growth
TR= Ratio of Tax to GDP
PG= Population Growth Rate
ADR= Age Dependency Ratio of working-age population
UR= Unemployment Rate of labour force'
SSE= Secondary School Enrollment
INF= Inflation (CPI)
FDI= Foreign Direct Investment as percentage of GDP
EXP= Export as percentage of GDP
ε = error term

When in the model there are multiple factors (predictors) , there is high possibility that they are highly correlated. This is referred to as multicollinearity among independent variables. Presence of multi-collinearity in the model gives furious results. Therefore, to tackle the problem of multi-collinearity among the independent variables, Variance Inflation Factor (VIF) method is used.

VIF measures how much the behaviour (variance) of an independent variable is influenced by its interaction/correlation with the other independent variables. The numerical value for VIF tells us (in decimal form) what percentage the variance (i.e., the standard error squared) is inflated for each coefficient. The value of VIF can be classified as 1= not correlated, between 1 and 5= moderately correlated and greater than 5 = highly correlated. Some papers argue that a VIF less than 10 is acceptable (Hair et al, 1995) but others say that the limit value is 5 (Everitt & Skrondal, 2010).

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Enter Method:

In order to check the problem of multicollinearity among the independent variables and to adjust the regression model accordingly, we have used the 'Enter' method. This method is there in SPSS package by default.

In Enter Method, all variables in a block are entered in a single step. All the independent variables are given equal importance in the model. The model is not making any presumption that one of these variables is more important as compared to other variables that typically happen in the case of theory building. This is an appropriate analysis when dealing with a small set of predictors and when the researcher does not know which independent variables will create the best prediction equation (IBM, 2016).

This method makes use of regression analysis. Initially, all the independent variables are entered simultaneously for the analysis in the Enter Method (Dependent variable is specified at bottom of table). After running the regression with the help of software, it removes variable at each step which has highest value of Variance Inflation Factor (VIF) in the model. Such steps are then repeated till we get variables having VIF value less than 5. Then, significant variables are chosen based on p-values for the model (SAS, 2016).

Step 1:

For Step 1, multiple linear regression equation specified is as follows:

$$\mathbf{GINI = M3/GDP + IG + SSG + TR + PGR + ADR + UR + SSE + INF + FDI + EXP + e}$$

SPSS regression output gives four tables. They are Variables Entered/Removed, Model Summary, Analysis of Variance (ANOVA) and Coefficients.

The first table is 'Variables Entered/Removed' (Table No.4).

Table No.4:
Variables Entered/Removed

Model (1)	Variables Entered (2)	Variables Removed (3)	Method (4)
1	EXP, M3/GDP, INF, UR, SSG, IG, FDI, TR, SSE, ADR, PGR	------.	Enter

a. All requested variables entered.

First column depicts number of model, as we have only one model for the analysis, Number One (1) is written in the first column.

Second column is Variables Entered, where all independent variables (predictors) are entered in the model. These variables are Exports, Ratio of M3 to GDP, Inflation, Unemployment Rate, Service Sector Growth, Industrial Growth, Foreign Direct Investment, Ratio of Tax to GDP, Secondary School Enrolment, Age Dependency Ratio and Population Growth Rate.

Third column is Variables Removed. At the beginning we do not remove any variable from the model, so it is kept blank.

Fourth column is name of the method used i.e. Enter Method. So, name 'Enter' is specified.

The next output table is Model Summary (Table No.5).

Table No.5: Model Summary

Model (1)	R (2)	R-square (3)	Adjusted R-square (4)	Std. Error of the Estimate (5)
1	.998[a]	.997	.995	.21288

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This table shows multiple regression model summary and overall fit statistics.
The value of R (correlation coefficient value) shows the correlation between the observed and predicted values of dependent variable. It is 99.8 percent.

Third column shows the value of R-square. It is the proportion of variance in the dependent variable (GINI) which can be predicted from the independent variables. It is also called the coefficient of determination. Note that this is an overall measure of the strength of association and does not reflect the extent to which any particular independent variable is associated with the dependent variable. It is 99.7 percent.

R-square computed on sample data tends to overestimate R-square for the entire population. Therefore, we prefer to report adjusted R-square, which is an unbiased estimator for the population R-square. The value of the Adjusted R-square (Fourth Column) is 0.995. This tells us that independent variables in our model accounts for 99.5% variance in the dependent variable.

Fifth column shows Standard Error of the estimate. It is a measure of accuracy of prediction. It represents average distance that observed value fall from regression line. Thus, it reflects the average error of regression model. It shows how wrong you could be if you use regression model to make predictions. As the standard error reflects how wrong you could be, we want standard error to be as small as possible (SAS, 2016).

Really speaking, in this table, values of R and Adjusted R-square are more useful for our purpose. Hence, from Step 2 of this analysis we shall focus on them only.

The SPSS does not include confidence interval for Adjusted R-square. However, the p-value found in Analysis of Variance (ANOVA) Table (Table No.13) applies to R and R-square. The p-value are used to decide whether results are significant enough to reject null hypothesis.

Table No.6: Analysis of Variance (ANOVA)

Model (1)	Sum of Squares (2)	DF (3)	Mean Square (4)	F-value (5)	p-value (6)
Regression	234.003	11	21.273	469.433	.000
Residual	.770	17	.045		
Total	234.773	28			

In Table No.6 First column in this model states Regression, Residual and Total. Regression is the proportion of variation explained by the independent variables, called Explained Variation. Residual is the proportion of variation which is not explained by the independent variables, called Unexplained Variation. It measures discrepancy (error) between actual values and estimated values of dependent variables by regression equation. Total is adding up of Regression and Residual.

Second column is Sum of Squares (SS). It measures the total variability in the observations. It measures deviation from the mean. The smaller the value of residuals sum of square relative to Explained Sum of Square (through regression), the better the regression line fits or explains the relationship between dependent and independent variables.

Third column is Degree of Freedom (DF). It is the number of independent pieces of information (11) that went into calculating the estimate. The residual error of the observations are (17). Thus, the total observation in the study are 28 (11+17).

Fourth column is Mean Square. It is an estimate of the population variance. It is computed by dividing a sum of square value by the corresponding degrees of freedom (SS/DF= MS).

Fifth column is F-value. The F-value is the Mean Square Regression divided by the Mean Square Residual, yielding F=469.43. It is a value we get when we run an ANOVA. An ANOVA is used to find out whether means between two population are significantly different. The F-value should always be used along with the p-value in deciding whether results are significant enough to reject the null hypothesis.

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Sixth column is p-value. P-value shows level of significance of the model. If the p-value is small (less than our alpha level 0.05), we can reject the null hypothesis (Chatterjee & Hadi, 2012). It means that the independent variables reliably predict the dependent variable. If the p-value were greater than 0.05, it means that the group of independent variables in the model does not show a statistically significant relationship with the dependent variable or that the group of independent variables does not reliably predict the dependent variable (SAS, 2016). In our model, p-value is 0.00 which is less than alpha level 0.05. It means that overall, the model is significant. It is rejecting the null hypothesis.

From the ANOVA Table, values given in Column No.2 i.e. Sum of Squares and values given in column no.6 i.e. p-values are important for our purpose. Hence, Step No.2 onwards we shall concentrate on them only.

The next output table is 'Coefficients' (Table No.7). It shows multiple regression estimates (column no.2) including the intercept and significance level (column no.4). The information in this table also allows us to check for multicollinearity (column no.5 & 6) in our multiple linear regression model.

Table No.7: Coefficients

Model (1)	Unstandardized Coefficients (2)		Standardized Coefficients (3)	(4)		Collinearity Statistics (5)	Collinearity Statistics (6)
	B	Std. Error	Beta	t-value	p-value	Tolerance	VIF
1(Constant)	58.080	5.968		9.732	.000		
M3/GDP	.045	.016	.240	2.755	.014	.025	39.48
IG	.001	.018	.001	.047	.963	.192	5.20
SSG	-.017	.024	-.020	-.707	.489	.234	4.27
TR	.087	.116	.032	.748	.465	.105	9.50
PGR	9.616	3.690	1.107	2.606	.018	.001	**935.80**
ADR	-.627	.132	-1.524	-4.736	.000	.002	536.19
UR	-1.675	.827	-.073	-2.027	.059	.149	6.71
SSE	.076	.032	.326	2.378	.029	.010	97.49
INF	.002	.020	.002	.111	.913	.406	2.46
FDI	-.164	.134	-.047	-1.228	.236	.129	7.73
EXP	.002	.005	.011	.527	.605	.455	2.19

a. Dependent Variable: GINI Coefficient

The B coefficients of our estimated regression model are:

GINI = 58.080 + 0.45 M3/GDP + 0.001 IG – 0.17 SSG + 0.87 TR + 9.616 PGR -0.627 ADR – 1.675 UR +0.76 SSE + 0.002INF – 0.164 FDI + 0.002 EXP

Each B coefficients indicate the average increase in income inequality (GINI) associated with a unit increase in predictor. The B coefficient is statistically significant is its p-value (given in Column No.4) is less than 0.05 (p-value is < 0.05).

B coefficients (Column No.2) don't tell us relative strength of our predictors. This is because these have different scales. One way to deal with this is to compare the Standardised Regression Coefficients. Beta coefficients (Standardized Regression Coefficient) are useful in comparing the relative strength of predictors. The standardization of variables (dependents and independent) means all variables are put on same scale and magnitude of coefficients are compared to see which one has more effect (SAS, 2016).
For model building what is important to us in this table is Collinearity Statistics (given in Column No. 5 & 6).

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Fifth column shows Tolerance values. Tolerance is used in regression analysis for diagnosing multicollinearity, which happens when variables are too closely related. It is associated with each independent variable and ranges from 0 to 1. It is calculated as we regress each independent variable on all of the other independent variables. So, subtract each R2 value from 1. Allison (1999) notes that there isn't a strict cut off for tolerance but suggests a tolerance of below 0.40 is cause for concern. Weisburd & Britt (2013) state that anything under 0.20 suggests serious multicollinearity in a model. High tolerance means low multicollinearity (above 0.40) and Low tolerance is high multicollinearity (below 0.40) (Allison, 1999).

Sixth column shows Variance Inflation Factor (VIF). VIF measures how much the behaviour (variance) of an independent variable is influenced (or inflated) by its interaction/correlation with the other independent variables. The numerical value for VIF tells us (in decimal form) what percentage the variance (i.e., the standard error squared) is inflated for each coefficient. The value of VIF can be classified as 1= not correlated, between 1 and 5= moderately correlated and greater than 5 = highly correlated. Some papers argue that a VIF less than 10 is acceptable (Hair et al, 1995) but others say that the limit value is 5 (Everitt & Skrondal, 2010). So, we have maintained the VIF limit value as 5.

At this stage, the variable Population Growth Rate (PGR) is eliminated from the model due to its high Variance Inflation Factor (VIF). Its value is equal to **935.80**.

Step 2:

For Step 2, multiple linear regression equation specified is as follows:

GINI = M3/GDP + IG + SSG + TR + ADR + UR + SSE + INF + FDI + EXP + e

Regression Output Tables, viz., Variables Entered/Removed, Model Summary, Analysis of Variance (ANOVA) and Coefficients for Step 2 are given in Tables No. 8, 9, 10 and 11 respectively.

Table No.8:

Variables Entered/Removed

Model (1)	Variables Entered (2)	Variables Removed (3)	Method (4)
1	EXP, M3/GDP, INF, UR, SSG, IG, FDI, TR, SSE, ADR	. PGR	Enter

a. All requested variables entered.

At this stage, ten variables are entered in the model (Column No.2). They are Exports, Ratio of M3 to GDP, Inflation, Unemployment Rate, Service Sector Growth, Industrial Growth, Foreign Direct Investment, Ratio of Tax to GDP, Secondary School Enrolment and Age Dependency Ratio.

One variable i.e. Population Growth Rate (PGR) is removed from the model (Column No.3).

Table No.9: Model Summary

Model (1)	R (2)	R-square (3)	Adjusted R-square (4)	Std. Error of the Estimate (5)
1	.998[a]	.995	.993	.24473

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Table No.10: Analysis of Variance (ANOVA)

Model (1)		Sum of Squares (2)	DF (3)	Mean Square (4)	F-value (5)	p-value (6).
1	Regression	233.695	10	23.370	390.191	.000
	Residual	1.078	18	.060		
	Total	234.773	28			

The value of multiple correlation coefficient (R) is 99.8 percent. The value of R-square is 99.5 percent. And the value of Adjusted R-square is 99.3 percent. Thus, the value of Adjusted R-square indicating that 99.3 percent variation in dependent variable GINI, on an average, is due to all the independent variables now entered in the model (Exports, Ratio of M3 to GDP, Inflation, Unemployment Rate, Service Sector Growth, Industrial Growth, Foreign Direct Investment, Ratio of Tax to GDP, Secondary School Enrolment and Age Dependency Ratio).

In Table No.10 (Column No.2), the value of Residual Sum of Square (1.078) is far smaller to Regression (Explained) Sum of Square (233.695), indicating that the regression line explains better relationship between dependent and independent variables.

The p-value is 0.00, which is less than alpha level 0.005, thus rejecting the null hypothesis. Hence, the overall model is significant.

Table No.11: Coefficients

Model (1)		Unstandardized Coefficients (2)		Standardized Coefficients (3)	(4)		Collinearity Statistics (5)	Collinearity Statistics (6)
		B	Std. Error	Beta	t-value	p-value	Tolerance	VIF
1	(Constant)	58.144	6.861		8.475	.000		
	M3/GDP	.041	.019	.218	2.181	.043	.026	39.097
	IG	.024	.018	.042	1.305	.208	.251	3.977
	SSG	-.025	.027	-.031	-.936	.362	.239	4.190
	TR	.051	.132	.019	.386	.704	.107	9.375
	ADR	-.302	.050	-.732	-5.992	.000	.017	**58.565**
	UR	-1.715	.950	-.075	-1.805	.088	.149	6.708
	SSE	.002	.017	.010	.134	.895	.047	21.080
	INF	-.016	.021	-.018	-.752	.462	.464	2.155
	FDI	-.007	.137	-.002	-.051	.960	.162	6.157
	EXP	.001	.005	.003	.136	.893	.465	2.152

a. Dependent Variable: Gini_Coeff

The B coefficients of our estimated regression model (Table No.11) are:

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GINI = 58.144 + 0.41 M3/GDP + 0.024 IG – 0.025 SSG + 0.051 TR -0.302 ADR – 1.715 UR +0.002 SSE - 0.16 INF – 0.007 FDI + 0.001 EXP

Each B coefficients indicate the average increase in income inequality (GINI) associated with a unit increase in predictor. The B coefficient is statistically significant is its p-value (given in Column No.4) is less than 0.05 (p-value is < 0.05).

At this stage, the Variance Inflation Factor (VIF) of variable Age Dependency Ratio (ADR) is highest (VIF = 58.565) among all the independent variables. Hence, the variable ADR is eliminated from the model.

Step No.3:

For Step 3, multiple linear regression equation specified is as follows:

GINI = M3/GDP + IG + SSG + TR + UR + SSE + INF + FDI + EXP + e

Regression Output Tables, viz., Variables Entered/Removed, Model Summary, Analysis of Variance (ANOVA) and Coefficients for Step 3 are given in Tables No. 12, 13, 14 and 15 respectively.

Table No.12:

Variables Entered/Removed

Model (1)	Variables Entered (2)	Variables Removed (3)	Method (4)
1	EXP, M3/GDP, INF, UR, SSG, IG, FDI, TR, SSE[a]	PGR & ADR.	Enter

a. All requested variables entered.

At this stage, nine variables are entered in the model (Column No.2). They are Exports, Ratio of M3 to GDP, Inflation, Unemployment Rate, Service Sector Growth, Industrial Growth, Foreign Direct Investment, Ratio of Tax to GDP and Secondary School Enrolment.

Two variables viz. Population Growth Rate (PGR) and Age Dependency Ratio (ADR) are removed from the model (Column No.3) due to their high VIF.

Table No. 13: Model Summary

Model (1)	R (2)	R-square (3)	Adjusted R- square (4)	Std. Error of the Estimate (5)
1	.993[a]	.986	.980	.41220

Table No. 14: Analysis of Variance (ANOVA)

Model (1)		Sum of Squares (2)	DF (3)	Mean Square (4)	F-value (5)	p-value (6)
1	Regression	231.545	9	25.727	151.415	.000[b]
	Residual	3.228	19	.170		
	Total	234.773	28			

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The value of multiple correlation coefficient (R) is 99.3 percent. The value of R-square is 98.6 percent. And the value of Adjusted R-square is 98.0 percent. Thus, the value of Adjusted R-square indicating that 98 percent variation in dependent variable GINI, on an average, is due to all the independent variables now entered in the model (Exports, Ratio of M3 to GDP, Inflation, Unemployment Rate, Service Sector Growth, Industrial Growth, Foreign Direct Investment, Ratio of Tax to GDP and Secondary School Enrolment).

In Table No.14 (Column No.2), value of Residual Sum of Squares (3.228) is far smaller to Regression (Explained) Sum of Squares (231.545), indicating that the regression line explains better relationship between dependent and independent variables.

The p-value is 0.00, which is less than alpha level 0.005, thus rejecting the null hypothesis. Hence, the overall model is significant.

Table No. 15: Coefficients

Model (1)		Unstandardized Coefficients (2)		Standardized Coefficients (3)	(4)		Collinearity Statistics (5)	Collinearity Statistics (6)
		B	Std. Error	Beta	t-value	p-value.	Tolerance	VIF
1	(Constant)	35.111	9.571		3.668	.002		
	M3/GDP	.108	.025	.579	4.315	.000	.040	24.867
	IG	-.009	.029	-.016	-.309	.761	.276	3.618
	SSG	-.040	.045	-.049	-.891	.384	.241	4.153
	TR	.039	.223	.014	.174	.864	.107	9.373
	UR	-2.253	1.593	-.098	-1.414	.173	.150	6.648
	SSE	.076	.020	.328	3.849	.001	.100	**10.030**
	INF	-.057	.034	-.063	-1.699	.106	.519	1.926
	FDI	.021	.231	.006	.090	.929	.163	6.150
	EXP	.005	.009	.023	.590	.562	.474	2.109

The B coefficients of our estimated regression model (Table No.15) are:

GINI = 35.111 + 0.108 M3/GDP - 0.009 IG – 0.040 SSG + 0.039 TR – 2.253 UR +0.076 SSE -0.57 INF – 0.021 FDI + 0.005 EXP

Each B coefficients indicate the average increase in income inequality (GINI) associated with a unit increase in predictor. The B coefficient is statistically significant is its p-value (given in Column No.4) is less than 0.05 (p-value is < 0.05).

At this stage, the Variance Inflation Factor (VIF) of Ratio of M3 to GDP (M3/GDP) is high (VIF = 24.867), but it is our main variable of study. So, we remove the variable Secondary School Enrolment (SSE), which has next high VIF value (VIF = 10.030). Hence, the variable SSE is eliminated from the model.

Step No.4:

For Step 4, multiple linear regression equation specified is as follows:

GINI = M3/GDP + IG + SSG + TR + UR + INF + FDI + EXP + e

Regression Output Tables, viz., Variables Entered/Removed, Model Summary, Analysis of Variance (ANOVA) and Coefficients for Step 4 are given in Tables No. 16, 17, 18 and 19 respectively.

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Table No. 16:

Variables Entered/Removed

Model (1)	Variables Entered (2)	Variables Removed (3)	Method (4)
1	EXP, M3/GDP, INF, UR, SSG, IG, FDI, TR	PGR , ADR & SSE	Enter

a. All requested variables entered.

At this stage, eight variables are entered in the model (Column No.2). They are Exports, Ratio of M3 to GDP, Inflation, Unemployment Rate, Service Sector Growth, Industrial Growth, Foreign Direct Investment and Ratio of Tax to GDP.

Three variables viz. Population Growth Rate (PGR), Age Dependency Ratio (ADR) and Secondary School Enrolment (SSE) are removed from the model (Column No.3) due to their high VIF.

Table No. 17: Model Summary

Model (1)	R (2)	R-square (3)	Adjusted R-square (4)	Std. Error of the Estimate (5)
1	.988[a]	.976	.966	.53600

Table No. 18: Analysis of Variance (ANOVA)

Model (1)		Sum of Squares (2)	DF (3)	Mean Square (4)	F-value (5)	p-value (6)
1	Regression	229.027	8	28.628	99.649	.000[b]
	Residual	5.746	20	.287		
	Total	234.773	28			

The value of multiple correlation coefficient (R) is 98.8 percent. The value of R-square is 97.6 percent. And the value of Adjusted R-square is 96.6 percent. Thus, the value of Adjusted R-square indicating that 96.6 percent variation in dependent variable GINI, on an average, is due to all the independent variables entered in the model (Exports, Ratio of M3 to GDP, Inflation, Unemployment Rate, Service Sector Growth, Industrial Growth, Foreign Direct Investment and Ratio of Tax to GDP).

In Table No.18 (Column No.2), value of Residual Sum of Squares (5.746) is far smaller to Regression (Explained) Sum of Squares (229.027), indicating that the regression line explains better relationship between dependent and independent variables.

The p-value is 0.00, which is less than alpha level 0.005, thus rejecting the null hypothesis. Hence, the overall model is significant

Table No. 19: Coefficients

Model (1)		Unstandardized Coefficients (2)		Standardized Coefficients (3)	(4)		Collinearity Statistics (5)	Collinearity Statistics (6)
		B	Std. Error	Beta	t-value	p-value	Tolerance	VIF
1	(Constant)	42.301	12.206		3.465	.002		

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M3/GDP	.172	.025	.917	6.946	.000	.070	14.229
IG	-.012	.038	-.021	-.316	.755	.277	3.615
SSG	-.043	.059	-.052	-.731	.473	.241	4.152
TR	.007	.289	.003	.024	.981	.107	**9.360**
UR	-3.465	2.031	-.151	-1.706	.103	.157	6.388
INF	-.039	.043	-.043	-.896	.381	.530	1.887
FDI	-.151	.295	-.043	-.510	.615	.169	5.922
EXP	.001	.012	.003	.059	.953	.483	2.071

a. Dependent Variable: Gini Coefficient

The B coefficients of our estimated regression model (Table No.19) are:

GINI = 42.301 + 0.172 M3/GDP - 0.012 IG – 0.043 SSG + 0.007 TR – 3.465 UR - 0.39 INF – 1.51 FDI + 0.001 EXP

Each B coefficients indicate an average increase in income inequality (GINI) associated with a unit increase in predictor. The B coefficient is statistically significant is its p-value (given in Column No.4) is less than 0.05 (p-value is < 0.05).

At this stage, the Variance Inflation Factor (VIF) of Ratio of M3 to GDP (M3/GDP) is highest (VIF = 14.229), but it is our main variable of the study. So, we do not remove this variable. Instead, we remove the variable Ratio of Tax to GDP (TR), which has next highest VIF value (VIF = 9.360). Hence, the variable TR is eliminated from the model.

Step No.5:

For Step 5, multiple linear regression equation specified is as follows:

GINI = M3/GDP + IG + SSG + UR + INF + FDI + EXP + e

Regression Output Tables, viz., Variables Entered/Removed, Model Summary, Analysis of Variance (ANOVA) and Coefficients for Step 5 are given in Tables No. 20, 21, 22 and 23 respectively.

Table No. 20:

Model (1)	Variables Entered (2)	Variables Removed (3)	Method (4)
1	EXP, M3/GDP, INF, UR, SSG, IG, FDI	PGR, ADR, SSE, TR.	Enter

a. All requested variables entered.

At this stage, seven variables are entered in the model (Column No.2). They are Exports, Ratio of M3 to GDP, Inflation, Unemployment Rate, Service Sector Growth, Industrial Growth and Foreign Direct Investment.

The variable Population Growth Rate (PGR), Age Dependency Ratio (ADR), Secondary School Enrolment (SSE) and Ratio of Tax to GDP (TR) are removed from the model (Column No.3) due to their high VIF.

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Table No. 21: Model Summary

Model (1)	R (2)	R-square (3)	Adjusted R-square (4)	Std. Error of the Estimate (5)
1	.988[a]	.976	.967	.52309

Table No. 22: Analysis of Variance (ANOVA)

Model (1)		Sum of Squares (2)	Df (3)	Mean Square (4)	F-value (5)	p-value (6)
1	Regression	229.027	7	32.718	119.575	.000[a]
	Residual	5.746	21	.274		
	Total	234.773	28			

The value of multiple correlation coefficient (R) is 98.8 percent. The value of R-square is 97.6 percent. And the value of Adjusted R-square is 96.7 percent. Thus, the value of Adjusted R-square indicating that 96.7 percent variation in dependent variable GINI, on an average, is due to all the independent variables entered in the model. These variables are Exports, Ratio of M3 to GDP, Inflation, Unemployment Rate, Service Sector Growth, Industrial Growth and Foreign Direct Investment.

In Table No.22 (Column No.2), value of Residual Sum of Squares (5.746) is far smaller to Regression (Explained) Sum of Squares (229.027), indicating that the regression line explains better relationship between dependent and independent variables.

The p-value is 0.00, which is less than alpha level 0.005, thus rejecting the null hypothesis. Hence, the overall model is significant

Table No. 23: Coefficients

Model (1)		Unstandardized Coefficients (2)		Standardized Coefficients (3)	(4)		Collinearity Statistics (5)	
		B	Std. Error	Beta	t-value	p-value	Tolerance	VIF
1	(Constant)	42.563	5.626		7.565	.000		
	M3/GDP	.172	.013	.919	13.561	.000	.254	3.943
	IG	-.012	.034	-.020	-.345	.734	.334	2.996
	SSG	-.042	.052	-.051	-.809	.427	.289	3.464
	UR	-3.507	1.044	-.153	-3.358	.003	.564	1.774
	INF	-.039	.042	-.043	-.924	.366	.534	1.872
	FDI	-.154	.241	-.045	-.642	.528	.242	4.138
	EXP	.001	.011	.003	.056	.956	.513	1.948

a. Dependent Variable: Gini_Coeff

The B coefficients of our estimated regression model (Table No.23) are:

GINI = 42.563 + 0.172 M3/GDP - 0.012 IG – 0.042 SSG – 3.507 UR - 0.039 INF – 1.54 FDI + 0.001 EXP

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Each B coefficients indicate the average increase in income inequality (GINI) associated with a unit increase in predictor. The B coefficient is statistically significant is its p-value (given in Column No.4) is less than 0.05 (p-value is < 0.05).

At this stage, all seven independent variables in the model having VIF value less than 5 (a prescribed limit), indicating that there is no multicollinearity exist among them as well as in the model. Hence, all these variables are retained in the model.

However, it is to be noted that, out of these seven variables, only two variables are significant as their p-value is less than 0.05. These two variables are Ratio of M3 to GDP (M3/GDP) and Unemployment Rate (UR). It means that these two variables influencing the dependent variable (GINI) in our model.

Thus, we identified two significant variables - M3/GDP and UR - on the basis of Enter Method for our model.

As we are using multiple linear regression model for our analysis, there is a need to see, at this stage of the analysis, whether our model is satisfying the basic assumptions of multiple linear regression model.

The assumptions are:

1) Independent Observations.
2) Normality. The regression residuals must be normally distributed in the population;
3) Homoscedasticity. The population variance of the residuals should not fluctuate in any systematic way;
4) Linearity. Each predictor must have a linear relation with the dependent variable.

Test for normality of data:

Normality assumption is that regression residuals must be normally distributed in the population. To test this assumption, we have applied Kolmogorov-Smirnov test (Table No.24). Observed p-value = 0.101 > level of significance (alpha level) = 0.05. It proves that Normality assumption is satisfied by our model.

Table No.24:

Test of Normality

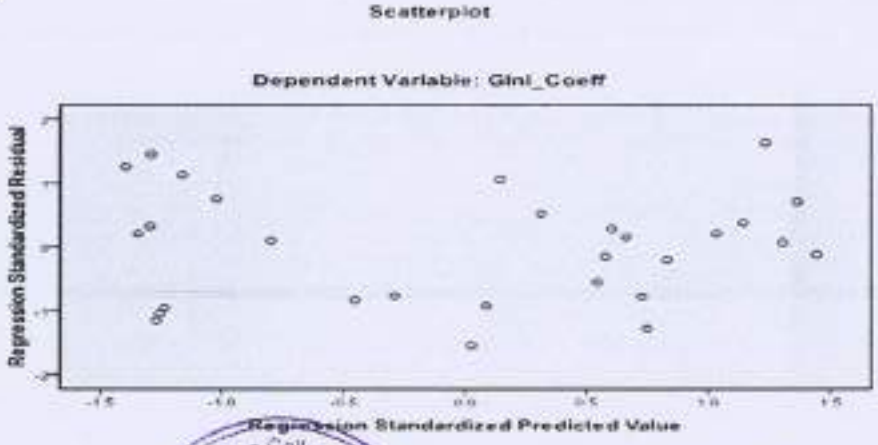
	Kolmogorov-Smirnov[a]		
	Statistic	df	p-value
GINI	.149	29	.101

a. Lilliefors Significance Correction

Homoscedasticity assumption is that population variance of the residuals should not fluctuate in any systematic way i.e. the variation in the residuals is similar at each point across the model. In other words, the spread of the residuals should be fairly constant at each point of the predictor variables (or across the linear model).

A special scatterplot (produced by SPSS software) for our whole model (Graph No.1) proves that variance of the residual is constant and the values of residual are normally distributed.

Graph No.1:

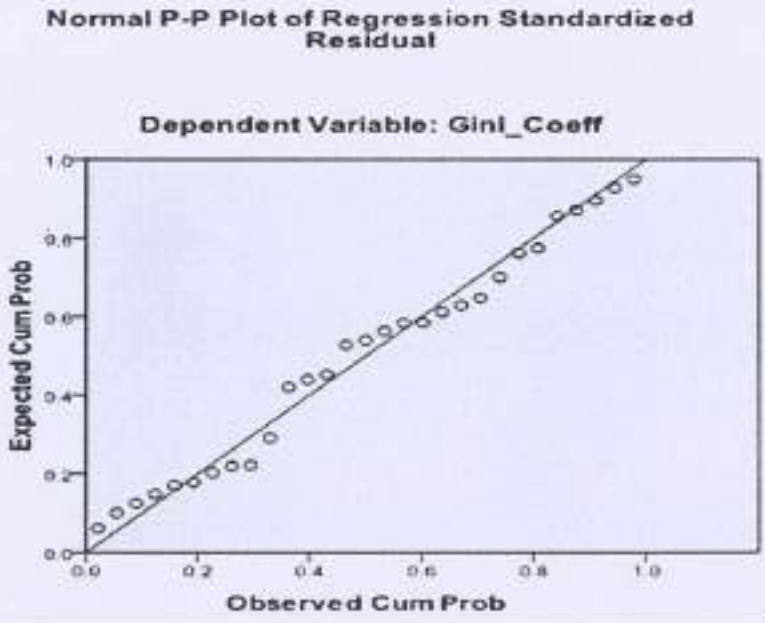


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In Graph No.1, on X-axis we measure regression standardized predicted values and on Y-axis measure regression standardized residuals. The values of these residuals lie between -2 and +2. So, we can conclude that the variance of the residual is constant. The values of the residuals are normally distributed.

This assumption can also be tested by looking at the distribution of residuals in the **Normal Probability Plot** (Graph No.2).

Graph No.2:



In Graph No.2, a Normal Probability Plot shows that the points generally follow normal (diagonal) line with no strong deviations. This indicates that the residuals are normally distributed.

In the Normal Probability Plot, almost all the points lie on the normal (diagonal) line. This shows that there is a linear relationship between dependent variable (Gini) and independent variables in our model.

Under this model, we can observe that all variables for VIF is coming less than 5. Hence, multicollinearity does not exist in our data. Hence, we will check remaining assumptions of multiple linear regression model.

Step No.6:

For Step 6, multiple linear regression equation specified is as follows:

GINI = M3/GDP + UR + e

Regression Output Tables, viz., Variables Entered/Removed, Model Summary, Analysis of Variance (ANOVA) and Coefficients for Step 6 are given in Tables No. 25, 26, 27 and 28 respectively.

Table No.25:

Variables Entered/Removed

Model (1)	Variables Entered (2)	Variables Removed (3)	Method (4)
1	M3/GDP UR	PGR, ADR, SSE, TR, EXP, INF, SSG, IG, FDI	Enter

a. All requested variables entered.

At this stage, two variables are entered in the model (Column No.2). They are Ratio of M3 to GDP and Unemployment Rate.

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The variables Population Growth Rate (PGR), Age Dependency Ratio (ADR), Secondary School Enrolment (SSE) and Ratio of Tax to GDP (TR) are removed from the model (Column No.3) due to their high VIF. And the variables Exports, Inflation, Service Sector Growth, Industrial Growth and Foreign Direct Investment are removed from the model (Column No.3) due to their insignificant p-value.

Table No. 26: Model Summary

Model (1)	R (2)	R-square (3)	Adjusted R Square (4)	Std. Error of the Estimate (5)	Durbin-Watson (6)
1	.983[a]	.966	.963	.55623	.481

Table No. 27: Analysis of Variance (ANOVA)

Model (1)		Sum of Squares (2)	Df (3)	Mean Square (4)	F-value (5)	p-value (6)
1	Regression	226.729	2	113.365	366.414	.000[a]
	Residual	8.044	26	.309		
	Total	234.773	28			

The value of multiple correlation coefficient (R) is 98.3 percent. The value of R-square is 96.6 percent. And the value of Adjusted R-square is 96.3 percent. Thus, the value of Adjusted R-square indicating that 96.3 percent variation in dependent variable (GINI), on an average, is due to the two independent variables namely Ratio of M3 to GDP and Unemployment Rate.

In Table No.27 (Column No.2), value of Residual Sum of Squares (8.044) is far smaller to Regression (Explained) Sum of Squares (226.729), indicating that the regression line explains better relationship between dependent and independent variables.

The p-value is 0.00, which is less than alpha level 0.005, thus rejecting the null hypothesis. Hence, the overall model is significant.

Table No.28: Coefficients

Model (1)		Unstandardized Coefficients (2)		Standardized Coefficients (3)	t-value (4)	p-value (5)	Collinearity Statistics (6)	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	39.453	5.044		7.822	.000		
	M3/GDP	.174	.007	.932	24.458	.000	.908	1.101
	UR	-3.195	.875	-.139	-3.652	.001	.908	1.101

a. Dependent Variable: Gini Coefficient

The B coefficients of our estimated regression model (Table No.28) are:

GINI = 39.453+ 0.174 M3/GDP – 3.195 UR

In the model, a unit increase in the Ratio of M3/GDP (financial development) increases the GINI (income inequality), on an average 0.174 units. And a unit increase in Unemployment Rate (UR) decreases the GINI (income inequality) by 3.195 units. Both these variables are statistically significant as their p-values are less than 0.05.

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Thus, the stated regression equation is:

$$\mathbf{GINI = a + b_1\ M3/GDP + b_2\ UR + e}$$

where,

GINI= Gini Coefficient
a= constant
M3/GDP = Ratio of M3 to GDP
UR = Unemployment Rate
e= error term

The estimated regression equation is:

GINI = 39.453+ 0.174 M3/GDP - 3.195UR

Regression Statistics	
R-square	96.6 %
Adjusted R-square	96.3 %
Standard Error	0.55623
Observations	29

Regression Statistics shows that nearly 96.3 percent of variation in dependent variable (GINI) is explained by these two independent variables i.e. M3/GDP and UR.

The model shows that the one unit increment in the ratio of M3 to GDP, increases the Gini Coefficient (income inequality) by **0.17 units**. And the one unit increment in Unemployment Rate, decreases the Gini Coefficient (income inequality) by **3.19 units**.

An increment in the ratio of M3 to GDP, (financial development) increases the Gini Coefficient (income inequality). This is because in India, economic and financial liberalization have a harmful effect on income distribution. It is seen that financial sector reforms benefited only small elites (Ang, 2008). It further led to regional imbalance and skewed investment patterns which affected livelihoods and employment generation (Pal & Ghosh, 2007). Hence, income inequality has increased along with financial development in India.

An increment in Unemployment Rate, decreases the Gini Coefficient (income inequality). It is seen that economic reforms in India have been associated with a drop in the rate of labour absorption, giving rise to unemployment. Although unemployment rate is increasing, one can see a shift in pattern of employment towards self-employment in urban-rural and men-women. Much of the employment growth has been in informal sector, which is manifest in high growth in self employment. Changing character of informal sector and its linkages with formal economic activities have given income earning opportunities as a result income inequality may show downward trend (Kundu & Mohanan, 2009).

II. CONCLUSION:

Quality Education has a long-term consequence for health, cognitive development and employment prospects (UNDP, 2019). Hence, attempts should be made to provide quality education.

Through education, by raising awareness or by changing incentives, government can change unequal power relationships among individuals within a community and also challenge deeply rooted gender roles in society. The three dimensions i.e., education, awareness and incentives often reinforce each other (UNDP, 2019). This will help women and the backward caste, the weaker sections of India to get education and employment opportunities to have better standard of living. This may help to reduce income inequality in the country. To attain this objective special financial institution like '**Education Bank**' be set up to provide education loans and other incentives. These banks should have tie up with quality education institutions and corporate world. These three entities should design the syllabi, at regular interval, to meet the market requirements on one hand and to provide army of required skilled people on other hand.

In case of India, attempt should be made to increase the tax revenue by simplifying the tax structure, extending the tax net and reducing the tax rates. This will help the government to raise more tax revenue which they can spend more on the welfare of the weaker sections of the community and their skill development. This

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skill development will create self-employment and raise income opportunities which in turn will reduce income inequality in the country.

To reduce the incidence of inequality, there is need to bring the unbanked- weaker segment of population in the mainstream of the economy. For this purpose, we have to increase the 'financial accessibility' of up-till-now ignored population. So, various scheme of 'financial accessibility' be innovated and implemented effectively. Scheme should be devised in such a manner that banks would reach to such population. For this purpose, Post Offices, which have made their appearances in almost all villages, be asked to provide banking services in their vicinity; mobile (van) banking should be introduced. Such 'banking vehicles' should visit at least two days in a week to provide banking services to needy people.

An effective combination of fiscal stimulus and financial inclusion may help to reduce the incidence of income inequality by helping up-till-now ignored people to come in mainstream of development and by increasing their participation rate.

This study shows that in India income inequality has increased along with financial development. So, more in-depth study is required to see how financial development can reach the grass root level to provide more income opportunities to the unemployed and the poor.

India has a high level of horizontal inequalities based on caste, class, religion, race, gender, and location. Horizontal inequalities are embedded in social and political structures and affect citizen's access to basic services such as education, health nutrition, sanitation and opportunities (Himanshu, 2019). One can work in depth each of the aspects of horizontal equity. This may help the policy makers to take more effective measures to correct the problem of income inequality in the country.

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भूमण्डलीय तापक्रम वृद्धि के परिप्रेक्ष्य में बाढ़-प्रवण भारत में बढ़ते बाढ़ प्रकोप : एक चिंतन

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सारांश :

चीन के बाद भारत वैश्विक स्तर पर सबसे अधिक बाढ़ प्रवण देशों में से एक है। 60% भारतीय जिलों में अत्यधिक भारी वर्षा के कारण बाढ़ की घटनाओं की बारंबारता एवं तीव्रता में वृद्धि देखी जा रही है। पिछले एक दशक के दौरान देश में भारी वर्षा की घटनाओं में लगभग 85% की वृद्धि हुई है। जलवायु परिवर्तन के अलावा उच्च बाढ़-प्रवण क्षेत्र, अनियमित मूसलाधार वर्षा, उच्च जनसंख्या घनत्व, वनों की कटाई, अवैध भवन निर्माण, पर्यावरणीय गिरावट और बांध या बैराज की वजह से नदियों के अनुप्रवाह में अत्यधिक अवसादन (सिल्टिंग) ने भारतीय राज्यों में बाढ़ से होने वाली जान-माल की क्षति को बढ़ाने में योगदान दिया है। इसके साथ साथ भूमि-उपयोग परिवर्तन, बाढ़ के मैदानों (फ्लड-प्लैन) का दोहन, सदोष ठोस (सॉलिड) अपशिष्ट प्रबंधन और जल निकासी का विनाश जैसे कारकों की वजह से बाढ़ की समस्या और जटिल बन जाती है। भारत की कुल प्राकृतिक आपदाओं में से 53 प्रतिशत घटनायें बाढ़ के कारण घटती है; जो यहाँ 68% आर्थिक नुकसान और 32% मौतों के लिए जिम्मेदार है। भूमण्डलीय तापक्रम वृद्धि के लिए जिम्मेदार कार्बन-डाइऑक्साइड की सांद्रता जिस दर से बढ़ रही है, उससे भारत में हर 13 साल में अत्यधिक बाढ़ या तूफान का खतरा दुगना हो सकता है। ग्रीनहाउस गैसों के उत्सर्जन से तापमान में प्रत्येक एक डिग्री सेल्सियस की वृद्धि 7% अधिक नमी धारण करती है। जिसके कारण आने वाले दशकों में भारी मूसलाधार बारिश में तीव्र वृद्धि के साथ-साथ बाढ़ और चक्रवात जैसी चरम जलवायु घटनाओं के प्रति भारत की भेद्यता (वल्नरेबिलिटी) बढ़ना सुनिश्चित है। प्राकृतिक आपदाओं के राहत कार्यों पर अपनी सकल घरेलू उत्पाद का 0.23 प्रतिशत खर्चा करना भारत जैसे विश्व के शीर्ष आपदा-प्रवण देश के लिए पर्याप्त नहीं है। बढ़ते बाढ़ प्रकोपों के मद्देनजर एक सर्वोच्च प्राथमिकता के तहत इस आपदा की जोखिम को कम करने के लिए भारत में पर्याप्त राहत निधि के प्रावधान के साथ साथ बेहतर बाढ़ प्रबंधन प्रयासों का कार्यान्वयन अनिवार्य है। प्रस्तुत शोध पत्र बाढ़ आपदा से जुड़े कुछ पहलुओं का हाल ही में प्रकाशित साहित्य के आधार एक समीक्षात्मक अध्ययन है।

(मूल शब्द: भूमण्डलीय तापक्रम वृद्धि, जलवायु परिवर्तन, ग्रीनहाउस गैस, बाढ़ प्रवणता, बाढ़ के मैदान, अवसादन (सिल्टिंग), ठोस (सॉलिड) अपशिष्ट)

प्रस्तावना :

बाढ़ या सैलाब तब आता है जब लबालब भरे जल निकायों - नहरों-नदियों, तालाबों, झीलों, तटवर्ती समुद्रों के अधिप्लावन (ओवरफ्लो) से भूमि जलमग्न हो जाती है जो आमतौर पर सूखी होती है। बाढ़ विभिन्न कारणों से हो सकती है, और इसे पांच प्रमुख प्रकारों में वर्गीकृत किया गया है - आकस्मिक बाढ़ (फ्लैश फ्लड), तटीय बाढ़, नदी (फ्लूविअल) बाढ़, झील या तालाब (प्लवियल) बाढ़, और शहरी बाढ़। आकस्मिक बाढ़ तेजी से

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आने वाली अप्रत्याशित बाढ़ है; जो तब होती है जब बहते जल स्तर में बादल फटने ने से एकाएक तेजी से वृद्धि होती है- जैसे कि अचानक भारी बारिश या ग्लेशियल झील के विस्फोट या प्रकोप के कारण। तटीय बाढ़ तब आती है जब उच्च ज्वार के साथ भारी तूफान के कारण समुद्र का जलस्तर एकाएक बढ़ जाता है; जो समुद्री जल को तट से सटे सामान्यत: शुष्क अंतर्देशीय क्षेत्रों में धकेल देता है। नदी या फ्लुवियल बाढ़ आम तौर पर तब होती है जब लंबे समय तक या महावृष्टि के कारण नदियाँ उफनती हैं, अपने नदी तटों को तोड़ते हुये और आसपास के क्षेत्रों में सैलाब लाती हैं। तालाब या प्लवियल बाढ़ समतल क्षेत्रों में तब होती है जब लंबे समय तक बारिश होने से भूमि की नदी या नहर प्रवाह के माध्यम से जल निकासी और भूजल या झील प्रणाली के माध्यम से जल अवशोषण क्षमता प्रभावित होती है। शहरी बाढ़ विशेष तौर पर तब होते हैं जब किसी शहर की मलप्रवाह (सीवेज) -प्रणाली और नाला या नहर प्रणालियाँ आकस्मिक या तटीय या नदी में बाढ़ या भारी वर्षा के कारण पानी के बड़े प्रवाह को पर्याप्त रूप से संभाल नहीं पाती हैं। ज्यादातर मामलों में, शहरी बाढ़ शहरों में खराब नियोजन तथा रखरखाव वाली जल निकासी प्रणालियों और झील-तल जैसे निचले इलाकों में अतिक्रमण के कारण होती है।

विश्व संसाधन संस्थान के नवीनतम अध्ययन के अनुसार पिछले 40 वर्षों में, बाढ़ के परिणामस्वरूप मानवता को एक ट्रिलियन यूरो से अधिक की लागत का नुकसान हुआ है और 2030 तक यह नुकसान में तेजी से घातांकीय स्तर पर वृद्धि होने की आशंका है। इस अध्ययन में किये गए पूर्वानुमान के अनुसार नदी बाढ़ से प्रभावित लोगों की संख्या 2010 में 65 मिलियन से बढ़कर 2030 में 132 मिलियन हो जाएगी, और तटीय बाढ़ से प्रभावित लोगों की संख्या 7 मिलियन से बढ़कर 15 मिलियन हो जाएगी। प्रभावित लोगों की संख्या में इस दुगनी वृद्धि से शहरी क्षेत्रों की मरम्मत के लिए लागत प्रति वर्ष 145 बिलियन यूरो से बढ़कर 500 बिलियन यूरो से अधिक हो जाएगी। तूफानों और तटीय बाढ़ों की उफनती लहरों के कारण तटीय क्षेत्रों की मरम्मत के लिए लागत 15 बिलियन यूरो से बढ़कर 163 बिलियन तक हो जायेगी। भारत, बांग्लादेश और इंडोनेशिया इन देशों की सबसे बड़ी आबादी हर साल नदी और तटीय बाढ़ से प्रभावित होती है। वैश्विक स्तर पर 2030 तक, इन देशों में प्रतिवर्ष नदी एवं तटीय बाढ़ से प्रभावित होने वाली कुल आबादी का क्रमश: 44% और 58% हिस्सा इन तीन देशो से होने का पूर्वानुमान है।

बाढ़ के तात्कालिक प्रभावों में मानव जीवन की हानि, संपत्ति की क्षति, फसलों का विनाश, पशुधन की हानि और जलजनित बीमारियों के कारण स्वास्थ्य की स्थिति में गिरावट शामिल है। 2021 में एक अध्ययन के अनुसार, भारत में पिछले 50 वर्षों में बाढ़ और चक्रवातों के कारण चरम मौसम संबंधी मानव मृत्यु की सबसे अधिक घटनायें हुई है। प्रति वर्ष चरम मौसम की घटनाओं के कारण होने वाली लगभग 75% मृत्यु के लिए बाढ़ और चक्रवात इन दोनों को जिम्मेदार माना जाता है। प्रारंभिक पहचान और चेतावनी प्रणालियों में प्रगति और आपदा प्रबंधन में बड़ी प्रगति के बावजूद, पिछले दो दशकों में भारत के कई राज्यों में चरम मौसम के कारण मृत्यु दर में भारी वृद्धि हुई है। आपातकालीन घटना डेटाबेस (2020) के अनुसार चीन के बाद भारत वैश्विक स्तर पर सबसे अधिक बाढ़ प्रभावित देशों में से एक है। इस डेटाबेस के अनुसार, 1980 से 2011 की अवधि में चीन में 194 बाढ़ें आईं, जो अन्य देशों में सबसे अधिक हैं, इसके बाद भारत (190) है। हालांकि

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पिछले दशक में भूमण्डलीय तापक्रम वृद्धि एवं वैश्विक जलवायु परिवर्तन के कुप्रभावों की पृष्ठभूमि बाढ़ बारंबारता एवं तीव्रता में निश्चित रूप से वृद्धि हुई है। भारत की भू-जलवायु परिस्थितियों के कारण बाढ़ से गंभीर मौतें और क्षति हुई है। इसके अलावा, अन्य कारक जैसे उच्च बाढ़-प्रवण क्षेत्र, अनियमित मूसलाधार वर्षा, उच्च जनसंख्या घनत्व, वनों की कटाई, अवैध भवन निर्माण और पर्यावरणीय गिरावट ने भारतीय राज्यों में बाढ़ से होने वाली क्षति को बढ़ाने में योगदान दिया है।

भारत की प्राकृतिक आपदाओं में से आधी घटनायें (53%) बाढ़ के कारण घटती है जिसके कारण बाढ़ को भारत में सबसे महंगी आपदा के रूप में दर्ज किया गया है, जो सभी प्राकृतिक आपदाओं से होने वाले नुकसान की तुलना में 68% आर्थिक नुकसान के लिए जिम्मेदार है। इसके अलावा, भारत में भूकंप और बाढ़ के कारण क्रमशः 39 % और 32% मौतें होती है जो अन्य प्राकृतिक आपदाओं की तुलना में सर्वाधिक है। भारत के लिए जलवायु जोखिम एटलस से यह पता चलता है 75% भारतीय जिले मोसम से जुडी चरम घटनाओं के प्रति अतिसंवेदनशील हैं, जिनमें से 60% से अधिक जिले अत्यधिक बाढ़ की घटनाओं के हॉटस्पॉट हैं। इन बाढ़ हॉटस्पॉटों में से अधिकांश में अत्यधिक भारी वर्षा से उत्पन्न बाढ़ में वृद्धि देखी जा रही है। जलवायु परिवर्तन मौसमी परिवर्तनशीलता को भी बाधित कर रहा है; 40% जिले अदला-बदली (स्थापिंग) की प्रवृत्ति प्रदर्शित कर रहे हैं, जहां पारंपरिक बाढ़ प्रवण क्षेत्र सूखाग्रस्त होते जा रहे हैं और इसके विपरीत भी। आने वाले दशकों में भारी बारिश और सूखे के दौर में तीव्र वृद्धि देखने को मिलेगी, जिसमें 10 में से 8 भारतीय चरम जलवायु घटनाओं के प्रति सुभेद्य (वल्नरेबल) होंगे। नवीनतम निष्कर्षों से पता चलता है कि शुष्क दिनों की संख्या बढ़ रही है जबकि लगातार और अनियमित वर्षा सभी सीमाओं को तोड़ रही है। भारतीय मौसम विज्ञान विभाग के अनुसार, पिछले एक दशक के दौरान देश में भारी वर्षा की घटनाओं में लगभग 85% की वृद्धि हुई है।

बाढ़ से बारंबार होने वाली जान-माल की बेशुमार तबाही के मद्देनजर निश्चित रूप से यह एक सबसे बड़ी राष्ट्रीय विपत्ति है; किंतु बाढ़ कई लाभ भी ला सकती है - जैसे भूजल स्तर का पुनर्भरण (रिचार्ज) करना, मिट्टी को अधिक उपजाऊ बनाना और कुछ मिट्टी में पोषक तत्वों को बढ़ाना। आर्द्रभूमि के स्वास्थ्य को संतुलित करना। बाढ़ का पानी शुष्क और अर्ध-शुष्क क्षेत्रों में बहुत आवश्यक जल संसाधन प्रदान करता है, जहां वर्षा कम होती हैं। बाढ़ जमें हुए मलबे को हटा या बहा देती है। बाढ़ से झीलों, तालाबों, नदियों और तटवर्ती समुद्र में पोषक तत्व डालकर उन्हें उपजाऊ बना सकती है, जिससे बायोमास में वृद्धि होती और कुछ वर्षों के लिए मत्स्य पालन में सुधार हो सकता है। बाढ़ अपने पीछे महीन रेत, मिट्टी, गाद और कार्बनिक पदार्थ छोड़ जाती है। बाढ़ के मैदान (फ्लड प्लेन) दुनिया के सबसे उपजाऊ कृषि क्षेत्रों में से एक हैं। बाढ़ विशेष रूप से नदी कॉरिडोर में पारिस्थितिकी तंत्र को बनाए रखने में महत्वपूर्ण भूमिका निभाती है और बाढ़ के मैदानों की जैव-विविधता को बनाए रखने में एक महत्वपूर्ण कारक है।

