Maratha Vidya Prasarak Samaj’s
**Shrimati Vimlaben Khimji Tejookaya Arts, Science and Commerce College, Nashik**
Office: 0253-2473132Email: iqac@mvpsvktcollege.ac.in
Affiliated to S.P.P.U. | Pune: PU/NS/ASC/029(1984) | AISHE: C- 41392
(NAAC Accredited 'A' Grade with CGPA of 3.11)(Best College Award by S.P.P.U., Pune 2023)

**Criteria III:**

**3.3.2 Number of research papers per teachers in the Journals notified on UGC website during the year**

| Sr. No. | Departent | No. Publication |
|---|---|---|
| 1 | Botany | 1 |
| 2 | Chemistry | 2 |
| 3 | Commerce | 6 |
| 4 | Economics | 3 |
| 5 | Mathematics | 3 |
| 6 | Microbiology | 4 |
| 7 | Physics | 2 |
| 8 | Political Science | 3 |
| 9 | Psychology | 1 |
| 10 | Zoology | 1 |
| Total | | **26** |

IQAC

PRINCIPAL
Smt. Vimlaben Khimji Tejookaya,
Arts, Science & Commerce College
Deolali-Camp, (Nasik)

Journal of Drug Delivery Science and Technology 82 (2023) 104373

Contents lists available at ScienceDirect

Journal of Drug Delivery Science and Technology

journal homepage: www.elsevier.com/locate/jddst

# Bio-inspired synthesis of CdO nanoparticles using *Citrus limetta* peel extract and their diverse biomedical applications

Khanderao Pagar [a,**], Krishna Chavan [b], Sunil Kasav [b], Parita Basnet [c], Abbas Rahdar [d], Navish Kataria [e], Rajeshwari Oza [f], Yogita Abhale [g], Balasubramani Ravindran [h,l], Onkar Pardeshi [i], Sachin Pawar [a], Balasaheb Pagar [j], Suresh Ghotekar [k,*]

[a] Department of Chemistry, S.S.R College of Arts, Commerce & Science College, Savitribai Phule Pune University, Silvassa, 396 230, Dadra and Nagar Haveli (UT), India
[b] Department of Chemistry, KKHA Arts, SMGL Commerce & SPHJ Science College, Savitribai Phule Pune University, Chandwad, 423 101, Maharashtra, India
[c] Department of Chemistry, Sikkim Institute of Science & Technology, Sikkim University, Sikkim, India
[d] Department of Physics, Faculty of Science, University of Zabol, Zabol, P.O. Box. 35856-98613, Iran
[e] Department of Environmental Sciences, J.C. Bose University of Science and Technology, YMCA, Mathura Rd, Sector-6, Faridabad, 121006, Haryana, India
[f] Department of Chemistry, S.N. Arts, D.J.M. Commerce & B.N.S. Science College (autonomous), Savitribai Phule Pune University, Sangamner, 422 605, Maharashtra, India
[g] Department of Chemistry, Government College Daman, (Veer Narmad South Gujarat University, Surat), Daman, 396 210, UT of DNH & DD, India
[h] Department of Environmental Energy and Engineering, Kyonggi University, Suwon-si, Gyeonggi-do, 16227, South Korea
[i] Department of Electronics, KKHA Arts, SMGL Commerce & SPHJ Science College, Chandwad, 423 101, Savitribai Phule Pune University, Maharashtra, India
[j] Department of Chemistry, M.V.P. Samaj's S.V.K.T Arts, Commerce & Science College, Savitribai Phule Pune University, Deolali camp (Nashik), 422 401, Maharashtra, India
[k] Department of Chemistry, Smt. Devkiba Mohansinhji Chauhan College of Commerce & Science (University of Mumbai), Silvassa, 396 230, Dadra and Nagar Haveli (UT), India
[l] Department of Medical Biotechnology and Integrative Physiology, Institute of Biotechnology, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Thandalam, Chennai, 602 105, Tamil Nadu, India

## ARTICLE INFO

*Keywords:*
Green nanotechnology
*Citrus limetta*
CdO NPs
Biomedical applications