परिकल्पना :

जलवायु परिवर्तन एवं भूमण्डलीय तापक्रम वृद्धि की पृष्ठभूमि में, तथा भारत की अंतर्निहित बाढ़ प्रवणता के मद्देनजर आनेवाले समय में बाढ़ प्रकोपों की बारंबारता एवं तीव्रता में वृद्धि सुनिश्चित है। इसी

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परिप्रेक्ष्य में एक सर्वोच्च प्राथमिकता के तहत एक ओर इस आपदा की जोखिम को कम करने के लिए पर्याप्त राहत निधी के प्रावधान के साथ साथ बेहतर बाढ़ प्रबंधन प्रयासों को कार्यान्वयन अनिवार्य है तो दूसरी ओर संधारणीय विकास लक्ष्यों एवं पॅरिस समझौते के प्रति अपनी प्रतिबद्धताओं को शिद्दत से निभाना है।

क्रिया-विधि :

प्रस्तुत लेख गुणात्मक विषय-वस्तु विश्लेषण के दायरे में असंरचित और गैर-संख्यात्मक डेटा पर निर्भर रहकर समस्या के सटीक स्वरूप को हल करने के लिए इस क्षेत्र के विशेषज्ञों एवं अनुसंधान कर्ताओं के संदर्भ सूचीबद्ध प्राथमिक एवं प्रकाशित साहित्य या डेटा का एक समीक्षात्मक अध्ययन है।

विचार विमर्श :

भूमण्डलीय तापक्रम वृद्धि के लिए जिम्मेदार कार्बन-डाइऑक्साइड की सांद्रता जिस दर से बढ़ रही है, उससे हर 13 साल में अत्यधिक बाढ़ या तूफान का खतरा दुगना हो सकता है जो भारत के लिए तबाही का कारण बन सकता है। हर साल लगभग एक चरम आपदा का सामना करने वाले भारत जैसे देश के लिए तीव्र जल-मौसम आपदाओं की संख्या में सालाना 5.4% की वृद्धि हो सकती है। जब कोई आपदा 100 या अधिक मौतों का कारण बनती है और / या 1,000 या अधिक लोगों को प्रभावित करती है तो उसे 'चरम आपदा' के रूप परिभाषित किया गया है। अत्यधिक वर्षा की घटनाओं को जन्म देने वाली भौतिक प्रक्रियाओं को समझना एक बहुस्तरीय चुनौती है; जिस पर व्यापक अनुसंधान की आवश्यकता है। 2020 का एक हालिया प्रकाशन, इस संदर्भ में विस्तृत जांच करता है, और बताता है कि पिछले दो दशकों में सबसे विनाशकारी बाढ़ों में से कुछ - अगस्त 2018 की केरल बाढ़, दिसंबर 2015 में चेन्नई बाढ़, जून 2013 की उत्तराखंड बाढ़, जून 2010 की लेह बाढ़ और 2005 की मुंबई बाढ़ - सभी में एक सामान्य कारक है। ये सभी घटनाएँ तब घटित हुई जब कई निम्न दबाव प्रणालियाँ अवकाशिक और कालिक रूप से एक साथ घटित हुईं और एक संगठित गहरी संवहन (कन्वेक्शन) प्रणाली बनाई जिसके कारण बड़े पैमाने पर भारी वर्षा हुई।

कार्बन डाइऑक्साइड उत्सर्जन के कारण होने वाले जलवायु परिवर्तन के अलावा, कई भूमि-उपयोग परिवर्तनों को बाढ़ के प्रमुख कारणों के रूप में पहचाना गया है। नदी घाटी में अवैध रेत खनन से इसके किनारे नष्ट हो जाते हैं; जिससे नदी का मार्ग प्रभावित हो जाता है, जिसके परिणामस्वरूप घाटी के खेत पानी से भर जाते हैं। अनुचित बांध (डॅम) प्रबंधन के कारण जिस क्षेत्र में बाढ़ आती है वहाँ कृषि भूमि को बड़े पैमाने पर फसल क्षति का सामना करना पडता है। बढ़ती हुई बाढ़ आपदाओं के लिए अवैज्ञानिक भूमि-उपयोग परिवर्तन जैसे कि खाई खोदना, रैखिक गलियारों (कॉरिडर) का विकास (रेल लाइनें, बिजली लाइनें और राजमार्ग बिछाना), और रिसॉर्ट्स के निर्माण को दोषी ठहराया गया है। बांध या बैराज के कारण नदी में भारी गाद (सेडीमेंट) जमा हो गई है। अत्यधिक अवसादन (सिल्टिंग) की वजह नदी का आकार छोटा हो जाता है, जिससे उसकी वहन क्षमता कम हो जाती है। बाढ़ का मैदान आम तौर पर नदी या जलधारा के बगल में स्थित भूमि का समतल क्षेत्र होता है। यह नदी के किनारे से लेकर घाटी के बाहरी किनारों तक फैला होता है और इसके प्राकृतिक विकास में दो प्रमुख प्रक्रियाएँ शामिल हैं: एक घिसाव या भूक्षरण और दूसरा -अवसादन

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(सेडीमेन्टेशन) द्वारा भूमिवृद्धि। नदी के अनुप्रवाही (डाउनस्ट्रीम) क्षेत्र में अवसादन की वजह से बारिश के हर मौसम में बाढ़ का खतरा जैसे का वैसा बना रहता है। अवसादन से नदियों- नालों में गाद जमा होने से नदी-तल का स्तर बढ़ता है। प्रदूषित पानी में जलकुंभी पनपती है, जिससे जल प्रवाह बाधित होता है।

मुंबई, चेन्नई, दिल्ली जैसे प्रमुख शहरों में, ग्रीन स्पेस (जैसे आर्द्रभूमि, दलदल और मैंग्रोव वन) का नष्ट हो जाना, झीलों और तालाबों को शहरी आवास या कार्यालय स्थान में शामिल करना और नालियों की अनुचित गाद सफाई (डिसिल्टिंग) और रखरखाव को बाढ़ के प्रमुख कारणों के रूप में पहचाना गया है। कई जगहों में सदोष डिज़ाइन वाले राजमार्गों और बुनियादी ढांचा परियोजनाओं ने स्थानीय जल विज्ञान को बाधित कर दिया है और बाढ़ के प्रभाव को बदतर बना दिया है। इन सभी परिवर्तनों के परिणामस्वरूप शहरों के भीतर पानी के प्रति अभेद्य सतहों का विस्तार हुआ है; इससे जल निकासी और मलमार्ग (सीवर) प्रणालियों पर ओवरलोड पड़ता है और अंततः स्थानीय बाढ़ आती है। सदोष ढंग से डिजाइन किए गए शहरी विस्तार और जल संग्रहण की संभावना वाले निचले इलाकों में आवास अतिक्रमण शहरी बाढ़ की समस्याओं को और बढ़ा देते हैं। शहरी बाढ़ पर विश्व मौसम विज्ञान संगठन की रिपोर्ट में कहा गया है कि बाढ़ से जल स्तर बढ़ने से घरों और इमारतों में अपशिष्ट जल (सीवेज) अधोमुख (रिव्हर्स) होकर जमा हो जाता है और क्षतिग्रस्त ट्रीटमेंट प्लॅन्ट से अनुपचारित अपशिष्ट जल की रिहाई या निकासी नहीं होती। क्षतिग्रस्त उत्पादन सुविधाओं या भंडारण क्षेत्रों से बाढ़ के पानी से खतरनाक रसायन और ईंधन फैल सकते हैं, या बाढ़ के पानी में तैरकर कंटेनर किसी और के बैकयार्ड में भी जा सकते है। अनुपचारित अपशिष्ट जल (सीवेज) और जहरीले रसायन दोनों ही सार्वजनिक स्वास्थ्य और जल आपूर्ति के लिए उल्लेखनीय खतरा पैदा कर सकते हैं।

अध्ययनों से पता चला है कि चक्रवातों का आकार और उनके लैंडफॉल का समय बाढ़ की तीव्रता निर्धारित करने में महत्वपूर्ण कारक हैं। जब चक्रवात का असर पानी के बाद जमीन पर पड़ने लगता है उस स्थिति को लैंडफॉल कहते हैं। एक अन्य अध्ययन में कहा गया है कि भविष्य में *अम्फान* जैसे महा चक्रवात वर्ष 2100 तक एक मीटर से अधिक की तूफान-उछाल बाढ़ का कारण बन सकते हैं। इसका मतलब यह होगा कि प्रभावित लोगों की संख्या ऐसी बाढ़ें *अम्फान* द्वारा लाए गए विनाश का सामना करने वालों की तुलना में 2.5 गुना अधिक होंगी। बाढ़ की तीव्रता की भविष्यवाणी करने में चक्रवात के लॅंडफॉल का समय भी महत्वपूर्ण है। शोध से पता चलता है कि पूर्व-मानसून में आने वाले चक्रवातों से शुष्क भूमि की स्थिति के कारण गंभीर बाढ़ आने की संभावना कम होती है। जब चक्रवात मानसून के साथ परस्पर -व्याप्त होते हैं या मानसून के मौसम के ठीक बाद आते हैं, तो बाढ़ आने की संभावना बढ़ जाती है। उदाहरण के तौर पर चक्रवात *फैलिन* से एक बात स्पष्ट होती है की जब एक चक्रवात भारी वर्षा लाता है, तो इससे बाढ़ आने की संभावना बढ़ती है क्योंकि मानसून की बारिश से भूमि में पहले से ही बहुत सारी नमी सोख लेती है। हालाँकि, यह स्पष्ट है कि बाढ़ की तीव्रता को प्रभावित करने वाले इन वायुमंडलीय कारकों के कारण जलवायु परिवर्तन और भूमण्डलीय तापक्रम वृद्धि में निहित हैं - ये दोनों अंततः मानव-जनित प्रभाव हैं।

एक अन्य अध्ययन के अनुसार, तीन मुख्य कारक दुनिया में बाढ़ के खतरे को बढ़ा रहे हैं। जलवायु परिवर्तन से प्रभावित भविष्य में, बारिश समय के साथ कहीं अधिक स्थानीयकृत और मजबूत होगी, जिससे बाढ़ का खतरा बढ़ जाएगा। पहला जलवायु परिवर्तन है, जो अधिक गंभीर तूफानों से उत्पन्न होने वाली

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मूसलाधार वर्षा और लहरों को तेज करता है। जलवायु परिवर्तन से ग्रीनहाउस गैसों का उत्सर्जन होता है जो वातावरण को गर्म करती हैं। तापमान में प्रत्येक डिग्री सेल्सियस की वृद्धि 7% अधिक नमी धारण कर सकती है। वातावरण जितना गर्म होगा, वह उतनी ही अधिक नमी धारण कर सकता है। यह एक स्पंज की तरह है जो पानी को सोखता रहता है और जब यह पानी को और नहीं रोक पाता है, तो इसे एक साथ छोड़ देता है। इस प्रकार गरमाहट अत्यधिक वर्षा का कारण बनती है।

बाढ़ के अन्य कारकों में से एक है जन सांख्यिकीय वृद्धि, क्योंकि आबादी के नए आगमन को समायोजित करने के लिए, दुनिया के कई शहर बाढ़ के उच्च प्रतिशत वाले क्षेत्रों में घर बनाना शुरू कर रहे हैं। विश्व के कई देशों में, 2030 तक जितने लोग सालाना नदी बाढ़ से प्रभावित होने की आशंका जतायी गयी है, जो मौजूदा जोखिम से दस गुना अधिक है, जिसका बड़ा कारण नदियों के पास नया भवन निर्माण या विकास है। जनसंख्या एवं मानव घनत्व में वृद्धि का अत्यधिक अतिभार शहरों की वहन क्षमता के परे हो जाता है; जो शहर में आने वाले प्रत्येक व्यक्ति के लिए जगह की मांग और भवन निर्माण की आवश्यकता पैदा करता है। शहरों में हालिया चलन यह है कि जल निकासी वाले नालों को कंक्रीट के नाली पाइप डालकर और उन पर सड़कें बनाकर ढक दिया जाए। बढ़ते शहरी यातायात जाम को इस तरह की अल्पजीवी एवं कुटिल शॉर्ट-कट द्वारा राहत देने की कोशिश की जाती है, लेकिन इससे नालों की क्षमता के साथ-साथ उनके रखरखाव में भी गंभीर बाधा आती है। बाढ़ मौसम विज्ञान-संबंधी - वर्षा की बारंबारता और तीव्रता, तूफान, तापमान, दाब - और जल विज्ञान संबंधी कारकों - भूजल स्तर, अभेद्य या अप्रवेशनीय सतह की सीमा) दोनों का मिलाजुला परिणाम है। जब शहरी केंद्रों में भूमि-उपयोग परिवर्तन, भवन-निर्माण और इसी तरह की गतिविधियों द्वारा बाढ़ के मैदानों का दोहन, सदोष ठोस (सॉलिड) अपशिष्ट प्रबंधन और जल निकासी का विनाश जैसे मानव जनित कारकों की वजह से जटिल बन जाता है।

उपसंहार :

जलवायु परिवर्तन के परिणामों का शमन या अल्पीकरण करने के लिए अपनाए जाने वाले व्यापक दृष्टिकोणों के अलावा, भारत जैसे बाढ़-प्रवण देश के लिए एक मजबूत बाढ़ प्रबंधन संरचनाओं की आवश्यकता है। इनमें न केवल बार-बार बाढ़ आने की संभावना वाले क्षेत्रों में बेहतर आपदा शमन प्रणाली शामिल है, बल्कि बाढ़ के मैदानों (फ्लड प्लेन) का उपयोग कैसे किया जाता है इसका बेहतर विनियमन भी शामिल है। इसके अलावा, तटीय शहरों के विस्तार को समायोजित करने के लिए बेहतर ढंग से डिजाइन करने की आवश्यकता है; जो प्राकृतिक पारिस्थितिकी तंत्र को बनाए रखे और भविष्य के जलवायु परिवर्तन के प्रति लचीला हो।

प्राकृतिक बाढ़-सुरक्षा प्रणालियों को पुनर्जीवित करने और इसके आपदा पूर्वानुमान, शमन और बचाव कार्यों को मजबूत करने के लिए सुविचारित वैज्ञानिक तकनीकों को लागू करके बाढ़ के प्रभाव को कम किया जा सकता है। हमारे प्रयास ऐसे हो जो बाढ़ के प्रति लचीलापन बनाने की दिशा में निर्देशित हो। दलदल, आर्द्रभूमि, नदियों पर केंद्रित पुनर्स्थापन और संरक्षण परियोजनाएं बाढ़ और सूखे दोनों के खिलाफ लचीलापन विकसित करने में महत्वपूर्ण कदम हो सकता है। भारी वर्षा की अवधि के दौरान दलदल, आर्द्रभूमि और झीलें पानी को

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संग्रहीत करने के लिए स्पंज के रूप में कार्य करती हैं, और ऐसी भारी वर्षा की घटनाओं के बाद पानी की निकासी के लिए स्वच्छ, मुक्त बहने वाली नदियाँ और जलमार्ग नेटवर्क महत्वपूर्ण हैं।

कुछ महानगरों में कम लागत वाले आवास के लिए के साल्ट-पैन या नमक क्षेत्रों को उपलब्ध कराने की योजना अनुचित है। ये नमक क्षेत्र, जिन्हें कभी आर्द्रभूमि माना जाता था, न केवल किसी क्षेत्र के लिए बाढ़ के लिए महत्वपूर्ण प्राकृतिक बाधाएं हैं, बल्कि क्षेत्र की नाजुक और संवेदनशील पारिस्थितिकी का भी हिस्सा हैं। ऐसी विकासात्मक योजनाओं के अलावा, अन्य, योजनायें जैसे नदी पुनर्जीवन परियोजना, पुनःस्थापन और संरक्षण के लिए अवैज्ञानिक या पुराने दृष्टिकोण के मुद्दों से ग्रस्त हैं। इसी तरह, बड़े पैमाने पर वृक्षारोपण गतिविधियों पर ध्यान केंद्रित करने वाला नदी पुनर्जीवन कार्यक्रम, शहरी अति विकास, प्रदूषण और नदी तट कटाव जैसे केंद्रीय मुद्दों को संबोधित करने में विफल रहा है, जो नदियों के मृत करने के लिए जिम्मेदार प्रमुख कारक हैं।

भारत सरकार प्राकृतिक आपदाओं के राहत कार्य से जुड़े सामग्री वितरण, निकासी (रिक्तीकरण) और पुनर्वास उपायों पर अपनी सकल घरेलू उत्पाद के एक प्रतिशत का चौथाई हिस्सा (0.23%) खर्च करती है। आपदा प्रबंधन के लिए निर्देशित सार्वजनिक व्यय का यह अनुपात भारत जैसे विश्व के सबसे अधिक आपदा-प्रवण देश के लिए पर्याप्त नहीं है। प्राकृतिक आपदाओं की बढ़ती बारंबारता एवं तीव्रता के मद्देनजर भारतीय राज्यों में आपदा जोखिम को कम करने के लिए पर्याप्त राहत निधी के साथ साथ बेहतर आपदा प्रबंधन प्रयासों को लागू करने की आवश्यकता है। संक्षिप्त में पॅरिस समझौते के प्रति अपनी प्रतिबद्धताओं को शिद्दत से निभाते हुये संधारणीय विकास रणनीति द्वारा एक सुरक्षित और आपदा प्रतिरोधी देश का निर्माण हो जिसमें सम्मिलित सभी हितधारक द्वारा रोकथाम, तैयारी और शमन की संस्कृति को बढ़ावा मिले।

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हृद्वाहिका रोग के प्रमुख चालक एवं त्वरक के रूप में इंसुलिन प्रतिरोध सिंड्रोम: एक समीक्षात्मक पुनरावलोकन

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सारांश

हृद्वाहिका (कार्डियोवॅस्क्युलर) रोग यह टाईप 2 मधुमेह की बृहत (मॅक्रो) रक्तवाहिनियों जटिलताओं की देन है; इसलिए हृदय रोग को डॉक्टर्स 'निदान नहीं हुआ (अनडायग्नोस्ड) डायबिटीज' भी कहते है। विश्व स्वास्थ्य संघटन ने मेटाबॉलिक सिंड्रोम को जिस तरह से परिभाषित किया है; उस में ना ही कुल कोलेस्ट्रॉल का जिक्र है और ना ही एलडीएल कोलेस्ट्रॉल का। किन्तु दुनिया भर में इन दोनों कोलेस्ट्रॉल के प्रति एक डर ज्यों के त्यों बना हुआ है; जिसके कारण दशकों से अतिग्लुकोजरक्तता (हायपरग्लायसेमिया), अतिइंसुलिनरक्तता (हायपरइन्सुलिनेमिया) और इंसुलिन प्रतिरोध (रेसिस्टेंस) की तरफ किसीका ध्यान आकर्षित नही हुआ और ना इसके ख़िलाफ़ कोई चेतना जागृत हुयी; जो दरअसल इस जानलेवा बीमारी के मुख्य चालक और त्वरक दोनों भी है। सिरम में ट्रायग्लिसेराइड्स मेद का बढ जाना और एचडीएल इस हृदय-हितैषी कोलेस्ट्रॉल का घट जाना और उनके परस्पर अनुपात का बढ जाना यह स्वयंसिद्ध जोखिम कारक इंसुलिन प्रतिरोध से जुड़े हुए है। इंसुलिन प्रतिरोध यह अतिग्लुकोजरक्तता एवं अतिइंसुलिनरक्तता इन दोनों से निर्मित एक दुष्चक्र है; जो शरीर के अंदर एथेरोजेनिक डिसलिपिडेमिया, नॉन-एल्कोहॉलिक फैटी यकृत (लिव्हर), प्रदाह, ऑक्सीडेटिव्ह तनाव, मायटोकॉन्ड्रीएल दुष्क्रिया आदि पतनकारक (डिजेनेरेटिव्ह) प्रक्रियाओं को बल देता है। हृदय तथा हृद्वाहिका रोग से मुक्ती के लिए कुल कोलेस्ट्रॉल या एलडीएल कोलेस्ट्रॉल के बजाय पूरा ध्यान और प्रयास अतिग्लुकोजरक्तता, अतिइंसुलिनरक्तता और इंसुलिन प्रतिरोध से बचने पर होना चहिये। मेटाबॉलिक तबाही ग्लूकोज, फ्रुक्टोज इन दो मोनोसॅकाराइड्स और वो जिस पॉलीसॅकाराइड्स से बनते है उस -स्टार्च का अति सेवन में अंतर्निहित है। इंसुलिन संवेदनशीलता की बहाली ही हृदयरोग से मुक्ति की कुंजी है। अंतिमतः टाईप 2 मधुमेह यह एक संवहनी (वॅस्कुलर) रोग है और हृद्वाहिका (कार्डियोवॅस्क्युलर) रोग यह उसी निदान हो चुकें या ना हो चुकें टाईप 2 मधुमेह की जानलेवा बृहत (मॅक्रो) रक्तवाहिनी जटिलता है।

मूल शब्द : हृद्वाहिका रोग, टाईप 2 मधुमेह, बृहत रक्तवाहिनी जटिलता, अतिग्लुकोजरक्तता अतिइंसुलिनरक्तता, इंसुलिन प्रतिरोध, एथेरोजेनिक डिसलिपिडेमिया, नॉन-एल्कोहॉलिक फैटी यकृत , प्रदाह, ऑक्सीडेटिव्ह तनाव, मायटोकॉन्ड्रीएल दुष्क्रिया)

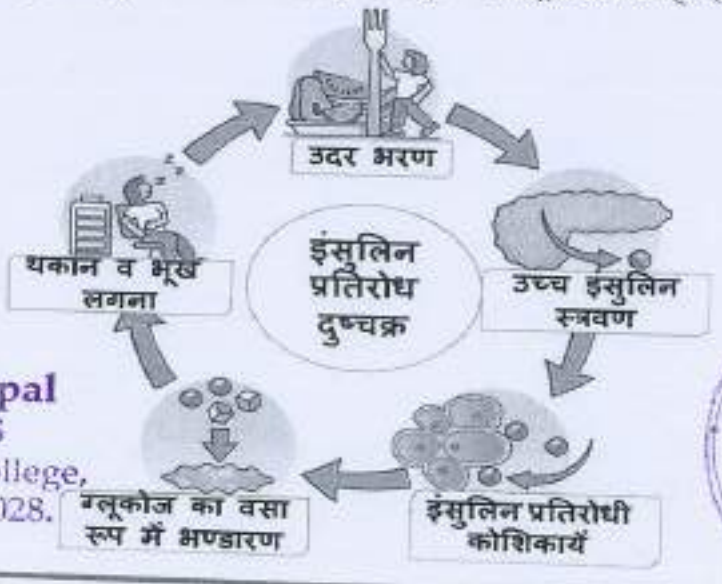
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प्रस्तावना:

अधिकांश टाईप 2 मधुमेह एवं पुर्व-मधुमेह रोगी **हृद्वाहिका** (कार्डियोवॅस्क्युलर) रोग से मरते हैं और तो और किसी औसत व्यक्ति की तुलना वे बहुत कम उम्र में मरते हैं। हृदय रोग को मधुमेह की बृहत (मॅक्रो) रक्तवाहिनियों जटिलताओं से संबंधित एक शक्तिशाली त्वरक (एक्सीलेटर) के रूप में स्वीकार किया जाता है, जो किसी भी अन्य चालक (ड्रायव्हर) या त्वरक से अधिक महत्वपूर्ण है। किन्तु आज भी विश्व मे और खास कर अपने देश में सिर्फ कोलेस्ट्रॉल को ही हृदय रोग से मृत्यु का मुख्य जोखिम कारक मान लिया जाता है; जो अत्यंत दुर्भाग्यपूर्ण है। विश्व स्वास्थ्य संघटन के अनुसार हृद्वाहिका रोग वैश्विक स्तर पर मृत्यु का प्रमुख कारण हैं, जिससे हर साल अनुमानित 17.9 मिलियन लोगों की जान चली जाती है। संघटन ने अस्वास्थ्यकर आहार, शारीरिक निष्क्रियता, तंबाकू से जुड़े धूम्रपान और शराब के हानिकारक सेवन को इसके महत्वपूर्ण व्यवहारिक जोखिम कारकों में माना है। इसके अलावा व्यवहारगत जोखिम कारकों का प्रभाव व्यक्तियों में बढ़े हुए रक्तचाप, बढी हुई रक्त ग्लूकोज, बढ़े हुए रक्त लिपिड अनुपात, और मोटापे के रूप में दिखाई देते हैं। विशेष बात यह है कि विश्व स्वास्थ्य संघटनने **हृद्वाहिका** रोग के जोखिम कारकों की सूची में कुल (टोटल) कोलेस्ट्रॉल या एलडीएल कोलेस्ट्रॉल का कही भी ज़िक्र नही किया है। किन्तु इन दो कोलेस्ट्रॉल को लेकर एक डर जनमानस में ज्यों के त्यों बना हुआ है; जिसके कारण दशकों से अतिग्लुकोजरक्तता (हायपरग्लायसेमिया), अतिइंसुलिनरक्तता (हायपरइन्सुलिनेमिया) और इंसुलिन प्रतिरोध (रेसिस्टेंस) को खुली छूट मिली हुई है जो इस जानलेवा बीमारी के मुख्य कारक और त्वरक भी है।

आधुनिक अनुसंधान रक्त में ट्रायग्लिसेराइड्स मेद का बढ़ जाना और एचडीएल या हृदय-हितैषी कोलेस्ट्रॉल का घट जाना और उनके परस्पर अनुपात इन स्वयंसिद्ध जोखिम कारकों को इंसुलिन प्रतिरोध से जुड़े **हृद्वाहिका** रोग के पूर्व सूचक के रूप में मानती है; किंतु यहाँ मरीज, चिकित्सा-कर्मी और आम जनता पूरी तरह से कुल कोलेस्ट्रॉल तथा अहितकारक कोलेस्ट्रॉल के रूप में जाना जाने वाले एलडीएल कोलेस्ट्रॉल की गिरफ्त में दिखाई देती है। अज्ञानी जनता को इन गहरी जड़ों वाली अस्वास्थ्यकर धारणाओं की पकड़ से मुक्त करना बड़ा मुश्किल और एक चुनौती भरा कार्य है। क्योंकि हृद्वाहिका रोग से मुक्ति तभी संभव है जब अज्ञान दूर होगा और इसके आधुनिक हेतु विज्ञान से जनमानस के रूह में कोलेस्ट्रॉल की जगह इसके असली कारक एवं त्वरक घर कर लेंगे।

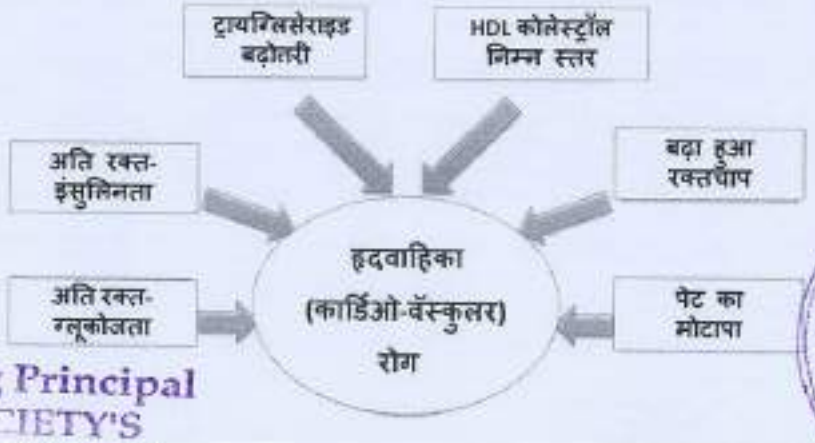


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हृद्वाहिका रोग को ठीक से संबोधित करने के लिए, हमें प्रदाह के माहौल के आहार (डायट) संबंधी मूल कारणों की व्याख्या करने की आवश्यकता है, जो लोगों को हृदयरोगी बना रहा है। हमें रोगियों को सूचित करना होगा कि इंसुलिन प्रतिरोध सिंड्रोम से ही इस जानलेवा बीमारी के तार जुड़े है और जो मुख्य रूप से आहार और खानपान की आदतों की ही देन है। हमें उन्हें यह विश्वास दिलाना होगा कि वास्तविक समाधान पोषण एवं खानपान की आदतों से संबंधित है, जिन्हें लागू करना उनके लिए व्यावहारिक और संभव है। इस पृष्ठभूमि में प्रस्तुत **समीक्षात्मक** पुनरावलोकन इंसुलिन प्रतिरोध सिंड्रोम और हृद्वाहिका रोग का परस्पर संबंधो को आधुनिक हेतु विज्ञान से मिली पुख्ता जानकारी के आधर पर उजागर करने की पहल एवं कोशिश करता है।

रोग कार्यिकी में पथ-प्रदर्शक अनुसंधान:

इतिहास के झरोखों से देखे तो 1988 में स्टैनफोर्ड यूनिवर्सिटी के अन्त:स्राव विज्ञानी (एंडोक्रिनोलॉजिस्ट) डॉ. जेराल्ड रीवेन ने बैंटिंग व्याख्यान में दुनिया को समझाया गया कि हृदय रोग वास्तव में चयापचय संबंधी दुष्क्रिया के कारण होता है। रीवेन ने हृदय रोग और फैट (वसा) और कोलेस्ट्रॉल की प्रचलित कड़ी से विपरीत इंसुलिन प्रतिरोध जनित मूल कारणों और रोग कार्यिकी (पैथोफिज़ियोलॉजी) को परिभाषित किया। उन्होंने टाइप 2 मधुमेह और हृदय रोग में इंसुलिन प्रतिरोध की केंद्रीय भूमिका को उजागर किया और रोगी परिणामों में सुधार के लिए एक व्यावहारिक दृष्टिकोण भी प्रदान किया। उन्होंने मधुमेह और हृदय रोग महामारी की जड़ में मौजूद व्यापक चयापचय दुष्क्रिया को विशद करने के लिए 'सिंड्रोम एक्स' शब्द गढ़ा। रिवेन के 'सिंड्रोम एक्स' को विश्व स्वास्थ्य संघटन आज 'मेटाबॉलिक सिंड्रोम' के नाम से जानता है। उस समय उन्हें पूरी तरह से एहसास नहीं था कि आधुनिक सूजन या प्रदाह (इन्फ्लेमेशन) संबंधी बीमारियों का बड़ा हिस्सा भी उनके सिंड्रोम से जुड़ा था। मेटाबॉलिक सिंड्रोम का अधिक सटीक शब्द 'इंसुलिन प्रतिरोध सिंड्रोम' है। मेटाबोलिक सिंड्रोम होने से न केवल हृदय रोग विकसित होने का खतरा बढ़ जाता है, बल्कि यह अन्य पुरानी दीर्घकालिक बीमारीयों का जोखिम भी बढ़ जाता है। निम्नलिखित पांच प्रमुख कारकों की पहचान की गई है, जो इंसुलिन प्रतिरोध को प्रो-थ्रोम्बोटिक (घनास्त्रता समर्थक) और प्रो-इंफ्लेमेटरी (प्रदाह समर्थक) चयापचय अवस्था के रूप में परिभाषित करते हैं:



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1. अतिग्लूकोजरक्तता (हायपरग्लायसेमिया): खाली पेट रक्त में ग्लुकोज की मात्रा 125 मिलीग्राम प्रति डेसिलिटर या ग्लायकेटेड हिमोग्लोबिन (एचबीए1सी) की मात्रा 6.4% हो जाती है।
1. अतिइंसुलिनरक्तता (हायपरइंसुलिनेमिया): रक्त में इंसुलिन की रेंज 0.2 से 25.0 mIU/L होती किन्तु इंसुलिन का स्तर जितना कम होगा उतना अच्छा और स्वास्थ्यकर होता है। अतिइंसुलिनरक्तता में इंसुलिन का स्तर हमेशा उपरोक्त रेंज की उच्चतम दिशामें बढ़ा हुआ रहता है।
2. भेदबुद्धजनक (एथेरोजेनिक) डिस्लिपिडेमिया: यह अवस्था आपके रक्त में एक या अधिक प्रकार के लिपिड (वसा) -जैसे उच्च घनत्व वाले लिपोप्रोटीन (एचडीएल), कम घनत्व वाले लिपोप्रोटीन (एलडीएल), और ट्राइग्लिसराइड्स के अस्वास्थ्यकर स्तर और उनके परस्पर अनुपात असंतुलन को संदर्भित करता है।
3. उच्च रक्तचाप, और
4. पेट का मोटापा: पेट के मोटापे को महिलाओं में 88 सेमी (35 इंच) से अधिक और पुरुषों में 102 सेमी (40 इंच) से अधिक की कमर की परिधि के रूप में परिभाषित किया गया है। आदर्श रूप से, आपकी कमर की माप आपकी ऊंचाई के आधे से कम होनी चाहिए। पेट के मोटापे ने यह कमर से ऊंचाई का अनुपात बढ़ जाता है।

निश्चित रूप से विचार करने के लिए आनुवंशिक कारक हैं, लेकिन पिछले सौ वर्षों के दौरान जनसंख्या में इनमें कोई बदलाव नहीं आया है, जिसके दौरान हमारी दीर्घकालिक असंक्रामक बीमारी दर में विस्फोट हुआ है। रोग कार्यिकी (पैथोफिज़ियोलॉजी) के आधार पर, आहार से ऊर्जा अधिभार की प्रतिक्रिया मे सिंड्रोम विकसित होता है। अग्न्याशय बीटा कोशिकाओं द्वारा इंसुलिन हार्मोन उत्पादित है, जो न केवल रक्त ग्लूकोज को नियंत्रित करता है बल्कि इससे भी महत्वपूर्ण रूप से उपयोग और भंडारण के बीच ऊर्जा को नियंत्रित और विभाजित करता है।

वर्षों तक अत्यधिक कार्बोहायड्रेटस् सेवन के बाद इंसुलिन प्रतिरोध नामक एक दुष्चक्र विकसित होता है- जिसमें शरीर निरंतर उपचय (एनाबॉलिक) अवस्था में अतिरिक्त ऊर्जा का प्रबंधन करने के लिए संघर्ष करता है। अतिरिक्त ऊर्जा को सामान्य शरीर वसा (चमड़े के नीचे) और/या आंत वसा (पेट के अंदर के अवयवों के इर्दगिर्द) के रूप में संग्रहित किया जा सकता है। पहला अतिरिक्त ऊर्जा से निपटने का अपेक्षाकृत 'सुरक्षित' तरीका है, जबकि दूसरा चयापचय रोग को बढ़ाता है। यह ध्यान रखना महत्वपूर्ण है कि ऐसे कई गैर-मोटे लोग हैं जो चयापचय संबंधी दुष्क्रिया से पीड़ित हैं; हालाँकि वे ठीक दिखते हैं, उन्होंने अपने पेट के अंदर खतरनाक आंत (विसेरल) वसा का भंडार बना लिया है। जैसे-जैसे इंसुलिन प्रतिरोध बढ़ता है, अंतिम अंग इंसुलिन अभिग्राहक (रिसेप्टर्स) इंसुलिन संकेत (सिग्नल) के प्रति तेजी से प्रतिरोधी होते जाते हैं। यह बदले में *हायपरइंसुलिनेमिया* को प्रोत्साहित करता है और दुष्चक्र को आगे बढ़ाता है।

इसमें कई अंग प्रणालियाँ शामिल हैं - मुख्य रूप से यकृत, लेकिन अग्न्याशय, वसा (एडीपोज) ऊतक, अंत्र (इंटेस्टाइन) और केंद्रीय तंत्रिका तंत्र भी। बदले में कई अन्य हार्मोन अनियमित हो जाते हैं, और लगातार

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बढ़ते वसा भंडार से सूजन (प्रदाह) संबंधी परिसंचारी साइटोकिन्स का उत्पादन होता है। जबकि रीवेन ने इंसुलिन प्रतिरोध पर ध्यान केंद्रित किया था, यह रोगविज्ञानी डॉ जोसेफ क्राफ्ट थे जिन्होंने हायपरइन्सुलिनेमिया और इसके प्रभावों को कूटानुवाद किया था। अपने करियर के दौरान, क्राफ्ट ने विभिन्न रोगियों पर और कुल मिलाकर 16,000 से अधिक लोगों पर पांच घंटे की इंसुलिन जांच की। यह असाधारण डेटा, मधुमेह और हृदय रोग पर उनके व्यापक शोध के साथ, गहराई से रहस्योद्घाटन करने वाला था। इससे उन्हें पता चला कि कैसे मधुमेह और हृदय रोग एक दूसरे से जुड़े हुए हैं।

मेटाबॉलिक (इंसुलिन प्रतिरोध) सिंड्रोम के अग्रणी अनुसंधान कर्ता



डॉ जेराल्ड रिवन
(1928-2018)



डॉ जोसेफ क्राफ्ट
(1920-2017)

क्राफ्ट ने इस प्रकार *हायपरइन्सुलिनेमिक* अवस्था को मेटबॉलिक (चयापचय) रोग के प्राथमिक चालक के रूप में पहचाना; उनकी राय में इसमें मनुष्यों में हृदय रोग का बड़ा हिस्सा शामिल था। अनुसंधानकर्ती कैथरीन क्रॉफ्ट्स, ने हाल ही में डॉ. जोसेफ क्राफ्ट के काम पर आधारित नया डेटा प्रकाशित किया है। वह डॉ. क्राफ्ट के समान निष्कर्षों पर पहुंचीं। उन्होंने *हायपरइन्सुलिनेमिया* और चयापचय रोग के तंत्र के बारे में भी विस्तार से बताया। संक्षेप में, अति-रक्तग्लुकोजता (*हायपरग्लायसेमिया*) और इंसुलिन प्रतिरोध दोनों ही मधुमेह/ चयापचय संबंधी दुष्क्रीया की पहचान करने के लिए देर से आए निष्कर्ष हैं। इस प्रकार मधुमेह से पीड़ित लोग वास्तव में लंबे समय से मधुमेह से पीड़ित हैं - उनके अंतिम निदान से बहुत साल पहले।

इस प्रकार उनकी धमनियों पर कई वर्षों से लगातार *हायपरइन्सुलिनेमिया* और *हायपरग्लायसेमिया* की विनाशकारी प्रक्रियाएं हमला करती रहती है। क्राफ्ट ने कहा कि "*मधुमेह के अधिकांश रोगियों को पता ही नहीं चलता कि वे मधुमेह से पीड़ित हैं- यानी, जब तक कि उन्हें अपना पहला दिल का दौरा न पड़ जाए।*" तो अब हम समझते हैं कि प्रारंभिक जांच महत्वपूर्ण है और प्राथमिक फोकस होना चाहिए। क्योंकि भारत में 10.1 करोड़ लोग मधुमेह से पीड़ित हैं और 13.6 करोड़ लोग पूर्व-मधुमेह (प्री-डायबेटीक) स्टेज से गुजरकर मधुमेह विकसित होने के कगार पर हैं। दुर्भाग्य से अधिकांश स्वास्थ्य देखभाल पेशेवर *हायपरइन्सुलिनेमिया*, *हायपरग्लायसेमिया* और इंसुलिन प्रतिरोध की ठीक से जांच नहीं करते हैं। वे मधुमेह और चयापचय रोग को

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चिह्नित करने के लिए रक्त शर्करा के आसमान छूने का इंतजार करते हैं। वे सिर्फ बरसों से चले आये पुराने 'खराब कोलेस्ट्रॉल' वाली रूढ़ोक्ति से निराशाजनक रूप से विचलित हैं।



एथेरोजेनिक डिसलिपिडेमिया:

एथेरोजेनिक डिसलिपिडेमिया चयापचय सिंड्रोम का एक और महत्वपूर्ण पहलू है और चयापचय स्वास्थ्य के इंसुलिन-केंद्रित निर्धारण के लिए एक सरल परोक्षी (प्रॉक्सी) के रूप में कार्य करता है। सरल रूप से परिभाषित, यह केवल कुल (टोटल) कोलेस्ट्रॉल की मात्रा या सांद्रण को देखने के बजाय लिपोप्रोटीन की गुणवत्ता और उनके परस्पर अनुपात (रेश्यो) को संबोधित करने के महत्व पर जोर देता है। डॉ. रीवेन ने कहा कि कुछ लिपोप्रोटीन पैटर्न कम एचडीएल कोलेस्ट्रॉल और उच्च ट्राइग्लिसराइड सहित इंसुलिन प्रतिरोध से निकटता से जुड़े हुए थे। आज हम एलडीएल कण आकार (बड़े अनुकूल कण बनाम छोटे कण) को भी माप सकते हैं जो एक और संकेतक प्रदान करता है जो कोलेस्ट्रॉल की गुणवत्ता को संबोधित करता है। वैसे, मेटाबोलिक सिंड्रोम मौजूद है या नहीं यह निर्धारित करने में कुल कोलेस्ट्रॉल एवं एलडीएल कोलेस्ट्रॉल सांद्रण को भी प्रासंगिक नहीं माना जाता है। यह निदान में माप के योग्य भी नहीं है। यह अपने आप में आपको काफी कुछ बता देगा।

हृदय रोग से जुड़े प्रमुख अध्ययनों में एचडीएल के महत्व को पहचाना, यह मृत्यु दर के साथ प्रतीपक्रमेण या विपरीत रूप से जुड़ा हुआ एक चिन्हक (मार्कर) है। हालाँकि यह निष्कर्ष 1988 में प्रकाशित हुआ था, लेकिन इस पर कम जोर दिया गया है (शायद इसलिए कि कम एचडीएल को सुरक्षित रूप से संबोधित करने के लिए कोई दवा नहीं मिली है)। इस प्रकार जोखिम कैलकुलेटर आज भी 'खराब कोलेस्ट्रॉल' को संबोधित करने पर जोर देते हैं, जबकि एचडीएल, 'अच्छा या हृदय हितैषी कोलेस्ट्रॉल' एक गौण लक्ष्य बना हुआ है। इसके अतिरिक्त, जबकि इन महत्वपूर्ण अध्ययनों के डेटा ने युवा वयस्कों में एलडीएल और मृत्यु दर के बीच एक छोटा सा या गौण संबंध प्रदर्शित किया किंतु वृद्ध व्यक्तियों में यह संबंध टूट गया। वास्तव में, उच्च एलडीएल वाले

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बुरा कोलेस्ट्रॉल इन पुराने समूहों में दीर्घायु से जुड़ा हुआ पाया गया। इस खोज की व्यापक रूप से रिपोर्ट नहीं की गई - क्योंकि इसने संपूर्ण 'खराब कोलेस्ट्रॉल' सिद्धांत को चुनौती दी थी। हालाँकि अधिकांश हृदय संघ अब मेटाबोलिक सिंड्रोम को पहचानते हैं, लेकिन यह निराशाजनक है कि मेटाबोलिक सिंड्रोम से संबंधित विशिष्ट उपचार वर्तमान किसी भी देश के हृदय रोग विशेषज्ञों के असोशिएशन के दिशानिर्देशों में शामिल नहीं है। ऐसा प्रतीत होता है कि उन्हें मूल कारण से संबंधित किसी भी चीज़ से घृणा है, और वे सहयोगी सरोगेट्स चिन्हकों के झोल को पसंद करते हैं जो प्राथमिक लक्ष्य के रूप में कोलेस्ट्रॉल पर अधिक जोर देता है।

मेटाबोलिक तबाही:

हृदय रोग की प्रगति में कई योगदानकर्ता हैं, लेकिन इंसुलिन प्रतिरोध सिंड्रोम उस स्थिति का सबसे अच्छा वर्णन करता है जो संवहनी (वैस्क्युलर) अध:पतन या जटिलताओं को तेज करता है। यह मूलत: चयापचय संबंधी गड़बड़ी की स्थिति है। कई अंग और जैविक मार्ग इसमें शामिल होते हैं, क्योंकि शरीर समस्थापन (होमोस्टैसिस) को बनाए रखने के लिए संघर्ष करता है। हर समय, एक प्रणाली-व्यापी आग किसी के संवहनी नेटवर्क के माध्यम से जल रही है। अनुप्रवाह की ओर जो विकसित होता है वह सूजन (प्रदाह), ऑक्सीडेटिव तनाव और उन्नत ग्लायकेशन या ग्लायकेटेड उत्पाद (एचबीए1सी) है, जो अंतत: कई अंग प्रणालियों - विशेष रूप से रक्त वाहिकाओं के अंत:स्तर - के लिए हानिकारक है।

रक्त वाहिकाओं के भीतर, धमनीकलाकाठिन्य (*एथेरोस्क्लेरोसिस*) उत्तेजित हो उठता है, और नेटवर्क के अचानक टूटने के जोखिम को उजागर करता है। यह अधिकांश दिल के दौरे की उत्पत्ति है। यह पहचानना महत्वपूर्ण है कि एथेरोस्क्लेरोसिस, मेदार्बुद (एथेरोमा) या प्लाक, शुरू में एक सुरक्षात्मक तंत्र का प्रतिनिधित्व करता है। वे रक्त वाहिका दीवार की क्षति की मरम्मत करना चाहते हैं। चयापचय संबंधी गड़बड़ी का अनुभव करने वाली प्रणाली में, कोलेस्ट्रॉल और लिपोप्रोटीन क्षति नियंत्रण के तत्व का प्रयास करते हैं। दुखद बात यह है कि लिपोप्रोटीन युक्त कोलेस्ट्रॉल भी सूजन या प्रदाह (इन्फ्लेमेशन) पैदा करने वाली ताकतों के आगे झुक जाता है। स्वयं क्षतिग्रस्त होकर यह रोग प्रक्रिया को कई प्रकार से आगे बढ़ाता है। यह किसी दुर्घटनाग्रस्त एयरलाइन में बचे जेट ईंधन की तरह हो जाता है। जहां पहले विमान को सुरक्षित रूप से ऊपर रखना महत्वपूर्ण था, अब यह जीवित यात्रियों को नष्ट करने में दुखद योगदान देता है। कोलेस्ट्रॉल अपने स्वाभाविक रूप से विषाक्त नही है। यह समझने के लिये एक सादृश्यता या समवृत्तिता का उपयोग करते है जहाँ कोलेस्ट्रॉल अणुओं की उपस्थिति आग लगने की जगह पर अग्निशमन कर्मियों या फायरमैन के रूप में करते है। जो वास्तव में आग बुझाकर क्षति की मरम्मत में मदद करता है। किंतु कोलेस्ट्रॉल को हृदय रोग का सबसे प्रबल जोखिम कारक मानने वाले अनुसंधान कर्ताओं ने मानो एक घर को जलते हुए देखा और निर्धारित किया कि जितनी बड़ी आग होगी, उतने अधिक फायरमैन मौजूद होंगे, और फिर यह निष्कर्ष निकाला कि फायरमैन ही घर जलने या जलाने का कारण हैं। कोलेस्ट्रॉल की दोषी मानना यह कुछ हद तक आग लगने के लिए अग्निशमन कर्मियों को दोषी ठहराने जैसा है, क्योंकि जब आग लगती है, तो वे वहीं मौजूद होते हैं।

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एक अन्य सादृश्यता या समवृत्तिता का उपयोग करते है जो विशेष रूप से उपयोगी है। एक सुझाव के अनुसार एलडीएल (बुरा कोलेस्ट्रॉल) दुर्घटना स्थल पर जाने वाली एम्बुलेंस की तरह है, जबकि एचडीएल (अच्छा कोलस्ट्रोल) घटनास्थल से निकलने वाली एम्बुलेंस की तरह है। हम दुर्घटनाओं के मूल कारण को दरकिनार (बायपास) करते हुए एंबुलेंस पर ध्यान केन्द्रित करते हैं। अवलोकन या निरीक्षण और संबंध (असोसिएशन) अक्सर धोखा देने वाले हो सकते हैं, और यह संभवतः वैज्ञानिक इतिहास का सबसे बड़ा मामला है जहां ऐसा हुआ है। वास्तविक मूल कारणों को जाँचना और उनकी शिनाख्त करना महत्वपूर्ण है, और परस्पर क्रिया और भ्रमित करने वाले कारकों से विचलित नहीं होना चाहिए। शुक्र है, रिवेन एवं क्राफ्ट के उत्तराधिकारी वैज्ञानिक और चिकित्साकर्मी धीरे-धीरे जाग रहे हैं; वास्तविकता को समझ रहे हैं और उसे अनुभव के स्तर पर स्विकार रहे है।

धमनीकलाकाठिन्य (*एथेरोस्क्लेरोसिस*) एक तेजी से फैलने वाली प्रक्रिया है, और यह एक अस्थिर बीमारी है, जो प्लाक पैदा करती है जिसके फटने का खतरा सबसे अधिक होता है। प्लाक के विभिन्न प्रकार काफी खुलासा करने वाले हैं- जिनमें चयापचय रूप से सक्रिय नरम, और अधिक स्थिर चूर्णियित (कैल्सिफाइड) या कठोर प्लाक शामिल हैं। प्लाक काफी जटिल दिखाई दे सकता है। उदाहरण के लिए, कुछ ज़ख्म या घावों में कैल्सिफाइड सतही कैप और नरम ऊतकक्षयी (नेक्रोटिक) कोर या भीतरी भाग होते हैं। अधिकांश तीव्र हृदय संबंधी घटनाएं इन कमजोर प्लाकों के टूटने, रक्त वाहिका में सूजन या प्रदाह वाले पदार्थों को बाहर निकालने और अचानक थ्रोम्बोसिस (घनास्रता) का कारण बनने के जिम्मेदार होती हैं। यह *एक्यूट कोरोनरी सिंड्रोम* है, एक जीवन-घातक स्थिति जिसमें तत्काल हस्तक्षेप की आवश्यकता होती है। यदि आप आपातकालीन कक्ष तक पहुंचने के लिए पर्याप्त भाग्यशाली हैं, तो थ्रोम्बोलाइटिक थेरेपी, एंजियोप्लास्टी और धमनी बायपास आपको तत्काल संकट से बाहर निकाल सकता है।

इन जीवन-विघातक परिस्थितियों में बाकी सब कुछ तुच्छ लगता है, और 'आपातकालीन नलकारी (प्लम्बिंग) कार्य' उस वक्त का सर्वश्रेष्ठ क्रम है। फिर भी बड़ी घटना की प्रतीक्षा करने के बजाय प्रारंभिक उप-नैदानिक रोग की उचित जांच कहीं अधिक प्रभावी होती। निकट भविष्य में दिल का दौरा पड़ने का खतरा है ऐसे लोगों को चिह्नित करने के लिए हृदय कैल्शियम स्कैन जैसे उपकरणों का उपयोग करने से सही लोगों पर ध्यान केंद्रित करने में हमारी सटीकता में काफी सुधार होगा। चयापचय रोग और मूल कारणों को उचित रूप से संबोधित करने से लाखों लोगों को पीड़ित होने और/या अपना जीवन खोने से रोका जा सकेगा। आप इसे जिस भी तरीके से देखें, **चयापचय संबंधी अफरा-तफरी** को सही ढंग से संबोधित करना ही कुंजी है।

इंसुलिन के प्रति सतर्कता :

कई अध्ययनों का अनुमान है कि विश्व के कई देशों की आधी से अधिक वयस्क आबादी या पूर्व-मधुमेही (प्री-डायबिटिक) है। यह संख्या और भी चकित कर देगी अगर हमने *हायपरइन्सुलिनेमिया* की जांच की तो हम और भी बड़े और गहरे संकट का खुलासा कर सकते है। यदि इस तरह *हायपरइन्सुलिनेमिया* का परीक्षण नहीं

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किया गया तो केवल ग्लूकोज परीक्षण के आधार पर वे बेपरवाह रहेंगे और इस बीमारी का सही वक्त पर व्युत्क्रमण या प्रतिबंधन करने से चूक जाएंगे। स्क्रीनिंग महत्वपूर्ण है; फिर भी दुख की बात है कि अधिकांश स्वास्थ्य देखभाल पेशेवर हृदय रोग के बारे में सोचते समय ग्लूकोज को सही ढंग से नहीं मापते हैं। इसके अलावा, वे इंसुलिन की जाँच नहीं करते हैं - न ही चयापचय रोग का ठीक से समाधान किया जाता है।

संवेगी हृदय देखभाल सेवाओं में सुधार और धूम्रपान समाप्ति के बावजूद, हृदय रोग की घटना अभी भी बढ़ रही है। दरअसल यह मधुमेह और मोटापे की बढ़ती घटनाओं को प्रतिबिंबित करता है। हालांकि मधुमेह और हृदय रोग के बीच संबंध अच्छी तरह से स्थापित है, फिर भी एक बाधा पर काबू पाना बाकी है। हमें यह प्रदर्शित करने की आवश्यकता है कि केवल 'खराब कोलेस्ट्रॉल' मेट्रिक्स को देखने की तुलना में चयापचय रोग पर नज़र रखने से जोखिम का बेहतर अनुमान लगाया जा सकता है। मौजूदा अध्ययनों के प्रचलन या झुकावों में हृदसंवहनी (कार्डियोवैस्कुलर) इमेजिंग और ग्लूकोज तथा इंसुलिन को अधिक उचित तरीके से मापने वाले अध्ययन शामिल हैं, जो 'खराब कोलेस्ट्रॉल' को देखने वाले अध्ययनों की तुलना में हृदय संबंधी जोखिम की बेहतर भविष्यवाणी करते हैं।

भविष्य के शोध निश्चित रूप से कोलेस्ट्रॉल से हटकर इन सूचनाओं की समर्थन एवं पुष्टि करेंगे, लेकिन उस समय तक *हायपरग्लायसेमिया, हायपरइन्सुलिनेमिया* और मेटाबॉलिक (चयापचय) सिंड्रोम को ठीक से संबोधित करना महत्वपूर्ण बना रहेगा। धमनीकलाकाठिन्य (एथेरोस्क्लेरोसिस) एक चयापचय रोग है, जो हार्मोनल विकृति, *हायपरग्लायसेमिया* और *हायपरइन्सुलिनेमिया* का परिणाम प्रतीत होता है। इसलिए परिभाषा के अनुसार उपचार को चयापचय रोग सुधार पर ध्यान केंद्रित करना चाहिए। किंतु वर्तमान चिकित्सा विचारधारा और हठधर्मिता (डोग्मा) या रूढ़ि ने हमें इसे प्रभावी ढंग से सुधार करने से रोका है।

उपसंहार:

एशियाई देशों और अधिकांश यूरोपीय और अमेरिकी देशों के बीच कार्बोहाइड्रेट सेवन की मात्रा काफी भिन्न होती है। शोध से पता चलता है उच्च कार्बोहाइड्रेट आहार रक्त लिपिड प्रोफाइल को प्रभावित करता है; जिसके परिणाम स्वरुप धमनीकलाकाठिन्य (एथेरोस्क्लेरोसिस) और विभिन्न संवहनी रोगों के विकास में योगदान कर सकता है, जिससे अंततः मृत्यु हो सकती है। उच्च कार्बोहाइड्रेट सेवन और हृद्वाहिका रोग जोखिम के बीच संबंध की जांच करने वाले अनुसन्धान से भारत सह एशियाई आबादी में उच्च कार्बोहाइड्रेट सेवन और बढ़े हुए हृद्वाहिका रोग जोखिम के बीच महत्वपूर्ण संबंध का पता चलता है। हृदय तथा हृद्वाहिका रोग से मुक्ती के लिए कुल कोलेस्ट्रॉल या एलडीएल कोलेस्ट्रॉल के बजाय पूरा ध्यान और प्रयास अतिग्लुकोजरक्तता (हायपरग्लायसेमिया), अतिइंसुलिनरक्तता (हायपरइन्सुलिनेमिया) और इंसुलिन प्रतिरोध (रेसिस्टेंस) से बचने पर होना चहिये। मेटाबॉलिक तबाही ग्लूकोज, फ्रुक्टोज इन दो मोनोसैकाराइड्स और वो जिस पॉलीसैकाराइड्स से बनते है उस -स्टार्च का अति सेवन में अंतर्निहित है। इंसुलिन संवेदनशीलता की बहाली ही हृदयरोग से मुक्ति की कुंजी है। अंतिमतः टाईप 2 मधुमेह यह एक संवहनी (वॅस्कुलर) रोग है और हृद्वाहिका (कार्डियोवैस्क्युलर) रोग यह उसी निदान हो चुकें या ना हो चुकें टाईप 2 मधुमेह की जानलेवा बृहत (मॅक्रो)

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रक्तवाहिनी जटिलता है। ये अध्ययन निष्कर्ष दीर्घकालिक, असंक्रामक बीमारियों, विशेषकर हृद्वाहिका रोगके लिए प्रभावी रोकथाम रणनीति विकसित करने में सांस्कृतिक और क्षेत्रीय आहार पैटर्न पर विचार करने के महत्व पर प्रकाश डालते हैं।

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Some Notes on the Impact of Millipedes (Myriapoda: Diplopoda) on Fungi and Bacteria

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Abstract

Millipedes, crucial detritivores belonging to the class Diplopoda, play a pivotal role in nutrient cycling, heavily affecting fungi and bacteria and exerting a remarkable influence on litter decomposition and soil fertility. Fungi ultimately benefit from dispersal activities of the animals although they may initially experience reduction in the form of feces. The process of litter breakdown by millipedes promotes bacterial growth, contributing to elevated nitrogen content in feces and enhanced microbial activity throughout the soil system. These complex associations emphasize the ecological importance of millipedes in maintaining ecosystem functioning.

Keywords: Arthropods; Diplopods; Microbes; Mutualism; Ecology

Abbreviations: pH: Potential of Hydrogen

Introduction

The class Diplopoda, with an estimated global fauna of 80,000 yet-to-be-described species, stands as the third most diverse group of terrestrial arthropods, currently comprising of roughly 12,000 described species classified into 16 orders, over 2,900 genera and 144 families [1-4]. Their significant contribution as efficient decomposers, nutrient recyclers and biogeographic indicators is important in maintaining the overall ecological balance [5]. Moreover, these detritivores are thought to have played a significant role in early soil formation and the establishment of terrestrial nutrient cycling processes [6,7]. The relationships between millipedes and microorganisms, particularly fungi and bacteria, represent a vital yet unexplored aspect of ecological research. These interactions play very essential roles in the fundamental process of decomposition, actively shaping nutrient cycling and soil fertility within ecosystems. Despite their significance, these interactions have received minimal attention in the scientific community. Therefore, we seek to shed light on some of the ways millipedes influence the populations of fungi and bacteria through this contribution.

Fungal and Bacterial Relationship with Millipedes

Fungi and bacteria, as vital microbes, play a crucial role in nutrient cycling by employing enzymes to break down complex polysaccharides that other organisms cannot. In the case of millipedes, the existence of these microbes facilitates the availability of simple sugars, calcium and vitamins on litter and feces surfaces [8]. The presence of millipedes affects fungi, causing a population reduction in feces [9]. Moreover, millipedes' capability to interfere with the mobilization of nitrogen from litter to mycorrhizae through their feeding behavior results in an increased movement of nitrogen in the substrate [10].

The vertical movement of invertebrates, such as millipedes, through the soil system promotes the dispersion of microorganisms, subsequently leading to an increase in litter decomposition. Fungi are frequently found both on and in millipedes. The notion has been that fungi most likely to be dispersed by millipedes are those that produce numerous spores and that have spores which readily germinate. However, much of the supporting evidence for this idea comes from samples cultured on plates. Laboratory culturing plates tend to favor the growth of organisms that excel at colonization [11]. Arthropod-assisted dispersal, though, could be especially critical for poor colonizers with limited self-dispersal abilities. The degree of success in millipede dispersal of poor colonizing fungi remains uncertain but it is not challenging to imagine how millipedes could carry much smaller fungal spores or fragments of fruiting bodies and thus disperse them. Given that feces with a pH greater than 6.5 are conducive to fungal growth [8], the promotion of fungal communities in feces should be anticipated. Nevertheless, in experiments conducted on soil fauna feces, Hanlon [12] initially observed no significant difference between fungal respiration on litter particulate versus feces. However, when the feces were inoculated with different organisms after passage through the gut, bacterial respiration was shown to be low while fungal respiration was high. Interestingly, when inoculation occurred through the passage through the gut of the millipede, bacterial standing crops increased by seven times. Millipedes contribute to the propagation of microorganisms through their death and

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subsequent decomposition. In laboratory cultures where millipedes die and their exoskeletons remain on the substrate, the growth of fungi and molds on these exoskeletons have been observed (personal observation of the authors). Decaying millipede remains exhibit a higher calcium content compared to living millipedes [13]. The reason behind this increase is believed to be the colonization of decomposing remains by fungi which elevate the calcium levels. Consequently, decaying millipedes serve as valuable resources for fungal, and potentially bacterial, populations. The gut of millipedes provides a suitable environment for microbial activities supported by various factors such as optimal pH levels, peristalsis and the presence of secreted, digestible products within their digestive systems. One of the most important effects of millipede respiration and fecal production is the significant rise in the nitrogen content of the substrate primarily in the form of ammonium found in their feces. This increase in nitrogen compounds along with pH within the feces harbors greater microbial diversity compared to the parent litter [12,14]. Notably, millipede feces contain substantially higher bacterial populations compared to the original litter [15].

There is strong evidence of well-established colonies of *Pseudomonas stutzeri*, specifically within the gut of *Glomeris hexasticha* (Brandt) and possibly in the guts of certain other arthropods [16]. The conditions within the millipede's gut, characterized by high humidity and low oxygen levels, are suitable for anaerobic bacteria [17]. Nevertheless, some researchers have observed a limitation in growth due to the lack of availability of monosaccharides [18]. It is known that certain bacteria face challenges in decomposing carbon compounds. Hence, it is possible that the survival of bacterial communities within the millipede gut is limited due to the absence of other organisms capable of performing this decomposition.

Conclusions

In summary, this study highlights the impact of millipedes on microbial communities, notably fungi and bacteria, and their crucial contributions to nutrient cycling and litter decomposition. Fungi assume a crucial role in the context of millipede-facilitated nutrient cycling by participating in litter decomposition and elevating calcium levels through their presence in feces and on millipede exuviae. Additionally, the gut of millipedes provides an ideal habitat for diverse bacterial populations to thrive. However, the survival of such bacterial communities in this environment may be constrained by the lack of certain factors. Despite this limitation, the process of litter breakdown by millipedes promotes bacterial growth, contributing to elevated nitrogen content in feces and facilitating the dispersion of microorganisms throughout the soil system.

The intricate association between millipedes and microbes showcases the dynamic relationships that shape ecosystem functioning and highlight the role of these arthropods in microbial dispersal and propagation. Greater recognition of the central role diplopods play in shaping microbial dynamics will surely assist in better managing and conserving ecosystems for the benefit of the broader ecological balance.

Author Statements

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कृषि जैव प्रौद्योगिकी द्वारा लवण सहिष्णु पराजीनी (ट्रान्सजेनिक) फसलों का नवनिर्माण : एक पुनरावलोकन

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सारांश:

लवण-युक्त मृदा 118 से अधिक देशों में लोगों की आजीविका सुरक्षा पर प्रतिकूल प्रभाव डालती है। वैश्विक भूमि क्षेत्र का 85% हिस्सा (लगभग 831 मिलियन हेक्टेयर) लवणता तनाव से प्रभावित है। लवणता तनाव के कारण सभी महत्वपूर्ण फसलों की उपज में 70% तक की कमी आयी है। वैश्विक जलवायु परिवर्तन तथा समुद्र के स्तर में वृद्धि, तूफान और तटीय भू-क्षरण के कारण कई क्षेत्रों में लवणता का तनाव और बढ़ने का अनुमान है। जबकि, दुनिया की आबादी बढ़ रही है, मिट्टी की लवणता के कारण वैश्विक शुष्क और अर्ध-शुष्क क्षेत्रों में कृषि मिट्टी हर साल लगभग 1-2% कम हो रही है। लवणता तनाव से जुड़ी लागत संभावित रूप से वैश्विक स्तर पर प्रति वर्ष 12 बिलियन अमेरिकी डॉलर होने का अनुमान है और यह बढ़ती जा रही है। लवणता तनाव से निपटने के लिये पौधें कई आकारिकीय, कार्यिकी या शारीरिक और जैव-रासायनिक प्रतिक्रियाएं जैसे जैसे एंटीऑक्सीडेंट गतिविधि, फायटोहॉर्मोन स्तर में परिवर्तन तथा सुसंगत या संयोज्य हानिरहित जैव अणुओं जैसे ग्लायसिन बिटेन, प्रोलाइन, ट्रेहैलोज आदि जमा करना इख्तियार करते है; जो उन्हें लवण सहिष्णु बनाने में महत्वपूर्ण भूमिका निभाते हैं। ग्लायसिन बिटेन सर्वोत्तम अध्ययन किए गए परासरण-संरक्षक, संयोज्य विलेय में से एक है जो पौधों को लवणता एवं सूखा (जलशुष्कन) जैसे अजैविक तनाव को सहने में सक्षम बनाता है। ग्लायसिन बिटेन जैव संश्लेषण अभिक्रिया दो एंजाइम और उनका कूटलेखन करने वाले दो जीन द्वारा निर्गमित होती है। कृषि जैव-प्रौद्योगिकी के परिप्रेक्ष्य में प्रस्तुत शोध-पत्र पौधों की लवण सहिष्णुता के जैवरासायनिक आधार तथा पराजीनी (ट्रान्सजेनिक) फसलों को लवण तथा जलशुष्कन सहिष्णु बनाने में ग्लायसिन बिटेन की केंद्रीय भूमिका का पुनरावलोकन करता है।

मूल शब्द: लवणता तनाव, लवण सहिष्णु, परासरण-संरक्षक, संयोज्य-विलेय, ग्लायसिन बिटेन, ट्रान्सजेनिक, कृषि जैव-प्रौद्योगिकी

प्रस्तावना :

पौधे, अपनी स्थानबद्ध या स्थावर प्रकृति के कारण, अपने जीवन चक्र के विभिन्न विकासात्मक चरणों के दौरान कई पर्यावरणीय (अजैविक और जैविक) तनावों का अनुभव करते हैं। प्रमुख अजैविक तनाव सूखा, भारी धातुएँ, लवणता, तापमान और पराबैंगनी (यूवी) प्रकाश हैं। लवणता कृषि क्षेत्र में अत्यंत गंभीर खतरों में से एक है, जो दुनिया भर में एक-चौथाई से एक-तिहाई फसल उत्पादन को प्रभावित करती है। खाद्य और कृषि

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संगठन की रिपोर्ट के अनुसार, 424 मिलियन हेक्टेयर से अधिक सतही या ऊपरी मिट्टी (0-30 सेमी) (85% लवणताग्रस्त, 10% सोडियम ग्रस्त, और 5% लवणता + सोडियम ग्रस्त) और 833 मिलियन हेक्टेयर उपमृदा (30 -100 सेमी) (62% लवणताग्रस्त, 24% सोडियम ग्रस्त, और 14% लवणताग्रस्त+ सोडियम ग्रस्त) है। इस तरह वैश्विक भूमि क्षेत्र का 85% हिस्सा लवणता तनाव से प्रभावित है। लवण-युक्त मृदा 118 से अधिक देशों में लोगों की आजीविका सुरक्षा पर प्रतिकूल प्रभाव डालती है। पूरे विश्व में लगभग 831 मिलियन हेक्टेयर भूमि क्षेत्र नमक से प्रभावित है। चित्र 1और 2 विश्व के देशों एवं महाद्वीपों में लवणग्रस्त मृदा प्रभावित क्षेत्र का वितरण दर्शाते है।

चित्र-1: वैश्विक स्तर पर 1980-2018 के बीच मृदा की लवणता से प्रभावित कुल अनुमानित क्षेत्र
स्रोत: Nima Shokri et. al. [2020]



खाद्य सुरक्षा सभी समाजों की मूलभूत आवश्यकता है। अगले 50 वर्षों के भीतर वैश्विक जनसंख्या लगभग 10 अरब तक बढ़ने का अनुमान है। अतिरिक्त खाद्य मांग को पूरा करने के लिए, प्रमुख खाद्य फसलों की पैदावार में अनुमानित 50% वृद्धि की आवश्यकता होगी। जबकि, दुनिया की आबादी बढ़ रही है, मिट्टी की लवणता के कारण वैश्विक शुष्क और अर्ध-शुष्क क्षेत्रों में कृषि मिट्टी हर साल लगभग 1-2% कम हो रही है। इन क्षेत्रों की कम वर्षा और उच्च तापमान विशेषता उच्च लवणता को बढ़ावा देती है और यह लवणता -संवेदनशील पौधों और यहां तक कि कुछ लवण सहिष्णु पादप (हेलोफाइट्स) के विकास को सीमित करने वाला एक महत्वपूर्ण कारक बन गया है। लवणता के तनाव के कारण गेहूं, मक्का, चावल और जौ जैसी महत्वपूर्ण फसलों की उपज में 70% तक की कमी आई है। इसके अलावा, वैश्विक जलवायु परिवर्तन के कारण कई क्षेत्रों में लवणता का तनाव और बढ़ने का अनुमान है। इस तनाव से जुड़ी लागत संभावित रूप से बहुत अधिक है, वैश्विक स्तर पर प्रति वर्ष 12 बिलियन अमेरिकी डॉलर का अनुमान लगाया गया है और यह बढ़ती जा रही है। उपजाऊ भूमि की उपलब्धता में कमी और परिणामस्वरूप सिंचित भूमि के व्यापक पुन: उपयोग ने हाल के वर्षों में लवणयुक्त मिट्टी आधारित कृषि के तेजी से विकास को प्रेरित किया है।

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चित्र-2: विश्व में लवण प्रभावित भूमि का वितरण



समुद्र के स्तर में वृद्धि, तूफान और तटीय भू-क्षरण से भी कुओं, खेतों और पारिस्थितिक तंत्र में लवणता के प्रवेश का खतरा बढ़ जाता है। अतिरिक्त नमक पानी को पीने के लिये अनुपयुक्त बना सकता है, मिट्टी को बर्बाद कर सकता है और बीजों के अंकुरण में बाधा उत्पन्न कर सकता है। तटीय भूमि के लवणीकरण से एशिया के नदीमुख-भूमि (डेल्टा) में रहने वाले लाखों छोटे धान किसानों की आजीविका को खतरा है। एक अनुमान के अनुसार दक्षिण और दक्षिण पूर्व एशिया में 16 से 20 मिलियन हेक्टेयर तटीय भूमि पहले से ही लवणता से प्रभावित है। भारत में, यह आंकड़ा 30 लाख हेक्टेयर है, जो पूर्वी राज्यों ओडिशा और पश्चिम बंगाल में केंद्रित है। शोध से पता चलता है कि, एक निश्चित सीमा रेखा से ऊपर लवणता में वृद्धि की प्रत्येक इकाई के लिए, चावल की उपज में 12 प्रतिशत की गिरावट होती है।

सामान्य और लवणीय मिट्टी के बीच अंतर को समझना बहुत जरूरी है। एक सामान्य मिट्टी में विनिमेय सोडियम प्रतिशत 15.0 से कम, पीएच 6.5 और 8.5 के बीच, विद्युत चालकता 4.0 डीएस एम$^{-1}$ से कम और ऋणायनों और धनायनों का समान अनुपात होता है। हालाँकि, लवणीय मिट्टी में विनिमेय सोडियम प्रतिशत लगभग 15.0, सोडियम अधिशोषण अनुपात 13.0 से कम (25^{0} C पर), विद्युत चालकता 4.0 डीएस एम$^{-1}$ से अधिक और pH 8.5 से कम होता है। लवणता तनाव पादप कोशिका में अत्यधिक नमक का एक शारीरिक परिणाम है जो पौधों के चयापचय पर हानिकारक प्रभाव डालता है। जब संतृप्त मिट्टी के अर्क की विद्युत चालकता लगभग 40 mM NaCl के बराबर है और लगभग 0.2 मेगापास्कल के परासरणी (ऑस्मॉटिक) दबाव को जन्म देता है, तो मिट्टी को लवणताग्रस्त के रूप में स्तरीकृत किया जाता है।

लवणता तनाव के प्रति पादप प्रतिक्रियायें

शुष्क और अर्धशुष्क क्षेत्रों में मिट्टी की लवणता मुख्य रूप से खराब कृषि पद्धतियों (सिंचाई और उर्वरक के लिए उपयोग किए जाने वाले उच्च लवणयुक्त जल) और समुद्र, नदियों आदि से खारे पानी के प्रवाह के कारण होती है। परिणामस्वरूप, यह पौधों की कोशिकाओं में उच्च आयनिक और उच्च परासरण तनाव पैदा करता है जो पौधे के विकास को प्रभावित करता है। उच्च परासरण तनाव के कारण, पौधों तक आवश्यक पोषक तत्वों का अवशोषण और परिवहन अत्यधिक प्रभावित होता है। लवणता का तनाव पौधों के शारीरिक विकास को प्रभावित करता है (पर्णरंध्र बंद हो जाना; अवधिपूर्व जीर्णता आना, प्रकाश संश्लेषण की दर कम हो जाना और

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ऑक्सीडेटिव क्षति बढ़ जाना आदि) और मिट्टी के सूक्ष्मजीविता (माक्रोबायोटा) पर प्रतिकूल प्रभाव पड़ता है, इस प्रकार संपूर्ण मिट्टी के स्वास्थ्य पर गंभीर प्रभाव पड़ता है।

लवणता तनाव से निपटने के लिये पौधों में कई आकारिकीय, कार्यिकी या शारीरिक और जैव-रासायनिक प्रतिक्रियाएं जैसे एंटीऑक्सीडेंट गतिविधि, फायटोहॉर्मोन स्तर में परिवर्तन, ग्लायसिन बिटेन (चतुर्थ एम्मोनियम यौगिक), प्रोलाइन (एमिनो अम्ल) , ट्रेहैलोज (शर्करा) स्तर में वृद्धि आदि होती हैं। मिट्टी की लवणता आम तौर पर प्रारंभिक परासरणी तनाव चरण के माध्यम से पौधों की संवृद्धि और प्रजनन को रोकती है, जिसके बाद कोशिकाओं के कोशिकाविलेय (सायटोसोल) में Na^+ और Cl^- आयनों के संचय के कारण आयनिक विषाक्तता होती है, जिसके परिणामस्वरूप अंततः ऑक्सीडेटिव्ह तनाव और पोषण संबंधी कमी होती है। जब पौधे लवणता तनाव के अधीन होते हैं तो प्रतिक्रियाशील ऑक्सीजन प्रजातियों की सफाई, आयन समस्थापन (होमियोस्टैसिस), परासरणी समायोजन और चयापचय गतिविधियां बहुत प्रभावित होती हैं।

इन विभिन्न अजैविक तनावों को दूर करने के लिए, पौधे सुसंगत या संयोज्य हानिरहित जैव अणुओं को जमा करते हैं जो पौधों की प्रक्रियाओं में महत्वपूर्ण भूमिका निभाते हैं। इनमें पॉलीअमाइन्स, हीट शॉक प्रोटीन शामिल हैं; नाइट्रिक ऑक्साइड और एब्सिसिक एसिड, सैलिसिलिक एसिड जैसे फायटोहॉर्मोन ठंड, सूखा और लवणता जैसे विभिन्न तनावों के खिलाफ प्रभावी पाये जाते है। इन संचित विलेय की ग्लायसिन, एक्टोइन और बीटेन जैसे प्रोटीन घुलनशीलता में और पिनिटॉल और मैनिटॉल जैसे अनावेशित विलेय में भूमिका होती है, जिनमें प्रतिक्रियाशील ऑक्सीजन प्रजातियों की सफाई गतिविधि होती है। एब्सिसिक एसिड एक प्रमुख पादप हॉर्मोन (फायटोहॉर्मोन) है जो लवणता, कम तापमान और सूखे जैसी तनाव स्थितियों के दौरान पौधों के प्रदर्शन को बेहतर बनाने में महत्वपूर्ण भूमिका निभाता है पौधों में एब्सिसिक एसिड का उत्पादन संवृद्धि, पचाये हुए के स्थानांतरण और प्रकाश संश्लेषण पर लवणता के प्रभाव को दूर करता है।

लवण सहिष्णु सूक्ष्मजीवों का साहचर्य

पौधों में लवणता के तनाव को दूर करने की एक और रणनीति विविध लवण सहिष्णु सूक्ष्मजीवों के साथ रहना है जो पौधों में विकास, तनाव सहनशीलता और पोषक तत्वों की मात्रा को बढ़ाते हैं, जिससे फसल की उपज बहाल होती है। लवण सहिष्णु सूक्ष्मजीव जो पौधों के साथ परस्पर क्रिया करते हैं -वे हैं (1)मूल परिवेश (रायज़ोस्फीयर), (2) अधिपादप (एपिफाइट्स) और (3) अंतः पादप (एंडोफाइट्स)। लवण-सहिष्णु, या लवणरागी (हॅलोफिलिक), पौधों की संवृद्धि प्रोन्नत करने वाले लवण-सहिष्णु, या लवणरागी (हॅलोफिलिक) रायज़ोबिया (नायट्रोजन का जैविक स्थिरीकरण करने वाले सहजीवी जीवाणु) की पहचान में लवणीय मिट्टी-आधारित कृषि को बढ़ावा देने की क्षमता है। लवण सहिष्णु पौधों की वृद्धि को बढ़ावा देने वाली क्षमताओं वाले लवण सहिष्णु जीवाणु का एक उपयोगी भंडार हैं। यहां, हम पौधों की वृद्धि को प्रोत्साहित करने और गैर-लवण सहिष्णु फसलों की लवणता के प्रति सहिष्णुता बढ़ाने के लिए लवणरागी जीवाणुओं के उपयोग पर हाल के अध्ययनों की समीक्षा करते हैं। ये अध्ययन दर्शाते हैं कि लवण सहिष्णु पौधों के प्रजातियों के मूल परिवेश (रायज़ोस्फीयर) से लवणरागी रायज़ोबिया लवणयुक्त मिट्टी में गैर-लवण सहिष्णु पादप प्रजातियों के उत्पादन को बढ़ावा देने के लिए प्रभावी जैव- संरोप्य (इनोकुलेंट) हो सकते हैं। ये अध्ययन गैर-लवण सहिष्णु फसल विकास की स्थायी वृद्धि के लिए एक रणनीति के रूप में लावनरागी रायज़ोबियम के साथ जैवसंरोपण (बायोइनॉक्यूलेशन) की व्यवहार्यता का समर्थन करते हैं। बढ़ती आबादी और निरंतर जलवायु परिवर्तन वाले विश्व के लिए स्थायी खाद्य उत्पादन सुनिश्चित करने के संदर्भ में इस रणनीति की क्षमता पर वृद्धि पर यह एक मार्ग है।

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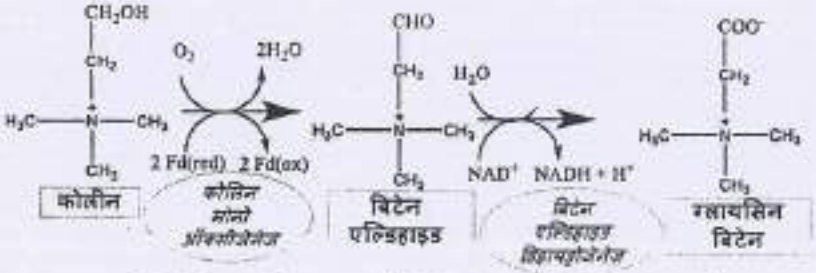
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ग्लायसिन बिटेन- परासरण संरक्षक, संयोज्य विलेय

ग्लायसिन-बिटेन सर्वोत्तम अध्ययन किए गए सुसंगत या संयोज्य विलेय में से एक है जो पौधों को अजैविक तनाव को सहन करने में सक्षम बनाता है। कुछ अध्ययनों ने पुष्टि की है कि जीवी पौधों के अस्तित्व और विकास या संवृद्धि में तनावपूर्ण और सामान्य दोनों स्थितियों में कई कार्य करता है। हालाँकि, कुछ अध्ययनों से पता चला है कि ग्लायसिन-बिटेन खनिज (मिनरल्स) पोषण के साथ भी परस्पर क्रिया करता है। एक नई प्रस्तावित क्रियाविली के अनुसार ग्लायसिन-बिटेन लवण तनाव सहिष्णुता में भाग लेता है। उन्होंने संकेत दिया कि ग्लायसिग-बिटेन लवण तनाव के तहत संकेत पारगमन (सिग्नल ट्रान्सडक्शन) मार्ग के सह-कारक या सह गुणक (को-फैक्टर) के रूप में कार्य करता है। ग्लायसिन-बिटेन आयन चैनल और ट्रान्सपोर्टरों को विनियमित कर सकता है, जिसके परिणामस्वरूप लवण तनाव की स्थिति में ट्रान्सजेनिक पौधों में लवण सहिष्णुता बढ़ाने के लिए उच्च पोटैशियम और निम्न सोडियम स्तर होते हैं। कोशिका में ग्लायसिन-बिटेन जैसे ऑस्मोलाइट्स (कार्बनिक यौगिक जो परासरणी दबाव को विनियमित करते है) का संचय परासरणनियमन (ऑस्मोरेग्यूलेशन) या परासरण सुरक्षा (ऑस्मोप्रोटेक्शन) के माध्यम से जीवों को अजैविक तनाव से बचाने के लिए जाना जाता है। ग्लायसिन-बिटेन का उत्पादन करने के लिए इंजीनियर किए गए पराजीनी (ट्रान्सजेनिक) पौधे ग्लायसिन-बिटेन की बहुत कम सांद्रता जमा करते हैं, जो ऑस्मोरग्यूलेशन के लिए पर्याप्त नहीं हो सकता है। ट्रान्सजेनिक पौधे ऐसे पौधे होते है जिन्हें जेनेटिक इंजीनियरिंग तकनीकों के माध्यम से संशोधित किया गया है और जिन्हें आनुवंशिक रूप से संशोधित जीव भी कहाँ जा सकता है।

इन ट्रान्सजेनिक पौधों में ग्लायसिन-बिटेन का संचय अंतर्जात कोलीन (ग्लायसिन-बिटेन का पूर्ववर्ती) ग्रहण करने की उनकी क्षमता, ग्लायसिन-बिटेन जैवसंश्लेषण मार्ग को उत्प्रेरित करने वाले जीन के प्रकार और एक विशेष कोशिकीय कक्ष (कंपार्टमेंट) में ट्रान्सजीन उत्पाद के स्थानीयकरण के आधार पर भिन्न होता है। ग्लायसिन-बिटेन की अन्य भूमिकाएं जैसे कोशिकीय वृहदणु (मैक्रोमॉलेक्यूल) संरक्षण और प्रतिक्रियाशील ऑक्सीजन प्रजातियों के निराविषीकरण को ट्रान्सजेनिक पौधों में अजैविक तनाव सहिष्णुता के लिए जिम्मेदार तंत्र के रूप में सुझाया गया है। इसके अलावा, ग्लायसिन-बिटेन ट्रान्सजेनिक पौधों में कई अंतर्जात जीनों की अभिव्यक्ति को प्रभावित करता है।

चित्र-3: ग्लायसिन बिटेन जैवसंश्लेषण अभिक्रिया



ग्लायसिन बिटेन 'कोलीन' नामक पूर्ववर्ती से दो चरणों में संश्लेषित हो जाता है: (i) कोलीन से बिटेन एल्डिहाइड और (ii) बिटेन एल्डिहाइड से ग्लायसिन बिटेन.

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ग्लायसिन-बिटेन को कोलीन मोनोऑक्सीजिनेज और बिटेन एल्डिहाइड डिहाइड्रोजनेज एंजाइम की क्रिया द्वारा पूर्ववर्ती कोलीन से संश्लेषित किया जाता है। चित्र क्र 3 ग्लायसिन बिटेन के बायोसिंथेटिक पाथवे में उसके पूर्ववर्ती -कोलीन तथा मध्यवर्ती- बिटेन एल्डिहाइड और उन्हें संश्लेषित करने वाले एंजाइम दिखाता है।

ट्रान्सजेनिक पौधों को उत्पन्न करने के लिए उपयोग की जाने वाली रणनीति को निम्नानुसार संक्षेपित किया जा सकता है: संबंधित जीन को किसी मजबूत प्रकाश-प्रेरक प्रवर्तक (प्रमोटर) के लिप्यंतरण (ट्रान्सक्रिप्शनल) नियंत्रण के तहत पेश किया जाता है जो ट्रान्सजेनिक पौधों में जीन की उच्च-स्तरीय अभिव्यक्ति सुनिश्चित करता है। प्राक्केंद्रकीय (प्रोकैरिऑटिक) मूल के एंजाइमों के उचित स्थानीयकरण के लिए, जीन को अक्सर संशोधित किया गया है ताकि कूटलेखित (एन्कोडेड) पॉलीपेप्टाइड को अनुवादोत्तर (पोस्ट-ट्रान्सलेशनल) रूप से इंजीनियर्ड पौधों के क्लोरोप्लास्ट में ले जाया जाए। रुबिस्को एन्ज़ाइम की छोटी सबयूनिट के पारगमन पेप्टाइड का उपयोग ऐसे परिवहन के लिए एक संकेत के रूप में किया गया है। ग्लायसिन बिटेन के उचित संश्लेषण के लिए एक मार्ग स्थापित करने के लिए, कोलीन का ऑक्सीकरण कई मामलों में आनुवंशिक हेरफेर के लिए एक शर्त है। हरितलवक (क्लोरोप्लास्ट) में ग्लायसिन बिटेन का संश्लेषण कई प्रकार के तनाव के प्रति सहिष्णुता को बढ़ा सकता है। हरितलवक में ग्लायसिन बिटेन का संश्लेषण विकास के विभिन्न चरणों में बढ़ी हुई सहिष्णुता से जुड़ा हो सकता है।

जीवाणुओं तथा समुद्री पौधों के ग्लायसिन बिटेन जैव संश्लेषण में पाये जाने वाले कुछ अन्य जीन के स्थानांतरण से ट्रान्सजेनिक पादपों में लवण सहिष्णुता बहाल हुई जैसे की उच्च लवणतायुक्त जल में पैदा होने वाले लवणमृदोद्भिद (हैलोफाइट) की एक प्रजाती से बिटेन एल्डिहाइड डिकार्बोक्सिलेज़ को एन्कोडिंग करने वाले जीन की अत्यधिक अभिव्यक्ति से तंबाकू के पौधों में लवणता सहिष्णुता में सुधार हुआ। *आर्थ्रोबैक्टर ग्लोबिफॉर्मिस* से कोलीन डिहाइड्रोजनेज जीन ने चावल में लवणता सहिष्णुता को वृद्धिंगत किया। नील हरित शैवाल (सायनोबैक्टेरिया) में एन-मिथाइल ट्रान्सफरेज़ जीन की अधिक अभिव्यक्ति के परिणामस्वरूप ग्लायसिन-बिटेन उच्च स्तर पर जमा हो गया और लवणता सहिष्णुता में सुधार हुआ।

उपसंहार

लवण -प्रभावित मृदा में भविष्य के कृषि उत्पादन के लिए लवण सहिष्णु भोजन फसलों तथा रेशेदार (फाइबर) फसलों के विकास की आवश्यकता है; जिसे पूरा करने में वैश्विक स्तर पर एवं भारत में कुछ संस्थाये कार्यरत है। जैसे कि फिलीपींस स्थित अंतर्राष्ट्रीय चावल अनुसंधान संस्थान ने 2007-2019 तक अफ्रीका और दक्षिण एशिया के लिए तनाव सहिष्णु चावल के लिए एक परियोजना चलाई। इस बहुराष्ट्रीय प्रयास ने अनुसंधान के बुनियादी ढांचे में सुधार किया, शोधकर्ताओं को प्रशिक्षित किया, और लवणता, सूखा और बाढ़ के लिए 1 मिलियन टन तनाव-सहिष्णु चावल के बीज प्राप्त करने में मदद की जो उप-सहारा अफ्रीका और दक्षिण एशिया- 30 मिलियन से अधिक किसानों में वितरित किया गया। भारत में करनाल- हरियाणा की केंद्रीय मृदा लवणता अनुसंधान संस्थान ने पिछले दशक में तनाव-सहिष्णु चावल की 120 किस्में विकसित की हैं, जिनमें से 40 में लवणता के प्रति उच्च प्रतिरोध है। इसमें से कुछ मानसून की फसल के लिए उपयुक्त हैं, जबकि अन्य शुष्क मौसम के लिए उपयुक्त हैं। विभिन्न प्रकार की भूमि और चावल की खपत प्राथमिकताओं के लिए विभिन्न प्रकार के लवण -सहिष्णु बीज भी निर्माण किये गए हैं। ऐसे बीज़ों की आवश्यकता बढ़ती जा रही है- जो एक साथ कई प्रकार के तनावों के प्रति सहिष्णु है। उदाहरण के लिए लवणता के साथ-साथ सूखा या जलशुष्कन के प्रति सहिष्णु फसलों की आवश्यकता बढ़ती जा रही है। अनुवांशिक अभियांत्रिकी (जेनेटिक इंजीनियरिंग) द्वारा हरितलवक में ग्लायसिन बिटेन का पूर्ववर्ती- कोलीन का कुशल परिवहन या ग्रहण भविष्य के अनुसंधान के लिए एक और संभावित तरीका है जिससे एक साथ लवणता तथा जलशुष्कन जैसे अजैविक पर्यावरणीय तनाव के प्रति पौधों की सहिष्णुता बढ़ सकती है।

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भूमी अवतलन (सब्सिडेन्स) : मानवजनित जलभृत दोहन से जुड़ा वैश्विक संकट

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सारांश

जलभृतों (एक्विफर) के लुप्त होने से पृथ्वी की सतह की संरचना में शीघ्रता से तीव्र परिवर्तन हो रहे हैं। वैश्विक आबादी का लगभग पांचवां हिस्सा उन क्षेत्रों में रहता है; जहां भूजल निकासी के कारण भूस्खलन एक बड़ा खतरा है। दुनिया भर में सभी भूमि अवतलन के मामलों में से 76.92% घटनायें मानवोदभवी (एंथ्रोपोजेनिक) हैं और वैश्विक भूमि अवतलन का 80% से अधिक धँसाव अत्यधिक भूमिगत जल निष्कर्षण के कारण होता है, जो अंतर-कणीय तनाव को बढ़ाता है और मिट्टी के कणों के पुनर्गठन को प्रेरित करता है, जिसके परिणामस्वरूप वास्तव में जलभृत संपीड़न और अंततः भूमि अवतलन होता है। भूजल निकासी और भूजल स्तर में गिरावट के साथ औसत भूमि धँसने का दर के बीच घातीय प्रवृत्ति के साथ प्रत्यक्ष एवं गहरा धनात्मक सह-संबंध देखा जाता है। मानवजनित भूमि अवतलन के कारण बाढ़ के जोखिम में वृद्धि, इमारतों की नींव, सड़कें, पुल, बांध जैसे बुनियादी ढांचे और जल निकासी, सीवरेज, पाइप जैसे भूमिगत संरचनाओं को नुकसान हो रहा है। भूजल दोहन से होने वाले सतही जमीन का दब जाना धीरे-धीरे होता है; जो सालाना मुश्किल से दिखाई देता है। इसलिए, बुनियादी ढांचों के संरचनात्मक क्षति के साथ इसका संबंध स्थापित करना कठिन है और दुर्भाग्य से भूजल निष्कर्षण की भूमिका पर संरचनात्मक इंजीनियरों और सिविल इंजीनियरों के बीच बहुत कम जागरूकता है। इस पृष्ठभूमिमें जल स्रोतों पर निर्भरता कम करने और भूजल निकासी पर दबाव कम करने हेतु औद्योगिक प्रक्रियाओं जैसे- गैर-पीने योग्य उद्देश्यों के लिये अपशिष्ट जल का पुनर्चक्रण और पुनः उपयोग को प्रोत्साहित करने की आवश्यकता है। जलभृतों का स्तर बढ़ाने के लिए और उस जरिये भूमि अवतलन से होने वाली संरचनात्मक हानि से बचने के लिए शहरों में ऊंची इमारतों की जल आपूर्ति के लिए वर्षा जल संचयन (रेन वॉटर हार्वेस्टिंग) को अनिवार्य करने की अत्यधिक आवश्यकता है।

मूल शब्द: भूमि अवतलन, जलभृत संपीड़न, अपशिष्ट जल पुनर्चक्रण, वर्षा जल संचय

प्रस्तावना

जोशीमठ, जहाँ पवित्र ज्योतिर्लिंग स्थित है- यह उत्तराखंड के चमोली जिले में बसा एक सुरम्य शहर है। यह शहर विवर्तनिक (टेक्टॉनिक) रूप से सक्रिय भूकंपीय क्षेत्र में है और हाल ही में भूमि अवतलन या धंसाव संबंधित भूवैज्ञानिक घटना का केंद्र बिंदु बन गया है। निजी एवं सरकारी निर्माण कार्यों के मानवजनित दबाव ने वर्तमान स्थिति को जन्म दिया है। भारतीय सुदूर संवेदन संस्थान ने जोशीमठ के धंसी हुई जमीन की सैटेलाइट तस्वीरें जारी की है । रिपोर्ट में दावा किया गया है कि 8 जनवरी 2022 के मात्र 12 दिनों में जोशीमठ शहर में अधिकतम 5.4 सेंटीमीटर की तेजी से भूमि अवतलन हुआ है। अप्रैल और नवंबर 2022 के बीच अधिकतम 9 सेंटीमीटर (3.5 इंच) की धीमी भूमि अवतलन दर दर्ज की गई है। यहाँ की भूमि का धंसना- बांधों के [illegible]

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वनों की कटाई, जंगल की आग और लाखों डॉलर की सड़क परियोजनाओं से परेशान उत्तराखंड और इसकी पर्वत श्रृंखलाओं की नाजुक पारिस्थितिकी के लिए उत्पन्न खतरों को उजागर कर रहा है।

जोशीमठ में कुल ८१४ घर एवं बुनियादी संरचनायें भूमिअवतलन की वजह से बुरी तरह प्रभावित



जोशीमठ जैसे कई दुर्गम इलाकों मे भूक्षरण या मिट्टी के कटाव के कारकों की विस्तृत जानकारी की कमी के कारण पहाड़ी और पर्वतीय इलाकों में अपरदन का आकलन करना शोधकर्ताओं और नीति निर्माताओं के लिए हमेशा एक बड़ी चुनौती बनी रहती है। हिमालय के रूप में भारत में पृथ्वी पर सबसे ऊंची पर्वत श्रृंखला है, जो भारतीय और यूरेशियन प्लेटों के टकराव के कारण बनी है, भारतीय प्लेट के चीन की ओर उत्तर की ओर बढ़ने से चट्टानों पर निरंतर तनाव होता है जिससे वे सुचूर्ण्य (भुरभुरी), कमजोर हो जाती हैं और भूस्खलन और भूकंप का खतरा होता है। इस अंतर्निहित भूवैज्ञानिक तथ्यों की जानकारी होने के बावजूद सरकार के असंधारणीय विकास एजेंडे के चलते आज जोशीमठ के साथ साथ हिमाचल प्रदेश एवं उत्तराखंड के कई स्थान ध्वस्त होने के कगार पर है। दिल्ली के राष्ट्रीय राजधानी क्षेत्र (एनसीआर) में जलोढ़ (अलुवियल) भूजल अनुसंधान से पता चला है कि जमीन धंसना शुरू हो गई है और काफी तेजी से धंसती जा रही है। 2014-2016 के दौरान, दिल्ली के विशिष्ट हिस्सों, जैसे कि इंदिरा गांधी अंतर्राष्ट्रीय हवाई अड्डे के इर्दगिर्द सालाना 11 सेमी की गति से भूमि धंसने का अनुभव हुआ, जो अगले दो वर्षों के दौरान हर साल 17 सेमी तक धंस गई थी।

पृथ्वी की सतह सदैव बदलती रहती है। भू-रंध्र (सिंक-होल) आस-पड़ोस की जमीन को निगल जाते हैं, नदी के डेल्टा धीरे-धीरे लहरों के नीचे खिसकते हैं, और उपजाऊ खेतों की जमीन उर्ध्वाधर रूप से नीचे धँसती है। चाहे क्रमिक और सूक्ष्म, या अचानक और नाटकीय, इन घटनाओं को अवतलन या धंसाव के रूप में जाना जाता है - द्रव्यमान के भूम्यन्तर्गत हरकत के कारण जमीन की सतह नीचे धंसना या दब जाना। गैस, तेल, भूजल, भू-तापीय (जिओथर्मल) और लवणीय (ब्राइन) जल के रूप में उपसतह जलाशयों से तरल पदार्थ हटाने से क्षीण संरचनाओं का एक संघनन (कॉम्पैक्शन) होता है; जो पूरी तरह या आंशिक रूप से सतही जमीन के धंसाव में स्थानांतरित हो जाता है और इस प्रकार मानवजनित भूमि अवतलन को प्रेरित करता है।

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एक अध्ययन के अनुसार दुनिया भर में, ग्रह की आबादी का लगभग पांचवां हिस्सा उन क्षेत्रों में रहता है; जहां भूजल निकासी के कारण भूस्खलन एक बड़ा खतरा है। भारत के संदर्भ में प्रतिवर्ष लगभग 6.6 बिलियन टन सतही मिट्टी नष्ट होने की सूचना है। भारत के विभिन्न क्षेत्रों या स्थानों पर एवं नदी घाटियों के कई क्षेत्र-आधारित अध्ययनों के आधार पर, हिमालय में 20-25 टन प्रति हेक्टेयर/ प्रति वर्ष से लेकर 92 टन प्रति हेक्टेयर/ प्रति वर्ष तक बहुत अधिक भूक्षरण की दर प्रदर्शित होने की सूचना मिली है। भविष्य के जलवायु परिवर्तन परिदृश्यों और वर्षा की तीव्रता में संबंधित भिन्नताओं को देखते हुए भूक्षरण के दरों में निश्चितही वृद्धि होने की संभावना है।

मानवोदभवी भूमि अवतलन

मानवजनित भूमि अवतलन के कुछ प्रमुख प्रभावों में शामिल हैं: जल निकासी प्रणालियों की कम प्रभावशीलता के कारण बाढ़ के जोखिम में वृद्धि और वर्षा से प्रेरित अधिक बाढ़; इमारतों की नींव, बुनियादी ढांचे (सड़कें, पुल, बाँध) और भूमिगत संरचनाओं (जल निकासी, सीवरेज, पाइप) को नुकसान। भूमि धंसाव कई समस्याओं का कारण बनता है जिनमें शामिल हैं: (1) नदियों, नहरों और नालों की ऊंचाई और ढलान में परिवर्तन; (2) पुलों, सड़कों, रेलमार्गों, तूफानी नालों, स्वच्छता सीवरों, नहरों और तटबंधों को नुकसान; (3) निजी और सार्वजनिक भवनों को नुकसान; और (4) जलभृत प्रणालियों में सूक्ष्म कणों के संघनन से उत्पन्न बलों के कारण कुओं के आवरण की विफलता। कुछ तटीय क्षेत्रों में, भूस्खलन के परिणामस्वरूप ज्वार निचले इलाकों में चला गया है जो पहले उच्च-ज्वार स्तर से ऊपर थे। दुनिया के कई शुष्क क्षेत्रों में, धरती की दरारें भूमि धंसने से जुड़ी हैं। पृथ्वी की दरारें 100 फीट से अधिक गहरी और कई सौ फीट लंबी हो सकती हैं। मध्य एरिजोना में एक असाधारण दरार 10 मील लंबी है। ये विशेषताएं एक इंच या उससे कम चौड़ाई वाली संकीर्ण दरारों के रूप में शुरू होती हैं।

भूमि अवतलन एवं समुद्री जल स्तर वृद्धि की दोहरी मार से डूब रहा है- इंडोनेशिया की राजधानी- जकार्ता



जावा द्वीप के उत्तर-पश्चिमी तट पर स्थित जकार्ता इंडोनेशिया की राजधानी है, और दुनिया का सबसे तेजी से डूबने वाला शहर है - कुछ स्थानों पर यह प्रति वर्ष लगभग एक फुट भूमि अवतलन की वजह से डूब रहा

है। शहर का लगभग 40 प्रतिशत हिस्सा समुद्र तल से नीचे है, और यहाँ बाढ़ आम बात है,-आंशिक रूप से इसके चारों ओर फैले जावा सागर के बढ़ने के कारण, और आंशिक रूप से अवैध कुओं की खुदाई के कारण। वैज्ञानिकों ने चेतावनी दी है कि 2030 तक जकार्ता का अधिकांश भाग रहने लायक नहीं रह जाएगा। इंडोनेशियाई सरकार ने हाल ही में अपने 10 मिलियन निवासियों को बाढ़ से बचाने के लिए राजधानी को जावा द्वीप पर अपने वर्तमान स्थान से 100 मील दूर स्थानांतरित करने की योजना को मंजूरी दी है। इस कदम में लगभग 10 साल लगेंगे और लागत 33 अरब डॉलर होगी। कई अन्य प्राकृतिक आपदाओं के साथ-साथ भूमि अवतलन से शेष विश्व की तुलना में एशिया पर अधिक प्रभाव पड़ने की आशंका है। 86 प्रतिशत एशियाई लोग भूमि अवतलन के प्रभावों के प्रति सुभेद्य (वल्नरेबल) हैं, जहाँ यकीनन लगभग 8.17 ट्रिलियन अमेरिकी डॉलर दांव पर है।

जलभृतों का अत्यधिक दोहन

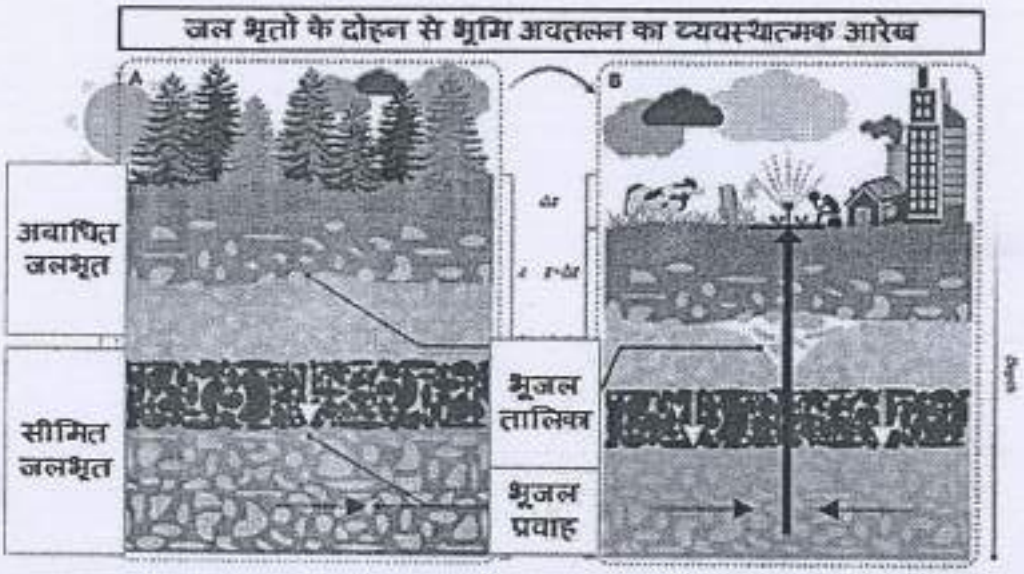
अमेरिका की स्पेस एजेंसी नासा के अनुसार, पिछले कुछ वर्षों में भारत के उत्तरी हिस्से में भूजल 88 मिलियन एकड़ फीट कम हो गया है। उत्तर पश्चिम भारत में कृषि पद्धतियाँ भूजल निकासी पर बहुत अधिक निर्भर हैं। केंद्रीय भूजल बोर्ड द्वारा वर्षों से इकट्ठा किए गए आंकड़ों से पता चलता है कि सीमित मानसूनी बारिश के कारण भूजल स्तर अनिश्चित रूप से नीचे है। उदाहरण के लिए, पंजाब में 76% भूजल ब्लॉकों का अत्यधिक दोहन किया गया है। चंडीगढ़ और दिल्ली में यह दोहन क्रमशः 64% और 50% है। इसका मतलब यह है कि जितना भूजल पुनर्भरण (रिचार्ज) किया जा सकता है, उससे कई अधिक निकाला जाता है। जब सतह के नीचे का जलभृत (जल भंडार) को समय के साथ रिचार्ज नहीं किया जाता है, तो वे सूख जाते हैं और उनके ऊपर की मिट्टी और चट्टान की परतें डूबने लगती हैं। वर्षों से कोयला, तेल और गैस के लिए जमीन से सैकड़ों मीटर नीचे किए गए खुदाई कार्यों में 'मिट्टी के बैठाव या खनन से उत्पन्न रिक्त स्थान को भरने के लिए मिट्टी के दबने या धंसने के उदाहरण सामने आए हैं। अगर तेल और गैस का निचोड़ या निष्कर्षण नीचे दबना या डूबने का कारण बनता है, तो निश्चित रूप से भूजल दोहन से भी इस तरह के परिणाम आते है।