## ABSTRACT

Nowadays, the green chemistry approach for nanoparticle (NP) synthesis has acquired a plethora of interest due to its expeditious and eco-benevolent nature. In the current study, *Citrus limetta* peel extract was applied as a unique natural reducing/stabilizing agent in the bio-inspired fabrication of cadmium oxide (CdO) NPs. The physicochemical features of the prepared CdO NPs were critically studied through XRD, FTIR, SEM, EDX, HRTEM, PL, and UV-DRS analyses. According to XRD examination, the CdO NPs were confirmed to have a single face-centered cubic Monteponite phase. The median particle size of CdO NPs was revealed by HRTEM investigation to be 51.5 nm, and the XRD study confirmed this finding. The UV-DRS was utilized to calculate the band gap of bio-fabricated NPs and was found to be 2.6 eV. FTIR analysis evinced the functional groups of biologically active molecules of *Citrus limetta* peel extract. Moreover, diverse biological applications such as antibacterial, antioxidant, anticancer, DNA damage, and biocompatibility studies of *Citrus limetta* peel extract-mediated CdO NPs were revealed. The antibacterial efficacy of the CdO NPs screened against human pathogens (*B. subtilis*, *E. coli*, *K. pneumoniae*, and *S. typhi*) and displayed higher bactericidal performance against *B. subtilis*. The CdO NPs displayed dose-dependent anticancer performance against the cancer cell line (A-549) in the MTT assay, with activity at an $IC_{50}$ of 152.2 μg/mL. The DPPH and ABTS assays were applied to determine the antioxidant capacity of CdO NPs. For the DPPH and ABTS assays, the $IC_{50}$ values of CdO NPs were determined to be 94.47 and 68.98 μg/mL, respectively. Additionally, *Citrus limetta* peel extract-mediated CdO NPs also displayed DNA damage and biocompatibility performance. Therefore, due to their biological functionality, these biogenically produced NPs perform as efficacious therapeutic agents.

---

* Corresponding author.
** Corresponding author.
*E-mail addresses:* khanderaopagar205@gmail.com (K. Pagar), ghotekarsuresh7@gmail.com (S. Ghotekar).

https://doi.org/10.1016/j.jddst.2023.104373
Received 10 December 2022; Received in revised form 6 March 2023; Accepted 15 March 2023

## 1. Introduction

Modern nanotechnology is now acknowledged as transforming competency of multidisciplinary sciences accompanied predominantly by chemistry, materials science, biology and physics because of its many structural consistency and astonishing breakthroughs in every science and engineering discipline [1–5]. Nanotechnology commonly accommodates the production of nanoparticles (NPs) with a size allocation range of 1–100 nm [6,7]. This promotes substantial bio-physicochemical features over their bulk component because of their catalytic, biological, magnetic, electronic, optical, and mechanical characteristics [2,8–11]. The shape, size, and surface topology of NPs are crucial in tuning the features of nano-sized metal particles and their promising applications in diverse sectors [12–14]. Therefore, NPs garner the utmost research attention among scientists due to their miraculous properties [15,16]. As a result, NPs offer spectacular applications in diverse sectors like medicine, energy, agriculture, cosmetics, environment, food, and many more [17–21].

All over the world, people are affected by cancer and foodborne illnesses. According to the World Health Organization, 200 distinct forms of cancer afflict more than 20% of the world's population, making cancer (uncontrolled cell proliferation) one of the most common diseases affecting people. Almost 10 million deaths, or roughly one in six deaths, were caused by cancer in 2020, making it the top cause of death globally. Breast, rectum, colon, lung, and prostate cancers are the most prevalent types of cancer [22]. In order to treat breast cancer, several studies have concentrated on producing anticancer drugs [23,24]. Food contamination with pathogens such as *Bacillus subtilis*, *Klebsiella pneumoniae*, *Escherichia coli*, and *Salmonella typhi* is a severe public health issue worldwide [25]. In addition, eating contaminated food can result in serious infections. Food can become contaminated by germs before, during, or after preparation. The poisons that bacteria in tainted food emit can be extremely harmful to human health. Moreover, foodborne pathogens have recently emerged as the most prevalent global public health issue [26]. Consequently, to solve this issue, new inorganic antibacterial compounds [27] must be developed to fight off *B. subtilis*, *K. pneumoniae*, *E. coli*, and *S. typhi*. Although metal oxide NPs have good antibacterial efficacies, they are inefficient against foodborne diseases [3,28]. However, composites made of several different metal oxides demonstrate better bactericidal performance against foodborne microorganisms [10,29,30].