अत्यधिक भूजल दोहन और भूमि धंसाव या अवतलन के बीच का संबंध ग्रेस (ग्रेविटी रिकवरी एंड क्लाइमेट एक्सपेरिमेंट) उपग्रहों से मिले डेटा की बदौलत स्पष्ट होना शुरू हुआ, जो पृथ्वी की सतह के विभिन्न हिस्सों पर गुरुत्वाकर्षण में सूक्ष्म परिवर्तन को माप सकते है। जल शक्ति मंत्रालय की सहायक संस्था, केंद्रीय भूजल बोर्ड को भारत के भूजल संसाधनों की स्थिति का आकलन करने का काम सौंपा गया है। यह संस्था भूजल अवलोकन और जल स्तर की निगरानी का काम वर्ष में चार बार करता है। हालाँकि, यह 'अत्यधिक दोहन के दुष्प्रभावों या दुष्परिणामों का विश्लेषण नहीं करता है। सेंटिनेल-1 उपग्रह से मिले डेटा के आधार पर यह देखा गया कि जिन हिस्सों में सतह के नीचे जलभृत में भूजल होता, उनमें कोई भूमि अवतलन नहीं देखा गया। हालाँकि, अन्य हिस्सों में जहां उप-सतह में पानी नहीं था, जमीन के डूबने के संकेत दिखाई दिये। मज़े की बात यह है कि जहाँ भूस्खलन देखा गया था, वहाँ वास्तव में तब सकारात्मक बदलाव देखा गया जब वर्षा जल संचयन (रेन वाटर हार्वेस्टिंग) प्रथाओं को लागू करने के बाद जलभृत का स्तर बढ़ गया।

भारतीय सुदूर संवेदन संस्थान (इंडियन इंस्टीट्यूट ऑफ रिमोट सेंसिंग), देहरादून के वैज्ञानिकों द्वारा 2021 में प्रकाशित एक अध्ययन के अनुसार, पंजाब के डेरा बस्सी, लांडरां, सिंहपुरा और हरियाणा के अंबाला में बुनियादी ढाँचों में संरचनात्मक क्षति के उदाहरण देखे गए थे, जिन्होंने प्रति वर्ष लगभग 7-12 सेमी भूमि अवतलन या धंसने की सूचना दी है और जहाँ भूजल दोहन या निष्कर्षण दर प्रतिवर्ष 46 से 236 सेमी है। भूजल निष्कर्षण की भूमिका पर संरचनात्मक इंजीनियरों और सिविल इंजीनियरों के बीच बहुत कम जानकारी है।

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ज्यादातर मामलों में, बिल्डिंग कोड का पालन करने से परिणामी क्षति का ध्यान रखा जाना चाहिए, लेकिन भूजल निष्कर्षण की भूमिका को नजरअंदाज नहीं किया जा सकता है। भूस्खलन या भूकंप से होने वाली भूमि की हलचल के विपरीत, भूजल दोहन से होने वाले भू-अवतलन या सतही जमीन का दब जाना धीरे-धीरे होता है; जो सालाना मुश्किल से दिखाई देता है। इसलिए, बुनियादी ढांचों के संरचनात्मक क्षति के साथ इसका संबंध स्थापित करना कठिन है। हालाँकि, हाल के वर्षों में किए गए ढेर सारे अध्ययन, जो कि उपग्रह-डेटा विश्लेषण में विशेषज्ञ संस्थानों और शोधकर्ताओं से प्राप्त किए गए हैं, उनमें से सभी भू-अवतलन के उपग्रह-आधारित विश्लेषण से प्राप्त हुए हैं, जिसमें भूजल निकासी के साथ भवन की विकृतियों का सहसंबंध पाया गया है।



तटीय मैदान और नदिमुख भूमि या डेल्टा क्षेत्र दुनिया भर में उच्चतम लगभग 47% धंसने वाले क्षेत्र हैं। जमीनी जांच (जैसे भूवैज्ञानिक सर्वेक्षण जीपीएस और मॉडलिंग) की तुलना में भूमि धँसने की अंतरिक्ष-जनित निगरानी अधिक प्रचलित तकनीक है। दुनिया भर में सभी भूमि धँसने की मामलों में से 76.92% मानव-प्रेरित मामले हैं और इन मामलों में भूजल निष्कर्षण का योगदान 59.75% है। भूजल निकासी (r =+0.950) और भूजल स्तर में गिरावट (r =+0.888) के साथ औसत भूमि धँसने का दर के बीच घातीय प्रवृत्ति के साथ सीधा मजबूत धनात्मक सहसंबंध गुणांक (कोएफिशिएंट) देखा जाता है। इस तरह भूजल के अत्यधिक एवं असंधारणीय दोहन से होनेवाली गिरावट के कारण आने वाली पीढ़ियों के लिए पानी की कमी हो जायेगी है, हालाँकि, यह यहीं तक सीमित नहीं है। भूजल में कमी सतह या ऊपर की भूमि को संकुचित कर रही है, जिससे जलभृतों या जलवाही स्तरों में अपरिवर्तनीय बदलाव आ रहे हैं। अत्यधिक भूजल पंपिंग के कारण दबाव और आयतन (वॉल्यूम) में परिवर्तन होता है जिससे भूमि धंसती है। इससे शहर बाढ़ और जलजमाव के प्रति और भी अधिक संवेदनशील हो जाने की संभावना हैं।

जलभृतों या जलवाही स्तरों से व्यापक जल निकासी, कार्बनिक मिट्टी की जल निकासी, खनिज भंडार, तेल और गैस के तलघर या बेसमेंट खनन, और बेधन छिद्र (बोरहोल) या स्थायी तुषार (पर्माफ्रॉस्ट) के पिघलने और भूकंपीय गतिविधि के कारण होने वाले प्राकृतिक संघनन (संकोचन) या पतन के कारण होने वाला जलभृत-प्रणाली संपीडन है। पर्माफ्रॉस्ट अथवा स्थायी तुषार भूमि वह क्षेत्र है जो कम-से-कम लगातार दो वर्षों से शून्य

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डिग्री सेल्सियस (32 डिग्री F) से कम तापमान पर जमी हुई अवस्था में है। नेचर साइंटिफिक पत्रिका में हाल में ही प्रकाशित एक शोधपत्र के अनुसार, भूमि धंसने से हर साल तेजी से नुकसान हो रहा है। वैश्विक भूमि अवतलन का 80% से अधिक अत्यधिक भूमिगत जल निष्कर्षण के कारण होता है, जो अंतर-कणीय तनाव को बढ़ाता है और मिट्टी के कणों के पुनर्गठन को प्रेरित करता है, जिसके परिणामस्वरूप वास्तव में जलभृत संपीड़न और अंततः भूमि अवतलन होता है। देश की बढ़ती पेयजल, कृषि-आधारित और औद्योगिक आवश्यकताओं को समायोजित करने के लिए भारत में भूजल निष्कर्षण का स्तर लगातार बढ़ रहा है। अपनी रोजमर्रा की पानी की जरूरतों के लिए लोग भूमिगत जल या निजी जल टैंकरों पर निर्भर हैं। भूजल के उत्थित उपयोग या अत्याधिक दोहन के मामले में भारत दुनिया में पहले स्थान पर है। भारत के अंदर भी, उत्तरी गंगा घाटियों का अन्य क्षेत्रों की तुलना में अधिक दोहन किया जाता है। जलभृतों के लुप्त होने से पृथ्वी की सतह की संरचना में शीघ्रता से तीव्र परिवर्तन हो रहे हैं।

समुद्र-स्तर में वृद्धि और भूमि अवतलन

जलवायु परिवर्तन और मानव-जनित भूमि धंसाव की दोहरी मार का मतलब है कि वैश्विक तटीय निवासी अत्यधिक समुद्र-स्तर में वृद्धि का अनुभव कर रहे हैं। नेचर क्लाइमेट चेंज पत्रिका में प्रकाशित एक अध्ययन में पाया गया है कि दुनिया के तटीय निवासी अनुमानित समुद्र स्तर में वृद्धि कई गुना अधिक वृद्धि का अनुभव कर रहे हैं क्योंकि वे उन स्थानों पर केंद्रित हैं जहां भूमि तेजी से डूब रही है। जैसे-जैसे पृथ्वी की बर्फ की चादरें पिघल रही हैं और समुद्र का पानी गर्म हो रहा है, वैसे-वैसे समुद्र का स्तर विश्व स्तर पर बढ़ रहा है। लेकिन स्थानीय स्तर पर, धंसाव, या डूबती हुई भूमि, समस्या को नाटकीय रूप से बढ़ा सकती है। न्यू ऑरलियन्स और जकार्ता जैसे शहर अपने समुद्र तट के सापेक्ष समुद्र के स्तर में बहुत तेजी से वृद्धि का अनुभव कर रहे हैं - जैसे-जैसे पानी बढ़ रहा है, जमीन भी डूब रही है।

डूबती ज़मीन दुनिया भर के तटीय निवासियों को बढ़ते समुद्र के प्रति असुरक्षित बना देती है: सामान्य तटीय निवासी वैश्विक औसत की तुलना में समुद्र के स्तर में तीन से चार गुना अधिक वृद्धि दर का अनुभव कर रहे हैं। जलवायु-प्रेरित समुद्र-स्तर में वृद्धि और तलछटी तटीय निचले इलाकों में प्राकृतिक और मानव-प्रेरित भूमी अवतलन सहित ऊर्ध्वाधर भूमि गति या हरकत, दुनिया के तटों के आसपास सापेक्ष समुद्र के स्तर को बदलने के लिए मिलकर काम करते हैं। स्थानीय भूमि अवतलन के परिणामस्वरूप सापेक्ष समुद्र-स्तर वृद्धि के कारण तटीय भूमि तेजी से नष्ट हो सकती है। चूंकि तटीय निवासी अधिमान्य ढंग से निचले स्थानों पर स्थित हैं, इसलिए वे समुद्र के स्तर में औसतन चार गुना तेजी से वृद्धि का अनुभव करते हैं। इन परिणामों से संकेत मिलता है कि प्रभाव और अनुकूलन की आवश्यकताएं रिपोर्ट किए गए वैश्विक समुद्र-स्तर वृद्धि मापों से कहीं अधिक हैं। 48 सबसे बड़े तटीय शहर, जो वैश्विक शहरी आबादी का 20% प्रतिनिधित्व करते है, इस अध्ययन में पाया गया कि सबसे तेज़ सापेक्ष समुद्र-स्तर वृद्धि का अनुभव करने वाले शहर एशिया में केंद्रित हैं।

उपसंहार:

आर्थिक विकास, शहरी विस्तार और तेजी से जनसंख्या विस्तार के कारण, विश्व के अनेक मुल्कों में भूजल का अवैज्ञानिक दोहन तेज हो गया है, जो इसे उन क्षेत्रों में सबसे तेज भूमि अवतलन दर वाला क्षेत्र बनाता है। यह अनुमान लगाया गया है कि 2040 तक, भूमि अवतलन वैश्विक भूमि की शीर्ष परत के लगभग 8% और विश्व के 21% बड़े शहरों में रहने वाले लगभग 1.2 बिलियन लोगों को प्रभावित करेगा। इससे बचने के लिए- भूजल पुनर्भरण एक प्राकृतिक तरीका है। यदि भूमिगत जल का पुनर्भरण दोहन की गई मात्रा के बराबर हो, या यदि हम पानी का उपयोग संधारणीय तरीके से करें तो लोग भूमि धंसाव को कम कर सकते हैं। कुछ क्षेत्रों में जहां भूजल पंपिंग के कारण भूस्खलन हुआ है, भूजल से सतही जल आपूर्ति पर स्विच करके

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भूस्खलन को रोक दिया गया है। यदि सतही जल उपलब्ध नहीं है तो भूमि धंसाव को कम करने के लिए अन्य उपाय करने चाहिए। संभावित उपायों में पानी के उपयोग को कम करना और पंपिंग और कृत्रिम पुनर्भरण के लिए स्थानों का निर्धारण करना शामिल है जो भूस्खलन को कम करेगा। ऐसी रणनीतियों को विकसित करने के लिए भूजल प्रवाह मॉडल के साथ मिलकर अनुकूलन मॉडल का उपयोग किया जा सकता है।

जल स्रोतों पर निर्भरता कम करने और भूजल निकासी पर दबाव कम करने हेतु औद्योगिक प्रक्रियाओं जैसे- गैर-पीने योग्य उद्देश्यों के लिये अपशिष्ट जल का पुनर्चक्रण और पुन: उपयोग को प्रोत्साहित करने की आवश्यकता है। भूक्षरण की दर और जोखिम क्षेत्र के क्षेत्रीय मूल्यांकन के बारे में महत्वपूर्ण जानकारी भूमि संसाधनों के संरक्षण और संधारणीय उपयोग के उद्देश्य से विभिन्न रणनीतियों को तैयार करने में नीति निर्माताओं और योजनाकारों की आवश्यकता पर प्रकाश डाल सकती है। विशेष रूप से, भूजल उपयोग और जल निकासी के लिए उचित नीति के साथ तटीय शहरों और आसपास के तटीय शहरों में मानव-प्रेरित भूमी अवतलन को तेजी से कम किया जा सकता है। ऐसी नीति समुद्र-स्तर में सापेक्ष वृद्धि के कारण तटीय बाढ़ जोखिम की वृद्धि को कम करने के लिए पर्याप्त और त्वरित लाभ प्रदान करेगी।

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4. Exploring the Depths: A Comprehensive Review of Recent Trends in Technology in Marine Archaeology

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Abstract

Marine archaeology is a relatively new field that involves the study of human activity in marine environments. It is essential for comprehending the evolution and history of human communities all over the world. The ability of marine archaeology to give insight into the evolution of human cultures and the part that maritime activities have played in influencing the world's history makes it important. Despite its importance, there are gaps in our knowledge of underwater heritage, necessitating the creation of new research techniques and technologies that can overcome the difficulties associated with operating in these types of settings. Diverse tactics and technologies have been utilized by various nations for marine archaeology, which has produced a wide variety of study methods and findings. To improve the precision and effectiveness of underwater research and excavation, recent trends in marine archaeology have concentrated on the use of cutting-edge technology, including remote sensing, 3D modeling, and virtual reality.

Keywords: Marine Archaeology, Undersea heritage, Excavation, Remote sensing, 3D modeling.

Introduction

Marine archaeology is also known as underwater archaeology, maritime archaeology, or nautical archaeology. Marine archaeology is an interdisciplinary field that focuses on studying human activity in the underwater environment, including shipwrecks and submerged landscapes (Adams, 2015). This branch of archaeology has significantly contributed to our understanding of the history and culture of coastal and maritime communities and our knowledge of seafaring, navigation, and shipbuilding technology. Marine archaeology has also played a crucial role in the

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protection and preservation of underwater cultural heritage and the development of sustainable approaches to coastal and marine resource management (Fitzpatrick & Pilar-Martin, 2019). Recent technological advancements in underwater remote sensing and robotics have led to discoveries, providing insights into past human activity in the ocean (Adams, 2015).

Due to technological advancements and a rise in interest in the study of human history, the area of marine archaeology, which is still relatively young, has become more significant in recent years. The study of undersea cultural heritage, shipwrecks, submerged landscapes, and other aspects of maritime interaction are all included in this discipline. It is an interdisciplinary field that integrates methods and ideas from anthropology, geology, oceanography, and the first two sciences. Understanding the past and protecting cultural assets require the study of marine archaeology.

The investigation of new study fields is one of the most important developments in maritime archaeology. The study of submerged landscapes and the effects of sea-level change on human cultures has attracted more attention in recent years. New archaeological sites, including submerged prehistoric towns and historic harbor facilities, have been uncovered as a result of this. These sites can be studied to learn more about how ancient people interacted with the water and adjusted to their changing circumstances.

Regardless of the recent advances in technology and the exploration of new arenas of research, there are still substantial gaps in knowledge in the field of marine archaeology. The difficulty of reaching and researching underwater sites is one of the main challenges facing marine archaeologists. The number of investigations and the amount of knowledge that can be acquired from underwater sites have been constrained due to the high cost and technical difficulties connected with underwater archaeology.

The absence of standardized procedures for the research of underwater locations is another knowledge gap. For the research and preservation of undersea cultural heritage, many nations and organizations employ various techniques, which can result in discrepancies in the data and conclusions. Standardized techniques would make it easier to verify that data is consistent and comparable across many sites and locations when conducting underwater archaeology.

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Methodology

This literature review provides an overview of the state of marine archaeology and points out any gaps and potential topics for further study. The review examines the value of studying shipwrecks, underwater cities, and prehistoric seafaring societies, as well as other aspects of marine archaeology, in understanding human history. The assessment also looks at current developments in marine archaeology, such as the use of new tools like sonar and remote sensing, as well as the investigation of brand-new fields like deep-sea archaeology. The study used a qualitative methodology to look into current developments in marine archaeology. A review of previously written articles, books, and other materials is used to conduct the study. The study concentrates on locating new fields, gaps in archaeology, and technology employed in other nations. The significance of marine archaeology in advancing our knowledge of human history is also included in the study.

Reviewing published works on the topic of marine archaeology is part of the data collection process. A thematic analysis method is used to examine the data that has been gathered. Themes such as new domains, gaps in archaeology, and technology employed in various nations are identified depending on the research goals and objectives. JSTOR and Google Scholar are just two examples of academic databases that are used for literature evaluation. The primary data collection method is through the Journal of Maritime Archaeology, Ballard, R. D. (2017). Advances in underwater archaeology, Adams, J. (2017) Marine Archaeology, and research papers on Tripati, S. (2015). Marine archaeology in India, Gaur, A. S., & Tripati, S. (2005). Underwater archaeology in India.

Limitations in initial tools/technologies

The old tools and techniques used for marine archaeology had several limitations, which include:

1. Limitations on depth: Due to divers' limited underwater endurance, many of the early diving techniques were only effective at shallow depths. Exploring deeper underwater places became challenging as a result.
2. Equipment limitations: Early diving gear had several movement issues that made it difficult for divers to maneuver around underwater environments and retrieve artifacts. Older equipment was also more prone to failure or malfunction.

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3. Inaccuracy: It was challenging to precisely identify and locate underwater things since early sonar and magnetometer equipment could only produce blurry images of underwater places.
4. Site destruction: Conventional excavation techniques like dredging and grappling have the potential to seriously harm underwater artifacts and sites.
5. Environmental considerations: Ocean currents and erosion are two examples of environmental elements that can over time scatter or bury artifacts at underwater sites.
6. Human error: Human error can happen throughout every archaeological excavation, such as incorrect data interpretation or incorrect artifact identification.

Modern technology has enabled significant advancements in marine archaeology, giving archaeologists new and more effective ways to explore and record underwater sites. While these tools and techniques were crucial for the early study and documentation of underwater cultural heritage sites, they were also necessary for those efforts.

Technical Developments

Technological advancements have greatly improved the field of marine archaeology, allowing for more accurate and detailed studies of submerged cultural heritage. This paper aims to provide a comprehensive overview of the recent technological advancements in marine archaeology,

Advanced imaging technology is increasingly used in marine archaeology. Archaeologists can find and map underwater sites more precisely using sonar and other imaging tools like magnetometers. For instance, side-scan sonar uses sound waves to produce detailed photographs of the ocean floor that can pinpoint the locations of shipwrecks and other underwater artifacts. However, the ability of these imaging methods to offer comprehensive information on the objects or structures they find is constrained.

Another recent innovation is the use of autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs) for exploration and excavation. According to (Cameron et al. 2013), ROVs and AUVs can be equipped with cameras and other sensing devices to provide detailed images and data about underwater environments. Because these vehicles can also be used to collect samples or perform other tasks remotely, divers and other workers are not as needed in dangerous or difficult-to-reach regions. However, the expensive price tag and need for specialized training to operate ROVs and AUVs successfully may restrict their use.

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In recent years, 3D printing has become more widely used as a technology. Researchers can produce exact copies of artifacts collected from underwater sites using 3D printing, which can then be utilized for either research or education. For instance, the Antikythera mechanism, an ancient Greek astronomical instrument discovered in a shipwreck, has been studied in greater detail thanks to a 3D-printed reproduction, which has prevented the deterioration of the original artifact (Freeth et al., 2016). However, the complete complexity of some artifacts, like fabrics or organic materials, cannot be captured by 3D printing.

DNA analysis is another recent innovation in marine archaeology that is being used to identify artifacts and materials found at underwater digs. According to Sato et al. (2017), DNA analysis can reveal important details about the composition and provenance of artifacts and details on the species and ecosystems in the aquatic environment. However, the quality and amount of genetic material present in the samples, as well as the availability of reference databases for comparison, might have an impact on how much DNA analysis can be used.

Finally, there are legal and ethical considerations in marine archaeology. In many cases, underwater sites may be protected by international or national laws, which may restrict access to the site or limit the types of excavations that can be carried out. Additionally, there are ethical considerations regarding the treatment of artifacts and the impact of excavation on the local community. To address these issues, archaeologists work closely with local communities and government agencies to develop excavation plans that are respectful of local cultures and traditions (Swan, 2011).

Complications in marine archaeology

The study of human activities and objects that have been submerged underwater is called marine archaeology. These artifacts' excavation provides a special set of difficulties and issues that are unique to this field. This study will look at some of the major issues that arise when doing marine archaeology excavations.

One of the main challenges in marine archaeology is the caustic and unpredictability of saltwater. Seawater can destroy artifacts and make maintaining them more difficult. Metals, for instance, can easily corrode and disintegrate in seawater, but bacteria and other marine organisms may affect wood and other organic materials. The constant flow of water can also bury or erode artifacts, making it difficult to locate and retrieve them (Jorgensen, 2017).

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In maritime archaeology, access difficulties to submerged sites are a major problem. To excavate effectively in maritime conditions, expensive equipment, and qualified labor are required. When diving in shallow water, areas with strong currents, or rough seas,

archaeologists can only spend a limited period below (Green et al., 2015).

Another challenge for marine archaeologists is the moral and legal questions that accompany the excavation of submerged sites. Since some sites may be covered by local, national, or international laws safeguarding them, archaeologists may frequently need particular licenses or approvals before excavating them. Additionally, there may be ethical problems with disturbing or damaging sensitive ecosystems or precious cultural artifacts

In underwater areas (Smith, 2019).

In marine archaeology, it is impossible to properly date or contextualize artifacts due to the scarcity of historical records or the negative effects of underwater environments on preservation. Without particular dates or background information, it may be challenging to adequately assess the significance of artifacts or understand how they relate to the people who created them (Westley & Phillips, 2021).

Discussion

Modern technology has fundamentally changed how marine archaeologists investigate sites of undersea cultural heritage. Before the development of modern technologies, maritime archaeologists made extensive use of labor-intensive and dangerous manual excavation. However, as technology improved, new instruments and methods were created that made exploring underwater locations more effective and thorough.

Scuba tank innovation is among the most important advancements in underwater archaeology. This advancement has improved divers' abilities to explore and record sites by allowing them to stay underwater for longer periods. This has made it possible to record high-quality photographs and videos of underwater locations and artifacts, together with the availability of underwater photography and video technology.

Magnetometers, side-scan sonar, ROVs, and AUVs are a few other examples of technological innovations that have significantly changed marine archaeology. Without physically digging the site, archaeologists can now find buried structures and artifacts thanks to magnetometers and side-scan sonar. Due to their ability to travel to locations that human divers

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might find too hazardous or challenging to reach, ROVs and AUVs have also made it possible for a safer and more thorough study of underwater places.

The discipline of marine archaeology has benefited much from modern technology, but it's crucial to be aware of its limitations and potential downsides. In contrast to human divers, remote exploration instruments like ROVs and AUVs, for instance, cannot offer the same level of tactile and sensory feedback, which may limit their capacity to precisely detect and interpret artifacts. Smaller research teams might not have access to some of these technologies because they may be expensive or require specialized expertise.

Overall, the advancement of contemporary technology has substantially improved marine archaeologists' capacity to discover and examine underwater sites of cultural value. However, it is crucial to take into account the potential restrictions and disadvantages of these tools and procedures and to keep developing and improving them when fresh difficulties appear.

Conclusion

- Recent trends in marine archaeology include the increased use of advanced imaging technology, the use of ROVs and AUVs for exploration and excavation, the use of 3D printing for artifact replication, and the use of DNA analysis for artifact identification.
- Each of these technologies has its limitations, but they also provide valuable new tools for researchers to explore and understand the underwater world and the human history it contains.
- In conclusion, due to the corrosive nature of saltwater, the difficulty of access, legal and ethical considerations, problems with dating and contextualization, and other factors, marine archaeology provides distinctive and complex challenges for digging artifacts.
- Through the use of advanced technology such as remotely operated vehicles and sonar imaging, we are able to explore areas that were once thought inaccessible.
- It is important that we continue to support and invest in marine archaeology research as it holds immense potential for future discoveries that could change our understanding of the world forever.

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7. Preliminary Observation of some Parameters of Water and Fish Quality at Madh along Mumbai Coast

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Abstract

The present study is based on the preliminary assessment of selected Water bodies in Mumbai and analysis of fish quality proportionate to contamination level. As we already aware that water is a significant part of our life and it must be retained and maintained. It is crucial for all forms of entity and it consists of 50- 97% of plant and animal weight. The seawater is a component that interacts with the terrestrial environment which leads to water pollution through anthropogenic interference . Study area madh jetty is connect to Malad creek which transfer wastewater from BMC's malad sewage treatment plant handles the waste of 35 lakh people and Coastal water quality is deteriorating due to the disposal of partially treated wastewater, open drainage and industrial wastewater, which are now the primary environmental concern.This highly polluted coastal waters affects the marine ecosystems by disturbing all the life processes of marine organisms. This research paper focuses on the analysis of the water quality and fish quality from the Madh which is located in Malad, Mumbai. Water quality analysed by measuring some preliminary parameters such as Temperature, Turbidity, pH, Salinity, Silicates, BOD and DO and Fish quality was analysed by Quality Index Method.Also fishermens survey was conducted in the area. The obtained results specified that the turbidity was high and BOD and DO level is low. Overall results concluded that the water was polluted and the fish survey indicates that the quality of fish has degraded as compared to past years.

(Keywords: Malad creek, Turbidity, Salinity, BOD, Fish quality, Water pollution, Contamination, Environmental concern)

Introduction

The biodiversity of marine water bodies offers a number of food sources which has a direct impact on human health and well-being. For humans, aquatic ecosystems are an indirect source of minerals, vitamins and protein and such a venue for leisure, commercial fishing and tourism. Sustainable social, and economic development depends on water as a fundamental

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source (Nair et.al 2022). As a result, water quality has been described extensively in the scientific literature. The most popular definition of water quality is " it is the physical, chemical, and biological characteristics of water" (Omer, 2019). The requirement for water is in all forms of life from microorganisms to man. It is a serious concern today because many water resources have reached at a point of environmental crisis due to rapid and unplanned urbanization and industrialization. (Nair et.al 2022). Mumbai is over populated and is the wide ranging industrial center in the country. It produces high amounts of domestic sewage and industrial discharge which are ultimately released into the Arabian sea (Behera, 2021). Hence it is necessary to analyze the factors that influence surface water since they all are crucial for humans and due to spatial and temporal variations in water quality (Deng, 2022). A monitoring program is necessary to provide a representative and reliable estimation of quality of water (Kamble, 2011).

The chemical and biological properties of the surface water is affected due to temperature. Living beings are affected by the fluctuations in the pH of the aquatic system. pH beneath optimal level makes fish capable of acquiring fungal infection and disturbs their reproduction system (Nair et.al 2022). Sea surface temperature (SST) is a major indicator of productivity, pollution as well as global climate change (Fingas,2019). The clearness of water determines the physical property of turbidity. Suspended matter like clay and silt particles, organic matter, microscopic organisms, and colloids is the major source of causing natural water to be turbid (Popek, 2018). The saline property of aqueous solution is pH. Since it affects chemical as well as biochemical properties like the chemical reactions and biological toxicity of water (Marion et.al 2011). Biochemical oxygen demand (BOD) is the most crucial and extensively used parameters in indentifying the organic pollution of water and wastewater. It is an crucial indicator for monitoring organic pollutants (Verma and Singh, 2013). The dissolved oxygen (DO) content of water is essential for survival of aquatic life. The dissolved oxygen content is a part of the water quality (Kulkarni, 2016). The salinity of the ocean fluctuate from place to place, chiefly at the surface of the water. (Nasreen,2022). The density of seawater raises with the increasing salinity. The relationship between temperature and density is altered by the salinity of seawater (Olson, et.al, 2022). Silicon in sea water might be present in suspension, in clay or sand, it might be also present in constituent of diatoms or in solution. Few silicon in solution appears in the form of silicates (Armstrong, 1951). It is necessary to analyze the parameters in order to check the quality of water.

As reported by FAO, global fish production is approximately 179 million tons, but only around 156 million tons make it to our plates (Saeed et.al, 2022). The seawater quality of

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Mumbai beaches and sea face, which are huge tourist hotspots, are inside the range of "medium to very bad"(Sanjana Bhalerao, 2020).

The madh jetty which is situated in malad, Mumbai is the connecting link between versova andheri and malad. Due to industrial waste and sewage discharged directly into seawater, water pollution has increased substantially.Water quality declined more significantly. Therefore it is important to keep under observation the sources and pathways of pollutants/contamination and to assess the quality of fish and to know the decline in the quality compared to past years.

Method and Methodology

Study area

In Mumbai, Madh Island which is bound by Arabian sea. It is located around 30 kilometers from Mumbai (19.132283°N, 72.794785°E). the island is a village which mainly comprises kolis, Marathi, East Indians, Roman Catholics, and people from different communities.

Madh island

Madh Island is full of incredible fish food and sea breeze with sunshine. The island is surrounded by lush and serenity. Study area is surrounded by hotels, resorts, restaurants, and beautiful villas near the island. The island is noticeable by attractive Sandy beaches such as Aksa beach,dana pani, Marva beach,Erangal and Madh jetty. Madh jetty is the connecting link between Malad and Versova. A wide part of the island is under the control of the defense establishment of the Government of India such as the Indian Navy and Indian Air force.

Approximately 2100 million liters per day of wastewater is discharged into Arabian sea and the creeks.

According to a global study, the sea near the coast of Mumbai is among the most polluted in the world. Hence the coastal water quality and fish quality is declining due to disposal of sewage, industrial wastewater and open drains. As it leads to an increase in water pollution over the last several years.



Fig 1. Image of Madh

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Fig 2. Satellite mapping of madh Island and madh jetty

Water sample collection

The sea water sample was collected from a site of madh, Mumbai. The water sample was collected from the surface of the sea. 3 water samples were collected at the interval of 15 days.

Observations were recorded for the preliminary analysis of parameters like Temperature, Turbidity, pH, BOD (Biological oxygen demand), DO (Dissolved oxygen), Salinity and Silicates.

Turbidity of sea water: Turbidity of sea water was measured by using the secchi disk.

Step 1:A secchi disk was lowered in the sea water until it disappeared and the depth was recorded.

Step 2: The disk was slowly raised until it became visible again and again the depth was recorded.

The average depth from step 1 and step 2 is recorded as secchi disk.



Fig 3. Secchi disk used to measure the turbidity at study area.

Surface water Temperature: The temperature of the surface seawater was recorded using the digital thermometer.

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pH: The pH of the sea water was estimated by using the pH meter with reference to standard buffer solution.

Estimation of DO (Dissolved oxygen): Collected water sample was titrated against the sodium thiosulphate using starch as an indicator. The Concentration of dissolved oxygen was measured by the method developed by Winkler in 1888.

Calculate the DO values

DO= V1×N×8×1000/sample volume

Estimation of BOD (Biological oxygen demand): The collected water sample was titrated against the sodium thiosulphate using starch as an indicator. The Concentration of dissolved oxygen was measured by the method developed by Winkler in 1888.

Calculation

BOD = (D1-D5)

Salinity: The collected water sample was titrated against the silver nitrate solution using the Potassium chromate as an indicator. The burette reading was noted and calculate

Calculation

1000 ml of 1N AgNo3 = 35.5 gm of Cl-

1 ml of 1N AgNo3 = 0.0355 gm of Cl-

(y). 1 ml of 0.28 N AgNo3 = 0.00944 gm of Cl-

Chlorinity of water sample = y×CBR×1000/volume of sample

Salinity= 0.03+(1.805× chlorinity)

Silicates: The collected water sample was tested with the help of colorimetric method at 425nm. The colorimetric method used is described by Swank and Mellon (1932).

Calculation: O.D & of sample × Conc.of std × 1000

O.D of Standard. Volume of sample

Fish quality

The quality of fish was determined by a survey method. A survey was carried out in the study area among fishermen and the response was noted. Organoleptic test was performed with the help of sensory assessment like smell, texture, color were recorded for Bombay duck(*Harpadon nehereus)* and Golden anchovy(*Coilia dussumieri)*

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Result and Discussion

Preliminary observation of some parameters of water

Test	Sample 1	Sample 2	Sample 3
Turbidity (Secchi disk in meter)	0.654 m	0.622 m	0.734 m
Temperature	33.1°C	32.4°C	25.3°C
pH	7.06	7.13	7.19
DO	4.8	4.4	4.6
BOD	1.0	0.6	1.0
Salinity	54.05 gm/kg	53.94 gm/kg	50.96 gm/kg
Silicates	921 µg/L	921 µg/L	789 µg/L

Table no. 3

The turbidity of seawater which was measured with the help of secchi disk was approximately (0.654 m - 0.734 m). The high turbidity is caused by the more amount of biota and the suspended matters like clay and silt.

The Temperature recorded was around standard range. In morning the temperature recorded is lowered as compared to the temperature recorded in afternoon.

The range of pH was also around the standard range but it was slightly alkaline. The pH value in addition indicates activity of photosynthesis. The rate of photosynthesis is concerned by the change in pH from the optimum range. Increase or decrease in pH level also decreases the activity of photosynthesis (Nair et.al 2022).

The DO (Dissolved Oxygen) values were high indicating that the Biological oxygen demand (BOD) is more of the study area.

Salinity influences the composition of seawater and distribution of fish and many other marine resources (Nasreen, 2022). The salinity value noted is high as compared to standard value. The reason for high Salinity of the area is due to the discharge of wastewater into the sea.

Silica is found as dissolved silica or suspended silicate particles in most of the natural waters. Silica has been majorly used in many of the industrial applications which comprises the food and pharmaceutical production, as an additive and also for water filtration purpose. The high value of silicates indicates that the water is polluted.

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Fish quality survey

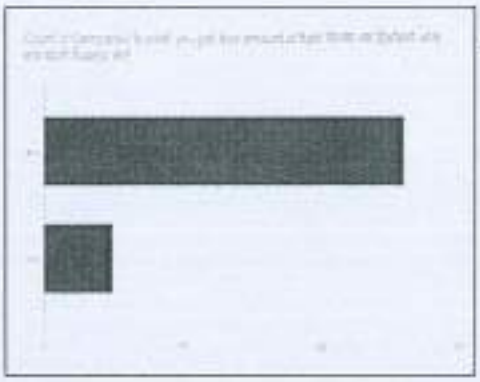


Fig 4. Chart based on a survey of amount of fish caught with comparison of past

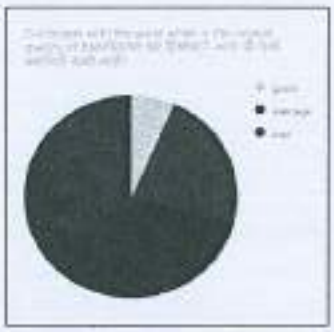


Fig 5. Chart based on survey of comparison of quality of fish with past

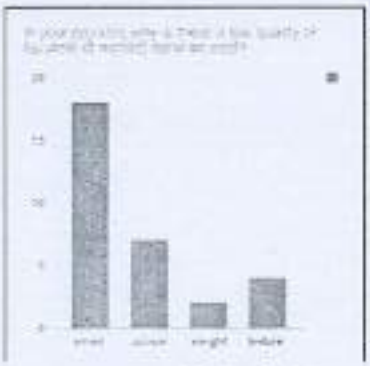


Fig 6. Chart based on a survey of why it is low. quality of fish .

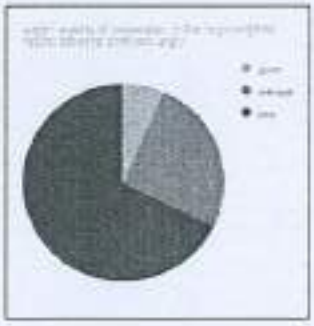


Fig 7. Chart based on survey of water of sea water in the region.

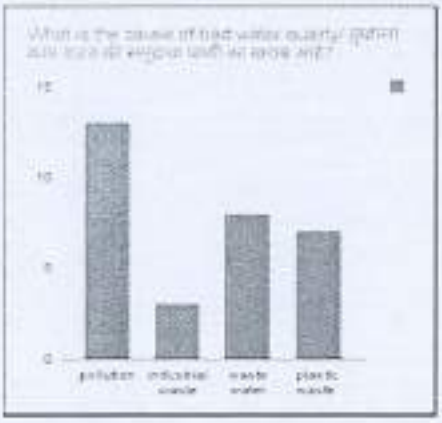


Fig 8. Chart based on survey of causes of bad water quality

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Quality Index test: Organoleptic test

Bombay duck (*Harpadon nehereus)*

Scale 1-5 1= good 5= bad	Smell	Colour	Texture of skin
3	Average smell	Cream colored	Soft
4	Smelly	Cream colored	Soft

Table no.4 Quality index test of Bombay duck (*Harpadon nehereus)*

Golden anchovy (*Coilia dussumieri)*

Scale 1-5 1= good 5=bad	Smell	Colour	Texture of skin
3	Smelly	Silvery orange	Rough
3	Smelly	Silvery orange	Little rough
4	Very smelly	Silvery orange	Rough

Table no.5. Quality index test of Golden anchovy (*Coilia dussumieri)*

The fish quality survey carried out in the study area among the local people and fishermens says that the fish quality is declining and the amount of fish caught is reduced as compared to the past. The survey also reveals that the water quality in the study area is bad and it also says that the major reason for bad water quality is pollution, waste water and plastic waste.

The Quality index method of organoleptic tests was done as a sensory assessment helps to determine the quality of fish captured at study area. This method indicates the fish condition with respect to some parameters declining (good to bad) quality which was scored from 1-5.

Conclusion

The conducted test reveals that the DO (Dissolved Oxygen) is higher in sample water due to excess disturbance of surface water by local activities and Subsequently BOD (Biological oxygen demand) value of the study area is low .Effluents from the Malad and Versova STP drain into the Malad creek, hence the turbidity of the study area is quite high.Sample water test confirmed that the pH is slightly alkaline .The Salinity and silicates value is higher than the standard values. The overall tests conducted reveals that the water in the Madh is polluted. For the assessment of the fish quality a survey was conducted based on offline questionnaire(for uneducated but experienced Fishermens) and fish quality index method (sensory assessment)was also conducted on the fishes captured at study area . Offline survey data was determined that the

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quality of fish has not been so great lately as mentioned by local fishermens. Fishermens said that taste, quality(nutritive value and organoleptic parameters) and texture of fishes is declining day-by-day. There should be awareness created among the people about the importance of water health. Also some preventive measures should be taken to clean the seawater and to maintain the seawater pollution free .As we are highly dependent on sea foods for food sufficiency and also for economic growth and also many of industries are dependent on Marine biodiversity and henceforth we need to conserve and maintain such waterbodies .

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5. Studies on Consumption Pattern of Fresh and Preserved Marine Fish along Mumbai

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Abstract

(Marine fishes is a major source of O-3 fatty acid (Eicosapentaenoic acid EPA, Docosahexaenoic acid, DHA) as key factor in human health. The present study is conducted to depict the status of fresh marine fish and preserved marine fish consumption. The study was conducted to gather information on the fish consumption among the randomly selected household using a distinct questionnaire survey in two area

(which is rural and urban area) along the Mumbai. The consumption of fresh marine fishes are more than preserved fish. Consumers commonly choice to consume fishes like cattla, common crap, rohu among the fresh water fishes. The price, availability, presence of intermuscular bone, fish smell are major barrier in fresh fish consumption. To this study know that the consumers consumed fresh fish because it provide nutrition, good quality, availability, and test. Survey shows that the range of fish species preferred (cost /price of fish) mainly focused on the household income.

Keywords: Consumption pattern, Fresh fish, Preserved fish, Mumbai, Sustainable fishing, Survey Household.

Introduction

The consumption of fish is a significant source of protein and essential nutrients for millions of people worldwide, especially in coastal regions. Mumbai, the financial capital of India, is situated on the Arabian Sea coast and has a long tradition of consuming fish, which is an essential component of the local diet. In recent years, the consumption of marine fish in Mumbai has increased rapidly, leading to concerns about its impact on the marine ecosystem and human health. This research paper aims to analyze the consumption patterns of fresh and preserved marine fish among the people of Mumbai .Several studies have investigated the consumption patterns of fish in India, including Mumbai. A study conducted by Joshi et al. (2018) reported that fish was the primary source of protein for the people of Mumbai, with an

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average consumption of 22.1 kg per person per year. The study also revealed that the consumption of fish was higher among non-vegetarians and the coastal population. Another study by Mhatre et al. (2020) analyzed the microbial quality of fresh and frozen fish sold in the retail markets of Mumbai. The study found that the microbial load was higher in fresh fish than froze fish. In recent times, however, there has been a shift in dietary patterns with an increasing preference for processed and preserved fish products over fresh fish. This trend has been attributed to factors such as convenience, affordability, and longer shelf life of preserved fish products. Mumbai, being a coastal city and one of the largest consumers of fish in India, has seen a significant rise in the consumption of preserved fish products. It is a rich source of protein, omega-3 fatty acids, vitamins, and minerals. In India, fish is a popular food item, especially along the coastal regions. Fresh and preserved marine fish are commonly consumed in Mumbai and form an important part of the local cuisine. Fishing is an important occupation for many communities in and around Mumbai. The fish catch is sold in the local markets and consumed by the local population. Fresh fish is commonly consumed in Mumbai and is available in the local markets and fishmongers. Preserved fish is also popular in Mumbai and is available in various forms, such as dried, salted, smoked, and canned.

Review Literature

There have been several studies conducted in the past to understand the consumption patterns of marine fish products in India. A study conducted by Sarkar et al. (2019) found that the consumption of fish in India has increased significantly in recent years, with the per capita consumption of fish increasing from 3.68 kg in 2012-13 to 5.2 kg in 2017-18. The study also revealed that while the consumption of fresh fish has remained stable, the consumption of processed and preserved fish products has increased significantly in urban areas.

Another study conducted by Zorriehzahra et al. (2020) analyzed the quality and safety of preserved fish products in India. The study found that while there was a significant demand for preserved fish products, the quality and safety standards were not always met, leading to health risks for consumers.

Materials and Methods

Marine fish consumption was estimated by conducting a household survey in 3 area with a questionnaire during April and May 2023 (Fig. 1). A well-structured questionnaire was developed with a vision to enlisting all the information related to the Fresh and preserved marine fish consumption. The questionnaire focused responses on household details of respondent, household Fresh and preserved marine fish consumption, consumer's knowledge and preference, and consumer's attitude towards the Fresh and preserved marine fish

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consumption. The questionnaire included open ended questions which allowed respondents to express themselves freely . Finally, the questionnaire was developed that allowed each respondent to answer all the questions comfortably and confidently without any hesitation. The participants will be asked to fill in a questionnaire, which will be designed to collect data on their consumption patterns, preferences, and reasons for choosing fresh or preserved fish products.

Study area

The study was conducted in Nallasopara region of three areas namely. The households were surveyed on fresh and preserved marine fish consumption. . Total households were surveyed on fresh and preserved marine fish consumption. The respondents were categorized into Gender (male and female) and two Ages (below 18 and 18 and above) In each area , 25 households were selected through stratified sampling based on it .

Data Collection

As the current study focused mainly on gathering information regarding fresh and preserved marine fish consumption from the local people in nallasopara , the primary data were collected through person to person interviews using the pre-designed questionnaire in each area Although the questionnaire was developed in English, so that the respondents were interviewed they

could provide information comfortably. The data collector visited each respondent's house for conducting this survey.

The Consumption Method of Determining Rate

To determine the fresh and preserved marine fish consumption among household members, method was used to collect relevant fresh and preserved marine fish consumption data from the respondents. Respondents were asked to mention if any specific fresh and preserved marine fish had been consumed by the household members, and if so, in a

month how many times you are consuming fish . In this research , respondents were also asking question about they are satisfied with quality of the preserved fish which are available in market , which consumption are good source of nutrition ? what is there packing types ? mostly the respondents like fresh fish consumption . The average fish consumption rate (g/capita/day) was estimated using the following formula:

Wfr = Wfc x 1000/ n x 7

Where, Wfr is the fresh and preserved marine fish consumption rate (g/capita/day), wfc is the amount of fish consumed by a household per week, n is the number of members in the household and 7 represents the no of days in a week.

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Data analysis

All the collected information were scrutinized and summarized carefully before the ultimate tabulation. The Data was collected from the questionnaires were computerized using Microsoft Access software.

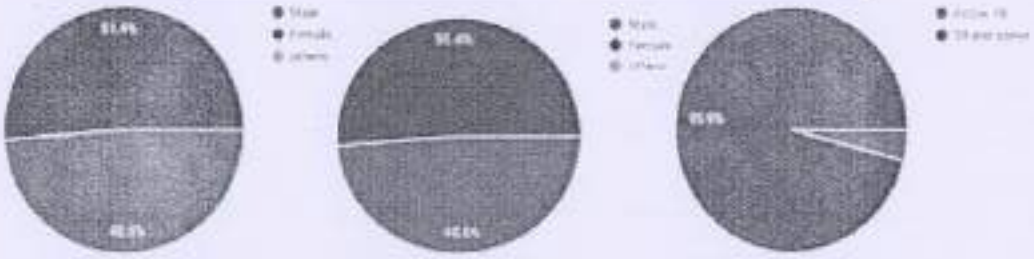
Results

Household details

Household details of respondent represents important socioeconomic characteristics such as the Gender , area, household status , level of education etc. In the present research, 54.1 % are female and 48.6% of male . manly the 95% respondent are 18 and above were as 5 % of 18 below .the respondents from urban areas is 74.3%, whereas the rest 25.7% from rural areas (Table I). Household status denoted the financial situation of a household and the household of respondents were categorized into low-income and high-income, based on the household income they are purches the fresh and preserved fish .

Table I. Household details of respondents interviewed Nallasopara

Profiles	Level	% of Respondents
Residential Area	Rural	74.3%
	Urban	25.7%
Household Status	Low-income	88%
	High-income	12%
Gender	Male	51.4%
	Female	48.6%
Ages	18 below	05%
	18 and above	95.9%

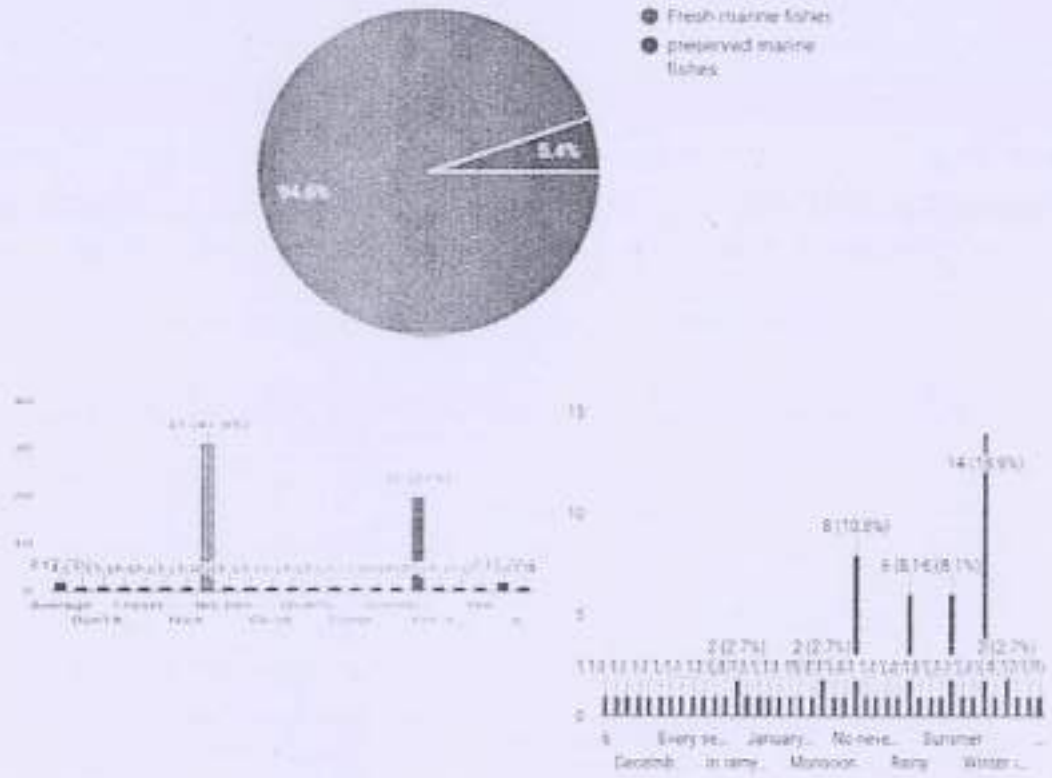


Fresh and preserved marine fish consumption

Households consumed marine fresh fish mostly, but there were some households where preserved fish was preferred over fresh fish. Almost all the households 91.9% consumed marine fresh fish whereas 8.1% of households consumed marine preserved fish. Price, consumer's behavior, smell, availability, bones were the major barriers to marine fresh fish consumption

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while quality remained a major issue in case of preserved marine fish consumption (Fig. 2). Apart from socioeconomic parameters, consumer's fish consumption is driven by major parameters such as quality, price, smell, taste and nutrition (Olsen 2001, Olsen 2004, Verbeke and Vackier 2005, Grieger et al. 2012). Fig. 2. In shrawan month less consumption of fresh and preserved marine fish. Mostly in the summer season consumers are consuming fresh and marine preserved fish. The preserved fishes are not beneficial for the health according to the respondent the fresh fishes are highly beneficial for the health because it contain vitamin , minarals , nutrition , good test etc. In a rainy season the preserved marine fish consumption is more because in rainy seasons are the breeding seasons for the marine fishes .