To date, biological, physical, and chemical strategies have been exploited to develop metal-based NPs [31,32]. The many physical and chemical techniques entail highly sophisticated instruments and skilful staffing, particularly being costly and using chemicals detrimental to human health and the ecosystem [33–36]. On the other hand, a bio-inspired synthesis technique is a one-pot synthesis NPs that involves comparatively minimal energy for commencement and is revealed to be non-noxious, inexpensive, and biocompatible [37–40]. Additionally, it provides the versatility to produce NPs of different sizes, considering it desirable over physical and chemical techniques [3]. Additionally, it provides the versatility to produce NPs of variable sizes, rendering them desirable over physical and chemical techniques. Additionally, NPs manufactured by plants as capping and bio-reducing agents had superior stability and variation in size and morphology than NPs generated by other species [41–43]. This could be accounted for by plants having diverse phytochemicals, including proteins, phenols, vitamins, carbohydrates, flavonoids, coumarins, and coenzyme-based intermediates. There is evidence that plant metabolites with functional groups like amine, carbonyl, and hydroxyl can diminish metal ions and dwindle them down to the nanoscale [3,5].

The inorganic compound cadmium oxide (CdO) is a colorless amorphous powder and red or brown crystals [44]. CdO is a significant n-type semiconductor with piezoelectric characteristics [45,46]. CdO has notable features of strong charge carrier mobility without further doping, very low electrical resistivity, and a high degree of transmission property in the visible zone [47,48]. Due to these properties, it can be deployed for a plethora of applications, including supercapacitors [49], solar cells [29], transparent electrodes [50], biological activity [51,52], gas sensors [53], and photocatalysts [54,55]. Besides, mesoscopic and quantum confinement phenomena would greatly augment CdO properties if its dimensions were altered from 3D bulk to nanoscale size [56]. Hitherto, diverse physical and chemical strategies [45] have been applied to produce CdO NPs, such as sol-gel [57], microwave-assisted [58], thermal decomposition [59], spray pyrolysis [60], laser ablation [61], solid state [62], hydrothermal synthesis [55], mechanochemical [63], solvothermal [64], chemical bath deposition [65], co-precipitation [66], etc. Unfortunately, these approaches harm the environment because they use toxic solvents and capping compounds, consume much energy, and produce noxious residues. Therefore, it is imperative to establish straightforward and environmentally acceptable processes that produce nanoparticles without deleterious reducing agents.

*Citrus limetta* (sweet lime), often called "Mosambi," is a familiar citrus fruit. Due to their peculiar and alluring flavour, taste, and aroma, sweet limes are a remarkably valuable fruit. The fresh or processed form of sweet lime juice is frequently consumed [67]. Along with the edible portions, the non-edible contents, such as the peels, are a substantial resource of important biologically active compounds, including flavonoids, phenols, carotenoids, ascorbic acid, essential oils, and vitamins [68]. Pectin, dietary fibre, and antioxidant chemicals in sweet lime peels are significant sources of reducing blood sugar and cholesterol [69]. Moreover, peels have a higher soluble-to-insoluble dietary fibre ratio than cereals. Additionally, the bioactive molecules (Fig. 1) present in sweet limes' peels [70] have many therapeutic properties, namely antiviral, antibacterial, anticancer, anti-inflammatory, and antioxidant activities [71]. Suppose proper processing methodologies for maintaining their nutrient bio-availability are investigated. In that case, due to their nutritional advantages, sweet lime peels may have possible uses as an ingredient in manufacturing beverages, jam, jelly, bakery and dairy goods, chocolate, and candy [72].

Many works have not been reported producing CdO NPs employing plant extract. Some plant extracts implemented for the biogenic production of CdO NPs are summarized in Table 1. To the best of our knowledge, *Citrus limetta* peel extract for the bio-inspired synthesis of CdO NPs has never been documented. As a result, our study reveals for the first time the completely bio-inspired fabrication of CdO NPs

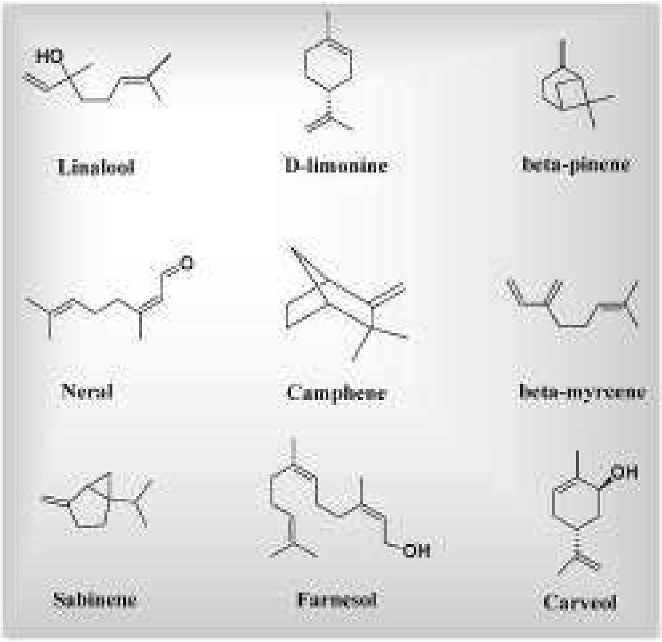


**Fig. 1.** Bioactive molecules in *Citrus limetta* peel.

**Table 1**
Eco-friendly production of CdO NPs employing diverse plant extracts.

| Name of the plant | Parts used | Metal precursor | Shape | Size (nm) | Ref. |
|---|---|---|---|---|---|
| *Agathosma betulina* | Leaves | $Cd(NO_3)_2.4H_2O$ | Quasi-spherical | 25–50 | [47] |
| *Andrographis paniculata* | Leaves | $Cd(CH_3COO)_2.2H_2O$ | Spherical | 22 | [73] |
| *Green tea* | Leaves | $Cd(NO_3)_2$ | Spherical | 5–17 | [74] |
| *Parkia speciosa Hassk* | Seeds | $Cd(NO_3)_2.4H_2O$ | Stick-like | 29–45 | [75] |
| *Hibiscus Sabdariffa* | Flowers | $Cd(NO_3)_2.4H_2O$ | Quasi-cuboidal | 28.55 | [76] |
| *Leucaena leucocephala* | Leaves | $Cd(NO_3)_2.4H_2O$ | Spherical | 36–57 | [51] |
| *Phoenix roebelenii* | Leaves | $Cd(NO_3)_2.4H_2O$ | Spherical | 24–48 | [48] |
| ***Citrus limetta*** | **Peels** | $\mathbf{Cd(NO_3)_2.4H_2O}$ | **Quasi-spherical** | **46** | **Present work** |

utilizing an efficient reducing and stabilizing agent-aqueous *Citrus limetta* peel extract without any other chemical reagents. The physicochemical features of the biosynthesized CdO NPs were revealed through XRD, FTIR, SEM, EDX, HRTEM, PL, and UV-DRS analyses. Afterwards, CdO NPs were examined for their antibacterial, anticancer, antioxidant, DNA cleavage, and biocompatible properties.

## 2. Experimental

### 2.1. Chemicals and materials

Cadmium nitrate tetrahydrate ($Cd(NO_3)_2{\cdot}4H_2O$, 99%) was procured from SRL Chem, India, and utilized in the experiment. The *Citrus limetta* fruits were purchased from the nearby market of Chandwad, Maharashtra, India. All additional chemicals involved in this experiment were of the analytical grade. Before usage, the glassware was completely washed with chromic acid, thoroughly rinsed with double-distilled water ($ddH_2O$) three times, and then dried in a hot air oven.

### 2.2. Preparation of aqueous peel extract

Fresh peels of *Citrus limetta* fruits were sliced into tiny pieces and rinsed properly using $ddH_2O$ to remove dust. A 250 mL beaker containing 100 mL $ddH_2O$ and 5 g of the cleaned peel pieces was then boiled for 20 min at 90–95 °C. A solution with a pale yellow color was obtained during the heating process. The resultant light yellow solution (aqueous peel extract) was filtered at room temperature (RT) using filter paper (Whatman No. 40). The resulting *Citrus limetta* peel extract was placed in a refrigerator at 4 °C for subsequent work.

### 2.3. Bio-inspired synthesis of CdO NPs

The cadmium precursor $Cd(NO_3)_2{\cdot}4H_2O$ was employed to produce CdO NPs through a green chemistry approach. After 3.08 g of $Cd(NO_3)_2{\cdot}4H_2O$ was mixed with 50 mL of peel extract, the reaction solution was constantly agitated at 1500 rpm for 60 min at RT with a magnetic stirrer. The reaction solution was dried in a hot oven at 100 °C for 4 h. In a muffle furnace, the resultant powder was calcined at 500 °C for 2 h. After being crushed, the resultant brown-colored CdO nanomaterial was used to perform various characterizations. Fig. 2 portrays the bio-inspired fabrication of CdO NPs employing an aqueous *Citrus limetta* peel extract.