The preserved marine fishes are mainly the respondents are using the packaging materials 32.4% and the glass jars are 25.7% , and the plastic boxes are in 13.4 % . according to the respondent the place where the people are buying the preserved fish they hygienic .

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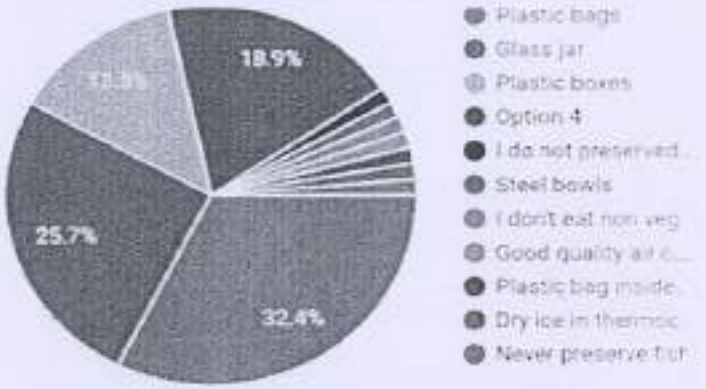


Fig. of different types of packaging materials

Conclusion

It can be concluded that the fresh marine fish consumption rate was higher in nalasopara. The people are consumed more fresh marine fish than the preserved fish. which might be due to the lower price and Availability . low price and awareness about health benefits among local people may lead to increased fresh marine fish consumption . the consumption patterns of fresh and preserved marine fish products in Mumbai have undergone significant changes in recent time. The findings of the research paper can be used to inform policy decisions aimed at promoting the consumption of fresh fish and ensuring the safety and quality of preserved fish products. This research paper will contribute to the understanding of the consumption patterns of fresh and preserved marine fish in Mumbai.

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शाश्वत शेती आणि ग्रामीण विकास

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कीर्ती महाविद्यालय, (स्वायत्त), दादर, मुंबई-२८.

प्रास्ताविक

भारत देश हा खेड्यांचा आहे, असे भारतीय अर्थव्यवस्थेत म्हणण्यात आले आहे. भारतीय अर्थव्यवस्थेत ग्रामीण विकासाला महत्वाचे स्थान आहे. कारण जोपर्यंत खेड्यांचा विकास होणार नाही तो पर्यंत देशाचा विकास होणार नाही असे महात्मा गांधीजी असे म्हणत. आज ग्रामीण भागात ६५% पेक्षा ग्रामीण भागात लोक वास्तव्य करत आहे. ग्रामीण भागात लोकांची गरज बघता अन्न, वस्त्र, निवारा, आरोग्य, शिक्षण आणि रोजगार असे महत्वाचे घटक आहे की, ते पूर्ण दिसत नाही. यासाठी सहकारी संस्था पुढे येणे आवश्यक आहे.

ग्रामीण भागात ग्रामीण ग्राम उद्योग व व्यवसायाला शेती व्यासायला महत्वाचे अग्रस्थान आहे. त्याच्याबरोबर इतर जोड व्यवसाय, पूरक व्यवसाय व इतर ग्रामोउद्योग याला महत्वाचे स्थान आहे. भारताची वाढती लोकसंख्या, रोजगार प्रश्न व गरिबी, बेकारी, अंधश्रद्धा इतर घटक समस्या सोडविण्यासाठी शेती पूरक व्यवसाय व उद्योगाला महत्व दिले आहे पाहिजे. आज भारत स्वयंपूर्ण देश म्हणून ओळखला जातो. शेतकरी भारताला अन्नधान्य पुरवण्याचे काम करतो. तसेच परदेशात मोठ्या प्रमाणात मागणी असल्यामुळे भारतीय शेतकऱ्याला अर्थव्यवस्था व अर्थसहाय्य शेती या व्यवसायात कोटयावधी आहार योजना लोकांना पुरविले जाते. अनेक रोजगार संधी उपलब्ध होणार आहे. त्यामुळे भारताचा इतिहासात शाश्वत शेतीला महत्वाचे स्थान देण्यात आले आहे. भारत व चीन देशाला हजारोवर्षांपासून शेती करत असतात. सेंद्रिय खत व सेंद्रिय शाश्वत शेती आधार घेवून शेती व्यवसाय करतात. सेंद्रिय शेती ही शाश्वत शेती ही निसर्गावर अवलंबून आहे. शेतीमध्ये रासायनिक खते व घातक असे पदार्थ न वापरता नैसर्गिक पद्धतीने संवर्धन, पर्यावरण संरक्षण आणि मानवाच्या आरोग्य सुदृढता व सुरक्षा ठेवण्यासाठी नियोजन व व्यवस्थापन केले पाहिजे चांगल्या प्रतीचे अन्न तयार करण्यासाठी सेंद्रिय शेतीचे उद्धेश समोर ठेवून उत्पादन वाढविणे आवश्यक आहे. त्यासाठी रासायनिक खताचे वापर टाळून शेती उत्पादनावर उद्योग मधून सेंद्रिय पदार्थाच्या कार्यक्षम पद्धतीने वापर करता येते. त्याचबरोबर घरातील ओला कचरा, तण, जनावराचे मलमूत्र तसेच शेण यांचा अवशेष यापासून शेतीमध्ये कुजवून सेंद्रिय खत तयार करता येते. शाश्वत शेतीला सेंद्रिय शेती असे म्हटले जाते. आणि भावी पिढीला आवश्यक असणाऱ्या मुलभूत स्त्रोतांना कोणत्याही प्रकारची हानी न पोहचता वर्तमान पिढीच्या गरजा भागवण्यासाठी अवलंबण्यात आलेली शेती पद्धती होय.

व्याख्या

शाश्वत शेती (SustainableAgriculture) म्हणजे जमीन, पिके, वने, पशुधन, वन्यजीव, मासे, पर्यावरण इत्यादी पुनर्जीत करण्याजोगे स्त्रोतांच्या प्रतवारीचा घसारा न होऊ देता संतुलित व्यवस्थापन करून वर्तमान व भावी पिढीसाठी अन्न, वस्त्र, निवारा, आरोग्य, शिक्षण व रोजगार यांचा पुरवठा करणे होय.

उद्धेश

१) शाश्वत शेतीमुळे जमिनीची उत्पादकता व उत्पादन सातत्य मिळते.
२) नैसर्गिक पद्धतीने व स्थानिक संसाधन यांचा वापर करणे या विषयी माहिती घेणे.
३) खर्चात बचत, वेळ, उत्पादन अधिक यांची सविस्तर अभ्यास करणे.
४) रासायनिक मुक्त अन्नाचे उत्पादन व सुरक्षितता याचा अभ्यास करणे.
५) तसेच शेती पद्धतीने शाश्वत शेती म्हणून ग्रामीण विकासाला चालना देणे.

गृहीतके

१) शेती ही ग्रामीण विकासाची गुरुकिल्ली असून सेंद्रिय शाश्वत शेतीमुळे ग्रामीण विकासाला चालना मिळते.
२) ग्रामीण भागात शाश्वत शेतीतून मोठया प्रमाणात रोजगार उपलब्ध होत आहे.

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३) रासायनिक शेतीला आळा घालण्यासाठी सेंद्रिय शाश्वत शेतीवर भर देणे.

संशोधन पद्धती

सदर संशोधन पद्धातीचा अभ्यास करताना दुय्यम साधनांचा वापर केला आहे. संशोधकाने संशोधन अभ्यास करत असताना मॅगझीन, पुस्तके, इंटरनेट, ॲग्रोवान पेपर, तसेच वर्तमान पत्रे इत्यादी.

माहितीचे विश्लेषण

आज जगामध्ये सेंद्रिय शाश्वत शेती जवळजवळ १२० ते १२२ देश आहेत. सेंद्रिय शेतीची जागतिक बाजारपेठेत मोठी मागणी आहे. सेंद्रिय शेतीखाली ३५० लाख हेक्टरहून जमिनीची क्षेत्राची नोंद करण्यात आली आहे. सेंद्रिय पद्धतीने घेतल्या जाणाऱ्या पिकांमध्ये तांदूळ, गहू, डाळी, केळी, मसाल्याचे पदार्थ, काजू, अक्रोड, चहा, कॉफी, फळपिके तसेच भाजीपाला, सोयाबीन, कापूस व औषधी वनस्पती या पिकांना निर्यातीमध्ये मोठे वाव आहे. निर्यात करत असताना सेंद्रिय शेती उत्पादनात सेंद्रियमध्ये मसाल्याचे पदार्थ, काजू, अक्रोड, आंब्यापासून तयार पदार्थ, तांदूळ, पापड,,= वनौषध वगैरे पदार्थ मोठया प्रमाणात निर्यात होतात. भारतामध्ये सेंद्रिय माल निर्यात होणारे अमेरिका, जर्मन, फ्रान्स, इटली, इंग्लंड, नेदरलँड, बेल्जीआम, इटली व युरोपीन देश तसेच जपान, कॅनडा, दक्षिण आफ्रिका, ऑस्ट्रेलिया इत्यादी देशातून भारताला डॉलर लाखात माल निर्यात दिसून येते. या निर्यातीला सातत्याने वृद्धी होत असताना देशाला परकीय प्राप्त झाले आहे.

सेंद्रिय शेती विषयक धोरण

आज महाराष्ट्र राज्यात सेंद्रिय शाश्वत शेतीला महत्वाचे स्थान आहे. सेंद्रिय शाश्वत शेती जवळपास ६.५० लाख हेक्टर जमीनीची नोंद करण्यात आली होती. आज भारतात सेंद्रिय शाश्वत शेतीला स्थानिक विपणनातून परदेशी मागणी जास्त आहे. सेंद्रिय शेती मालाच्या प्रमाणीकरणाचा खर्च कमी केल्यास विक्री मालाची उत्पादन वाढू शकते. त्यासाठी शासन वेगवेगळ्या कार्यक्रमात शासकीय धोरण राबवत आहे. तसेच सेंद्रिय शेतीला मोठया प्रमाणात देशामध्ये मोठी मागणी बाजारपेठेत आहे. वेगवेगळ्या राज्यात सेंद्रिय शाश्वत शेती गरज भासू लागली आहे. सेंद्रिय शेती केल्यामुळे ताजी भाजीपाला, फळभाज्या व इतर वस्तूंना मोठया प्रमाणात वाढ झालेली दिसून येते. उदा. तांदूळ, मसाल्याचे पदार्थ व तेल इत्यादी.

शाश्वत सेंद्रिय शेती उत्पादनाची वैशिष्टये

१) सेंद्रिय शेतीमुळे उत्पादन वाढीमुळे जमीनीची मशागत कमीतकमी केली जाते.

२) या पद्धतीत सर्व प्रकारची उत्पादन घेतली जाते.

३) सेंद्रिय पदार्थाचे वेगवेगळ्या खंताचा वापर करून चागल्या दर्जाची पिके घेतली जाऊ शकते.

४) कुजलेल्या सेंद्रिय खत व गांडूळ खत यांचा वापर केल्यामुळे उत्पादनात वाढ होते.सेंद्रिय पदार्थांचे पिकांमध्ये फेरपालट आंतर पिके तसेच मिश्र पिक उत्पादन जास्त प्रमाणात घेतले जाते.

५) सेंद्रिय शेतीमध्ये पाण्याचा वापर कमी तसेच कीड नियंत्रण चांगल्या पद्धतीने व्यवस्थापन केले जाते.

६) तणांचे अच्छादन केले जाते व जैविक खतांच्या वापरामुळे सेंद्रिय शेतीमध्ये उत्पादनात वाढ झालेली आहे.

सेंद्रिय खतांचे विविध प्रकार

आपल्या देशामध्ये अनेक वर्षापासून शेतजमिनीचा सातत्याने वापर करण्यात आल्यामुळे जमिनीचा कस खूप कमी होऊ लागला आहेत. त्यामुळे नैसर्गिक खंताचे आणि रासायनिक महत्वाचे दोन प्रकार आहेत. नैसर्गिक खत हे जास्त काळ टिकून ठेवते. जमिनीचा पोत सुधारण्यासाठी जास्त खंताचा वापर दिसून येते. पिकांची लवकरात लवकर पिक येण्यासाठी रासायिक खतांचा वापर झालेला दिसून येत आहे. तसेच वाढ व्हावी शेती उत्पन्न वाढ व्हावे या उद्धेशातून खतांचा वापर अधिक आहे. तसेच रासायनिक खतांना बरखते सुद्धा असे म्हणतात. सेंद्रिय खतांचे दोन प्रकार पडतात. ते पुढील प्रमाणे आहेत.

अ) नैसर्गिक खत सेंद्रिय भरखते

आ) सेंद्रिय जोरखते

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अ) सेंद्रिय खत (भरखते)

१) शेणखत

- शेणखत यामुळे जमिनीचा पोत सुधारण्यास मदत होते.
- शेणखत वापरल्यामुळे पीक उत्पादनात अधिक प्रमाणात वाढ होते.
- शेणापासून उत्तम प्रकारचे भरखत तयार करता येते.
- शेण, गोबरगॅस किंवा बायोगॅस संयंत्रामध्ये टाकल्यानंतर मिथेनवायू तयार होतो आणि चांगल्या प्रकारचे नायट्रोजनयुक्त खत तयार होते.

२) हिरवळीचे खत

- हिरवळ खतांमुळे पीक उत्पादन लवकर वाढतात तसेच जास्त प्रमाणात हरितद्रव्ये मिळत असतात.
- हिरवळ खतांमुळे कमी पाण्यात पीके आणि हलक्या जमिनीत जोमाने वाढणारी आहेत.
- ही पीके खोलवर मुळे जाणारी असावीत व त्यांची पाने कोवळी, सुंदर, लुसलुशीत असावी.
- या खतामुळे पिक सुधारत असताना भरपूर पाने येत असतात.
- हिरवळीच्या खत तयार करण्यासाठी चवली, मेथी, गवार, मूग वगैरे पीक घेतले जाते.
- तसेच जमिनीत पावसाचे पाणी साठवण्याची शक्ती वाढत जाते आणि जमिनीची धूप थांबवता येते.
- पिकांना देण्यात आलेल्या अन्नद्रव्य निचरा होत नाही.
- चिकन मातीत चिकटपणा कमी असतो.
- जमिनीचा नायनाट होण्यास मदत होऊन जमीन मशागत केल्याने भूसभूशीत रहाते.

३) कंपोस्ट खत

- एका विशिष्ट खड्यामध्ये ठराविक कालावधीसाठी गाडल्याने त्यापासून कंपोस्ट खत तयार होते.
- या खतापासून नायट्रोजनयुक्त अन्नद्रव्य, तसेच सेंद्रिय अन्नद्रव्ये मुबलक प्रमाणात मिळते.
- तसेच या खतामुळे जमिनीचा पोत सुधारण्यास मदत होते.
- या खताला तयार होण्यासाठी अगोदर खत शेतामध्ये न वापरता ते खड्याच्या बाहेर ठेवून किमान पंधरा दिवस सूर्यप्रकाशात ठेवून ते पूर्णत: सुकेल नंतर शिल्लक राहिलेला पदार्थ कुजून जातो.

४) सोनखत

- सोनखतामुळे आपणास नायट्रोजनयुक्त अन्नद्रव्ये विपुल प्रमाणात होत असते.
- सोनखतामुळे मोठया प्रमाणात बागायती पिके घेवून उत्पादनात चांगल्या प्रकारे उत्पन्न घेता येते.
- त्याचबरोबर जमिनीची सुपीकता वाढवण्याच्या दृष्टीने या खताची खूप मदत होते.

आ) सेंद्रिय जोरखते

१) पेंड

- सेंद्रिय पदार्थ सर्वात जास्त प्रमाण नत्र नसून जास्त प्रमाणात स्फुरद आणि पालाश यांचे प्रमाण अधिक असते.
- तसेच सूक्ष्मजीवाणू प्रक्रिया करून सेंद्रिय नत्राचे अमोनिया नायट्रेट नत्रामध्ये रुपांतर होऊन पिकांचा वाढीसाठी उपयोग होतो.
- पेंडयाचा खाद्य म्हणून गुरांना दुध उत्पादन वाढण्यासाठी देतात तसेच खत म्हणून सुद्धा वापरले जाते.एरंडी, निम, करंज आणि माहुआच्या पेंडी खाण्यायोग्य नसल्याने त्यांना मिश्र खतातून वापरली जाते.
- पेंड खत टाकण्याअगोदर त्याची भुकटी करावी म्हणजे ती एकसारखी पसरता येते.
- शेणखत व हिरवळीचे खत यासारख्या सेंद्रिय भरखते सारख्या पेंडीच्या खतांचा दीर्घकाळ परिणाम न होऊ देता ज्या पिकला आवश्यक आहे त्या पिकला दिले जाते.

२) वाळलेले खत

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- या खतामध्ये काळ्या रंगाची कोरडी, गाठी असलेली किंवा रवाळ असून खूप लवकर कुजते व सर्व पिकांवर इतर जमिनीत त्यांचा वापर परिणामकारक ठरत असते.
- वाळलेल्या रक्तात किंवा भुक्टीत १० ते १२ % अतिप्राप्य नत्र १ ते १.५ % स्फुरद आणि ०.६ ते ०.८ % पालाश दिसून येते.
- या खतामुळे मातीत मिसळून एकसारख्या जमिनीत पसरता येते.

३) मासळीचे खत

- या खतामध्ये मासळीचे भुक्टी, वाळलेले मासे व मासळीचे बारीक तुकडे याचा खत तयार करून जमिनीत मिश्रण केले जाते.
- त्याच्याबरोबर या मासळीपासून तेल सुद्धा काढले जाते.
- माश्यामध्ये ५ ते २० % पर्यंत नत्र, ३ ते ९ % स्फुरद आणि ०.३ ते १.५ % पालाश असते.
- नत्र व स्फुरद ही दोन्ही जास्त प्रमाणात असल्यामुळे सर्व पिकांसाठी तसेच जमिनीची योग्यता वाढविण्यासाठी वापरली जाते.

४) हाडे आणि हाडांचा चुरा

- सेंद्रिय खतापैकी हाडे हे महत्वाचे साधन असून त्यात कॅल्शियम, स्फुरद आणि नत्र पुरविले जातात.
- कच्च्या हाडांच्या चुऱ्यात ३ ते ४ % नत्र, २० ते २५ % स्फुरद, त्यात ७ ते ९% सायट्रेट द्रावणात मिसळले स्फुरद असते.
- हाडांचा चुरा आम्लयुक्त जमिनीचा योग्य आणि हलक्या निचरा होणाऱ्या व चांगली हवा खेळणाऱ्या जमिनीत परिणामकारक होते.
- ह्या हाडांचा चुरा सर्व पिकांवर वापरता येते आणि भात तसेच फळझाडे यांना उपयुक्त ठरते.

शाश्वत सेंद्रिय शेतीचे फायदे

१) शाश्वत सेंद्रिय शेतीमुळे पर्यावरणात संतुलन राहण्यास मदत होते.

२) शाश्वत शेतीमुळे बाजारपेठ भावामुळे होणारे नुकसान टाळता येते.

३) वातावरण व प्रतिकूल हवामानामुळे झालेले बदल दिसून येतात.

४) सेंद्रिय शेती पद्धतीत शेती केल्यास उत्पादन खर्च कमी येते.

५) शाश्वत शेतीमुळे कोणत्याही प्रकारची हानिकारक नसलेले अन्न तसेच शुध्द पर्यावरण राहण्यास मदत होते.

शाश्वत सेंद्रिय शेतीचे महत्व

१) सेंद्रिय शेतीमध्ये रासायनिक खतांचा वापर टाळून सेंद्रिय खत निर्माण करणे व त्यामध्ये सेंद्रिय पदार्थांचा आच्छादन वापर करून सेंद्रिय खत तयार करणे.

२) सेंद्रिय पदार्थामध्ये रासायनिक कीटकनाशका ऐवजी जैविक कीड यांचा उपयोग करून पिकांचे संरक्षण करणे.

३) तसेच जमिनीची कमीत कमी मशागत करून आधुनिक पद्धतीचा वापर न करता पारंपारिक पद्धतीने शेती केली जाते. उदा. बैल नांगरणी.

निष्कर्ष

ग्रामीण भागात शाश्वत सेंद्रिय शेती ही महत्वाची भूमिका असून त्यापासून शेतकऱ्याच्या उत्पादनात व उत्पन्नात अधिक भर पडते. तसेच रासायनिक खंताचा वापर टाळता येते.

संदर्भ सूची

१) सकाळ अॅग्रोवन पेपर

२) संजय भा. गुंजाळ, सेंद्रिय शेती, नोडवा कृषी प्रकाशन.

३) एम. एस. देशमुख, तानाजी नामदेव घागरे, सेंद्रिय शेती : कृषी भारताची नवी ओळख.

४) अप्पा जोशी, निसर्ग शेती,कॉनटीनेटल प्रकाशन, पुणे.

५) जगन्नाथ शिंदे, सेंद्रिय शेती, गांडूळ शेती व शाश्वत शेती, गोदावरी प्रकाशन, नाशिक.

६) डॉ. एस. एस. कोळपे, कृषी सुक्ष्मतत्वे व सेंद्रिय शेती, कृषी तंत्र विद्यालय, पुणतांबा.

७) सेंद्रिय शेती पद्धती, प्रशिक्षण पुस्तिका, महाराष्ट्र ऑर्गेनिक फार्मिंग फेडरेशन, पुणे (मॉफ).

८) www.mahanagari.com

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महाविद्यालयातील विद्यार्थी वाचकांची वाचन अभिरूची- एक अभ्यास

रेग्वा श्रीकांत च-हाटे
कीर्ती महाविद्यालय,दादर

प्रस्तावना :

प्राचीन काळापासून ग्रंथाला अनन्यसाधारण महत्व प्राप्त झाले आहे. ग्रंथ नेहमीच वाचकांना,अभ्यासकांना,विद्यार्थ्यांना ज्ञानदान , शिक्षणदान करीत आले आहेत. सध्याचे युग तंत्रज्ञानचे युग आहे. जग झपाटयाने प्रगती करीत आहे. सर्वच क्षेत्रातील माहितीचा विस्फोट झाला आहे आणि अजून होत आहे. विज्ञान ,तंत्रज्ञान या बाबतीत अधिकाधिक नवनविन माहितीचा उगम करीत आले आहेत.ग्रंथालय म्हणजे अनेक ग्रंथाचे ,माहितीचे व ज्ञानाचे एकीकरण एकाच वेळी एकाच ठिकाणी वेगवेगळ्या पुस्तकांमधून महिती मिळण्याचे ठिकाण होय. शैक्षणिक , सामाजिक ,व सास्कृतिक क्षेत्रातील सर्वांच्या सेवेस ग्रंथालय सदैव तत्पर असते.विज्ञान तंत्रज्ञानाच्या बाबतीतही ग्रंथालयाने उंच उभारी घेतली आहे. जगातील कुठल्याही विषयावरील माहिती आपणास ग्रंथालयात मिळते. अर्थात अद्ययावत माहिती साधनांचा ही व –याच प्रमाणात प्रगती झाली आहे. उदा. भ्रमणध्वनी (मोबाईल) ,संगणक इ. संगणकातील इंटरनेट हे प्रभावी माध्यम ठरत आहे. त्यातील (E-books & E-journal) च्या सुविधांमुळे वाचकांना बसल्या जागी एखादया ग्रंथामधील माहिती उपलब्ध होते. या शेरीज वृत्तपत्रे , मासिके , बातम्या इ. प्रसारमाध्यमातून वाचकांच्या ज्ञानात दिवसेदिवस भर पडत आहे, असे जरी असले तरी ही शोध साधने वाचकांना पुरेपुर सर्वांगीण माहिती देण्यास सक्षम असतातच असे नाही.त्यांच्यावर देखील मर्यादा असतात. एखादया विषयावरील सर्वांगीण ज्ञान हवे असेल तर वाचकांना ग्रंथाचा वापर करणे जास्तीत जास्त प्रभावी ठरते.अभ्यास करीत असतांना वाचकांना हवी असलेली माहिती ग्रंथालयाकडून निरनिराळ्या स्वरूपात मिळते व मार्गदर्शन ही केले जाते. त्यामुळे वाचकांच्या ज्ञानात भर पडते.

एकंदरीतच जगाच्या विकासाबरोबरच ग्रंथाच्याही विकासात गती प्राप्त होऊ लागली आहे. विविध विषयावरील ग्रंथाना एकत्रित आणण्याची आवश्यकता वाढू लागली. कारण पुढे वाचकांना निरनिराळ्या विषयाच्या ग्रंथाचे वाचन करून नवीन संशोधने करण्यासाठी त्याची आवश्यकता होती, व त्यातूनच विविध प्रकारची ग्रंथालये अस्तित्वात आली.ग्रंथालयाचे अनेक प्रकार आहेत.आणि कोणत्याही प्रकारचे ग्रंथालय हे कुठल्याही संस्थेचा आत्मा आहे. वाचकांना अभ्यासासाठी संशोधनासाठी ज्या गोष्टींची आवश्यकता असते त्या सर्वच गोष्टी ग्रंथाच्या स्वरूपात ग्रंथालयात उपलब्ध असतात. उदा. संदर्भ ग्रंथ, नियतकालिके, विश्वकोष, ज्ञानकोष ,वार्षिके , विषयसूची,स्पर्धापुस्तके इ. ग्रंथालयाचे विविध प्रकार आहेत.खाजगी ग्रंथालय ,शैक्षणिक ग्रंथालय ,सार्वजनिक ग्रंथालय , विशेष ग्रंथालय , महाविद्यालयीन ग्रंथालयाना महाविद्यालयाची आधारशिला म्हटले जाते.विद्यार्थ्यांना त्यांच्या शैक्षणिक वर्षाच्या अभ्यासासाठी व संशोधकाला आपल्या संशोधनासाठी अनेक प्रकारच्या माहितीची आवश्यकता असते. एस.एच गोपाल यांच्या मते

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संशोधन म्हणजे अत्यंत पद्धतशीर पणे घेतलेला सत्याचा शोध किंवा अज्ञातांचा शोध होय. अशा शोधाद्वारे आपल्याला अनेक गोष्टींच्या अस्तित्वांचे आकलन होते.

वाचन संस्कृतीचा विकास ही काळाची गरज आहे. आजचा विचार करता मुलांच्या वाचनासाठी शिक्षक आणि पालकवर्ग किती जागृत आहे ही चिंतनीय बाब आहे.
अध्ययनासाठी व ज्ञान ग्रहणासाठी वाचन हे अतिशय महत्त्वाचे कौशल्य आहे. सध्याच्या बदलत्या परिस्थितीत व माहिती तंत्रज्ञानाच्या युगात वाचन संस्कृती विसरून चालणार नाही. वाचनाने विद्यार्थ्यांचे व्यक्तिमत्व बहुआयामी बनते. खर तर वाचनाची आवड मूल शाळेत दाखल होण्यापूर्वीच घरातूनच लागायला हवी. मुलांना लहानपणापासूनच छान रंगीत चित्रांची पुस्तकं त्यांच्यासमेर ठेवा, त्यांना ती उलट -सुलट करून बघू दयावी. त्यातील वेगवेगळे प्रकार ,आकार , रंग त्यांना आवडतील ,त्यांचा अर्थ लावण्याचा प्रयत्न ते मूल करेल. त्याची मानसिक वाढ चांगली होईल. सुरवातीच्या काळात रामायण , महाभारतातील कथा ऐकूनच वाचनाची अभिरुची विकसित होत असे. संस्कारदिपिका,इशापनीती, तेनालीरामनच्या गोष्टी ,प्राणी- पक्षी यांची माहिती देणारे साहित्य, शास्त्रज्ञांच्या कथा, संस्कार गीते, चरित्र यांचा समावेश असलेले साहित्य मुलांना बालवयातच दिले गेले पाहिजे. वाचनाची आवड बालवयातच निर्माण व्हायला हवी. वाचनाचे अनेक फायदे आहेत.
वाचनामूळे मनोव्यापार तयार होतो, मुलांना नवनविन कल्पना सुचतात . यातूनच त्यांची मानसिक वाढ होते. आपल्या कल्पना,भावना,विचारशक्ती , ज्ञानोपासना ,स्थिरता व आकलनशक्ति हे वाचनामूळे त्यांची क्षमता मोठ्या प्रमाणात विकसित होते.

ज्ञानस्त्रोत केंद्राचे स्वरूप

पूर्वीपेक्षा मोठ्या प्रमाणात ग्रंथरूपाने प्रकाशित करण्याची सोय उपलब्ध झाली आणि मानवी जीवनाच्या प्रगतीचे एक नवीन युगच सुरु झाले. ग्रंथालय ही ज्ञानदानाची भंडारे आहेत. ग्रंथालयाशिवाय आज कोणीही चांगल्या प्रकारे ज्ञान संपादन करू शकत नाही. ग्रंथालयाची भूमिका ही नेहमी वाचकांना व्यापक दृष्टीने सर्वांना ज्ञान प्राप्त करून देण्यासाठी तसेच व्यक्तिमत्व फूलविणारी व मनोरंजनात्मक व्यापक दृष्टीने मदत करेल अशी असावी. यासाठी ग्रंथालयसेवेचा सर्वांना व्यापकता शोधणे. आजच्या संगणक युगात प्रत्येक दिवशी ज्ञानशाखेमध्ये प्रचंड प्रगती होत आहे. मानव्य आणि सामाजिक शास्त्रामध्ये सुदधा नवनवे मतप्रवाह पुढे येत आहेत. आजच्या माहिती साधनांचे स्वरूप पार बदलून गेले आहे. केवळ ग्रंथ नियतकालिकेच नव्हे तर चित्रफिती, ध्वनीफिती, मायक्रोफिल्मस ,ध्वनीमुद्रिका ,संगणक अशा निरनिराळ्या स्वरूपामध्ये मुद्रणाबरोबरीने इतर अनेक साधने उपलब्ध आहेत.

वाचकांना अपेक्षित संदर्भसेवा लक्षात घेऊन, त्यांना आवश्यक असणारी संदर्भसाधने उपलब्ध करून देणे ही ग्रंथपालाची जबाबदारी असते. ग्रंथालयाची सामाजिक माहिती केंद्र म्हणून प्रतिष्ठा निर्माण करणे आवश्यक असते . ग्रंथालयात येणा-या सर्व वाचकांना त्यांच्या आवडीनुसार व आवश्यकतेनुसार योग्य ग्रंथ उपलब्ध करून देणे हे ग्रंथालय सेवेचे मुख्य उद्दिष्ट मानले जाते. यासाठी नवनविन पद्धतीचा वापर केला

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गेला पाहिजे. ग्रंथालय सेवा वाचकांना देणे व समाधानकारक होण्यासाठी ग्रंथालयात सर्व साधनसुविधा तसेच वेगवेगळया विषयावरील नियतकालिके उपलब्ध असावेत. ग्रंथालयात येणा-या प्रत्येक वाचकांच्या त्यांच्या गरजा पूर्ण होतील यादृष्टीने. अशा सेवा देण्यात याव्यात जसे की आंतरग्रंथालयीन देवघेव ,वाचकांच्या मागणीनुसार विशिष्ट ग्रंथ राखून ठेवणे, वाचकांना तालिकापत्राचा वापर व उपयोगाबाबत ग्रंथसूची, संदर्भ साधने यांच्या उपयोगाबाबत सूचना देणे, नविन ग्रंथाची यादी , नविन खरेदी केलेल्या ग्रंथाचे प्रदर्शन भरविणे ,वाचनाची आवड निर्माण व्हावी म्हणून साहित्य व विविध विषयाची निवड करण्याकरीता वाचन मार्गदर्शन सेवा निर्माण करणे, ग्रंथालयाची नविन वाचकांना माहिती देणे.

विद्यार्थ्याकडून मिळालेल्या माहितीचे संकलन आणि विश्लेषन

संशोधनासाठी माहितीचे स्त्रोत आवश्यक असतात. अशी माहिती संघटित करीत असताना ती प्रश्नावलीच्या सहाय्याने , व मुलाखतीव्दारे मिळविलेली आहे. त्या माहितीचे पृथक्करण खालीलप्रमाणे केले आहे व त्याआधारे निष्कर्ष काढण्याचा प्रयत्न केला आहे. ही माहिती विद्यार्थी वाचक तसेच प्राध्यापक वाचकांकडून मिळालेली असून माहितीचे विश्लेषण केले आहे. विद्यार्थ्याकडून प्रश्नावली भरून घेतांना सूरवातीला काही प्राथमिक स्वरूपाची माहिती प्रश्नावलीव्दारे जाणून घेण्याचा प्रयत्न केला आहे. यात विद्यार्थ्याचे नाव , वर्ग, असे जुजबी प्रश्न विचारण्यात आले.

विद्यार्थ्यांमध्ये वाचनवृध्दी व्हावी याकरता आपले ग्रंथालय कसे असावे / कोणत्या प्रकारच्या सुविधा असाव्या असे आपणास वाटते जेणे करून त्यांच्या वाचनात वाढ होईल. अशा प्रकारची माहिती गोळा करण्यात आली.

ग्रंथालय स्वच्छ,निटनिटके, व शांतता असावी .ग्रंथालयात सर्व सोयी सुविधा युक्त असाव्यात.

ग्रंथालयात ज्ञिज्ञान अभ्यासपूर्ण होण्यासाठी स्थानिक संस्कृतिविषयक ,दुर्मिळ ग्रंथ, नकाशे अशा प्रकारचे साहित्य असावे. ग्रंथालयातील वाचनसाहित्य कार्मचारी असावे. वाचनाकरीता योग्य ती जागा असावी ,पुरेसा वेळ विद्यार्थ्याना ग्रंथालयात बसण्याकरीता मिळावा ,जी पुस्तके आवश्यक आहे ती उपलब्ध करून देणे सोयीची जागा तत्पर ग्रंथपाल उपयुक्त ग्रंथाचा संग्रह ग्रंथाची शास्त्रशुध्द रचना व आर्थिक सुस्थिरता ही आदर्श ग्रंथालयाची महत्वाची अंगे मानली जातात. परंतू स्पर्धा परिक्षेचा अभ्यास करतांना (Question Solving) हा एक महत्वाचा भाग असतो अशावेळी विद्यार्थी व विद्यार्थीनींना एकत्र बसून अभ्यास करण्याची संधी उपलब्ध करून द्यावी.

मागणीनुसार पुस्तके उपलब्ध करून देण्यात यावी. एकत्र बसण्याची परवांगी तसेच ग्रुप स्टडी ला देण्यात यावी.

ग्रंथालयात शांत बसण्याची नियम करावे. वेगवेगळे ग्रंथ पाहण्यास ,व घरी नेण्याची अनुमती असावी. आणि बसण्यास व्यवस्थित (टेबल-खूर्ची) -आरामदायी व्यवस्था / जागा असावी.

ग्रंथालयात एसी ची सक्त गरज आहे. वाचनालय तसे हवेशिर आहे. पण गरमीच्या महिण्यात एसी ची गरज लागेल.

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ग्रंथालयात प्रत्येक प्रकारचे पुस्तक व इतर सर्व पुस्तके ज्यातून न्याय प्राप्त होणार आहे अशी उपलब्ध करून दिले पाहिजे . ग्रंथालयात येणा-या प्रत्येक व्यक्तिला वाचन करण्यासाठी सुविधा उपलब्ध करण्यात आले पाहिजे .

खूप छान ,ज्या सुविधा आहे खूप छान आहे आणि आम्ही ग्रंथालय मध्ये अभ्यासासाठी येतो,ग्रंथालय व्यवस्थापक पण छान आहे .

नैसर्गिक प्रकाशाने परिपूर्ण शेल्फ चे अवरूप पोहचणे सोपे आहे . तंत्रज्ञान संरक्षकांसाठी प्रवेशयोग्य आणि कर्म चा-यांना दृश्यमान आहे . गटकार्यासाठी आणि स्वतंत्र कामासाठी आसनव्यवस्था आहे . वेगवेगळ्या वापरासाठी वेगळे झोन आहेत आणि सर्व प्रकारचे पुस्तके ही आहेत .

We have everything in our library each and everything is available what the students need. Its in a very good condition. There is nothing that should be changed in library. Everything is perfect , we got almost everybook we need , we can also study if we have need. Ventilation is also good in summer.

आधुनिक काळात शिक्षणप्रसाराचे कार्य अव्याहतपणे चालू आहे . ज्ञानाचा प्रसार होऊ लागला आणि ग्रंथानी आपले जीवन व्यापून टाकले आहे . ग्रंथामध्ये मानवाच्या संस्कृतीचा इतिहास आहे . असे ग्रंथभांडार वाचकांच्या उपयोगाकरिता आणले जाते . ग्रंथालय ही संस्था केवळ आजच्या पिढीकरता नसून त्यातील विचारधन पुढील अनेक पिढ्यांकरता जतन केले जायला हवे . प्रत्येक वाचकाला आयुष्यभर ज्ञानर्जन करता यावे . जगातील घडामोडीची माहिती मिळावी,प्रचलीत जागरूकता सेवा मिळावी . महाविद्यालयीन शिक्षणाचा स्तर शालेय शिक्षणापेक्षा बराच उच्च दर्जाचा असतो . नेमून दिलेल्या पुस्तकांव्यतिरिक्त इतर संदर्भ पुस्तकांचा, अवांतर वाचनाचा शिक्षकांना अभ्यास करावा लागतो . विद्यार्थ्यांच्या अभ्यासाकरिता वेगळी सुविधा निर्माण केली जाते .

सारांश :--

महाविद्यालयीन ग्रंथालये ही शिक्षण पध्दतीची केंद्रे आहेत . वाचकांची विषयानुसार ,अभ्यासक्रमानुसार वर्गवारी करून विभाजन करणे व वाचकांना त्यांच्या उपयोगीते प्रमाणे प्रशिक्षण देणे . वाचकांच्या सूचना व अपेक्षा मागविणे व त्यांना योग्य प्रतिसाद देणे, आजच्या माहितीच्या युगात विद्यार्थ्यांना आणि अध्यापकांना दर्जात्मक ग्रंथालय सेवा तसेच वाचनसाहित्य देण्यासाठी महाविद्यालयीन कार्यक्राज परिपूर्णतेचा स्विकार करणे आवश्यक बनले आहे . वाचकांना वाचन साहित्य मागविण्यापासून ते वाचकांच्या गरजा पुरविण्यापर्यंत आणि वाचकांना हवी असणारे वाचन साहित्य अचूकपणे आणि कमी वेळात उपलब्ध करून दिले पाहिजे . आजपर्यंत आपण जे कार्य करीत आलो आहोत त्या कामच्या पध्दतीत सुधारणा करणे होय . व त्यामूळे वाचक वृध्दी होण्यास निश्चितच मदत होईल .

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A STUDY ON THE IMPACT OF ENVIRONMENTAL AWARENESS ON THE ECONOMIC AND SOCIO-CULTURAL DIMENSIONS OF SUSTAINABLE TOURISM

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Keywords

Sustainable tourism, Sustainability, Responsible tourism

Abstract

Purpose: Economic, socio-cultural and environmental awareness aspects play a crucial role in the sustainability of the tourism sector worldwide. The research aimed to analyze the impact of environmental awareness on economical & socio-cultural attributes of sustainable tourism.

Methodology: The research work is a social science research that has applied both the methods of data collection i.e., primary & secondary sources. Responses were collected using the convenient non – probability sampling technique. For testing of hypotheses, a Parametric test of Regression was applied.

Findings: The researcher concluded that all three dimensions are interrelated and have a significant impact on each other. Economic, Socio-cultural and environmental awareness are the most important three pillars for sustainable and responsible tourism development goals.

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1. INTRODUCTION

The essence of sustainable tourism aims to balance economic growth with environmental protection and social responsibility, ensuring that tourism activities contribute positively to local communities while minimizing the adverse effects on the environment and cultural heritage. Sustainable tourism strives to create long-term benefits for all stakeholders involved, including local residents, businesses, visitors and future generations.

In the year 1988, the United Nations World Tourism Organization (UNWTO) defined: "Sustainable tourism development meets the needs of present tourists and host regions while protecting and enhancing opportunity for the future. It is envisaged as leading to management of all resources in such a way that economic, social, and aesthetic needs can be fulfilled while maintaining cultural integrity, essential ecological processes, biological diversity, and life support system." [WTO 1998:19]

After further studies and research in the year 1992, at Rio de Janeiro, Brazil, during the United Nations Conference on Environment and Development (UNCED) 'Earth Summit', three-layered principles of conservation and environmental awareness, socio – economic sustainability were discussed and recognized. Therefore, these principles of sustainable tourism were adopted by the tourism industry all over the world. The Ministry of Tourism, Government of India also adopted the same principles for environment conservation and awareness among travellers.



Figure 1: *Sustainable Development Goals: United Nation's Agenda by 2030* (Source: https://www.unwto.org/tourism4sdgs)

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It highlights the importance of integrating tourism practices with the broader framework of the Sustainable Development Goals (SDGs) to ensure a holistic and sustainable approach to tourism development. This approach emphasizes the interconnectedness of various aspects of sustainability, including economic prosperity, environmental conservation, social inclusion, and cultural preservation all of which are essential for achieving the SDGs.

2. REVIEW OF LITERATURE

Khan, Khan & Khan (2022) stated the consequence of economic, socio-cultural & environmental aspects of sustainability on the satisfaction of the local residents along with the SDGs of the tourism industry. *Maichum, Parichatnon & Peng (2016)* studied, identified and analyzed the construct of environmental awareness in maintaining sustainability towards purchasing recyclable, green and eco-friendly products among buyers and tourists. *Cottrell, Vaske & Roemer (2013)* analyzed and provided constructs and statements for the various factors and dimensions of sustainability in the tourism sector. *Florek (2012)* in her study applied and highlighted the principles of sustainable development that will reduce and prohibit the adverse impacts of tourism and thus promote responsible, sustainable and eco-friendly tourism. The paper also considers the three dimensions of sustainable tourism i.e., economic, environmental, and socio-cultural dimensions which can be achieved by effective planning and management of tourism. *Kulshreshtha (2012)* studied that the promotion of rural tourism destination projects has substantially changed the lives of the local community and their way of earning. Also, there has been efficient and effective use of prevailing natural resources for the purpose of sustainable tourism. *Yazdi (2012)* highlighted in her study the use of various factors of sustainable tourism. The study also indicated that sustainable tourism can be applied as an instrument to evaluate and implement overall growth and tourism development.

3. OBJECTIVES OF THE STUDY

(i) To analyze the impact of environmental awareness on economical and socio-cultural attributes of sustainable tourism.

4. HYPOTHESES OF THE STUDY

(i) H0 – There is no significant impact of environmental awareness on the economic dimension of sustainable tourism.

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H_1 – There is a significant impact of environmental awareness on the economic dimension of sustainable tourism.

(ii) H_0 – There is no significant impact of environmental awareness on the socio-cultural dimension of sustainable tourism.

H_1 – There is a significant impact of environmental awareness on the socio-cultural dimension of sustainable tourism.

5. RESEARCH METHODOLOGY

This study is descriptive and analytical social science research. Both primary and secondary data have been utilized and applied in this study. The researcher prepared an online questionnaire. The researcher gathered primary sources of information from 162 respondents using convenient non-probability sampling technique. The secondary data has been collected from published journal articles, conference proceedings, reports, websites, e-data, etc. For testing of hypotheses, a Parametric test of Regression was applied.

6. IMPACT OF SUSTAINABLE TOURISM

Sustainable tourism brings a myriad of benefits to local communities. Firstly, it introduces new sources of income by attracting visitors who patronize local businesses and services. Moreover, it generates employment opportunities for residents, thereby bolstering the local economy. By promoting local products and crafts, sustainable tourism opens up new markets and avenues for economic growth. Its positive economic impact extends further, as sustainable tourism contributes significantly to the overall economic prosperity of a region.

Additionally, sustainable tourism plays a pivotal role in fostering cultural appreciation and preservation. It encourages the celebration and continuation of local traditions and customs, enhancing cultural values within the community. Furthermore, sustainable tourism supports the maintenance and restoration of tourist sites, ensuring their longevity and cultural significance for future generations.

One of the distinguishing features of sustainable tourism is its harmonious coexistence with the environment. By adopting eco-friendly practices and minimizing resource consumption, sustainable tourism endeavours to protect and preserve natural landscapes and ecosystems. As a conscientious

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tourist committed to reducing consumption and respecting environmental conservation efforts, one can actively contribute to the sustainability of tourism destinations.

The positive effects of sustainable tourism extend beyond the economic and environmental realms. It enhances the attractiveness of areas by preserving their natural beauty and cultural heritage, ultimately improving the overall quality of life for residents. Thus, sustainable tourism serves as a catalyst for holistic development, fostering prosperity, cultural richness, and environmental stewardship within local communities.

Several phases to follow in the sustainable tourism technique as responsible travellers:

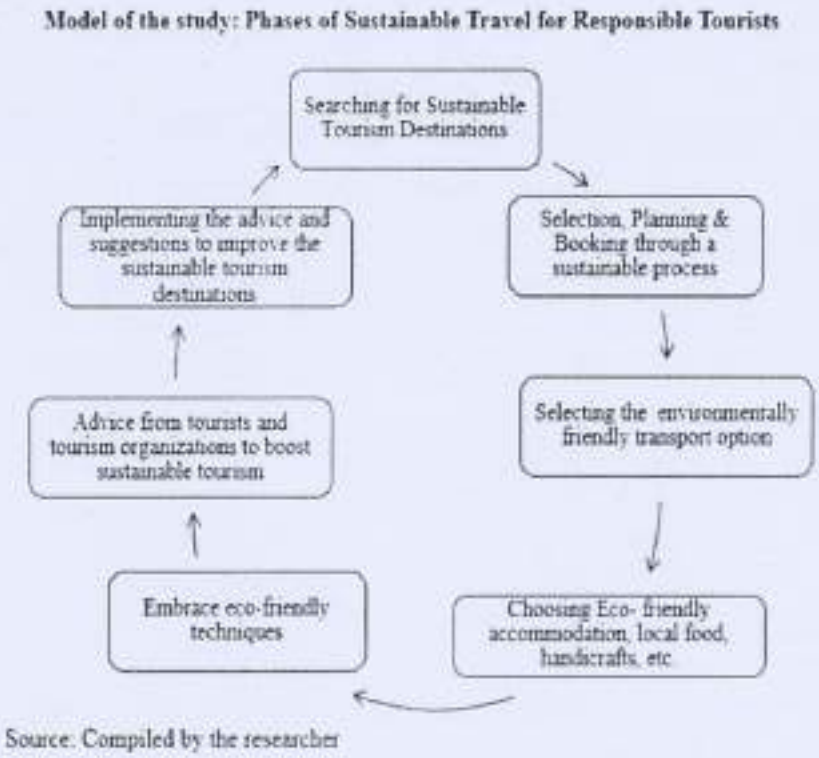


Figure 2: Model of the study: Phases of Sustainable Travel for Responsible Tourists

Thus, the researcher designed a model for this paper that aims to promote and make tourists and various tourism organizations to embrace and follow the initiative of sustainable tourism for the benefit of future generations.

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7. TESTING OF HYPOTHESES

7.1 1st Hypothesis of the study

Table 1: ***Parametric Test – Linear Regression 1st Hypothesis***

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.598[a]	.357	.353	.40092

a. Environmental awareness Dimension

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.303	1	14.303	88.986	.000[b]
	Residual	25.717	160	.161		
	Total	40.020	161			

a. Economic Dimension

b. Environmental awareness Dimension

In this case, R = 0.598, indicates a positive relationship between environmental awareness and economic indicator of sustainable tourism. The standard error shows a standard deviation between the data points and the fitted value. As the ANOVA table shows the significance value is 0.000 which is less than the P – Value 0.05, it can be predicted that the model is a significantly fit. This proves that there is a significant impact of environmental awareness on economic dimension of sustainable tourism. Therefore, the researcher fails to accept the null hypothesis and accepts the alternative hypothesis.

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7.2 2nd Hypothesis of the study

Table 2: ***Parametric Test – Linear Regression 2nd Hypothesis***

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.728[a]	.530	.527	.33697

a. Environmental awareness Dimension

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.446	1	20.446	180.067	.000[b]
	Residual	18.167	160	.114		
	Total	38.613	161			

a. Socio-cultural Dimension

b. Environmental awareness Dimension

In this case, R = 0.728, indicates a strong positive relationship between environmental awareness and socio-cultural dimension of sustainable tourism. The standard error shows a standard deviation between the data points and the fitted value. As the ANOVA table shows the significance value is 0.000 which is less than the P – Value 0.05, it can be predicted that the model is a significantly fit. This proves that there is a significant impact of environmental awareness on the socio-cultural dimension of sustainable tourism. Therefore, the researcher fails to accept the null hypothesis and accepts the alternative hypothesis.

8. LIMITATIONS

a. This study has been conducted in the Mumbai region only, so the findings and conclusions might not be universally accepted.

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b. If different other statistical tests and tools are applied, the results might have variations.

c. Time and resources constraints.

9. CONCLUSION AND SUGGESTION

The researcher concluded that all three dimensions are interrelated and have a significant impact on each other. Economic, Socio-cultural and environmental awareness are the most important three pillars for sustainable and responsible tourism development goals. Selecting a sustainable tourism destination provides tourists with a sensible attitude towards all phases of their travel.

The suitable and beneficial available method to prevent, preserve and maintain tourism destinations from damage and destruction in terms of environmental and socio – cultural manner would be to apply the principles of sustainability. Sustainable Tourism development is a combined effort of the private sector, along with multiple numbers of contributors and organizations as well as the Government. The efforts and determination of all the representatives and supporters of tourism, together with the travellers and residents will determine whether there would be an overall positive or negative impact of tourism on the environment. The researcher concluded that all three dimensions are interrelated and have a significant impact on each other. Economic, Socio-cultural and environmental awareness are the most important three pillars for sustainable and responsible tourism development goals.

"While the strong performance of developed nations is encouraging, as developing countries grow in prominence as tourism destinations, they will take on a greater role in driving sustainability in this field, worldwide." – *Sustainable Innovation Forum, Europe, January 2018.*

The researcher concluded that sustainable tourism will be more ideal and feasible economically, provide ecological continuity and be socially acceptable in the near future.

10. CONFLICT OF INTEREST: Nil

11.SOURCES OF FUNDING: This research work is not funded by any national and international government body or organization.

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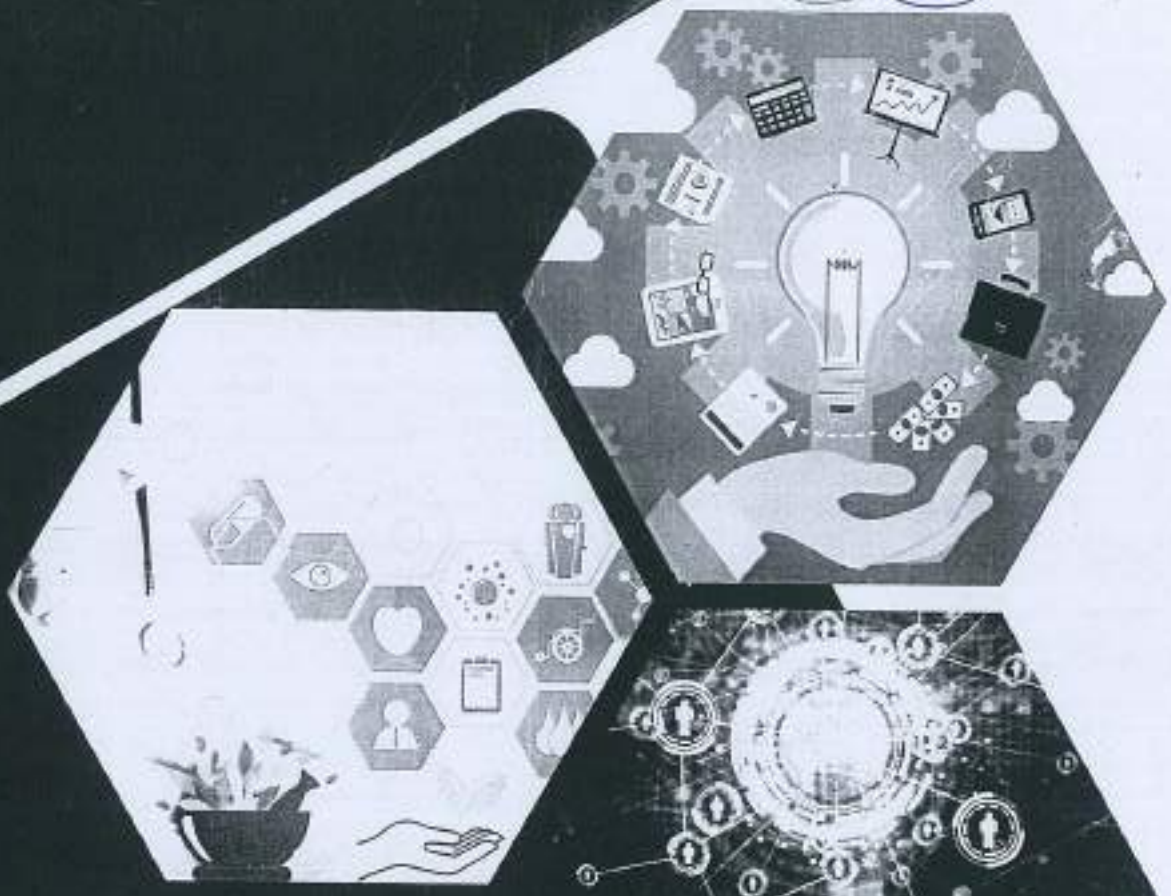
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'NEP 2020 AND ENVIRONMENTAL EDUCATION'- INSTILLING VALUES OF ENVIRONMENTAL RESPONSIBILITY AND SUSTAINABILITY

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Abstract

The National Education Policy (NEP) 2020 is a policy framework for the development of education in India. It was approved by the Union Cabinet of India in July 2020. While the NEP primarily focuses on educational reforms, it does mention the importance of environmental education and sustainability. Environmental humanism is a philosophical approach that emphasizes the interconnectedness between human beings and the environment. It recognizes the intrinsic value of nature and promotes a harmonious relationship between humans and the natural world. The NEP 2020 acknowledges the significance of environmental education in fostering a sense of responsibility and respect towards nature. It emphasizes the integration of environmental concepts across various subjects and grade levels, with the goal of nurturing environmentally conscious citizens. Under the NEP 2020, schools are encouraged to incorporate environmental education and sustainability into their curriculum. This includes teaching students about environmental issues, ecological balance, conservation, and sustainable development. The policy also promotes hands-on learning experiences, such as field trips and practical activities, to deepen students' understanding of environmental concepts. Furthermore, the NEP 2020 recognizes the need for environmental awareness among teachers and calls for their professional development in the area of environmental education. It suggests that teacher education programs should include courses on environmental studies and sustainable development. By integrating environmental education into the curriculum and promoting a holistic approach to education, the NEP 2020 aims to instill values of environmental responsibility and sustainability in students. This aligns with the principles of environmental humanism by emphasizing the importance of a harmonious and respectful relationship between humans and the environment.

Keywords: Environmental humanism, sustainable development, NEP 2020, environmental education (EE).

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Introduction

A person who is environmentally literate makes informed decisions about the environment both on their own and in collaboration with others, is prepared to act on these decisions in order to improve the welfare of other people, societies, and the environment at large, and engages in civic activities. Environmentally literate people have, to varying degrees, knowledge and understanding of a variety of environmental concepts, issues, and problems, as well as a range of cognitive skills and abilities, cognitive dispositions, and the necessary behavioural strategies to apply this knowledge and understanding in a variety of environmental contexts. One of the most glaring problems which the world faces today is environmental pollution. Man has exploited nature excessively at the cost of the environment. There is an immediate need to make people aware of environmental degradation. UNESCO claims "Environmental education is a method of putting the objectives of environmental conservation into practise". It is a lifelong multidisciplinary subject

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of study, not a distinct branch of science. It refers to education for environmental preservation and improvement, as well as education as a tool for growth to raise human societies' standards of living. India has started several initiatives, one of which is making environmental education mandatory at all educational levels. There is a need to reorient the environmental education curriculum to make it more appealing and responsive to the local environmental issues in today's world where environmental conditions are changing negatively, and all living things are suffering because of environmental pollution and climate change. The environment must prepare students with the necessary Life Skills besides academic skills. India's National Education Policy 2020 takes great care to address the common issues related to the learning environment and proposes measures to keep it in top shape

The National Education Policy (NEP) 2020 emphasises the need for curriculum in schools to effectively incorporate environmental awareness, sensitivity to its conservation, and sustainable development. A few of NEP 2020's recommendations for incorporating environmental education into school curricula are to include environmental awareness, including water and resource conservation; introduce environmental education as a modern subject at appropriate levels; incorporate traditional Indian knowledge systems and India's future environmental aspirations; instill respect for the environment; and properly integrate environmental awareness into the curriculum.

The goal of Environmental Education is to increase everyone's environmental literacy. It is a continuous process that starts at home and progresses to include communities, enticing students to form connections with their immediate environment. The awareness, expertise, and abilities required for local contexts serve as a foundation for comprehending and tackling bigger, more complex problems. Through EE, people can develop the knowledge and behaviours necessary to comprehend environmental issues for the rest of their life. It develops the capacity to detect uncertainty, conceive alternate outcomes, and adjust to shifting circumstances. EE helps create a community of active learners where students may exchange ideas. Environmental Education supports efforts to achieve the Sustainable Development Goals SDG with a focus on developing learners' capacity to act both individually and together to improve environmental quality, social fairness, and economic success. Environmental Education would gain from being incorporated into the perspective of education for the development of responsible societies, as inspired by the Treaty on Environmental Education for Sustainable Societies and Global Responsibility (Earth Council, 1992), thus going beyond the somewhat constrained framework of sustainable development.

Environmental humanism is a philosophical and ethical approach that emphasizes the interconnectedness between humans and the natural environment. It recognizes that humans are not separate from nature but rather an integral part of it, and it advocates for the protection and sustainable use of natural resources for the benefit of both humans and the environment. At its core, environmental humanism promotes the idea that humans have a responsibility to act as stewards of the environment, taking into consideration the well-being of both present and future generations. It emphasizes the importance of respecting the intrinsic value of nature, beyond its instrumental value for human needs and desires. Environmental humanism recognizes the need for sustainable development and seeks to balance human activities with the preservation and conservation of ecosystems. It promotes the adoption of practices that minimize negative impacts on the environment and promote ecological integrity. Central to environmental humanism is the belief that environmental issues are not solely technical or scientific problems, but fundamentally ethical and moral challenges. It emphasizes the need for values, ethics, and cultural perspectives

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to be integrated into environmental decision-making processes. This approach also acknowledges the interdependence between social justice and environmental sustainability. It recognizes that vulnerable communities, including marginalized populations and future generations, are disproportionately affected by environmental degradation and climate change. Therefore, environmental humanism advocates for equitable access to resources and opportunities, and it seeks to address environmental injustices. Environmental humanism can inspire a range of actions and practices, such as promoting conservation efforts, advocating for sustainable energy sources, supporting policies that protect ecosystems, promoting environmental education, and fostering a deeper connection between humans and the natural world. Overall, environmental humanism combines humanistic values, ecological awareness, and ethical considerations to guide human behaviour and decision-making towards a more sustainable and harmonious relationship with the environment.

There has always been disagreement and conflict surrounding environmental concerns. The 1972 United Nations Conference on the Human Environment, which in turn influenced environmental management for the following 50 years, was formed by these discussions. Because of the debates inspired by the conference, important concepts like sustainable development and organisations like the United Nations Environment Programme (UNEP) exist today. The Stockholm Conference showed that collaboration on environmental and sustainable development challenges is feasible when leaders take the initiative and pay attention to everyone's concerns.

According to the NEP 2020, "Concerted curricular and pedagogical initiatives, including the introduction of contemporary subjects, such as Artificial Intelligence, Design Thinking, Holistic Health, Organic Living, Environmental Education, Global Citizenship Education (GCED), etc. at relevant stages will be undertaken to develop these various important skills in students at all levels." The policy hopes that EE will become an essential component of academic programmes. To achieve this, it suggests that all B Ed programmes incorporate environmental awareness and sensitivity in a way that is acceptable for its conservation and sustainable development. The policy recommends that "...flexible and innovative curricula of all HEIs [Higher Education Institutions] shall include credit-based courses and projects in the areas of community engagement and service, environmental education, and value-based education" in order to achieve a more comprehensive and multidisciplinary education. Climate change, pollution, waste management, sanitation, biological diversity conservation, management of biological resources and biodiversity, forest and wildlife conservation, and sustainable living will all be covered in environmental education.

Historical Perspectives in Environmental Education

The concept of environmental education in India is not unusual nor recent. It has been around since prehistoric times. With a clear warning on the consequences of environmental deterioration and the necessity for conservation for human life, every religion and every culture in India emphasised environmental concerns while representing the traditions and societal viewpoints. Nature is viewed as an all-encompassing force in Indian culture. The Indian educational system has incorporated environmental education into its courses since 1930. The foundation for today's informal environmental education was created by the Kothari Commission Report on Education (1964–1966). The Report's initial phase made the following recommendation: "The primary school scientific curriculum should focus on helping children obtain a complete understanding of the key facts, ideas, principles, and processes in the physical and biological environment.

Environmental education in India has a rich history and has evolved over time to address the country's environmental challenges. Here are some historical perspectives on environmental education in India:

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1. **Traditional Knowledge and Practices:** India has a long-standing tradition of environmental conservation and sustainable practices. Many indigenous communities in India have been practicing sustainable agriculture, forest management, and water conservation for centuries. These traditional knowledge systems have served as the foundation for environmental education in the country.
2. **Post-Independence Era: After** India gained independence in 1947, there was a growing recognition of the need to address environmental issues. The Indian government established several institutions and policies focused on environmental conservation and sustainable development. Notable initiatives during this period include the establishment of the Indian Council of Forestry Research and Education (ICFRE) in 1986 and the National Environmental Engineering Research Institute (NEERI) in 1958.
3. **Environmental Movements:** India witnessed various environmental movements that played a crucial role in raising awareness about environmental issues. The Chipko movement in the 1970s, led by local communities in Uttarakhand, highlighted the importance of protecting forests and led to a greater emphasis on community involvement in environmental conservation. Similar movements like the Narmada Bachao Andolan and the Silent Valley movement also contributed to the environmental education discourse in India.
4. **Environmental Education in Schools:** Environmental education started gaining prominence in the formal education system in the 1980s. The National Council of Educational Research and Training (NCERT) introduced environmental education as a subject in schools, emphasizing experiential learning, field visits, and practical activities. This integration aimed to instill environmental values and knowledge among students from an early age.
5. **Policy Initiatives:** The Indian government has implemented several policies and programs to promote environmental education. In 2003, the Ministry of Environment and Forests launched the National Environment Awareness Campaign (NEAC) to create awareness and promote environmental education and sustainable development. The National Green Corps (NGC) program was also initiated, involving students in environmental activities at the grassroots level.
6. **Higher Education and Research:** Environmental education has expanded in higher education institutions in India. Universities and research institutes offer specialized courses and programs in environmental sciences, ecology, and sustainable development. These institutions also conduct research and collaborate with international organizations to address environmental challenges.
7. **Non-Governmental Organizations (NGOs):** NGOs have played a significant role in promoting environmental education in India. Organizations like the Centre for Science and Environment (CSE), Greenpeace India, and the World Wildlife Fund (WWF) have been actively involved in environmental awareness campaigns, educational outreach, and capacity-building initiatives.

Over time, environmental education in India has evolved to encompass a holistic approach, addressing issues such as climate change, biodiversity conservation, waste management, and sustainable development. It aims to foster a sense of responsibility, promote sustainable practices, and empower individuals and communities to become environmental stewards.

Methodology

The research paper is based on qualitative analysis based on primary and secondary resources. The National Education Policy (NEP) 2020, which was implemented in India, emphasizes the importance of environmental education and sustainability. The policy recognizes the need to create

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awareness and understanding among students about environmental issues and their impact on society.

Under the NEP 2020, environmental education is integrated into the curriculum at all levels of education, from early childhood to higher education. The policy aims to promote a multidisciplinary approach to environmental education, incorporating concepts from science, social sciences, and humanities.

Some Key Aspects of the NEP 2020 Related to Environmental Education Include

1. **Awareness and Sensitization:** The policy emphasizes creating awareness and sensitizing students about environmental issues, such as climate change, pollution, conservation, and sustainable development.
2. **Interdisciplinary Approach:** The NEP encourages an interdisciplinary approach to environmental education, integrating environmental concepts across various subjects. This approach helps students understand the interconnectedness of environmental issues with other domains of knowledge.
3. **Practical Learning:** The policy emphasizes hands-on and experiential learning methods to enable students to actively engage with the environment. It encourages field visits, nature walks, and practical activities that promote environmental understanding and conservation.
4. **Sustainability Education:** The NEP emphasizes the need to incorporate sustainability education into the curriculum. It aims to promote sustainable practices, such as waste management, energy conservation, and water conservation, and instill a sense of responsibility towards the environment.
5. **Eco-Clubs and Green Initiatives:** The policy encourages the establishment of eco-clubs in schools and colleges to actively engage students in environmental activities and projects. It also supports green initiatives, such as setting up eco-friendly infrastructure and adopting sustainable practices within educational institutions.

By integrating environmental education into the curriculum, the NEP 2020 aims to foster an environmentally conscious generation that understands the importance of sustainable development and actively participates in environmental conservation efforts.

New Education Policy 2020: Opportunities and Challenges

In order for us to become a world leader (Vishwaguru) where equity, equality, and brotherhood would be honored, NEP2020 offers a way for reclaiming, re-articulating, and reconstructing the Bhartiya self. It doesn't make the current environmental education system any better. It is content with how environmental education is currently set up. The strategy also lays a great emphasis on the diffusion of indigenous knowledge, which is excellent for solving environmental challenges. It does provide the correct weight to sustainable development goals, which are equally concerned with environmental benefits.

However, it is sad that the Indian educational system has not recognised the need for more environmental education. The Indian educational system does not place a high premium on environmental issues. India is lagging behind in environmental research as a result of this approach. Therefore, it was crucial that we talk about the needed pedagogical and curriculum changes for environmental education.

If the current rate of environmental destruction is allowed to continue, we will see the beginnings of a trend that dangerously risks destroying the entire foundation of human existence within our generation. The kind of environmental harm we are currently experiencing is unheard of in human

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history. Since overconsumption is mostly to blame for the environmental problem, environmental education must place a strong emphasis on consumption moderation. Ultimately, changing our consumption patterns will contribute to the preservation of biodiversity and our own environmental welfare. We must reevaluate how we conduct research, educate and train environmental professionals and educators, create legislation, and convey environmental knowledge to the general public in light of the issues facing environmental education.

Due to a dearth of reference materials on the environmental issues and challenges particular to each state as well as subpar school infrastructure, educators find it challenging to include EE into their teachings. Here are some ideas for resolving the issues listed:

From several governmental and nonprofit organisations, the school libraries may get reliable reference materials. This would aid the instructor in placing the state's environmental problems in context.

- It is crucial to encourage teachers of core disciplines to pay attention to EE themes that are interwoven with the material of other subjects.
- Giving schools access to information and communications technology (ICT) would give them quick access to digital materials and contribute to raising awareness of environmental concerns in the country and throughout the world.
- Organising modules, seminars, and frequent discussion forums would be necessary to support the instructor in the classroom.
- To encourage an inquiry- and exploration-based mindset in students, case studies, field trips, nature hikes, and project work should be encouraged in the context of instruction.
- The curriculum for environmental learning may involve the development of environmental awareness, environmental comprehension abilities, environmental curiosity and inquiry, as well as an individual sense of responsibility and care.

Conclusion

We must focus on global change to make environmental education more relevant. Students' lack of concern for environmental issues as personal issues is a factor in the stagnation of their attitudes. Giving students more reasons to safeguard the environment could address this issue. It's wonderful that so many natural science classes encourage positive thinking in children and engage their minds and hearts. However, studies have repeatedly shown that doing so independently might not necessarily result in the desired results. One must recognise his involvement in the current problem before considering any change. By creating green classrooms that provide students a space to order themselves personally in their surroundings, teachers may support this.

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EVALUATION OF NUTRITIONAL COMPONENTS OF A LEAF OF *PIPER BETLE* L. (PAAN)

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ABSTRACT

The leaf of Piper *betle* L. is eaten raw and is well known for its taste. There are numerous methods of eating the leaf specially during various occasions. In general people tend to consume the leaf (paan) after dinner. An extensive range of researches on a *Piper betle* L. leaf suggest better health benefits. Due to its enrichment in the essential components the leaves of *Piper betle* L. is known to be effective in terms of clinical aspects too.

The current research experiment is completed to analyze the nutritional aspect of the leaf of *Piper betle* L. Study shows a good impression on the nutritional aspect such as carbohydrate, protein, total fats, dietary fibre, moisture content, ash content and the energy value (*k. cal.*) with the enrichment of vitamin A (Retinol) in the plant leaf. The research provides an effectiveness for consumption of *Piper betle* L. leaf.

Keywords: Nutritional Value, Vitamin A(Retinol), *Piper Betle* L.

I. INTRODUCTION

Piper betle L. belongs to family Piperaceae known to be Paan in India with different veterinarian languages as per the traditions and religions that resides in the nation. Very often the leaf is consumed by large population as a mouth-fresheners after the lunch or dinner in order to improve the palate and to create easiness in digestion process of the consumed food materials. Hence the plant leaf is economical (Sriram Sandeep, Suryasnata Das *et.al.*) in nature along with its medicinal (Nayaka N., Sasadara M. *et. al.)* value in India. Asian continent is well-known for cultivation of this plant since its high demand for the edible leaf worldwide and its use in the industry of the fragrance and flavoring. This is due to its enrichment in the essence (Opeyemi Avoseh, Opeoluwa Oyedeji *et.al)* of the biomolecules present in the leaf.

The plant explored in the industry of bioactive extraction for its leaf is of greater importance. Hence the various therapeutic effects (Abdul Rahman H., Ranitha M. *et.al.*) just by normal consumption of the leaf can be visualized with the help of it's in a daily use. Thus, an intense effect of its use; points out the importance of the nutritional aspect of the leaf of the *Piper betle* L. However, the taste of the leaf differs from species to species (Swagata Karak, Jayashree Acharya *et. al.*) due to its difference in the characteristic feature of the aroma and the cultivation practices.

The experimental research is competed to understand the efficacy of the nutritional aspect of the *Piper betle* L. leaf so as to analyze the calorific value and the importance of its basic nutritive value when its consumed often after the lunch or dinner or during special occasions. The research experimental sample was tested from an approved *fssai* laboratory which intensely work for the quality and security of the food safety standards. The outcome of the research successfully concludes the importance of the leaf in a diet due to its enrichment in the nourishing components present in it.

II. MATERIALS AND METHODS

The leaf of *Piper betle* L. bought from the nursery was chopped into small pieces which was further process into an aqueous extract and tested for the following nutritional value.

a) Carbohydrates
b) Protein
c) Total fats
d) Moisture
e) Ash
f) Dietary fibre
g) Vitamin A (Retinol): NABL, approved *fssai* protocol by HPLC method

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h) Energy: calculated in *k. cal.*

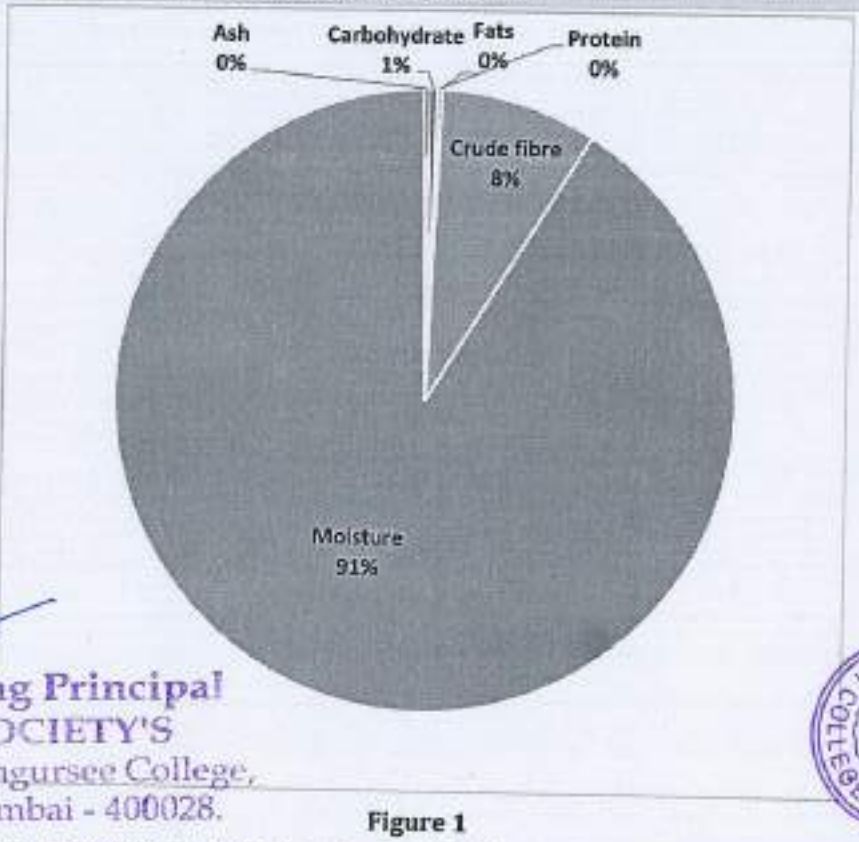
The standard protocol as given by *fssai* was followed

III. RESULTS AND DISCUSSION

The results obtained as per the regulations of *fssai* protocols is presented in Table 1 which is graphically presented in Figure 1.

Table 1

Sr. No.	Quality characteristics	Name of method of test used	Fresh leaf
			Results (%)
1	Carbohydrate	By difference	0.39
2	Protein	Kjeldahl method (AOAC,2005, 979.09)	0.22
3	Fats	Soxhlet method (AOAC 922.06)	0.025
4	Crude fibre	Hot air oven method (AOAC,2005, 962.09)	8.2
5	Moisture	Hot air oven method (IS 4333, PART II)	90.91
6	Ash	Gravimetric method (ISO 2171:1993)	0.26
7	Vitamin A (Retinol)	SOP-CHM-40-00 (AOAC Methods)	< 50 *µg/100g*
CALORIFIC VALUE (Kcal / 100 gram)			2.66



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Figure 1

The Table 1 represents the amount of moisture to be the highest viz. 90.91% and the crude fibre 8.2% at its highest. The carbohydrate observed to be 0.39%, protein 0.22%, fats 0.025%, ash 0.26% and vitamin A retinol < 50 *µg* for 100gram of sample. The energy calories obtained is 2.66 *k.cal.*

IV. CONCLUSION

The extract of the *Piper betle* L. determines the amount of moisture and the crude fibre to be the highest. The enrichment of crude fibre presence in the aqua-extract leaf describes it to be better in terms of supportive

function in the digestion process after consuming the foodstuffs especially after a lunch or dinner. The total of fats in the extract such as 0.025% regulates the least calorific values of the leaf of *Piper betle* L. However, the protein 0.22% and the carbohydrate 0.39% content is also considered to be suitable for consumption after heavy intake of diet materials. The vitamin A(Retinol) observed to be < 50 μg is one of the suitable values for intake on a daily basis as suggested by Recommended Dietary Allowances (RDA).

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A. Deuri

Editor in Chief

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COMPARATIVE ANALYSIS OF A DIETARY FIBRE FROM THE LEAVES *OF POLYALTHIA LONGIFOLIA SONN*

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ABSTRACT

Polyalthia longifolia Sonn. is a well-known indigenous native tree found extensively in the Sri-Lanka and India. The plant has varied properties commonly called to be False ashoka. Besides the use for its ornamentation purpose this plant is known to have medicinal properties too.

The current research experiment is carried out to determine a Dietary Fibre from the leaves of this plant. The leaves semidried at different temperature conditions were analyzed for the Fibre content. The research experiment successfully shows better results to gain good amount of Dietary Fibre at high temperature and its use for wide application in the industrial field.

Keywords: *Polyalthia Longifolia Sonn.*, Dietary Fibre, Comparative Study, Pharmacological Study, Nutritional.

I. INTRODUCTION

Polyalthia longifolia Sonn. is an evergreen plant species widely found in the southern tropical region of India and Sri-Lanka. The plant grows straight upwards in triangular style having a lengthy leaf in structure with acute apex. The plant is easily grown with much less care and maintenance. The plant is exploited in a wide range for its pharmacological and phyto-constituent's properties. The plant is known for its property to alleviate the noise pollution. Though a medicinal enriched and a pollution controller, this plant is also used for ornamentation / beautification purpose along a roadside. The production and utilization of indigenous food (A.O. Dauda, G.O Adegoke) extracted from the different useful plants plays a greater role for developing a self-sufficiency. The studies have shown the plant leaves highly effective in phyto-chemical analysis with rich source of its application in treatment of various diseases such as fever, diabetes, hypertension etc. Along with the phyto-constituents and the pharmacological properties to have its impact on the small and large intestine (Rana, Vikas & Bachheti *et.al.*). The nutritional properties also play a major role. Fiber as a nutritional source required for the human body with consumption affects the digestibility of fat and protein (Baer DJ, Rumpler W.V, Miles C.W, Fahey G.C Jr.). However, a healthifed-nutrition leads to competent and also balanced nutrition (Filiz Yangilar). Hence a research study on focusing of amount of various nutritional properties can be taken into consideration for exploring the plant species more enough. The current research attempt is made to complete the study on determining the Dietary Fibre under different conditions so as to identify and understand the plant enriched source for its greater extraction. The research successfully concludes an amount of Dietary Fibre to be observed in the ***Polyalthia*** leaves with varied results at different temperature.

II. MATERIAL AND METHODS

The leaves of ***Polyalthia longifolia Sonn.*** plant was semidried at a temperature of 37°C and 70°C in a "Hot Air Oven" respectively. The leaves were then grounded in a mixer and a fine powder was obtained. Thus a semi dried sample of the leaves were further experimented for the quantification of Total Dietary Fibre by a method of enzymatic –gravimetric protocol prescribed by AOAC; 2000, 985.29. The sample with triplets were analyzed and the average value was considered for the results and discussion.

III. RESULTS AND DISCUSSION

The Dietary Fibre obtained by the analysis is given below in Table 1.

Table 1.

	Temperature	
mg/gram	37°C	70°C
	1.98	**2.71**

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The value of Dietary Fibre estimated at 37°C is 1.98 mg per gram while that of 70°C is 2.71 mg/gram. Hence the calculated value for 100 gram of sample contains 198mg of the Dietary Fibre at 37°C, while that of 70°C is found to be 271mg. Thus the estimated quantity is found to be greater at 70°C. The statistical presentation is given in Figure 1.

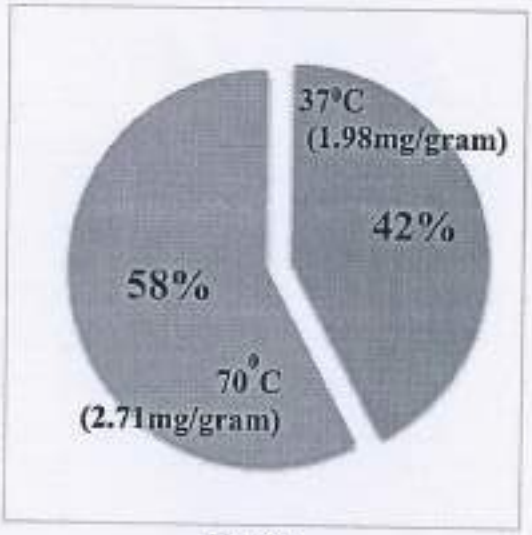


Figure 1.

The Figure 1. estimates that 58% of Dietary Fibre is achieved when the sample is processed at 70°C while only a 42% is estimated at 37°C. Thus the quantity is expressed more when the leaves are dried at 70°C. The extracted Dietary Fibre when processed can be exploited for various research purposes. While it may be used in edible products to enrich it by a Dietary Fibre source. As per the limits given **"Food and Nutrition Board, Institute of Medicine", 'National Academics'**, under by **Dietary Reference Intake (DRI's)** the below given is the presented value in Table 2.

Table 2

Life Stage Group	Total Fiber (g/d)
Infants	
0 to 6 mo	ND
6 to 12 mo	ND
Children	
1–3 y	19*
4–8 y	25*
Males	
9–13 y	31*
14–18 y	38*
19–30 y	38*
31–50 y	38*
51–70 y	30*
> 70 y	30*
Females	
9–13 y	26*
14–18 y	26*
19–30 y	25*
31–50 y	25*
51–70 y	21*
> 70 y	21*
Pregnancy	
14–18 y	28*
19–30 y	28*
31–50 y	28*
Lactation	
14–18	29*
19–30 y	29*
31–50 y	29*

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IV. CONCLUSION

Nutritional importance from plants as source for various components can be utilized and exploited in greater amount since its available in abundance in the natural form. Such natural forms when scientifically estimated and utilized for human welfare can bring a greater impact for the enrichment of the nutritional properties. The

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experiment performed for the comparative analysis of Dietary Fibre concludes at 70°C the amount was greater and hence a successful amount of estimated quantity can be brought into applied industrial field for the production of Dietary Fibre products.

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वसई तालुक्यातील परोळ येथील शिवमंदिर- सर्वेक्षण आणि प्रलेखन

सहा. प्रा. अश्विनी पतंगे

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प्रस्तावना

उत्तर कोकणातील वसई तालुका हा ऐतिहासिक दृष्ट्या जसा आधुनिक काळात महत्वाचा आहे, तसाच, किंबहुना त्याहून अधिक प्राचीन आणि मध्ययुगीन काळात महत्वाचा होता. आजच्या पालघर ह्या जिल्ह्यात येणाऱ्या वसई तालुक्यात सुमारे ५० गावांचा समावेश होतो, तर वसई रोड आणि इतर शहरी भाग हा वसई-विरार महानगरपालिकेच्या आख्यारीत येतो.ह्या सगळ्या भागाला प्राचीन काळापासून इतिहास आहे. येथील सोपारा ह्या प्राचीन बंदर आणि व्यापारी पेठेचा उल्लेख सतत तत्कालीन प्रवासी वर्णनात आणि बौद्ध साहित्यात "शूरपारक" म्हणून येतो. येथे मौर्य सम्राट अशोक ह्याचा एक शिलालेखआढळला आहे. तसेच बौद्धकालीन एक स्तूप देखील आहे. ह्याशिवाय पाचूबंदर, आगाशी,अर्नाळा ही देखील उत्तम नैसर्गिक बंदर आहेत. वैतरणा आणि उल्हास नदी ह्या वसई तालुक्यातील अर्नाळा खाडी आणि वसईची खाडी बनून सागराला मिळतात. अर्नाळायेथे येण्यापूर्वी वैतरणा नदीत तानसा आणि सूर्या ह्या आकाराने जरी लहान असल्या तरी पण तालुक्याच्या दृष्टीने महत्वाच्या उपनद्या येऊन मिळतात. येथील उथळ आणि सखोल अश्या नैसर्गिक रचनेमूळे ह्या खाड्यांच्या मुखाजवळ बेटांची देखील निर्मिती झाली आहे. ज्यामुळे सागरी व्यापार आणखी सोयीस्कर झाला आहे. तसेच अर्नाळा ह्या खाडीच्या सविस्तर आणि खोल मुखामुळे छोटी ते मध्यम आकाराची गलबते मुख्य भूमीत आतपर्यन्त आणणेही शक्य होते, त्याने दळणवळण अधिक सोपे आणि कमी खर्चिक होते. तानसा, उल्हास आणि वैतारणा ह्या नदीतून देखिल मालवाहतूक होत असत. म्हणून गेली अनेक शतके वसई, सोपारा, विरार, श्रीस्थानक (ठाणे), भिवंडी, कल्याण व्यापारी मार्गावरील महत्वाचे थांबे आहेत.

पारोळ

व्यापारी सुबत्तेमुळे येथील ह्या बंदरांचा विकास तर झालाचपण अजूबाजुतील अनेक गावांची देखील भरभराट झाली. त्यामुळेच वसई तालुक्यातील अनेक गावांना आज देखील समृद्ध असा सांस्कृतिक वारसा लाभलेला आढळतो. त्यापैकीच एक गाव म्हणजे पारोळ. तानसा नदीच्या दक्षिण तीरावर अर्नाळापासून २५ किलोमीटर तर वसई किल्ल्यापासून सुमारे २४ किलोमीटर दूर असणारे हे एक गाव. आज हे मोठ्या आकाराचे गाव आहे.२०११ च्या भारतीय जनगणनेनुसार गावात ४७८ कुटुंबे राहतात. एकूण लोकसंख्या ही २१५३ इतकी आहे.गावात प्राथमिक शिक्षण,प्राथमिक आरोग्यसेवा, रस्ते बीजपुरवठा, सार्वजनिक स्वच्छता,पाणी पुरवठा इत्यादी आवश्यक गोष्टी उपलब्ध आहे. महाराष्ट्र राज्य परिवहन महामंडळाच्या बस,वसई तसेच विरार येथील बस स्थानकावरून येथे येण्यासाठी ठराविक वेळी उपलब्ध असतात. रिक्षासुद्धा वसई आणि विरार वरून उपलब्ध असतात. त्याशिवाय वसई, नालासोपारा किंवा विरार येथून राष्ट्रीय महामार्ग क्रमांक ४८, येथून सुमारे ६ किलोमीटर वर आहे. आडणे,आंबोडे, भिनार, चांदीप, शिरवली, टोकारे,उसगाव, शिवणसई,मांडवी, खैरपाडा, तिवरी, देपिवली, वज्रेश्वरी,सायवन ही अवळपासची गावे आहेत.पारोळ गावाची स्वतंत्र ग्रामपंचायत आहे. भातशेती ही मुख्य उपजीविकेचे साधन असून भाज्या आणि फळबाग देखील आढळून येतात. वज्रेश्वरीहे एकमहाराष्ट्रातील मुख्य देवी मंदिर आणि गरम पाण्याच्या कुंडासाठी प्रसिद्ध असलेले गणेशपुरी, नित्यानंद महाराज ह्यांचे समाधीस्थान आणि आश्रम तसेच गावाला लागूनच असणारी तुंगारेश्वरच्या टेकड्या ही येथील आजूबाजूचे आजचे प्रसिद्ध पर्यटन आणि आध्यात्मिक क्षेत्र.

तानसा नदी ही जरी आकाराने लहान नदी असली तरी मुंबईची जलतृष्णातोषिणी आहे. ह्या नदीच्या दोन्ही तटातील अंतर हे अत्यंत कमी असून उन्हाळ्यात तर अनेक ठिकाणी नदीचे पात्र पूर्ण कोरडे होऊन पायी १५ मिनिटात पार करावे इतके निमुळते आहे. तरीदेखील ह्या संपूर्ण नदीतटाला मोठा आध्यात्मिक वारसा लाभला आहे. स्वामी नित्यानंद महाराज, त्यांचे जगभरातील अनेक शिष्य ह्यांच्या तपाने ही भूमी पवित्र झाली आहेच, पण त्याशिवाय इतर अनेक पंथांचे मठ, आखाडे येथे आढळतात.

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मुख्यमंदिर- प्रथम जीर्णोद्धार

सदर मंदिर हे एक शिवालय असून,दुसऱ्यांदा [illegible] रोजी, गावातील लोकांनी पुढाकार घेऊन मोडकळीला आलेल्या मंदिराचा जिर्णोद्धार केला. पहिल्या जिर्णोद्धाराचे कोणतेही संदर्भ तरी उपलब्ध नाही, मात्र गावकऱ्यांनी दिलेल्या माहितीनुसार मंदिराचे पूर्वीचे [illegible] ही सध्या तरी उपलब्ध झाली नाहीत. प्रयत्न सुरू आहे. पण स्थानिक गावकऱ्यांच्या मते येथे शिवालय होते, ज्याची पूर्णपणे पडझड झालेली, आणि मग

Officiating Principal

ग्रामस्थांच्या पुढाकाराने विटांचे मंदिर बांधले. आता असणारे गर्भगृह हे प्रथम जिर्णोद्धारचेच आहे. मंदिर कालपरत्वे पडले नसून, धर्मांध इस्लामिक आणि पोर्तुगीज आक्रमणांचे बळी ठरले असे स्थानिकांचे म्हणणे आहे. वसई पासून असणारे अंतर आणि वसई येथील धार्मिक इतिहास पाहता ह्यात तथ्य असावे.

दुसरे जीर्णोद्धार आणि मुख्य मंदिरात वापरलेले प्राचीन अवशेष

अ. गर्भगृह

प्रस्तुत मंदिराचा द्वितीय जीर्णोद्धार हा २०१५ ला झाला. ह्या समयी त्याचा पहिल्या जिर्णोद्धारतील गर्भगृह भाग हा बऱ्यापैकी तसाच ठेऊन सभोवताली मंडप बांधून घेतले आहे. पहिल्या जिर्णोद्धारात देखील प्राचीन मंदिराच्या गर्भगृह द्वारशाखेला मुळ अवस्थेत वापरले गेले आहे. त्यामुळे ती अजूनही, शाबूत आहे. ह्या शिवाय, शिवलिंग देखील मुळ असून त्यामागील पार्वतीची मूर्ती मात्र बदललेली आहे. तसेच ह्या गर्भगृहात आत सुमारे दीड ते दोन फुट कोरीवकाम होते जे दुसऱ्या जिर्णोद्धारच्या वेळेस लादी लाऊन गाडून टाकले आहे.

ब. द्वारशाखा



सुमारे १०५ इंच लांबीची आणि ७९ इंच उंचीची द्वारशाखा, एकूण तीन शाखा अजून आपले अस्तित्व टिकवून शाबूत आहे. चौरीधारीचे सध्याचे स्थान पाहता ह्यांची संख्या ही आणखी कमीत कमी दोन म्हणजेच एकूण ५ तरी असावी. द्वारशाखेच्या स्तंभावर मधील भागातील कोरलेले बरेच काम हे दुसऱ्या जिर्णोद्धारात केले आहे. मात्र कीर्तीमुख आणि दोन द्वारपाल, आणि गंगा,यमुना नि त्यांच्यासोबत असणाऱ्या दोन चौरीधारी हे मुळ प्राचीन मंदिराचा भाग आहेत. द्वारशाखेवर पुढील प्रमाणे शिल्प आढळतात.

१. मंदिराच्या डावीकडील चौरीधारी (बाहेरील बाजूस)
२. शैव द्वारपाल (मध्ये)
३. यमुना (आतील बाजूस)
४. मंदिराच्या उजवीकडील चौरीधारी (बाहेरील बाजूस)
५. शैव द्वारपाल (मध्ये)
६. गंगा (आतील बाजूस)

1.मंदिराच्या डावीकडील चौरीधारी (बाहेरील बाजूस)

१९*६ इंच असणारी ही चौरीधारी अतिशय सुबक आणि रेखीव आहे. तिने आपल्या उजव्या हातात चौरी धरली असून डाव्या हाताने आपले वस्त्र सावरले आहे. ती सालंकृत असून त्रिभंग अवस्थेत उभी आहे. सध्या मूर्तीला तैल रंग लावला असल्यामुळे तिचे वस्त्र आणि दागिने ह्याबद्दल योग्य भाष्य करणे मुश्किल आहे. परंतु तिने अधोवस्त्र परिधान केलेले असून सोबत हार, कर्णआभूषण हातात कडा, मेखला, आणि पायात तोडे घातलेले आहेत.

2. शैव द्वारपाल (मध्ये)

मंदिरात असणाऱ्या द्वारपाला वरून गाभाऱ्यात मुख्य देवता कोणती असावी बाबद्दल अनुमान बांधता येतात. बऱ्याचदा पडीक मंदिरासाठी किंवा मोडकळीला आलेल्या मंदिराच्या बांधकामाच्या वेळी या द्वारपालांची मदत मुख्य मंदिर कसे असावे कोणत्या देवतेचे असावे हे ठरवण्यासाठी होते. अशाच प्रकारची मदत पारोळ येथील द्वारपाल देखील नक्कीच करतात.मंदिर नक्की शिवाचे असावे याची साक्ष द्वारपाल देतात. मधल्या द्वार शाखेवर द्वारपाल असून तो

चतुरहस्त आहे. प्रदक्षिणा क्रमांकानुसार त्याने गदा डमरू खटवाङ आणि पात्र धरले आहे. त्याने असुरमुंडमाळ परिधान केली असून कर्णकुंडले आणि जटामुकुट देखील दिसते. पायाशी कोणतेही वाहन नाही. या मूर्तीला देखील किंवहुना मंदिरातील इतर सर्व मूर्तीना देखील तैलरंग लिंपले असल्यामुळे कुंडले आणि मुकुटाची बरीचशी नक्षी त्याखाली दबली गेली आहे. हा समपाद अवस्थेत उभा असून 24*12 इंच इतका मोठा आहे जरी आता तेल रंगाने मूळ शिल्पाचे खरे सौंदर्य झाकले असले तरीही सध्या अस्तित्वात असलेले शिल्प हे अतिशय सुबक आणि प्रमाणबद्ध आहे.

यमुना

मंदिराच्या आतील बाजूस द्वार शाखेवर18*7 इंच असलेली पहिली मूर्ती ही यमुनेची असून तिचे कुर्म वाहन तिच्या बाजूला कोरलेले आहे. ती द्विहस्त असून एक हात वरद मुद्रेत आहे बाकीच्या दोन शिल्पांच्या मानाने यमुना समपाद आणि त्रिभंग अवस्थेत असून, तिने पायात तोडे, पदग्राम, गळ्यात हार, कमरेत मेखला धारण केला आहे. तिची केशरचना सुंदर आणि वैविध्यपूर्ण अशी आहे.

4. उजवीकडील बाहेरील बाजूस असणारी स्त्री

उजवीकडे बाहेरील बाजूस द्वार शाखेवर असणाऱ्या स्त्रीची प्रतिमा ही काहीशी संभ्रमात टाकणारी जाणवते. हीचा डावा हात वर असून त्यात तिने तबकासारखे काहीतरी धरताना जशी हातांची रचना होईल तशा प्रकारे हात धरला आहे मात्र तिच्या हाताची बोट आता जिर्णोद्धरात मुख्य मंदिराच्या भिंतीत शिरल्यामुळे हे काहीसे अनाकलनीय आहे. तिचा उजवा हात हा तिच्या उजव्या मांडीवर विसावला आहे. त्यामुळे हे शिल्प मूळचे द्वारशाखेवर असावे की नसावे असा संभ्रम निर्माण होतोय कारण स्त्रीच्या डाव्या हातात तबक असणे किंवा चामर असणे मुश्कील आहे.कसेही असले तरी मूर्ती अतिशय सुंदर असून 18*7 इंच इतकी आहे. तिने दागिने घातले असून तिची केस रचना ही अतिशय मोहक आहे. रंगाने रंगवलेल्या तिच्या सोनेरी केसांच्या बटा नीट विंचरलेल्या दिसून येतात तसेच तिने मागे अंबाडा घातला असावा. तिच्या कानात आभूषण असून हार, मेखला, बाजूबंद, पाटल्या आणि तोडेदेखील घातलेले आहेत. तिच्यावस्त्राबाबत मात्र शंका असून अधोवस्त्र म्हणून तिने परिधान केलेल्या वस्त्राचा कासोटा आणि पायघोळ असलेल्या चुण्यायावरून दिसून येते.

5. द्वारपाल

डावीकडे असल्याप्रमाणेच मंदिराच्या उजव्या बाजूला सुद्धा द्वारपाल आहे. त्याच्या हातात देखील गदा त्रिशूळ नागपाश असून एक हात भग्न आहे त्या हातात कोणत्याही आयुधा चे लक्षण दिसत नाही पण हात वरदहस्त मुद्रेत देखील नाही तर अक्षमाळा धरलेल्या हाता सारखी बोटांची रचना दिसत आहे. शैव म्हणावला म्हणून या मूर्तीच्या खाली वाहन म्हणून वृषभ ची मूर्ती ही पाय दुमडून बसल्याप्रमाणे आहे. मुर्ती अत्यंत प्रमाणशीर आणि रेखीव आहे तिची उंची 24 इंच असून रुंदीला बारा इंच आहे

6.गंगा

द्वारशाखेच्या आतील बाजूला गंगेची मूर्ती असून ती समपाद त्रिभंग अवस्थेत उभी आहे. तिच्या पायाशी तिचे वाहन सुसर स्पष्ट दिसत आहे. तिने एका हातात कलिका धारण केली असून तिच्या दुसरा हात मोकळा आणि कोपऱ्यात दाबला गेलेला आहे. ही गंगा देखील सालंकृत असून सुंदर अशी केशभूषा करून हार,कर्ण आभूषण, मेखला, तोडे, बांगड्या आणि बाजूबंद यांनी सुशोभित आहे हिच्या मागून येणारे एक वस्त्र तिने हातात गुंडाळले आहे. नवीन केलेल्या रंगकामामुळे त्या वस्त्राचे इतर कोणतेही अवशेष समजेनासे झाले आहेत.

3. बाहेरील स्तंभ



१)चामुंडा २)महिषासुरमर्दिनी ३)चौथरा आणि इतर अवशेष जोडुन बनवलेली दीपमाळ

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अ. मंदिराच्याडावीकडील स्तंभ

डावीकडे असणारा स्तंभ हा अर्धा दुसरा जिर्णोद्धारात कोरलेला आहे तरीही यातील पायाशी असणाऱ्या चार दिशेने असणाऱ्या मूर्ती, कीर्तीमुख हे जुन्या मंदिराच्या अस्तित्वाच्या खुणा आहेत. यापैकी वरचा भाग बहुदा भार वाहकांनी सजवलेला होता परंतु आता ते खांब भारवाहकांनी सजलेले नसून मंदिराच्या मूळ स्थानावर देखील नाहीत तर त्यांना बाहेर प्रांगणातसुशोभीकरणासाठी आणि नव्याने लावलेल्या पत्र्यांना आधार देण्यासाठी वापरले आहे. याचा वरचा भाग आता सिमेंटने जोडला आहे तर खालचा भाग देखील बराचसा जमिनीच्या आत पुरला असून त्यावर नवीन पेवर ब्लॉक बसवले आहेत.मंदीर स्तंभाच्या खालील भागावरती महिषासुरमर्दिनी, कार्तिकेय,सरस्वती, शिव आणि भैरव कोरले आहेत.

1. महिषासुरमर्दिनी

चतुरहस्त असणारी त्रिशूलाने महिषाचा वध करणारे ही महिषासुरमर्दिनी आपले वाहन सिंहाबरोबर आक्रमक अवस्थेत उभी आहे. तिने आपला उजवा पाय महिषावर ठेवला असून डावा पाय जमिनीवर आहे. प्रदक्षिणा क्रमांकानुसार डाव्या खालच्या हातात त्रिशूल असून ते त्रिशूल महिषासुराच्या शरीरात रुतले आहे तर वरील हाताने तिने खडग उगारले आहे, तिच्या उजव्या हातात ढाल असून उजव्या खालच्या हाताने तिने महिषासुराचे मुंडके धरले आहे. महिषासुर पुढील पायाने वाकलेला तर मागच्या पायाने मातेच्या वजनानें दबलेला दिसतो तसेच सिंह देखील महिषासुराच्या पार्श्वभागाचा फडशा पाडतोय अशा हावभावात अतिशय उग्र मुद्रा घेऊन उभा दिसतो. बाकी मूर्तीच्या मानाने ही मूर्ती जरी सुस्थितीत असली तरी ह्या मूर्तीचे वक्ष मात्र पूर्ण तोडले आहेत. मानसिक दुर्बलता!

2. सरस्वती

चार भुजा असणारी स्त्री प्रतिमा ही सरस्वतीची आहे. हिने हातात प्रदक्षिणापथानुसार वरदहस्त पुस्तक धरले असून तिच्या डाव्या वरील हातातील आयुध स्पष्ट दिसत नाही डाव्या खालच्या हातात तिने कमांडलू धरले असून तिचे वाहन मोर पायाशी दिसत आहे.

3. ईशान

हे शिल्प चातुर्हस्त असून पुरुष देवतेचे आहे. या देवतेने ऋषभ वाहनावर ठेवलेला आहे. गळयात असूरमुंड माळ धारण केलेली आहे प्रदक्षिणा क्रमाने हातात उजव्या खालच्या हातात त्रिशूळ धरला असून त्याचा वरील भाग हा डाव्या वरच्या हाताने धरला आहे उजव्या वरच्या हातात डमरू असून डाव्या हातात खालच्या हातात कपाल असल्यासारखं दिसत आहे. त्याच्या हातातील आयुध ही शिवाला मिळती जुळती असूनही हा बहुदा ईशान असावा.कारण यापैकी एका खांबावर इंद्र कोरला आहे त्यामुळे अष्ट दिगपालांचे आठ खांब असण्याची दाट शक्यता आहे.

४. भैरव

या खांबावर असणारी चौथी मूर्ती ही भैरवाची असावी. ही मूर्ती चतुर्हस्त असून प्रदक्षिणा क्रमांकानुसार डावा खालचा हात भग्न आहे तर वरील हातात त्रिशूल आणि वरदहस्त आहे. या मूर्तीच्या पायाशी असणारे वाहन भग्न असल्यामुळे निश्चित शिव सांगता येत नाही परंतु वाहनाचे एकूण अस्तित्व हे श्वानसारखे भासते त्यामुळे हा भैरव असावाअसा अंदाज बांधता येतोय.

ब. मंदिराच्या उजवीकडील स्तंभ

या स्तंभावर देखील चार दिशेने चार मूर्ती कोरलेल्या आहेत. त्या अनुक्रमे गणेश, कार्तिकेय, चामुंडा आणि इंद्र ह्या आहेत.

१. गणेश

चतुर्हस्त, प्रदक्षिणा क्रमांकानुसार एका हातात अक्षमाला धारण केलेला, त्यानंतर शुल, कमलकलिका आणि मोदकपात्र धारण केलेला एकदंत गणेशाची सुंदर मूर्ती आहे. त्याने जानवे, वनमाला आणि इतर अनेक अलंकार धारण केलेले असून त्याच्या शरीराचे एकूण प्रमाण पाहता काहीतरी चुकल्यासारखे वाटते. ही मूर्ती शुर्पकर्ण न वाटता लहान कानांची आहे. त्याचे वाहन मूषक त्याच्या पायाशी आहे.

२. कार्तिकेय

25 बाय 11 इंच उंचीची ही मूर्ती द्विहस्त आहे इतर सगळ्या देवमूर्ती या चतुरस्त असताना फक्त हीच मूर्ती द्विहस्त का असावी हा प्रश्न पडतो. त्याच्या पायाशी त्याचे वाहन मयूर स्पष्ट दिसते तसेच हा कुमारावस्थेतील असावा असा चेहरा भासतो. हा देखील सालंकृत असून कुंडले, हार, मेखला बाजूबंद आणि वनमाला धारण केली आहे.

३. चामुंडा

इथे असणाऱ्या सगळ्या मूर्तींमध्ये अतिशय उठावदार दिसणारी मूर्ती म्हणजे चामुंडीची ही मूर्ती. प्रदक्षिणा क्रमांकानुसार चार हातात चोरी का डमरू असून ती डाव्या हाताची करंगळी आपल्या ओठात धरून शीळ घालत आहे. तिने ह्या डाव्या हाताच्या कोपरा आणि दंडाच्या मध्ये खटवाङ्, अलगद धरला आहे. तर डाव्या हाताच्या खालच्या हातात तिने कपाल धरले आहे. इथे जरी असुरमुंड हातात नसले तरीही त्याचं रक्त टिपणारा श्वान स्पष्ट दाखवला आहे

तसेच तिचे वाहन असणारे प्रेत देखील अतिशय कल्पकतेने आणि सुंदर रित्या कोरले आहे. तिने नरमुंडमाल धारण केली असून ती देखील सुंदर कोरलेली दिसते. तिच्याजटा एकूणच कृष शरीरयष्टी तिच्या पायावरून जाणवते. तिचे स्तन उघडलेले न दाखवता रेखीव दाखवले आहेत परंतु स्तनांखाली असणाऱ्या रेषांवरून ते बहुदा ओघळलेलेच दाखवले होते. परंतु नवीन कारागिरांनी त्यांना थोडेसे डौलदार केले असावे.

४. इंद्र

शेवटची मूर्ती ही इंद्रची आहे. चतुरहस्त असणारी वरद, वज्र, अंकुश, कमंडलू धारण केलेली ही मूर्ती आहे. या मूर्तीच्या पायाशी एक डौलदार ऐरावत कोरला असून मूर्तीचा किरीट मुकुट दागिने अतिशय सुबक आणि रेखीव दिसतात.

क. चौथरा आणि इतर अवशेष जोडुन बनवलेली दीपमाळ

या दोन खांबा व्यतरिक्त मंदिराच्या समोर एक दीपस्तंभ रूपाने स्तंभ ठेवला आहे. हा स्तंभ खरं तर विविध तीन भागाचे एकरूप करून बनवलेला आधुनिक काळातील दीपस्तंभ आहे. मुळात हा मंदिराचा एक स्तंभ असावा असे वाटते आहे.

एक मोठा दोन ते अडीच फुटांचा चौथरा बांधून त्यावर तो उभा केला आहे परंतु असे करताना नवनिर्मित स्तंभाच्या खालील भागात असणारे चार बाजूंना चार असणाऱ्या मूर्तीचा पायाखालचा भाग मात्र या चौथऱ्यात गाडला गेला आहे.त्याशिवाय या चौथऱ्यावर मंदिराच्या जंघाभागावरील तसेच द्वारशाखेवरील आणि कोष्टकातील बहुदा असणारे काही शिल्प हे एकत्र करून जोडले आहेत.

या दिपस्तंभावर चार मूर्ती असून पहिली विष्णूची असावी या मूर्तीची बरीच झीज झाल्यामुळे नक्की सांगता येणे कठीण असले तरीही खाली हात जोडल्यासारखा असणारा गरुड आणि चक्र यावरून विष्णू असावा असा अनुमान करता येतो. ही मूर्ती सध्या 17 बाय 21 इंच इतकी आहे परंतु इतर खांबावरील मुर्त्यांची मूर्तीची मापे पाहता ही सुद्धा वीस बाय 21 असावी. तिचा मुकुट किरीट असून अंगावर अनेक दागिन्यांच्या खुणा आढळतात.

त्यानंतर असणारी पुढील मूर्ती ही चतुर्हस्त असून तिची आयुधे तसेच हात बरेच भग्न झाले आहेत. उजव्या वरच्या हातात त्रिशूळ असावे, तर डाव्या वरच्या हातात नक्की काय असावे हे कळत नाही. परंतु खाली असणाऱ्या वृषभ वाहनावरून ही मूर्ती शिव परिवारातील देवतेची असावी. शिल्पाच्या अंगावर असणारा दागिन्यांमुळे याला शिव म्हणणे योग्य ठरत नाही.

स्तंभाच्या तिसऱ्या शिल्पात चतुर्हस्त पुरुष देवता दिसत असून ती तिने प्रदक्षिणा क्रमानुसारअक्षय माला, स्रुक, पुस्तक आणि कमंडलू धरले आहे. ही मूर्ती त्रिमुख असून ब्रह्माची आहे. पायाशी ब्रह्माचे वाहन हाऊस डौलाने बसलेले दिसते आहे.

यानंतर असणारे चौथे शिल्प हे स्त्री देवतेचे आहे परंतु अत्यंत भग्न असल्यामुळे कोणतेही अंदाज बांधणे शक्य होत नाही.तीच्या पायाशी मेंढा अथवा वृषभअसावा असे एकूण अस्तित्वावरून जाणवते.

चौथरा

ह्यानंतर हा स्तंभ ज्या चौथऱ्यावर उभा केला आहे, त्याला सिमेंट ने बांधले आहे.ह्या चौथऱ्याच्या दोन बाजूंना विविध मूर्ती वेगवेगळ्या ठिकाणच्या गोळा करून लावल्या आहेत. त्यात एकसमान असणारे आकारमान हे एकच निष्कर्ष पाळल्यामुळे सगळी सरमिसळ झालेली दिसून येते.

साधारणतः ही सगळी शिल्पे 12 ते 15 इंच ह्या मापत आहेत. एकूण पूर्वेकडील भागात 5 शिल्प आहेत. ह्यातील पहिले डावीकडील शिल्प हे पुरुष देवतेचे असून चतुर्भुज आहे. त्याची आयुधे स्पष्ट दिसत नसून भग्न झाली आहेत परंतु डाव्या वरच्या हातात तलवार किंवा छुरिका असावी. हे शिल्प डाव्या बाजूला वळलेले असून आक्रमक दिसते.

ह्यानंतर असणारे दुसरे शिल्प हे स्त्री चे असून मंदिर प्रांगणात आढळणाऱ्या नायिकेचे लहान स्वरूप असावे असे वाटते. तिचे वस्त्र वानर खेचत आहे असे वाटतेय. तिने भला मोठा असा अंबाडा बांधला असून अतिशय कमनीय बांधा असणारी स्त्री आहे.

पुढील शिल्प हे चतुर्भुज असून पुरुष देवतेचे आहे. त्याने उजव्या खालच्या आणि डाव्या खालच्या हातात त्रिशूळ अथवा दंड धरला आहेआणि त्यावर एक मानवी आकृती दिसत आहेत तर वरचा डावा हात चपटदान मुद्रेत असून वरच्या उजव्या हातात काही तरी धरले आहे असे वाटते आहे.

त्यानंतर पुढील मूर्ती ही द्विहस्त असून स्त्रीची आहे. तिने आपल्या डाव्या हातात दर्पण पकडले असून आपल्या उजव्या हाताने ती केशसंभार सजवते आहे. ही देखील आकाराने फक्त 13*11 इंच इतकीच असली तरी अतिशय सौष्टव आणि एकूणच मंदिराच्या बाहेर असणाऱ्या नायिकेच्या तोडीची आहे.

ह्यानंतर असणारे शिल्प हे चतुर्भुज पुरुषाचे आहे. त्याचे शिरस्त्राण हे अतिशय वेगळे असून त्यावर इतर शिर अथवा सर्प असावे असे वाटते. त्याने असुर मुंडमाला अथवा वनमाला धारण केलेली आहे.

ह्याच चौथराच्या पुढील बाजूस(पश्चीमेकडील बाजूस) चार मूर्ती असून त्या सर्व प्रतिमा आहेत.

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ह्यातील पहिली प्रतिमा ही ब्रह्माची आहे. तर दुसरी गणेशाची आहे. तिसऱ्या देवाकोष्टक स्वरूपात शिव असून चौथ्यात एकमुखी कार्तिकेय आहे. सुरवातीला ही गणेशपट्टी असावी. असे आभास होत असला तरी पुढे ही देवकोष्टक असून त्या सर्वांना गावकऱ्यांनी जिर्णोधाराच्या वेळी एकत्र जोडून ठेवले आहे. साधारणत समान ऊंची आणि रुंदी, साधारणत १०*१८ इंच, असणारी सगळी सापडलेली शिल्प एकत्र करणे हाच दुवा असावा.

ड. कुंड

मंदिराच्या डाव्या बाजूला पुढे एक कुंड होते अशी माहिती येथील स्थानिकांनी दिली. हे कड गरम पाण्याचे असून आता मात्र गाळ साचल्यामूळे ते नष्ट झाले आहे. गणेशपुरी येथे असणाऱ्या गरम पाण्याच्या कुंडामूळे ही शक्यता आहे. सध्या तरी हे कुंड पूर्ण तुटले असून त्याच्या पायऱ्यांचे अस्तीव काही प्रमाणात शाबूत आहे.

ह्या कुंडात देखील अनेक मंदिराचे अवशेष विखुरलेले आहेत,

मंदिराच्या आवारातील विखुरलेले अवशेष:



सदर पारोळ या गावातील मंदिराच्या आजुबाजुच्या परिसरात अंदाजे ५० मीटर अंतरापर्यंत मंदिराचे अनेक अवशेष विखुरलेले दिसुन येतात तसेच येथील शेतांमध्ये अनेक अवशेष गाढले गेल्याचे दिसुन येते. येथील स्थानिकांनी मिळालेले अवशेष मंदिराजवळ ठेवलेले दिसुन येतात. त्यात प्रामुख्याने मंदिराचे कोरीव स्तंभ, स्तंभांवरील चतुर्हस्त भारवाहक दिसुन येतात.तसेच मंदिराच्या शिखराचा तुटलेला भाग, २सिंह कोरलेली शिळा तसेच इतर विविध अवशेषांचा यात समावेश होतो. स्तंभ व छत या जोडस्थानावर छताचा भार आपल्या हातांनी पेलून धरणाऱ्या भारवाहक किंवा वितान गंधर्व यांच्या संख्येवरुन मंदिराच्या स्तंभांच्या संख्येची व पयार्याने मंदिराच्या आकारमानाची कल्पना करता येते.

आभार

ह्या सर्वेक्षणासाठी श्री. विनोद पाटील, कु. नेहा पाटील आणि कु. तृप्ती घरत यांनी मोलाची मदत केली. त्यासाठी त्यांचे मनपूर्वक आभार.

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१५. गौरी-सण आणि नृत्य

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प्रस्तावना

महाराष्ट्रात अनेक जन-जमाती आढळतात, त्यापैकी वारली ही एक प्रमुख आणि संख्येने अधिक असणारी जमात आहे. ह्यांचा मुख्य व्यवसाय हा शेती असून वन उत्पादने गोळा करणे आणि त्यांची विक्री करणे ही देखील उत्पन्नाचे एक साधन आहे. काबाडकष्ट करून दमलेली स्त्री-पुरुष सण-सभारंभ, पूजन, अश्या विविध निम्मीताने एकत्र येतात आणि हातात हात गुंफून, एकमेकांच्या खांद्यावर हात ठेऊन, किंवा कमरेत हाताचा विळखा घालून बेभानपणे , दंग होऊन काठ्याच्या[i] मार्गदर्शनात, तारपा,[ii] ढोल[iii] अशा त्यांनी स्वतः बनवलेल्या वाद्याच्या वापर करून नृत्य करतात.

वारली स्त्री पुरुषांच्या विविध लोकगीतांतून वारलींच्या लोकगीतांमागील हेतू, त्यांचे प्रयोजन, स्वरूप, त्यांची वैशिष्ट्ये, समजतो. आदिवासी वारलींच्या लोकसाहित्याचा अभ्यास करताना वारलींच्या समृद्ध सांस्कृतिक वारश्याची व्याप्ती समजते. प्रस्तुत अभ्यासात अश्याच एक वारली नृत्य प्रकारची, त्यांच्या सणाची आणि त्याच्याशी निगडीत निसर्ग-विज्ञान ह्यांची माहिती घेण्याच प्रयत्न करणार आहोत. वारली स्त्रिया नृत्य करताना नमन गीते व मनोरंजनपर गीते गातात. कोणत्याही नृत्य प्रकाराची सुरुवात देवाच्या आळवणीने म्हणजेच नमन गीताने होते है वारलींच्या नृत्य गीतांचे वैशिष्टच पाहायला मिळते, गौरीच्या सणाला स्त्रिया आणि पुरुष डोलकीच्या तालावर नृत्य करून गीत गातात ते असे.

गौर नाच किंवा गौरी नाच

स्त्रिया नागाला भाऊ मानून नागपंचमीच्या दिवशी भावासाठी उपवास करतात. दूध, भाताची फूल (लाह्या), नारळ, काकडी, करटोलीच्या ताना (वेल), गोमेठीचा ताना, बेल, उदबत्ती या साहित्याने नागाची पूजा करतात. बहुतेक ठिकाणी या सुमारास जंगलात ठरावीक जागी नाग निघतात. ज्या ठिकाणी नाग निघत नाहीत तेथील बायका तांदळाच्या पिठाचा नाग बनवून पूजा करतात. संध्याकाळी माठाची भाजी खाऊन उपवास सोडतात. नागपंचमीची फारशी गाणी म्हटली जात नाहीत. नागपंचमीच्या दिवसापासूनच गौरीचा नाच व गाणी सुरू होतात.

वारली समवेत संपूर्ण कोकणात गौरी हा अतिशय महत्वाचा सण मानला जातो. तर उत्तर कोकणात वारलीच नव्हे तर इतर जातीतiv थोड्या फार फरकाने, गौरीचे पूजन सारखेच केले जाते. इथे मूर्ती अथवा मुखवटा न पूजता गौर पानाफुलांची, वेलींची असते. इंदईची फुलं आणि वेल (कळलावी), टाकळा, तेरडा, गोमेठी(रान तोंडली), कोंबडा, सागाची काडी, करंटोलीचा ताना, गायबारीचा ताना, डीनाचे पान या सगळ्यांची एक बुडी बनवली जाते, ती एखाद्या मडक्यात ठेवतात. हे सर्व साहित्य अगोदरच्या दिवशी

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संध्याकाळीच घरी आणून ठेवले जाते. अशी गौर आणण्यास गेलेल्या एका मुलहेरक्यास वाघाने खाल्ले, तेव्हापासून काही वारली पाड्यात लोक गौर घरी आणत नाहीत. तथापि गौरी नाच मात्र ते नाचतात.

गौरीसाठी वापरल्या जाणाऱ्या वनस्पतींचे औषधी गुण

कोकणात गौरी, पश्चिम महाराष्ट्रात महालक्ष्मी, तर काही भागात अंबाबाई या विविध नावाने साजरा होणार हा सण खरे तर आदिम काळापासून साजरा केला जातोय. मातृत्व, प्रजनन, सर्जनशीलता ह्या सगळ्यांशी ह्याच सहसंबंध आहे, ह्याचा पुरावा वारली गौरी म्हणून पूजतात त्या वनस्पतीच्या उपयोगावरून होते. पिढ्यान पिढ्या ही वनस्पतीशास्त्र ह्या वारली भगिनी वापरतात, आणि त्याबद्दल कृतज्ञता म्हणून मातृ-देवतेच्या नावाने साजऱ्या होणाऱ्या सणाला ह्या वनस्पतींना पूजतात. ह्या सगळ्या वनस्पती फक्त प्रसूती सुलभ करायलाच नव्हे तर शरीराला शक्ति देण्यासही मदत करतात.

1. कळलावी / इंदिया वेल

सुलभ प्रसूतीसाठी आदिवासी आणि पारंपरिक औषधी पद्धतीमध्ये मुळाचा लेप ओटीपोटावर लावला जातो. बाळंतिणीला प्रसूतीच्या वेळी कळा आणण्यासाठी वापर होत असल्याने या वनस्पतीला "कळलावी' म्हटले जाते. कळलावीच्या फुलांच्या पाकळ्यांची टोके तांबडी व मधला भाग पिवळा असल्याने अग्निज्वाला असल्याचा भास होतो. अग्निज्वालाप्रमाणे असणाऱ्या या पाकळ्या दुरून समईत ज्योती तेवल्याप्रमाणे दिसतात, म्हणूनच या वनस्पतीला 'अग्निशिखा' असेही म्हणतात.फुलांच्या वैशिष्ट्यपूर्ण रचनेमुळे या वेलीला अग्निमुखी, अग्निशिखा, कलहारी, खड्यानाग, गौरीचे हात, नखस्वामिका, वचनाग आणि अशी खूप नावे आहेत.सूज, व्रण, गंडमाळ, शोथ, अर्श इत्यादी विकारांत कललावीचा वापर केला जातो. विंचू व सर्पदंशावर हिचा वापर होत असे. कृमी, काष्ठ, विषमज्वर, दौर्बल्य यांमध्येही कळलावी उपयोगी आहे. फुले धार्मिक उत्सवासाठी गौरीचे हात म्हणून गौरी गणपतीला वाहिली जातात. कर्करोग, पोटाचे विकार यावरही कळलावी गुणकारी आहे. पानाच्या रसाचा उपयोग विषारी बाण तयार करण्यासाठी केला जात असे. जनावरांच्या कर्करोगातही या वनस्पतीचा वापर होतो.

2. तेरडा

याच्या बियांच्या चूर्णाचा वापर सुलभ प्रसूती साठी केला जातो.तसेच गर्भार बाईला सुरवातीच्या दिवसांमध्ये होणारा त्रास टाळण्यात पण ही वनस्पती मदत करते. पांढरा, लाल, गुलाबी, फिकट जांभळ्या रंगात असलेली विशेषतः पावसाळ्यात फुलणारी ही नाजूक सुंदर दिसतात. या झाडाला गौरी किंवा गौरीची फुले किंवा गुलमेहन्दी असे म्हटले जाते. तेरडा हा पित्तशामक असून त्याची फुले पौष्टिक आणि थंड असतात. भाजलेल्या ठिकाणी लावल्यावर आराम पडतो. ही वनस्पती विरेचक (पोट साफ करणारी), मूत्रक (म्हणजे शरीरातील अतिरिक्त पाणी काढून टाकणारी), तसेच संधीवातासाठी साठी उपयोगी आहे. याच्या बियांपासून तेल निघते ज्याचा वापर खाण्यासाठी तसेच दिवा लावण्यासाठी होतो. फुलांचा उपयोग कम्बर दुखी साठी केला जातो. कीडा किंवा साप चावल्यावर याच्या पानांचा रस लावल्यास फायदा होतो. हाड मोडल्यास याच्या पानांचे पोटीस लावले जाते. कफ बाहेर काढण्यासाठी याच्या बियांचा वापर होतो. तसेच कॅन्सर मध्ये देखील याचा उपयोग होतो असे बोलले जाते.

3. कोंबडा/ कुरडू

नावाप्रमाणेच अत्यंत कडू अशी ही वनस्पती आहे. ही वनस्पती यकृत विकारांवर अत्यंत उपयुक्त आहेकिरिआत, किरियात, चिरायता, कडू किरियत अशा विविध नावाने ही वनस्पती ओळखली जाते. या वनस्पतीला पांढऱ्या आणि गुलाबी रंगाची फुले असतात. याला कुरडू पांढरा कोंबडा मोर पंख असेसुद्धा म्हणतात. आयुर्वेदानुसार कुर्डू ही वनस्पती अनेक व्याधींवर फायदेशीर आहे. सांधेदुखी जाण्यासाठी, नामर्दाला मर्द बनवणारी, कमजोरी दूर करण्यासाठी, थकवा जाण्यासाठी, मुतखडा बाहेर काढण्यासाठी, दाताचे कोणतेही विकार असो म्हणजे दातातील किडा बाहेर काढण्यासाठी दात दुखत असेल तर दुखणे नाहीसे करण्यासाठी कमी करण्यासाठी दातातून रक्त येत असेल तर ते बंद करण्यासाठी याचा फायदा होतो आणि तर ह्या कुरडू वनस्पती ची फुले पाने व मुळे अत्यंत चमत्कारीक असतात.

4. टाकळा

टाकळ्याच्या पानांत विरेचन द्रव्य व लाल रंग असतो. टाकळा सर्व प्रकारच्या त्वचारोगांत देतात. त्वचा जड झालेली असल्यास याचा विशेष उपयोग होतो. त्वचारोगात पानांची भाजी देतात व बिया वाटून लोप करतात. बिया लिंबाच्या रसातून वापरण्याचा प्रघात आहे. मुळे उगाळून लिंबाच्या रसात बनविलेली पिष्टी गजकर्णासाठी वापरतात. पाने व बियांमध्ये 'क्रायझोजेनिक आम्ल' असून, ते त्वचारोगात मौल्यवान आहे.

तर अश्या ह्या गौरीसाठी वापरल्या जाणाऱ्या प्रत्येक वनस्पती ही अत्यंत गुणकारी असून स्त्रियांच्या आरोग्यासाठी वापरली जाणारी आहेत.

गौरी पूजन पद्धती

गौरीची तयारी म्हणून आधी घर सारवले जाते. तांबडमाती कालवून तिचे पट्टे जमिनीवरून भिंतीवर चढवतात, चुलीजवळ नेतात, खांबावर चढतात. तांदळाचे पीठ पाण्यात कालवून ताटलीत घेऊन हाताच्या उभ्या मुठींनी दारापासून चुलीपर्यंत ठसे देतात. हे पांढरेशुभ्र ठसे लहान लहान पावलांसारखे दिसतात. त्यानंतर कुमारिकेच्या हातात ह्या सर्व वृक्ष वेलीची जुडी सुपात देऊन घरात घेऊन येतात, तिची दाराशी आरती करतात. या पावलांच्या वाटेवरून तिला घरात नेऊन चुलीच्या मागे पाटावर एका मडक्यात एक पायली तांदूळ मोजून ठेवलेले असतात. त्यावर ही पानाफुलांची जुडी ठेवली जाते. मडक्याच्या आजूबाजूला पाटावर काकड्या, नारळ, दोडकी, भाकरी, चामट्याv, केळी अशा गोष्टींचा नैवेद्य ठेवतात. त्यानंतर पुन्हा तिची आरती करतात. आरतीनंतर रांधलेल्या जेवणाचा दुसरा नैवेद्य गौरीपुढे ठेवून मगच घरातील सर्व लोक जेवण करतात.

गौरीचे स्थान महत्त्वाचे असले तरी गणपती मात्र आदिवासींमध्ये आणला जात नाही. गौरी नाच गोलाकार फेर धरून सुरू जातो. गोल पुढे सरकत असतो आणि थोड्या वेळाने उलटदिशेने फिरू लागतो. चार-चार स्त्रिया एकत्रपणे गात असतात, त्याला सर्व नृत्य करणारे साथ देत असतात. ढोलकीवजा ढोलक याची साथ नृत्याला मिळते. यात पुरुष व स्त्रिया एकत्र नाचतात. जेवण उरकले की

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नाचगाणी सुरू होतात. प्रत्यक्षात नागपंचमीच्या दिवसापासूनच गौरीचे वेध लागलेले असतात व नाचगाणी सुरू झालेली असतात. गौर अडीच दिवस घरात असते.

विसर्जनाच्या दिवशी मडक्यातील फक्त जुडी उचलून भातशेतात नेऊन ठेवतात. त्यानंतर मडक्यातील तांदूळ मोजतात. ते एक पायलीहून अधिक भरल्यास आपली बरकत होईल असे मानले जाते.

वेशभूषा

कमरेला लंगोटीवजा कापड, अंगाने उघडे, उजव्या पायात घुंगरू. स्त्रिया अर्धे लुगडे आणि चोळी

गौरीचे नमन गीत

वारली स्त्रिया नृत्य करताना नमन गीते व मनोरंजनपर गीते गातात. कोणत्याही नृत्य प्रकाराची सुरुवात देवाच्या आळवणीने म्हणजेच नमन गीताने होते है बारलींच्या नृत्य गीतांचे वैशिष्टच पाहायला मिळते, गौरीच्या सणाला स्त्रिया आणि पुरुष ढोलकीच्या तालावर नृत्य करून गीत गातात ते असे.

(१)

पहिला नमीन कोणाला देवा नमीन कोणाला

धनतरी मातेला देवा धनतरी मातेला....

दुसरा नमीन कोणाला देवा नमीन कोणाला

कणसरी मातेला देवा कणसरी मातेला....

तिसरा नमीन कोणाला देवा नमीन कोणाला

गावतरी मातेला देवा गावतरी मातेला....

चवथा नमीन कोणाला देवा नमीन कोणाला

गौराई देवीला देवा गौराई देवीला....

या गीतात धनतरी मातेला (बहुदा धरती माता,) कणसरी(शेतात पीक देणारी देवता), गावतरी, ग्रामदेवता, अभिवादन करून गौराई मातेला नमन केले आहे.

(२)

सोड नांगर हाकल तारू जाऊदे किनारीला रं

सोयऱ्या जाऊदे किनारीला रं

ढोलक्या भाऊना आमंत्रण केलय ढोलकी वाजवायला रं

सोयऱ्या ढोलकी वाजवायला रं

सोड नांगर हाकल तारू जाऊदे किनारीला रं

सोयऱ्या जाऊदे किनारीला रं

नाच्या भाऊना आमंत्रण केलय गौरी नाचायला रं

सोयऱ्या गौरी नाचायला रं

सोड नांगर हाकल तारू जाऊदे किनारीला रं

सोयऱ्या जाऊदे किनारीला रं

गाणार भाऊना आमंत्रण केलय गाणी म्हणायला रं

सोयऱ्या गाणी म्हणायला रं

सोड नांगर हाकल तारू जाऊदे किनारीला रं

सोयऱ्या जाऊदे किनारीला रं

ताईला आमंत्रण केलय गाणी म्हणायला रं

सोयऱ्या जाऊदे म्हणायला रं

सोड नांगर हाकल तारू जाऊदे किनारीला रं

सोयऱ्या जाऊदे किनारीला रं

भाऊना आमंत्रण केलय गौरी नाचायला रं

सोयऱ्या गौरी नाचायला."

वा गाण्यातील स्त्री आपल्या पतीला म्हणते, ढोलकीवाला, नाचणारा भाऊ गाणारा भाऊ, गाणारी ताई या सर्वांना गौरीच्या सणाला नाचगाणे करण्यासाठी वाद्य वाजविण्यासाठी मी आमंत्रित केले आहे. तेव्हा आपला काठावर बांधलेला ताराफा सोड व पलिकडच्या किनाऱ्याला घेऊन चल. सदर गाण्यातून वारली स्त्रीचा गौरीच्या सणाकडे पाहाण्याचा दृष्टिकोन व सण साजरा करण्यामागील तिचा उत्साह किती दांडगा आहे, याची कल्पना येते.

गौरीचा गण

गण गौरीचे नंदना

आरती घेऊन करू भोजन

पहिला करू हिरोबाला

नंतर करू हिमायीला

दुसरी करू गावदेवीला

नंतर करू वाघोबाला

तिसरी करू चोडोबाला



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नंतर करू मारुतीला

चवथी करू गणपतीला

नंतर करू गवरायीला

वात गावानुसार बदलणाऱ्या देवतांच्या नावे आणि क्रम वगळता, पहिल्या गीतासारखे नमन गितच आहे.

गौरीची कथा-व्यथा

गऊर खेलायला गेली

गऊर खेलून घरी आली

हाका मारीते सासऱ्याला

हाक मारीते सासूला

उघडा दाराची कुलूपा

मला घरात येऊ द्या

गऊर घरात शिरली

सासूनं धरली

सासऱ्यानं मारली

नंदेनं धरली

नवऱ्यानं मारली

भावड्यानं धरली

नवऱ्यानं मारली

ओढून टाकली अंगनामधी

गऊर वनवासाला गेली

अंगावर घंगाल्याच्या पुरू गेली

पाटलाच्या वलेला हाका मारी,

पाटलीन बाई पानी पाजा गवरायला

पाटलीन घराबाहेर आली छी छी करत घरात गेली

गेली वारल्याच्या वलेला गेली

कोल्याच्या वलेला

पानी पाजा गवरायला

वारलीन घराबाहेर आली

कोलीन घराबाहेर आली

पानी वाढलं गवरायला

गऊर पुढे निघून गेली गेली

महाराचे वलीला हाका मारी

महारीनबाई पानी पाजा गवरायला

महारीन घराबाहेर आली

धरला गवरायचे हाताला

नेऊन पाटार बसवलं

गौरायच्या आंघोला केला

गौरायला भोजन वाढली

गवराय भोजनी बैसली

भोजन आटोपून शांत झाली

गवरायची माथी उकलली (माथी उकलली – केस मोकळे सोडले)

निघून गेली वनामधी

ह्या अश्या गीतांमध्ये स्त्रिया आपल्या व्यथा गाताना दिसतात. हयात सासरच्यांचा त्रास आणि त्यावर प्रतिक्रिया म्हणून तिने घर सोडत स्वतंत्र होण्यासाठी दाखवलेली हिम्मत ही पंढरपेश्या समजपेक्षा नक्कीच वेगळी आहे.

संदर्भग्रंथ सूची

१. सदानंद राणे, लोकगंगा-महाराष्ट्रातील लोककला आणि लोकनृत्य, प्रथम आवृत्ती, डिंपल पब्लिकेशन,ठाणे.

२. डॉ. भगवान राजपूत, पालघर जिल्हा आदिवासी समाज लोकजीवन व लोकसाहित्य, अथर्व पब्लि0केशन,

३. डॉ. पंजाब शेरे आणि डॉ. राजू मोतेराव, आदिवासी साहित्य:जाणीव व जागर

४. डॉ. धनाजी गुरव, आदिवासी साहित्य, शब्दालय प्रकाशन

५. डॉ. महेंद्र गावीत, आदिवासी मावची जमातीची लोकगीते

६. आदिवासी वारलींचे लोकसाहित्य

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तळटीप

१. घुंगरू बांधलेल्या काठीला हातात घेऊन नृत्याला वळण देणारा व्यक्ती

२. सुकलेला लांबट दुधी भोपळा, बांबूच्या दोन नळ्या आणि ताडाची पाने यांच्या कुडु साझाने हे वाद्य बनवितात. गारुड्याच्या पुंगीसारखे हे वाद्य दिसते. बांबूच्या नळ्या भोपळ्याच्या एका बाजूस असतात. त्या आवळ्याच्या पाव्यासारख्या असतात आणि दुसऱ्या बाजूस भोगा असतो. हा भोंगा माडाच्या झावळापासून तयार करतात.

३. बकऱ्याच्या कमावलेल्या कातड्याने ते मढवितात. ते वाजविण्याच्या अगोदर विस्तवावर शेकतात. त्या ढोलीची एक बाजू कधी टिपरीने किंवा दोन कांड्यांनी वाजवितात. ढोलाचे दुसरे तोंड बोटांनी व मनगटाने वाजवितात.

४. वाडवळ, पाठरेप्रभू, आगरी, कुणबी, चौकळशी, भंडारी आणि इतर अनेक उपजाती.

५. तांदळाच्या पिठाचा गूळ घालून केलेला गोड पदार्थ

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CRISS-CROSS CORRIDORS OF TWO BOLLYWOOD FILMS: *KABIR SINGH* AND *JERSEY* THROUGH THE LENSES OF R.W. CONNELL'S THEORY OF MASCULINITIES.

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Abstract

Popular culture's (literary texts or media) representation of masculinity has a direct impact on the masses as being very powerful and influential agents. It has always generated discussion and intrigue at the same time. R.W. Connell's theory of masculinities provides insights into the perpetuation and challenge of hegemonic masculinity in popular culture. The present paper examines the two Indian films Kabir Singh and Jersey through R.W. Connell's theory of masculinities. The research paper aims to analyze the representation of masculinity in select movies. The research methodology involves content analysis and comparative analysis. The study uses a critical qualitative analysis of the movies to examine the characters, stories, and social circumstances in Jersey and Kabir Singh. It also tries to analyze the impact of the portrayal of masculinity in the movies on the viewer's perceptions of male identity. In the process, it attempts to identify the extent to which the movies reinforce or challenge existing norms and stereotypes of masculinity. The research clarifies how these films mirror and critique conventional ideas of masculinity in Indian culture. The paper argues that the films offer complex and nuanced representations of masculinities, challenging traditional gender norms while also reinforcing them to some extent. The study provides insights into how popular culture perpetuates and challenges hegemonic masculinity, offering implications for future research and social interventions aimed at promoting more inclusive and equitable gender norms.

Keywords: *R.W. Connell, Masculinities, Hegemony, Subordinate, Bollywood, Kabir Singh, Jersey, marginalized.*

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- **Dr Jyoti S. Mundhe**

Introduction:

R. W. Connell is an Australian sociologist who developed the theory of masculinities, which explores how different forms of masculinity are constructed, maintained, and enforced in society. According to Connell, masculinity is not a fixed biological trait, but rather a social construct that is shaped by cultural, economic, and political factors. She defines masculinity as a socially constructed set of behaviors, attitudes, and characteristics that are associated with being male within a specific cultural and historical context, including the dominant form of masculinity known as hegemonic masculinity.

Popular culture's representation of masculinity has always generated discussion and intrigue. The study provides insights into the perpetuation and challenge of hegemonic masculinity in popular culture. The theory of masculinities by R.W. Connell offers a thorough framework for examining the complexity and variety of male identities. This study applies Connell's theory to critically examine the portrayal of masculinities. The selected movies are the best examples of how masculinity is created, negotiated, and challenged in Indian cinema. To provide a critical analysis of the chosen texts, and investigate their representations of masculinity through R.W. Connell's theory of masculinities, it is indispensable to briefly summarize the main features of the films *Kabir Singh* and *Jersey*.

1. *Kabir Singh*: Sandeep Reddy Vanga is the director of the 2019 Hindi film "Kabir Singh." Remade from the Telugu movie "Arjun Reddy." The film's main character is Kabir Singh, a talented but irritable medical student who, after experiencing heartbreak, descends into destructive behavior. Due to its portrayal of toxic masculinity and promotion of aggressive behavior, the movie enjoyed both commercial success and controversy.

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2. *Jersey*: Gowtham Tinnanur is the director of the 2020 Hindi film *Jersey*. It is a remake of the same-named Telugu movie. The story of Arjun, a gifted cricketer in his mid-thirties, who attempts to make a return in the sport while dealing with personal and professional obstacles, is told in the film. *Jersey* won praise from critics for its subtle storytelling and emotional complexity.

Thus, *Kabir Singh* is a more commercial film that is driven by its star power and its controversial subject matter. *Jersey* is a more personal film that is focused on its characters and its message of hope. However, both films are worth watching for their unique strengths and weaknesses.

Theoretical Framework:

The present paper uses R.W. Connell's theory as an analytical framework to examine and contrast how masculinities are portrayed in *Kabir Singh* and *Jersey*. The paper is based on the hypothesis *Kabir Singh* and *Jersey* represent different types of masculinities. Kabir Singh represents a toxic and hegemonic kind of masculinity and Jersey represents a more sensitive and progressive one providing a more complex and nuanced representation of male identity in cinema.

A great and extensive amount of research has been produced by applying Connell's gender and hegemonic masculinity theories to various texts. Many scholars have researched and analyzed the portrayal of masculinity in Indian cinema and how it reflects Indian society and its cultural norms. However, the research on the film *Jersey* has been overlooked, despite its potential to depict positive and non-hegemonic forms of masculinity. While some research has been conducted on exploring masculinity in Indian cinema, there is still a gap in the literature. Existing studies have predominantly focused on female victimization and feminist movements, leaving room for a more in-depth analysis of masculinity.

Connell's theory of masculinities emphasizes that masculinity is not a monolithic, fixed concept, but rather a complex and dynamic social process that is shaped by a variety of factors. It's important to note that these forms of masculinity are not mutually exclusive, and a person can embody multiple forms of masculinity at different times or in different contexts. Furthermore, the types of masculinity valued and privileged in a given society can change over time and are influenced by a variety of factors such as social, cultural, and economic changes.

The theory is more relevant than at any time in a world gender order that continues to favor men over women while also raising difficult issues for men and boys. This theory is the fundamental study of masculinity as a foundational factor in modern social inequality, as well as one of the most influential books in the social

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sciences in recent times. The theory states, there is no such thing as a singular masculinity. According to the book, various types of masculinity vary over time, across cultures, and among individuals. The main ideas in this book are an important part of contemporary society's discussions and their applicability in our daily lives.

Analysis:

Underlying themes in both films explore the drawbacks and restrictions of carefully upholding hegemonic masculinity. The movie *Kabir Singh* illustrates how toxic masculinity can be harmful since Kabir's erratic actions have negative effects on his personal and professional life. The movie drew criticism for glorifying Kabir's abusive behavior and failing to appropriately explore its detrimental ramifications. However, *Jersey* adopts a more nuanced approach by emphasizing the value of emotional openness and personal development. The idea that masculinity should only be characterized by physical domination or strength is contested by Arjun's journey. The movie presents a more optimistic and inclusive view of masculinity by highlighting the importance of tenacity, emotional fortitude, and the capacity to face one's vulnerabilities.

Kabir Singh primarily maintains and portrays hegemonic masculinity because its protagonist exhibits aggressive and violent behavior. Through supporting players who facilitate and excuse the protagonist's harmful behavior, the film depicts complicit masculinity. In contrast, *Jersey* challenges conventional ideas of masculinity by focusing on vulnerability and personal development. It questions hegemonic masculinity's definition and offers glimpses of subordinated masculinity through people who negotiate their desires and social pressures. *Kabir Singh* presents a complex portrayal of masculinities, primarily focusing on hegemonic and toxic masculinity. The film depicts the consequences and negative impacts of these forms of masculinity on individuals' mental health, relationships, and overall well-being, while also highlighting the need for broader discussions on healthier and more inclusive forms of masculinity.

Jersey showcases the transformative potential of masculinities. Arjun's journey represents a shift from a single-dimensional understanding of masculinity to a more inclusive and balanced portrayal that encompasses emotional connection, sacrifice, and personal growth.

According to Connell's theory, there is a dominating kind of masculinity known as hegemonic masculinity that serves as the benchmark for all other masculinities. In the movie "Kabir Singh," the title character represents a typical manifestation of hegemonic masculinity. He is described as being violent,

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domineering, and emotionally unstable, frequently using violence to impose his will. Kabir's actions conform to the stereotypical image of a macho, dominating male figure. However, *Jersey* challenges this idea by offering a more complex examination of masculinity. The main character, Arjun, is originally shown as a failing cricketer who battles with his self-esteem and societal expectations. He challenges the conventional notions of hegemonic masculinity as the plot develops by learning to embrace weakness and express his emotions.

Certain masculinities are marginalized or oppressed within the dominant system, according to Connell's theory. In "Kabir Singh," marginalized masculinities are only briefly explored. The interconnectedness of masculinity with other social identities is mostly ignored as the movie concentrates primarily on the experiences of wealthy, upper-caste, and heterosexual men. The film's ability to convey a thorough grasp of masculinity is constrained by this omission.

As opposed to this, *Jersey* focuses more on the experiences of marginalized masculinities. The main character, Arjun, is portrayed as an aging cricketer who has setbacks and social pressures as a result of his age, career, and financial difficulties. The movie offers a more nuanced picture of marginalized masculinities by reflecting on the difficulties faced by middle-aged men seeking to achieve success in a field that is dominated by young people.

The analysis of the portrayal of masculinity in *Kabir Singh* and *Jersey* using Connell's theory of masculinity as a framework revealed that both of the male protagonists of the movies depicted different forms of masculinity. Dominant forms of masculinity including the hegemonic and hypermasculine portraits were depicted in both the characters while also showing some moments of vulnerability and introspection. *Kabir Singh* is a romantic film whereas *Jersey* is a sports drama. Although their genres were different, the comparison between the two movies highlighted the nuances in the portrayal of masculinity across different contexts and genres within Indian cinema.

While the titular protagonist of *Kabir Singh* showed predominantly hegemonic masculinity, the protagonist of the film *Jersey* has depicted various masculinities at different points of time throughout the film. Thus, the comparison of masculinity in the movies *Kabir Singh* and *Jersey* has revealed significant insights into different forms of masculinity portrayed in Indian cinema.

Since the time Connell propounded her theory, the most traditional and most acceptable form of masculinity has been hegemonic masculinity. The ideals of hegemonic masculinity are unrealistic and unattainable by most of the common men. Hence there is a need to give importance to other forms of masculinity as well.

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Arjun in *Jersey* represents a different form of masculinity from hegemonic masculinity as he represents a more inclusive, caring, and emotionally intelligent form of masculinity.

Kabir represents a traditional form of masculinity characterized by violence, aggression, and dominance. Hegemonic masculinity is defined by Carner as the idealized form of masculinity that represents the cultural norm and is often associated with power and privilege.

Kabir has been shown as being in total control of his life and his surroundings and his behavior is justified by his status as a successful doctor and his ability to win over the love of his life.

Arjun in *Jersey* is portrayed as a more sensitive and emotionally available character who challenges the traditional notion of masculinity. He is shown as a devoted husband and a father who values relationships and feelings over material success. This form of masculinity represents a shift towards a closer caring masculinity which is not defined by traditional gender roles but instead values relationships, emotions, and personal growth. Arjun is a stay-at-home father and he does not mind performing all the duties that supposedly a mother has to perform for their child such as dropping the child off at school or packing his school bag. He is involved in the upbringing of his child and he shares equal responsibility with his wife in looking after his son. This was against the hegemonic masculine order which stereotypes males as being independent and the primary breadwinners. Arjun is financially dependent on his wife hence society judges him at every step for not being a "successful man".

In addition to the analysis of *Kabir Singh* and *Jersey*, it is important to consider the broader societal context in which these movies are situated. Indian society, like many others, has a history of traditional gender roles that have perpetuated certain forms of masculinity while suppressing others. These gender roles have been shaped by cultural, social, and religious norms that have been passed down over generations.

There are several stereotypes placed on men which are that men are the breadwinners and they have to be tough, active, successful, and strong. These are the characteristics that are expected out of a man. The gender stereotypes based on physical appearance, social behavior, interests, and roles performed are different for men and women. Regarding the social behavior of men and women, society prescribes a set of rules such as that men should be physically violent and aggressive and men are not supposed to be emotional because men who are not aggressive or emotional are "unmanly".

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Men feel a tremendous pressure on them to live up to the standards set by the society. Men are supposed to act brave and confident even if they feel nervous or scared inside. Several stereotypes believe that men should use violence to get respect if necessary. These gender-specific stereotypes put men and women into a box type of thinking. However, it should be remembered that there are more genders than just men and women.

People share the common belief that men do not have to cry, this belief is in itself toxic because it supports repressing emotions within oneself. Kabir has been seen repressing his emotions throughout the movie which ultimately leads to his downfall and consequent drug addictions. It adversely affects his mental health and he suffers from depression. Whereas, on the other side, Arjun from *Jersey*, openly expresses his emotions and is in a better state of mental health compared to Kabir. Arjun is a good-hearted human being, he tries to do the right thing every time. He is hard-working, self-sacrificing, loving, caring, protective about family, and fatherly. Men like Arjun who show traits of subordinate and marginalized masculinity are not given equal representation and importance compared to men who fit into the hegemonic form of masculinity like Kabir which is supposed to be the "macho man" representation.

Connell's theory of hegemonic masculinity helps to explain how these traditional gender roles are perpetuated and reinforced in society. It is important to recognize that the hegemonic form of masculinity, as exemplified by Kabir Singh, is not the only form of masculinity that exists. There are other forms of masculinity, such as the more inclusive and emotionally intelligent form represented by Arjun in *Jersey*, that challenge traditional gender roles and norms.

Conclusion:

This study reveals the researcher's some of perceptions of these portrayals and their impact on gender attitudes and behaviors. The researcher has made a conscious effort to remain free from bias and form impersonal opinions on the subject.

In conclusion, the comparison of masculinities in *Kabir Singh* and *Jersey* through the lens of Connell's theory provides important insights into the different forms of masculinity that exist in Indian society. It is crucial to recognize that the traditional hegemonic form of masculinity is not the only form of masculinity that exists and that other forms of masculinity challenge traditional gender roles and norms. Furthermore, media plays a significant role in shaping societal attitudes toward masculinity, and it is important to consider the impact of media in shaping our understanding of gender.

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The research summarizes the results of the investigation of *Kabir Singh* and *Jersey* in light of R.W. Connell's theory of masculinities. It draws attention to the divergent portrayals of masculinity in the two films and their effects on cultural attitudes and gender dynamics. The article focuses on the significance of critically engaging with the plots and characters depicted in popular culture as well as the necessity of having a nuanced grasp of masculinity in Indian cinema. The research highlights the complexity and variety of male identities in the Indian setting, adding to the body of knowledge on masculinity studies.

The research compels people to challenge the stereotypical portrayals of masculinity often perpetuated in the media, fostering greater inclusivity and breaking down harmful gender norms. The discussion has promoted a more nuanced understanding and representation of diverse masculinities.

The paper has discussed the formation, negotiation, and difficulties of various types of masculinity within the Indian cinematic environment by critically analyzing the representation of masculinity in these Hindi remakes of Telugu films. *Kabir Singh* represents a traditional, hegemonic form of masculinity characterized by aggression, dominance, and toxic behavior. In contrast, *Jersey* presents a different form of masculinity that challenges societal norms, emphasizing empathy, vulnerability, and personal growth. It's crucial to analyze these representations critically which proves that although *Kabir Singh* promotes harmful parts of masculinity, *Jersey* makes an effort to convey a more progressive and inclusive viewpoint. R.W. Connell's theory of masculinities gives a deeper understanding of the representations and how they both reflect and defy social standards.

The study gives insightful analysis of how masculinities are portrayed in popular culture and adds to the larger conversation about gender and society. It is crucial to talk about stopping the harmful effects of toxic masculinity on society. The hegemonic masculine male should not be considered the ideal form of masculinity. Such harmful representations in media affect the psyche of young teenagers. Society needs to broaden its view and be more accepting of the different forms of being a

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male as there is no right way to be a man. Further research and exploration of Connell's theory can contribute to a deeper understanding of masculinities and their impact on society, encouraging positive change.

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थॅंक यू मिस्टर ग्लाड या कादंबरीचे अध्यापन

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थॅंक यू मिस्टर ग्लाड ही अनिल बर्वे यांची कादंबरी आहे. पॉप्युलर प्रकाशनाने तिची पहिली आवृत्ती १९७६ ला प्रकाशित केली. आजवर या कादंबरीच्या सहा आवृत्त्या प्रकाशित झाल्या आहेत. अनिल बर्वे यांच्या सदर पुस्तकासहित पाच कादंबऱ्या, सात प्रकाशित व एक अप्रकाशित नाटक, एक दीर्घकथा संग्रह व दोन लेखसंग्रह एवढे साहित्य प्रकाशित आहे. पत्रकार व राजकीय कार्यकर्ता असलेल्या अनिल बर्वे यांचे लेखन त्यांची भूमिका आणि अनुभवाची मांडणी या करीता सुपरिचित आहे थॅंक यू मिस्टर ग्लाड ही त्यांची पहिली कादंबरी.

कादंबरीच्या अध्यापनासाठी त्यांना कथनात्म साहित्यप्रकारांची विशेषत: कादंबरी या साहित्यप्रकाराची तपशीलवार माहिती द्यायची आहे, ती त्यांना घटक १ च्या अध्यापनान दिली जाईल. या पार्श्वभूमीवर थॅंक यू मिस्टर ग्लाड या कादंबरीचे अध्यापन करायचे आहे. या कादंबरीचा विचार वेगवेगळ्या दृष्टिकोनातून शक्य असला तरी अभ्यासक्रमातील कादंबरी या साहित्यप्रकारांतर्गत अध्यापनाचा मुख्य संदर्भ सदर टिपणात अपेक्षित आहे. थॅंक यू मिस्टर ग्लाड या कादंबरीचा विचार करताना कादंबरीचे कथानक, आशयसूत्रे, व्यक्तिरेखांची रचना, निवेदनपध्दती, भाषा व एकूण संरचना या मर्यादित हा विचार केला जाणार आहे.

थॅंक यू मिस्टर ग्लाड चे कथानक

ग्लाड हा राजमहेंद्री जेल चा सुपरिंटेंडेंट आणि फाशीची शिक्षा झालेला नक्षलवादी वीरभूषण पटनाईक यांच्या संघर्षाची तसेच ग्लाडच्या आंतरिक संघर्षाची ही कहाणी आहे. या कहाणीला काही राजकीय संदर्भ आहेत. ग्लाडच्या अधिपत्याखाली असलेल्या तुरूंगात फाशीची शिक्षा झालेला वीरभूषण पटनाईक हा कैदी येतो. अंगी कौर्य बाणलेला कैद्यांना अमानुष वागणूक देणारा ग्लाड वीरभूषणशी त्याच पध्दतीने वागण्याचा प्रयत्न करतो. वीरभूषणचे धैर्य आणि ठामपणा त्याना अनपेक्षित आहे. ग्लाडचे कौर्य आणि वीरभूषणचे धैर्य यांच्यातील संघर्ष उत्तरोत्तर वाढत जातो. दरम्यान घडलेल्या वेगवेगळ्या घटनांमुळे एका टप्प्यावर हा संघर्ष ग्लाड विरूध्द वीरभूषण असा न राहता तो ग्लाडचा आंतरिक संघर्ष बनतो. वीरभूषणला फाशीचा कैदी, छळास पात्र गुन्हेगार म्हणून मानण्यापासून क्रांतिकारक व वीरमरणास पात्र सैनिक म्हणून कॉम्रेड म्हणून मान्यता देण्यापर्यंतचा ग्लाडचा प्रवास होतो. आपल्यावर कर्तव्यभंगाचा गुन्हा दाखल होईल याची जाणीव असून वीरभूषणला फाशी देण्याऐवजी गोळी घालून ठार मारतो. कादंबरीचे कथानक म्हणावे, तर इतकेच आहे. (विद्यार्थ्यांसाठी आपण यात कादंबरीतील अधिक घटनांची भर घालून विवेचन करू शकतो.) या मुख्य कथानकास ग्लाड, त्याचे पूर्वायुष्य, त्याची मुलगी जेनी, वेंधळा जमादार यांची उपकथानके आहेत. ही उपकथानके मुख्य कथानकास पूरक आहेत.

ग्लाड हा ॲंग्लो–इंडीयन, त्याचे लग्न मरियम उर्फ मारा या जर्मन ज्यू स्त्रीशी झाले आहे. ती दुसऱ्या महायुध्दाच्या काळातील नाझी वंशवादाचा बळी ठरलेली आहे. आपण मरियमला वाचवू शकलो नाही, नाझींच्या कौर्यापुढे ठामपणे उभे राहू शकलो नाही याची ग्लाडता खंत आहे. या घटनांनी ग्लाडच्या व्यक्तिमत्वावर खोलकर परिणाम झाले आहेत. माराच्या माघारी ग्लाडने जेनीची वाढ परदेशातच केली आहे. वाट्याला आलेल्या कौर्याची छाया तिच्यावर पडू नये याची पूरेपूर काळजी त्याने घेतलेली आहे. मारा, रातराणी आणि जेनी या त्याच्या आयुष्यातील हळव्या जागा आहेतत्र वीरभूषणचा त्याच्यावर झालेला परिणाम जेनीला माहिती आहे. वीरभूषणचे मृत्यूपत्र तिला एखाद्या कवितेप्रमाणे वाटते. आपल्यापोटी वीरभूषणसारख्या मुलाने जन्म घ्यावा अशी तिची रोमॅंटिक इच्छा आहे. जेनीच्या बाळंतपणाच्यावेळी सर्जन असलेल्या वीरभूषणने केलेली मदत ग्लाडला आमूलाग्र बदलवून टाकते. तो आधी उल्लेखिल्या प्रमाणे वीरभूषणला फाशी न देता (कथित) वीरमरण प्राप्त करून देतो.

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'थँक यू मिस्टर ग्लाड' ला असलेले संदर्भ

या कादंबरीला राजकीय विचारप्रणालीचे दाट संदर्भ आहे. कादंबरीतील एक मुख्य व्यक्तिरेखा वीरभूषण पटनाईक हा फाशीची शिक्षा झालेला नक्षलवादी आहे. नक्षलवाद ही हिंसेवर विश्वास असलेली अतिडाव्या, माओ व लेनिन यांना मानणाऱ्या कम्युनिस्ट गटाची विचारधारा आहे. चारू मुजूमदार, कनू सान्याल व संथाल यांनी पश्चिम बंगालमधील नक्षलबारी या भागात जमिनीच्या पुनर्वाटपाकरीता केलेल्या रक्तरंजित संघर्षामुळे या चळवळीला नक्षल चळवळ संबोधले गेले. पुढे या चळवळीचे रूप बदलले. यासंदर्भात ही चळवळ आणि शासन यांच्यातील संघर्षाचे हिंसक अध्याय आहेत. सध्या नक्षलवाद दहशतवादाचे, देशद्रोहाचे एक रूप मानले जाते. आपल्या येथील हेतू कादंबरीच्या संदर्भातील नक्षलवादाची प्रस्तुतता समजावून घेण्याइतपतच आहे. प्रस्तुत निबंधवाचकास नक्षलवादाचा विश्वास असलेल्या हिंसेचे समर्थन अपेक्षित नाही. (विद्यार्थ्यांना अध्यापन करताना याचे भान आपल्याला ठेवावे लागणार आहे.) कादंबरी ज्या काळात लिहिली गेली त्या काळात कम्युनिस्ट व समाजवादी विचारांचे आकर्षण समाजातल्या वेगवेगळ्या विशेषत: बुध्दिजिवी वर्गास होते. परिवर्तनसंबंधीचा आशावादी कालखंड होता. कादंबरीतील वीरभूषण सर्जन आहे हे यासंदर्भात सूचक आहे. वीरभूषणने केलेले मृत्यूपत्र म्हणजे नक्षलवादाचा जाहिरनामा आहे. कादंबरीतील हा सर्वात स्फोटक भाग आहे. कादंबरीच्या एकूण रोमँटिक आवरणात तो दडलेला आहे. वीरभूषणची मार्क्स, लेलिन, माओ यांच्या विचारांवर श्रध्दा आहे. कष्टकऱ्यांचे शासन येण्यासाठी सशस्त्र, हिंसेवर आधारीत कृती केली पाहिजे अशी त्याची धारणा आहे. दयेचा अर्ज करणे चळवळीचा अपमान ठरेल असे त्याला वाटते. तो आपल्या कृत्यांना क्रांतीच्या वाटेतील एक पाऊल मानतो. एका व्यक्तीच्या मरण्याने ही क्रांती थांबणार नाही, ती जनता पुढे नेईल असे त्याला वाटते. शासन आपले प्राण हिरावून घेऊ शकेल, विचार नाही असे तो मांडतो. आपले शरीरही संपत्ती मानून तिचे वाटप भाडवलदार वगळून इतर समाजात व्हावे अशी त्याची अंतिम इच्छा आहे. वीरभूषणचे हे मृत्यूपत्र ग्लाडला धैर्याचा, विचारांवरील अविचल निष्ठेचा नमुना वाटते. जेनीला हे मृत्यूपत्र उत्तम काव्य वाटते.

सदर कादंबरीला दुसऱ्या महायुध्दा दरम्यानच्या नाझी वंशवादाचा संदर्भ आहे. ग्लाड स्वत: या वंशवादाचा बळी आहे. नाझींचे क्रौर्य त्याने अनुभवले आहे, तरीही तो त्याच क्रौर्याचा अवलंब करतो. आपली त्यावेळची हतबलता नंतरच्या काळात क्रूर वागून बाहेर काढण्याचा प्रयत्न करतो. ग्लाड्ची पत्नी मारा मात्र या अन्यायाविरूध्द झुकत नाही. विचारांकरीता मरणे तिला मान्य आहे, पण शरणागती कबूल नाही. ग्लाडचे दयेकरीता याचना करणे तिला भेकडपणाचे वाटते.

कादंबरीत या विचारप्रणालींचे संदर्भ आलेले असले तरी त्यांची चिकित्सा नाही. कादंबरीतील व्यक्तींच्या मनातील विचारप्रणालीसंदर्भातील संघर्षापेक्षा बाह्य, कृतीपातळीवरील विवेचनास प्राधान्य दिले आहे. ग्लाडचे वीरभूषणला नमविण्याचे प्रयत्न आणि त्याविरूध्दात वीरभूषणचा संघर्ष यावर जास्त भर दिला आहे. वीरभूषणच्या या ठामपणामागे त्याची विचारप्रणाली आहे, तर ग्लाडच्या क्रौर्यामागे शासनाची दमनकारी भूमिका अशा स्वरूपात हा संघर्ष पुढे येतो. ग्लाडचे परिवर्तन होते, परंतु त्यामागे वीरभूषणचा विचारव्यूह पटला असे नाही. ग्लाडचे काही व्यक्तिगत अनुभव, त्याचे पूर्वायुष्य, वीरभूषणने त्याला केलेली मदत यातून ग्लाडचे परिवर्तन होते. विद्यार्थ्यांना या विचारप्रणालींची ओळख करून देणे कादंबरीच्या अध्यापनास उपयुक्त ठरेल.

थँक यू मिस्टर ग्लाडमधील व्यक्तिरेखा

अत्यंत ठाशीव व्यक्तिरेखा हा या कादंबरीचा महत्वाचा विशेष आहे. कादंबरी ग्लाड हा वीराभूषण यांच्या संघर्षावर उभी आहे. यातील वीरभूषण ही स्थीर तर ग्लाड ही विकासी व्यक्तिरेखा आहे. वीरभूषणच्या तुलतेन ग्लाडची व्यक्तिरेखा अनेक गुंतागुंतीच्या छटा असलेली आहे. बुटाचा सोल फाटेपर्यंत कैद्यांची चामडी लोळविण्याची इच्छा असणारा ग्लाड रातराणी बद्दल हळवा आहे. बाहेर आरडाओरडा करून मारहाण करून दहशत निर्माण करणारा ग्लाड अंतर्यामी घाबरलेला आहे. महिला कैद्याला अंगाखाली घेण्याची इच्छा असणारा ग्लाड मुलीच्या आठवणीने निवळतो. दिडशे जणांना फाशी देणाऱ्या ग्लाडला वीरभूषणने दयेचा अर्ज करावा असे वाटते, त्याकरिता तो त्याला

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मारहाणही करतो. वीरभूषणच्या पत्नीला तासनतास उन्हात उभे करून घरी जाताना तिला आपल्याकडील पैसे पाठवितो. शिव्या देतो तशा कविता व गाणीही म्हणतो. अशा ग्लाडचे होणारे परिवर्तन वाचकाला आवडते. त्याचे बाहेर येणारे चांगुलपण वाचकाला सुखावते.

वीरभूषण ही पारंपारिक पध्दतीने नायकत्व बहाल केलेली व्यक्तिरेखा आहे. वीरभूषण शूर, करारी, धाडसी, परिवर्तनवादी, अन्यायाचा प्रतिकार करणारी भूमिका असणारा व त्या दिशेने कृती करणारा, विचारांवर निष्ठा असलेला, त्याकरिता मृत्यूही पत्करणारा, मरणानंतरही आपण समाजाच्या कामी यावे अशी इच्छा असणारा, त्यागी, उच्चशिक्षित, मायकोवस्कीच्या कविता वाचणारा, स्त्रीयांबद्दल आदरभाव असणारा, शत्रूच्याही मदतीला जाणारा, सगळयांशी मैत्रभाव असणारा, सर्वांना आवडणारा, कवीमनाचा, आदर्शवादी, रोमँटिक असा आहे. तो तसा असावा याची पुरेपूर काळजी लेखकाने घेतली आहे. वीरभूषण हा लेखकस्वर आहे असे आपल्याला सातत्याने जाणवते. वीरभूषणने केलेल्या कृती, त्याचे बोलणेचालणे, वर्तन, त्याचे मृत्यूपत्र, त्याच्याविषयी इतर पात्रांचे निवेदन यांची उदाहरणे घेऊन लेखक व्यक्तिरेखेची उभारणी कशी करतो, लेखकस्वर म्हणजे काय इत्यादी बाबी विद्यार्थ्यांना समजावून सांगता येतील. कादंबरीतील काही उताऱ्यांचे प्रत्यक्ष वाचन यासदर्भात उपयुक्त ठरेल.

वीरभूषणची पत्नी, ग्लाडची पत्नी मरियम उर्फ मारा आणि जेनी या स्त्री व्यक्तिरेखा या कादंबरीत आहेत. करारी, विचार व भूमिकांवर ठाम विश्वास असलेल्या, त्याकरिता छळ, हालाअपेष्टा पत्करणाऱ्या प्रसंगी मृत्यू पत्करणाऱ्या आपल्या पतींकडून तशाच निर्धाराची अपेक्षा करणाऱ्या मारा व वीरभूषणची पत्नी या व्यक्तिरेखा आहेत. जेनी ही व्यक्तिरेखा पारंपारिक रोमँटिक नायिकेप्रमाणे आहे. कवीमनाची, सुंदर, राजकन्येप्रमाणे वाढविलेली, कविता लिहिणारी, वीरभूषणने आपल्या पोटी मुलगा म्हणून जन्म घ्यावा अशी स्वप्नाळू अपेक्षा बाळगणारी आहे. कादंबरीतील या स्त्री व्यक्तिरेखा फार गुंतागुंतीच्या व अधिक छटा नसलेल्या आहेत. वीरभूषण आणि ग्लाड यांच्यातील संघर्षावर त्यातील नाट्यावर कादंबरी केंद्रित असल्यामुळे इतर व्यक्तिरेखांना गौण स्थान मिळालेले आहे.

५. कादंबरीचे निवेदन, भाषा व संरचनात्मक विशेष

थँक यू मिस्टर ग्लाड या कादंबरीचे निवेदन अन्यपुरूषी आहे. सर्वसाक्षी निवेदक जेलचे आवार, बराकी, फाशीची कोठडी, ग्लाडचा बंगला यांचे वर्णन करतो. अर्थात हे वर्णन तटस्थ नाही. कादंबरीतील पात्रांची मनस्थिती, वातावरणातील ताण, घटनेची पार्श्वभूमी याकरिता हे वर्णन उपकारक ठरते. किंबहुना भौतिक गोष्टींच्या वर्तनात त्या गोष्टींना मानवी भावनांशी हेतुतः जोडले जाते. जेलचा बंदिस्तपणा, तेथील घुसमट, ग्लाडची दहशत यांची उभारणी करण्याकरीता हे वर्णन केले गेले आहे. कादंबरीत जेलबाहेचा मुक्त अवकाश अभावानेच येतो. जेलबाहेरचा वीरभूषणची पत्नी वाटा पहात असलेला अवकाश रखरखतीत वैराण आहे. सबंध कादंबरीभर हा वातावरणाचा ताण जाणवेल अशी भाषिक रचना लेखकाने केली आहे. कादंबरीतील यासंदर्भातील उदाहरणे विद्यार्थ्यांना सांगता येतील. उदाहरणार्थ दिवस बंद्यांची काळजे कुरतडत उगवतो, ग्लाडच्या येण्याने पाखरांची किलबिल शांत होते, जेलमधील वडापिंपळाची झाडे अंग चोरून उभी राहतात, तर उत्तरार्धात वडपिंपळ सळसळतात, मातीचा मंद सुवास दरवळतो. विद्यार्थ्यांना दुसऱ्या एखाद्या संहितेतील मुक्त अवकाश व्यक्त करणारा नमुना दाखविणे उपयुक्त ठरेल. उदाहरणार्थ दिनानाथ मनोहर यांच्या रोबो कादंबरीतील बराकींचा बंदिस्त परिसर विरूध्द नायक छावणी सोडून बाहेर जातो तेथील परिसर.

थँक यू मिस्टर ग्लाड मधील पात्रांच्या कृतींबाबत केलेले निवेदन पात्रांच्या व त्यांच्यातील संबंधांच्या संबंधात पाहणे उपयुक्त ठरते. ग्लाड आणि वीरभूषणच्या कृती यासंदर्भात नमुन्यादाखल पाहता येतील. पूर्वार्धातील ग्लाड तिरस्काराने पाहतो, सातव्यावर आठवा सूर लावतो, गर्रकन वळतो, ओरडतो, कडाडतो, अंगावर धाऊन जातो, गचांडी धरतो, थोबाडात भडकावतो, संतापाने फणफणतो, कुणाला शिक्षा झाल्यास ब्रेकफास्टमध्ये चार अंडी, लोणी खातो, तर उत्तरार्धातील ग्लाडचे डोके बधीर होते, घशाला कोरड पडते, भोवळ येते, घोगऱ्या आवाजात सूचना देतो, पियानो वाजवतो दिवेलागण होते, ग्लाडचे मन कातरवेळेत जाते, उदास होते, मऊ बोलतो, त्याची खाडखाड वाजणारी पावले खरडू लागतात. तो अजिजीने बोलतो, वीरभूषणला आधी कैद नंतर आठसो बयालीस वरून पोरा, माय बॉय, व शेवटी कॉम्रेड म्हणून संबोधतो. उच्च स्वरात मुक्त असे गाणे म्हणतो. त्याच्या

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डोळ्याच्या कड्या ओलावतात, आसवांचे दोन थेंब मानेवर घरंगळतात. तर वीरभूषण आरामात बसतो, शांतपणे रोखठोक बोलतो, मंदस्मित करतो, चढत्या धारदार आवाजात ओरडतो, तपासणीच्या वेळी शांतपणे कपडे काढतो, दयेच्या अर्जाच्या कागदाची शांतपणे घडी करून साहेबाच्या खिशात घालून त्याची छाती थोपटतो, त्याच्या चेहऱ्यावरची सुरकुतीही हलत नाही, जेनीच्या भावनांपुढे निष्प्रभ होतो, त्याची छाती भरून येते, मरतांना ग्लाडच्या तोंडून कॉम्रेड ही हाक ऐकून समाधानाने हसतो. जेलच्या भिंती थॅंक यू मिस्टर ग्लाड म्हणतात.

कादंबरीतील नाट्यात्म संवाद हा महत्वाचा विशेष आहे. पात्रांच्या व्यक्तिमत्त्वाला उठाव देण्याचे काम हे संवाद करतात. ग्लाड आणि वीरभूषण यांच्यातील संघर्षाला हे संवाद परिणामकारक करतात. संवादाबरोबरच पात्राचे निवेदन, मनोगते, आठवणी, स्वप्ने यांचा विचार केलेला आहे. लेखकाने येथे वापरलेली शैली पारंपारिक लोकप्रिय कादंबऱ्याप्रमाणे आहे. विचारप्रणालींमधील संघर्ष या लोकप्रिय शैलीच्या आवरणाखाली आहे. विद्यार्थ्यांना कादंबरीतील अवतरणांची उदाहरणे देऊन हे समजावून देता येईल.

कादंबरीतील काळाची हाताळणी नैसर्गिक कालक्रमानुसार नाही. वर्तमानकाळ — भूतकाळ — वर्तमानकाळ अशा चक्रातून कादंबरीची कथा सांगितली गेली आहे. ग्लाडच्या आठवणी, निवेदकाने केलेले निवेदन यातून हे व्यक्त होते. ग्लाडचा भूतकाळ यातून विशेषरूपाने व्यक्त होतो. कादंबरीत नक्षलवादी असलेला वीरभूषण आधी तुरुंगात येतो. नंतर त्याची पार्श्वभूमी सांगितली जाते. कादंबरीतील या प्रसंगाची उदाहरणे देऊन हे दाखवून देता येईल.

कादंबरीचे मुखपृष्ठ तिच्यातील आशयाला पूरक आहे. काळी दमनकारी वज्रमूठ शोषक व्यवस्थेचे प्रतिक आहे, तर तिच्यातील जोमाने वर येऊ पाहणारा कम्युनिस्ट क्रांतीचे सूचन करणारा लाल हात, रोखून पाहणारा डोळा दमनाविरूध्द एकवटलेल्या चळवळीची सूचना करतो. पहिल्या आवृत्तीत असलेली पाठराखण आणि नव्या आवृत्तीची पाठराखण भिन्न आहे. पहिल्या आवृत्तीत लेखकाची ओळख आहे, तर नव्या आवृत्तीत कादंबरीविषयीची निरीक्षणे आहेत. विद्यार्थ्यांना पुस्तकाच्या मुखपृष्ठाचे व पाठराखणीचे असणारे महत्त्व या आधारे समजावून सांगता येईल.

थॅंक यू मिस्टर ग्लाड ही कम्युनिस्ट, नक्षल विचारांना मानणाऱ्या वीरभूषण पटनाईक व नाझी छळाचे चटके सोसलेल्या दमनकारी व्यवस्थेचे प्रतिनिधित्व करणाऱ्या ग्लाडमधील संघर्षाची कहाणी आहे. फारशा तत्त्विक चर्चेत न अडकता नाट्यात्म पध्दतीने परिवर्तनाची कथा व्यक्त होते.

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A review of botany, phytochemistry, and pharmacology of the mangrove apple *Sonneratia alba* J. Sm.

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ABSTRACT

Mangroves are salt-tolerant plants that form distinctive communities and ecosystems. To survive in a harsh environment, mangroves are believed to produce numerous phytochemicals. *Sonneratia alba* J. E. Smith is a true type of mangrove plant belonging to the family Lythraceae. This evergreen tree has been widely distributed in the Indo-West Pacific region and is a common species along both the east and west coasts of India. It is the maiden mangrove species in India that has received recognition as the state mangrove plant by the state of Maharashtra. This mangrove has been widely used in traditional medicine for treating skin disorders, bleeding injuries, diarrhea, and so on. Its bioactivity can be attributed to its phytochemical content, which is rich in phenolics, steroids, tannins, terpenoids, and so on. This review is an attempt to compile various phytochemical and bioactivity investigations done on *S. alba*. Results indeed showcase its therapeutic prospects as indicated by the wide range of secondary metabolites and biological activities.

INTRODUCTION

Plants and products derived from them have tremendous pharmacological importance. They produce a number of phytochemicals, many of which have ethnomedicinal applications and have also found a place as lead molecules for discovering new drugs [1,2].

Mangroves are special plants that have been used in folklore medicine for a long time. They have developed unique adaptations and several novel metabolites to tolerate and thrive in harsh, salty waters. Distributed in over 120 countries globally, they form unique and extremely productive communities with other mangroves and associated flora and fauna. They are also of ecological, economical, and medicinal importance. No wonder there exist numerous reports that establish the therapeutic potential of mangroves [3–6].

Sonneratia alba J. E. Smith is a true mangrove species. This evergreen tree is a core mangrove occurring in the Indo-West Pacific region of the globe [7]. Inspite of having numerous applications, a dedicated review on *S. alba* could not be found. Therefore, an attempt has been made to compile up-to-date information available on this plant to highlight its significance.

MATERIALS AND METHODS

Globally recognized databases such as Google Scholar, Scopus, PubMed, Scilit, ResearchGate, and Science Direct were screened to gather the reported work done on *S. alba*. The specific keywords included *Sonneratia alba*, *S. alba*, phytochemistry, pharmacognosy, antibacterial, mangrove, pedada, perepat, bioactivity, phytomedicine, pharmacological activity, and ethnobotany. While the focus has been on articles dated 2013 to 2023 (the last 10 years), few published before 2013 have been also included to avoid missing out on some important observations on the study plant. Relevant references cited in these articles were also considered to make this narrative review as complete as possible.

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RESULTS AND DISCUSSION

Classification and taxonomy

The name of genus *Sonneratia* has been conferred in honor of a French explorer and botanist, Petrre Sonnerat whereas the name of the species *alba* was given owing to the presence of peculiar white-colored stamens and petals in this species (*Alba* meaning white in Latin) [8]. Earlier this species used to be classified into the Sonneratiaceae family but phylogenetic studies using molecular markers have shown that Sonneratiaceae happens to be a sub-set of the family Lythraceae [9]. The Lythraceae family includes more than 30 genera having 620 plus species; the majority of which are widespread in tropical regions and few in temperate regions of the world [10].

Earlier, *Sonneratia* genus was represented by five main species viz. *S. alba* Sm., *Sonneratia ovata* Backer, *Sonneratia apetala* Banks, *Sonneratia griffithii* Kurz, and *Sonneratia caseolaris* (L.) Engler [11,12]. However, it was improved by the inclusion of *Sonneratia lanceolata* Blume [13], making it a total of six species that can be distinguished from each other on the morphological characters such as size and shape of the fruit and leaf, the color of the flowers, and so on. In the overlapping regions, these species often hybridize naturally, resulting in *Sonneratia* × *hainanensis*, *Sonneratia* × *gulngai*, and *Sonneratia* × *urama* [12]. The hybrids, however, exhibit reduced genetic fitness than their true parent species with a large number of sterile pollens [14,15].

English botanist Sir James Edward Smith in the year 1816 first described *S. alba* in Cyclopedia with a typified name of *Sonneratia acida* var. *mucronata*. Other synonyms for *S. alba* include *S. acida* Benth., *Sonneratia iriomotensis* Masam., *Sonneratia mossambicensis* Klotzsch *ex* Peters, and *Chiratia leucantha* Montr. *Sonneratia griffithii* Watson is now a synonym of *S. alba* Sm. [12,15].

This mangrove species is taxonomically classified as follows:

Kingdom: Plantae
Sub-kingdom: Viridiplantae
Infra-kingdom: Streptophyta
Phylum: Tracheophyta
Sub-phylum: Spermatophytina
Class: Magnoliopsida
Super-order: Rosanae
Order: Myrtales
Family: Lythraceae
Genus: *Sonneratia*
Species: *Sonneratia alba*

Sonneratia alba is most commonly identified as "mangrove apple" or "sweet-scented mangrove apple" for the apple-like fruits it produces. This mangrove is also known by several region-specific names as mentioned in Table 1 [12,14–22].

Botany

Sonneratia alba (Fig. 1) usually grows to a height of 10–15 m. However, shrub-like specimens of 3 m tall and huge trees growing to 30 m have also been occasionally found. The tree is branched and the creamish/brownish bark is characterized by longitudinal fissures. This mangrove is surrounded by thick, short, blunt pneumatophores having an average size of 25–30 cm. Leaves are glabrous, leathery, stalked, simple, opposite having elliptic to obovate shape. At the apex, they become sub-orbicular obtuse. Leaves are normally 5–12 cm in length having a breadth of 4–6 cm. The base of the leaf is narrowed into a short petiole of just 3–5 mm long. This mangrove produces bisexual, white-colored flowers (3–6 cm) which are usually present singly or at times, in groups of three. The petals are small and white. Six to eight lobes are present inside the calyx tube which resembles a cup. Sepals are long and have a green color outside and a red color inside. Stigma is capitate, style is around 4 cm long whereas the ovary is globose. Every flower has long, attractive, 5–8 cm long, white stamens which are many in number. Flowers are nocturnal; they open in the late evening and last only for that one night. The calyx is filled with large amounts of nectar, attracting insects (such as Hawk moths), birds, and mammals (bats) that facilitate its pollination [14,15]. Flowering season has been observed to vary from country to country having different geographical and climatic conditions. In general, it usually flowers from February to July. Fruits are hard, around 4 cm in diameter, have a smooth surface, and are green in color. Around 150 small-sized, curved seeds are produced inside each fruit. The fruiting season depends upon the region-specific flowering season and in general, the fruiting is observed from August to February [15,23].

Global distribution

The species has a widespread global distribution in tropical and sub-tropical countries ranging from East Africa to northern tropical Australia (passing through India and South East Asia), the west Pacific Islands, and southwest Oceania. *Sonneratia alba* has been reported in more than 23 countries in

Table 1. Common and Vernacular names of *S. alba*.

Bengali: *Sadachak kvora*	Kannada: *Karpu*	Sinhala (Sri Lanka): *Kirilla, Kirala*
Chinese: *Bei e hai sang*	Konkani: *Pandhari Chipi*	Swahili (East Africa): *MLilana*
Khmer (Cambodia): *Ampouthmar, Rompea-chheu*	Marathi: *Karpu, Chipi*	Telugu: *Pedda Kalinga*
English: *Mangrove apple*	Malayalam: *Chakkarakaanal, Nokshathrakandel*	Tagalog/Filipino (Philippines): *Bunayao, Patpat, Bungalow, Pulalan, Ilukabban, Payan*
Indonesian: *Perepat, Posi-posi, Bidada, Pidada, Pedada, Bogem, Tumidao*	Malay: *Perepat, Pidada, Pedada*	Thai: *Lampoo thale, Lampoo talay*
Japanese: *Mayapushiki*	Odia: *Orua*	Vietnamese: *Ban dang*

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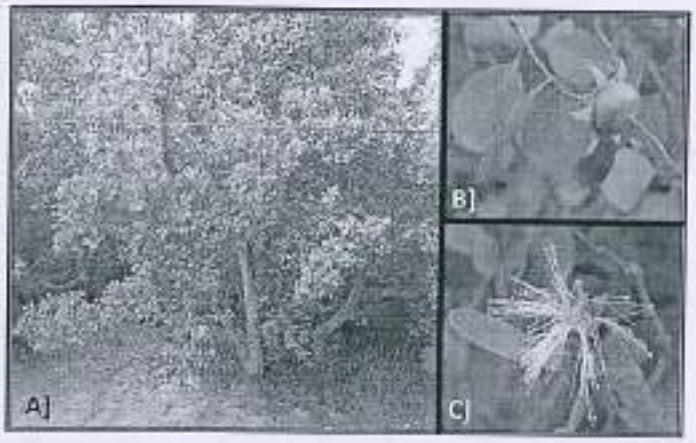


Figure 1. *Sonneratia alba* with its important parts. (A) Tree with spike-like pneumatophores. (B) Close-up of the leaves and fruit. (C) White flower (stamens) with pink colored base.

Africa, Asia, and Australia continents. Being a quite commonly seen species through most of its global range, it is categorized with the "Least Concern" tag in the IUCN's Red List Book of Threatened Species [24].

Habitat

It is a pioneer species which means that it prefers higher salinities of 18%–30% and is generally present on the seaward side (away from the mainland). It is unable to tolerate much of freshwater. It has been often found thriving in sandy clay habitats or on the recently developed mud flats but at times, has been also seen growing along rocky coastal shores [15,25].

Local and ethno-medicinal uses

Sonneratia alba is well-known by the locals for its edible fruit which is often consumed. In the Goa state of India, ripe fruits of *Sonneratia* sp. are used for making curries while unripe ones are used in making jellies [25]. They are also used in making pickles and vinegar. Tribals of Bhitarkanika Wildlife Sanctuary in Odisha state, India have been preparing a vegetable using it [18]. Cakes are also made for eating [26]. The bark is used for the extraction of tannins and as a source of fuel whereas honey is also gathered thanks to its nectar-producing flowers [23]. Wood is utilized for making boxes, as a packing material as well as in the building material. In the Sulawesi province of Indonesia, boats and houses are constructed using the timber of *S. alba*. There are reports of bridges, cabinets, wharfs, furniture, floorings, and musical instruments being made from wood. Tribal folks from Papua New Guinea have been making use of pneumatophores in making floats and corks [15]. Fishing communities of East African coastal countries have been using *S. alba* wood for making ribs and keels of large watercraft (dhows) and also in oars, paddles, and masts [20,27]. Bark extract has been regularly used by natives in Indonesia to delay the fermentation and thereby preserve the alcoholic, palm tree-based drink [28].

Traditional healers and tribes have been using this plant for treating health ailments. Extracts or pulp from the fruit are used as a poultice for treating muscular swellings and sprains. A compression is made using the fruit pulp and is applied to stop hemorrhage. It is also used to cure various skin disorders [15]. The plant is believed to have antiseptic properties. *Sonneratia alba* is commonly used in Indian and Indonesian folklore medicine for treating injuries (sprains and wounds), diarrhea, and fever [18,21,23].

Phytochemistry

Plants produce phytochemicals in the form of primary and secondary metabolites. The former is involved in metabolic activities, while the latter is involved in protecting the plant from the attack of herbivores by playing a crucial role in the defense mechanisms [1]. Members of the genus *Sonneratia* are rich sources of phytochemicals [29]. Primary metabolites in *S. alba* include various carbohydrates and sugars, proteins and amino acids, lipids and fatty acids whereas a wide range of secondary metabolites belonging to classes such as triterpenoids, phenolics, steroids, and so on, have also been documented.

Several reports are available involving qualitative as well as quantitative analyses, showing the presence of all major phytochemical classes such as alkaloids, phenolics, flavonoids, saponins, tannins and terpenoids, quinones, and steroids in *S. alba* leaf, fruit, bark samples indicating it produces a wide range of primary as well as secondary metabolites [30–35].

Table 2 depicts the proximate elemental content in different parts of *S. alba* [36–41]. Values seem to vary in different parts. Analyzing ion concentrations of Na^+, Cl^-, and K^+ is essential in the case of mangroves such as *S. alba* that grow in a harsh, saline habitat. Stress experienced from such abiotic factors acts as inducers in mangroves leading to the production of novel metabolites [5].

The composition of natural saturated, monounsaturated, and polyunsaturated fatty acids was studied in the freshly collected leaves and stems. Results indicated that *S. alba* can act as a rich alternative source of natural essential fatty acids (EFAs), predominantly gamma linolenic acid (GLA). Higher percentages (36%) were found in leaf samples whereas stem had 11% GLA. EFAs are required in important metabolic reactions governing normal body functioning and are known to prevent the risk of heart attack and cancer [42].

From the elemental analysis of *S. alba* fruits and flour, it was evident that content and nutritional value in terms of carbohydrates and proteins increased when the flour was prepared from the fruits. On the contrary, fruits contain relatively higher fat content than those found in flour prepared from the fruits [38]. Owing to the presence of a higher vitamin content (294.26 ppm) and significantly higher antioxidant activity, it is suggested to use *S. alba* leaf tea as a nutritionally rich, healthier beverage [34]. Tannin content (hydrolysable type) in the bark of *S. alba* has been reported at 7.6% [43].

The floral scents of mangrove species found on the Iriomote Islands, Japan, were analyzed for chemical characterization [44]. *Sonneratia alba* floral scent was reported to have the presence of four main compounds viz. trans-β-ocimene (a mono-terpene), 2, 4-dithiapentane (an organo-sulfur), 2-heptanone (a ketone), and methyl-2-methylbutanoate (a fatty acid ester). Detection of 2, 4-dithiapentane in floral scent is attributed to the fact that nocturnal flowers of *S. alba*

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Table 2. Proximate elemental composition in different parts of *S. alba*.

	Bark	Leaves	Fruits	Fruit flour
Water/moisture	38.23%	48.11%	30.71%	10.1%
Ash	6.21%	4.16%	5.06%	5.3%
Carbohydrates	37.16%	31.56%	52.16%	74.5%
Proteins	1.91%	2.78%	3.48%	8.5%
Fats	0.85%	1.04%	8.59%	1.49%
Fiber	15.64%	12.35%	-----	-----
		Young leaves		Old leaves
Low molecular weight carbohydrates (mol./m³ plant water)				
Glucose		21.7		9.1
Fructose		25.4		7.0
Sucrose		5.8		10.1
Hexitols		199.7		79.1
Myo-inositol		1.7		1.1
Pinnitol		1.8		0.4
Nitrogenous compounds (mol./m³ plant water)				
Total nitrogen		345.1		222.3
Total methylated onium compounds		10.3		5.8
Total free amino acids		4.7		2.3
Proline		0.51		0.08
Glutamic acid		1.17		0.66
Aspartic acid		1.09		0.53
Alanine		0.37		0.24
Organic acids (equ./m³ plant water)				
Malate		42.9		43.7
Citrate		12.0		9.4
Concentration of ions (equ./m³ plant water)				
Chloride		472		745
Sodium		356		669
Potassium		128		36
Magnesium		139		106
Sulphate		32		53

are pollinated by bats. Other molecules are believed to help in attracting other pollinating insects and birds.

The composition of lipids in *S. alba* leaves and roots was studied [45]. Wax ester is the largest component comprising 19.3% of the total lipid, followed by sterol ester (16.8%) and polar lipids (11.7%). Similar to other mangroves, triterpenoid alcohols and phytosterols are commonly found in *S. alba*. Studying triterpenoids is crucial since they are known to play an important role in the adaptation process of several plants such as mangroves to the salt stress [46,47].

Table 3 and Figure 2 show a few important novel compounds and phytochemical classes isolated from the different parts of *S. alba*. Many of these have been reported to have bioactivities, and their pharmacological importance has been well-documented.

Pharmacological studies

Anti-bacterial

There are numerous reports highlighting the broad range of antibacterial potential of *S. alba* against both Gram-positive and negative bacteria [61].

Promising activity *in vitro* was reported by ethanol and aqueous leaf extracts against human bacterial pathogens *Staphylococcus aureus*, *Streptococcus* sp., multidrug-resistant *Salmonella typhi*, *Proteus vulgaris*, and *Proteus mirabilis* [62]. The antibacterial activity of crude methanol extract of bark showed promising activity against eleven tested bacteria. *Staphylococcus auerus*, *Salmonella typhimurium*, *Shigella flexneri*, and *Vibrio cholera* were found to be the most susceptible [63]. Carbon tetrachloride (CTC) fraction of methanol bark extract exhibited moderate inhibition of various

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Table 3. Novel compounds/secondary metabolites isolated/identified from *S. alba*.

Sr. no.	Name of the compound and class	Part used and place of work	Bioactivity (if any)	Reference
1.	Lupeol, oleanolic acid, betulinic acid (triterpenoids); 2,6-dimethoxy-p-benzoquinone (quinone); a mixture of stigmasterol and β-sitosterol (phytosterol)	Twigs Thailand	Antimycobacterial Antimalarial	[48]
2.	Oleanolic acid, betulin, betulinic acid, alphitolic acid (triterpenoids); methyl gallate (phenolic compound) and 5-hydroxymethylfurfural (furan)	Leaves Vietnam	----------	[49]
3.	Lupeol, oleanic acid (triterpenoids); β-sitosterol, β-stigmasterol (phytosterol); and sitost-4-en-3-one (steroid)	Leaves Bangladesh	Antioxidant Antibacterial Cytotoxic	[50]
4.	3,3'-Di-O-methylellagic acid (phenolic compound)	Bark Indonesia	Antioxidant	[51]
5.	3β-Hydroxy-lup-9(11),12-diene, 28-oic acid, lupeol, lupan-3β-ol (triterpenoids)	Bark Indonesia	Antibacterial	[52]
6.	Oleanolic acid, tarsolic acid, α-, and β-amyrin cinnamate, lupeol (triterpenoids); β-sitosterol and stigmasterol (phytosterol); and squalene (lipid)	Fruits, twigs and leaves	----------	[53]
7.	Lupeol (triterpenoids)	Leaves Indonesia	Antibacterial	[54]
8.	Lupeol (triterpenoids)	Leaves Indonesia	Anti-cholesterol	[55]
9.	Five novel sonneratiosides: A–E and β-D-glucopyranoside (sesquiterpene glycosides); ampelopsisionoside, lauroside A (megastigmane glycosides); alangionoside A (ionol glycosides); benzyl alcohol β-D-glucopyranoside; luteolin 7-O-rutinoside, isovitexin (flavone), arbutin (glycosylated hydroquinone)	Leaves Japan	Tyrosinase Inhibitory	[56]
10.	Mixture of the stigmasterol and β-sitosterol (phytosterol)	Roots Indonesia	Weak antioxidant	[57]
11.	β-Sitosterol (phytosterol)	Roots Indonesia	Cytotoxic	[58]
12.	Orientin, vitexin, luteolin (flavonoids); oleanolic acid (triterpenoid)	Leaves Indonesia	Anti-diabetic	[59]
13.	Luteolin, apigenin, and diosmetin (flavonoids)	Leaves Indonesia	Anti-diabetic	[60]

Gram-stain-positive bacteria viz. *Bacillus cereus*, *Bacillus subtilis*, *Sarcina lutea* as well as Gram-stain-negative bacteria viz. *Pseudomonas aeruginosa* and *Shigella dysenteriae* [64]. Another *in vitro* study done in Malaysia reported that the methanol leaf extract was found to be effective against Gram-stain-positive *S. aureus* and *B. cereus*, and the Gram-stain-negative *Escherichia coli* bacteria [65]. These bacteria were reported to be sensitive to methanol as well as ethanol extracts prepared from the leaves and bark but tolerant to chloroform extract [66]. Aqueous extracts prepared from leaves, fruits, and bark have been found active against *E. coli* and *S. aureus* [67].

Quorum sensing (QS) involves cell-to-cell communication, a life process controlling mechanism in bacteria (such as expression of pathogenicity and production of biofilms). Hence, disturbing QS can kill the bacteria. *Sonneratia alba* root extract is reported to have anti-QS activity *in vitro* against the bacteria *Chromobacterium violaceum* [68].

Flavonoids extracted from the *S. alba* fruits exhibited activity against pathogenic *Vibrio alginolyticus* whereas the isolated triterpenoid inhibited pathogenic *S. aureus*, *P. aeruginosa*, and *E. coli in vitro* [54,69]. Three lupane-type triterpenoids isolated from *S. alba* inhibited Gram-positive bacteria *S. aureus* ATCC 6538 and *Streptococcus mutans* ATCC 25175 [52]. Synthesized zinc oxide nanoparticles using *S. alba* leaf extract have shown excellent *in vitro* antibacterial activity against Gram +ve as well as −ve bacteria [70].

In an *in vivo study*, giant tiger prawn post-larvae were fed with Brine shrimps enriched with *S. alba* fruit extracts and later challenged with their common pathogen *Vibrio harveyi*. Treated larvae showed a significantly higher survival rate clearly indicating that *S. alba* extracts can have an important application in inhibiting *V. harveyi* infection in cultured prawns, ultimately increasing the commercial production [71]. Similar results have been reported of the protection conferred against *Saprolegnia* sp. [72]. *Sonneratia alba* ethanol leaf extract was highly antibacterial against a fish pathogen *Salmonella*

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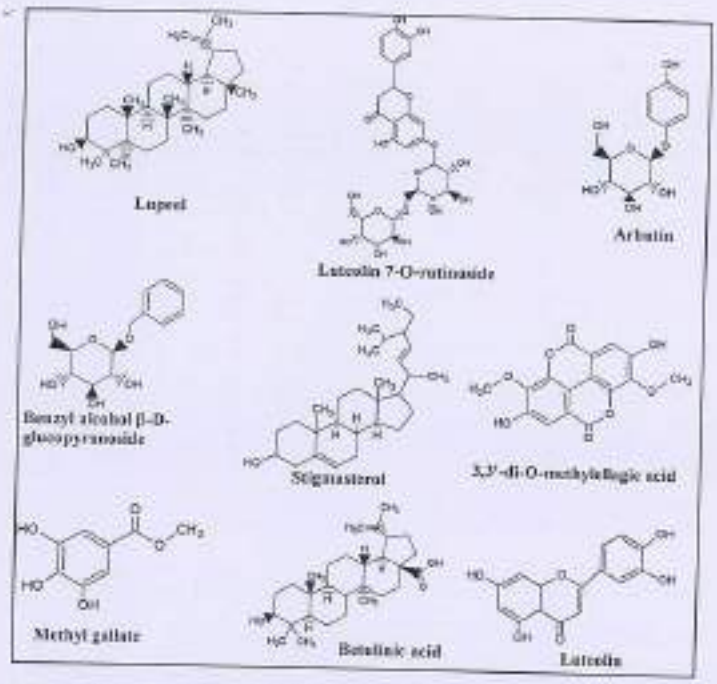


Figure 2. Representative bioactive compounds identified in *S. alba*.

arizonae with a zone of inhibitions comparable with those shown by standard antibiotics. Further testing *in vivo* showed a clear reduction and delay of the onset of goldfish mortality when infected with *S. arizonae* [73].

Anti-fungal

Extracts of *S. alba* fruits prepared in n-hexane, ethyl acetate, and ethanol exhibited moderate *in vitro* activity against the fungus *Candida albicans* whereas methanol fruit extracts inhibited the growth of the fungus *Helminthosporium* sp. which is known to cause corn leaf blight [74,75]. Methanol leaf extract was found to be effective against the fungus *Cryptococcus neoformans* [65]. CTC fraction of methanol bark extract showed mild antifungal activity against *C. albicans*, *Aspergillus niger*, and *Saccharomyces cerevisiae* when tested *in vitro* [64].

Anti-viral

Sonneratia alba leaf-synthesized silver nanoparticles tested *in vitro* at concentrations of 5–15 µg/ml were able to down-regulate the expression of the gene responsible for the envelope and a crucial protein in the dengue virus (serotype DEN-2) [76].

Insecticidal

In an *in vivo* study, methanol, ethyl acetate, and hexane extracts of *S. alba* fruits at 10% concentration exhibited 98%, 44.5%, and 28.4% mortality in *Nezara viridula* larvae. *Nezara viridula* commonly known as green stink or shield bug is a polyphagous plant eater and, therefore, needs to be controlled [77]. Silver nanoparticles synthesized using *S. alba* leaves were found to be lethal against the larvae and pupae of *Aedes aegypti* mosquitoes (LC_{50} of 3.15–15.61 ppm) *in vivo*. When treated with these *S. alba*-derived nanoparticles, adult guppy fish were found to predate mosquito larvae at an accelerated rate [76].

Antioxidant

Lipid peroxidation is known to be involved in aging, cancer, and so on [78]. Antioxidants are known to protect our body cells from harmful damage caused by free radicals. Therefore, studying antioxidant activity is considered to be important since it can lead to the identification of a bioactive molecule with therapeutic potential [79].

There are numerous *in vitro* studies that report the antioxidant potential of *S. alba*. Ethanol and methanol crude extracts of both leaves and bark along with the fractions partitioned in water showed IC_{50} values in the range of 0.019–0.038 mg/ml clearly indicating the antioxidant ability when compared with the IC_{50} value of 0.018 mg/ml by the standard vitamin C in the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay [66]. Ethyl acetate fraction of methanol extract prepared using sepals was found to be a very strong antioxidant having an EC_{50} of 2.57 µg/ml and it also showed a strong lipid peroxide formation inhibition activity with IC_{50} of 0.84 µg/ml [80]. Nufus *et al.* [37] reported anti-oxidant activities at 9.83, 15.17, and 8.38 ppm for n-hexane, methanol, and ethyl acetate extracts prepared from *S. alba* fruits and described them as very strong since they were below 50 ppm. The chloroform bark extract showed the highest free radical scavenging activity with an IC_{50} value of 12 µg/ml in comparison with positive control butylated hydroxyl toluene (10 µg/ml). At the same time, the crude methanolic extract also exhibited strong antioxidant potential having an IC_{50} value of 14 µg/ml [64]. Methanol extract of stem and leaves showed an IC_{50} of 62.5 and 87.5 µg/ml whereas ethanol extract of bark and leaves showed an IC_{50} of 67.2 and 88.7 µg/ml [30,81].

It is well established that the total phenolic contents and antioxidant activities are positively correlated, flavonoids and other phenolic compounds contribute to antioxidant activity [82]. Scopoletin (a coumarin) along with other phenolics detected in the ethanol extract were suggested to be contributing to the activity. Extracts prepared from young leaves using soxhlet (in methanol) and by maceration (in ethanol) reported IC_{50} of 5.16 and 5.01 µg/ml, respectively, comparatively better than shown by standard ascorbic acid (5.21 µg/ml) indicating potent *in vitro* antioxidant activity [32]. Aqueous and methanol extract of *S. alba* bark showed almost double the concentration of total phenolic content than found in green tea and, therefore, exhibited potent *in vitro* DPPH radical scavenging activity [83]. Sumartini *et al.* [34] reported very strong *in vitro* antioxidant activity (average IC_{50} of 50 ppm) of the tea prepared using *S. alba* young and old leaves powder. 3,3'-di-O-methylellagic acid, an isolated phenolic compound, methanol bark extract, and ethyl acetate fraction all showed potent *in vitro* antioxidant activity when compared with L-(+)-ascorbic acid as standard by using DPPH assay. The samples tested exhibited significantly lesser IC_{50} values around 12 µg/ml than the standard which showed 17.64 µg/ml [51].

Thalassemia patients require antioxidant supplements to prevent oxidative stress. Ethanol leaf extract when tested *ex vivo* was found to be a decent antioxidant and could be

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supplied as a natural antioxidant to anaemic thalassemia patients [84]. Ethyl acetate root extract and the isolated phytosterol, however, showed relatively weaker activity *in vitro* [57]. Silver nanoparticles synthesized from aqueous stem extracts and zinc oxide nanoparticles synthesized from leaf extract have also exhibited remarkable *in vitro* antioxidant activities [70,85].

Hypoglycemic/anti-diabetic

A polysaccharide isolated from the leaf extract of *S. alba* exhibited remarkable blood glucose attenuating activity *in vivo* as it lowered the blood sugar concentration by 19.2% during the first 6 hours and reduced it further to 66.9% post 12 hours of treatment [86]. In another *in vivo* study on STZ drug-induced hyperglycemic mice, a promising lowering of blood sugar levels (average being 39.6%) was observed post 6 hours after administration of *S. alba* nontoxic fraction separated from the leaf extract which further dropped to 56.4% 12 hours after the injection, clearly highlighting the presence of hypoglycemia-inducing principle present in the tannin-containing purified fraction [87]. Using *en silico* molecular docking studies, phytochemical compounds identified from methanol and ethyl acetate extract of leaves of *S. alba* were found to be α-glucosidase inhibitors and suggested to have a potential to be developed into anti-diabetic agents [59,60].

Analgesic

Methanol fraction of *S. alba* leaves extract was tested *in vivo* for its pain-relieving potential by observing formalin-induced hind foot/paw licking in Swiss albino mice. Mice that were pre-treated with methanol fraction (at 200 and 400 mg/kg) exhibited an encouraging dosage-dependent decrease in the hindfoot licking induced by formalin. Analgesic activity was comparable with the standard painkiller drug diclofenac but at a higher dose of 400 mg/kg suggesting further purification was warranted to enhance the activity [88].

Anti-inflammatory

Sonneratia alba extract at a dose of 150 and 300 mg/kg was found to be effective against inflammation (carrageenan-induced edema in albino mice). Results of this *in vivo* study, were highly promising when compared to the groups treated with the standard anti-Inflammatory drug Ibuprufen [88]. Silver nanoparticles synthesized from aqueous stem extracts and zinc oxide nanoparticles synthesized from leaf extract have also exhibited remarkable *in vitro* anti-inflammatory activities when tested for albumin protein denaturation inhibition and human erythrocytes membrane stabilization, respectively [70,85].

Acetyl cholinesterase inhibitory activity

Compounds with this ability can enhance the neuromuscular transmission process by increasing the levels and available time of the neurotransmitter enzyme acetylcholine in the central nervous system (CNS). A positive correlation has been reported between the % inhibitory activity and concentration of the *S. alba* leaf and bark extract prepared in methanol and dichloromethane when tested *in vitro* [89].

CNS depressant

Methanol faction of *S. alba* leaf extracts was tested *in vivo* to study the locomotor exercise, by employing gap cross and open-up field analysis tests in study mice. Results clearly showed that the samples tested were able to decrease the frequency and the degree of movement. Since the CNS plays a decisive role in regulating locomotor activity, the reduced activity is suggested to result from the sedation caused by the tested plant samples [88].

Tyrosinase inhibitory

Enzyme tyrosinase plays a pivotal role in melanin pigment production in the skin. Hence, anti-tyrosinase agents are being explored since they can help reduce melanin formation thereby skin darkening. Bark extract was found to have the highest anti-tyrosinase activity (82.4%), followed by leaf extract (72.5%). Root extracts exhibited relatively lower activity (40%). Results of this *in vitro* experiment suggest that purified products from bark and/or leaves could find a place in developing cosmetics [83]. Luteolin 7-O-rutinoside (a flavonoid), and arbutin (a hydroquinone) isolated from the leaves showed *in vitro* tyrosinase inhibitory activity in terms of IC_{50} at 387 ± 38.2 and 525 ± 77.4 µM, respectively [56]. Acetone leaf extract showed an IC_{50} of 0.55 mg/ml indicating potent anti-tyrosinase activity *in vitro* [90].

Polyphenol oxidase (PPO) inhibitory

It is studied since PPO inhibitors can control/delay the post-harvest browning of vegetables and fruits; increasing the shelf life and sale value. Promising inhibition of 82% of PPO in sweet potato was exhibited by *S. alba* extract in an *in vitro* investigation [91].

Anti-atherosclerotic

Atherosclerosis is defined as inflammation in blood vessels, specifically in the medium-sized arteries, it is a significant risk factor for cardiovascular disease. Masdar *et al.* [92] employed an *in vivo* rat model for the investigation of the anti-atherosclerotic potential of *S. alba* fruit extract. Atherosclerosis condition was induced in Wistar rats by administering a high-fat diet. *Sonneratia alba* fruit methanol extract showed an inhibitory effect on high-fat diet-induced atherosclerosis at the initial stage but did not affect the lipid profile in blood in Wistar rats [92]. In an *in vitro* study, a triterpenoid compound (lupeol) isolated from leaf methanol extract was shown to reduce cholesterol in a concentration-dependent manner from concentrations of 5 to 80 ppm at 13.7% to 77.0% indicating its potential [55].

Cytotoxic

There are *in vivo* cytotoxicity studies done against brine shrimps *Artemia salina*. *Sonneratia alba* leaf extracts prepared in three different solvents were found to be toxic against *A. salina*. LC_{50} values recorded were 3.59, 6.37, and 98.37 ppm for ethyl acetate, ethanol, and n-hexane extracts indicating ethyl acetate extracts to be most cytotoxic [91]. In another study, leaf methanol extract showed LC_{50} values of 817.5 and 515.8 ppm

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in the case of acute and chronic treatments with brine shrimps which indicate mild toxicity [86]. Cytotoxicity against *A. salina* exhibited by the CTC soluble partitionate of methanol bark extract was found to be promising [64]. Phytosterol isolated from the root extract was found to have an IC_{50} of 10.04 µg/ml clearly indicating its toxic nature and potential to be developed into an anticancer drug [58].

Anticancer

Leaf extract prepared in ethyl acetate was found to have moderate cytotoxicity *in vitro* against cervical cancer HeLa cells with an IC_{50} value of 478.63 µg/ml. If the extract is further purified, isolated compounds could exhibit potent anticancer activity [93]. In a recent *in vitro* study, gold nanoparticles synthesized from the fruits showed promising cytotoxic activity against A549 nonsmall cell lung adenocarcinoma [94].

Anti-malarial

In an *in vitro* experiment, 2, 6-dimethoxy-p-benzoquinone isolated from *S. alba* twigs has been reported to be a potent antimalarial compound with an IC_{50} of 3.08 µg/ml against a multidrug-resistant strain of *Plasmodium falciparum* [48]. Methanol leaf extract (rich in quinones) was found to be effective in reducing the parasitemia levels in mice erythrocytes infected by protozoan *Plasmodium berghei*. This *ex vivo* study reporting anti-plasmodial activity was noteworthy since the activity recorded was even better than the one exhibited by the standard anti-malarial drug pyremethamine [95].

CONCLUSION

Mangrove apple *S. alba* has a wide range of bioactivities such as antimicrobial, anti-oxidant, anti-diabetic, anti-viral, insecticidal, analgesic, cytotoxic, and so on. Having acetyl cholinesterase inhibitory activity can have numerous medicinal applications in the treatment of conditions such as myasthenia gravis, glaucoma, Alzheimer's disease, and so on. It is found to be a strong anti-oxidant, in addition to being nutritionally rich, edible, and cholesterol inhibitor, making it a good candidate to be developed as a food additive. Being a tyrosinase inhibitor, it can find applications in cosmetics for manufacturing creams that can control skin darkening. *In silico* studies have suggested that leaf extract of *S. alba* would have anti-diabetic potential. These activities are attributed to the presence of various phytochemicals such as terpenoids, phytosterols, flavonoids, coumarins, and so on. It is concluded that this mangrove can be an excellent natural resource for carrying out purification, isolation, and chemical characterization of bioactive principles to make the best of its therapeutic potential.

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All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work. All the authors are eligible to be an author as per the International Committee of Medical Journal Editors (ICMJE) requirements/guidelines.

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ETHICAL APPROVALS

This study does not involve experiments on animals or human subjects.

DATA AVAILABILITY

All data generated and analyzed are included in this research article.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declares that they have not used artificial intelligence (AI)-tools for writing and editing of the manuscript, and no images were manipulated using AI.

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