### 2.4. Characterizations

Diverse analytical tools well studied the biosynthesized CdO NPs. Using the X-ray powder diffraction (XRD) profile acquired on a "Panalytical X'PERT PRO" diffractometer with Cu-Kα radiation ($\lambda = 1.5406$ A°), the crystallinity of the as-prepared CdO NPs was studied. The FT-IR-4600 typeA was utilized to analyze the infrared spectrum of the CdO NPs. On a VEGA3 TESCAN, scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX) spectral analysis were performed at a 10 kV accelerating voltage. Transmission electron microscopic (TEM) images on a JEM-2100 running at an accelerating 60–200 kV voltage were used to examine the CdO NPs' crystallite size and shape. The FP-8200 Spectrofluorometer was utilized to do a photoluminescence study at RT. The UV–Visible diffuse reflection spectrum (UVDRS) of the CdO NPs was captured through a Jasco Spectrophotometer V-770.

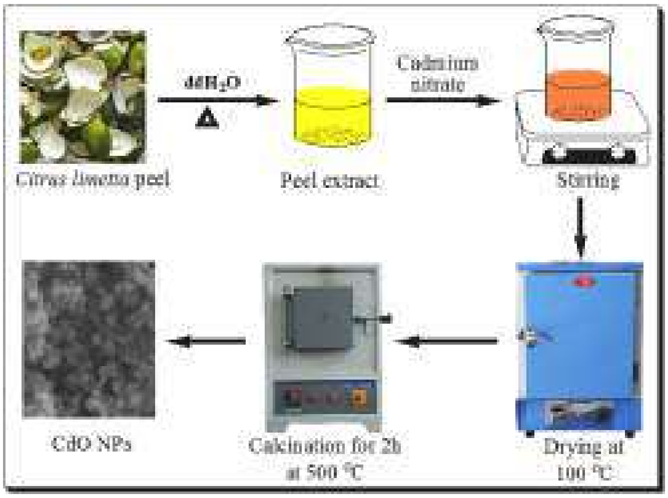


**Fig. 2.** A pictorial depiction for the bio-inspired fabrication of CdO NPs from *Citrus limetta* peels extract.

### 2.5. Antibacterial study

An agar well diffusion bioassay was considered to ascertain the bactericidal performance of NPs [10]. In accordance with the procedure, the strains to be tested were refreshed in 20 mL test tubes containing autoclaved nutrient broth, and the tubes were placed in an incubator. At the time of assay, freshly prepared corresponding strain cultures were spread over the entire surface of nutrient agar medium in a Petri plate using a sterile cotton swab. After outspreading the culture, wells with a diameter of 6 mm were made using a cork borer. The wells were later sealed with nutrient agar, labelled, and mapped according to the samples to be tested. Afterwards, different concentrations of CdO NPs were poured into a corresponding well in the plate. Subsequently, the plates were carefully placed in an incubator (24 h at 37 °C), and the bactericidal performance of the CdO NPs was measured as the zone of inhibition (ZOI) in mm. Tetracycline was taken as a positive control. The experiments were conducted in triplicate to mitigate the errors of the whole protocol.

### 2.6. Anticancer activity

Using the MTT assay, the anticancer potential of CdO NPs against A549 lung cancer cells was assessed. The entire procedure for the antioxidant capacity of both assays was described in our previous report [10, 77,78]. In a nutshell, a 96-well plate containing DMEM/RPMI supplemented with 10% inactivated FBS, penicillin (100 IU/mL), and streptomycin (100 g/mL) was seeded with 50,000 cells (per well). The plate was incubated at 37 °C with 95% humidity and 5% $CO_2$. The consumed medium was changed to a fresh medium with various CdO NP concentrations to assess cytotoxicity performance. The plate was put back into the incubator for another 24 h under the same culture conditions. Following that, each well received 100 μL of the MTT solution, which was then incubated for 4 h at 37 °C. After removing the unreduced MTT reagent from the medium, 100 μL of dimethyl sulfoxide was mixed into each well. After 15 min of shaking to dissolve the formazan crystals, the plate was put in an ELISA microplate reader to detect the absorbance solution at 570 nm. The accompanying formula (equation (1)) was applied to compute the viability percentage:

$$\%\text{Viability} = \frac{A_{570}\text{ of treated sample}}{A_{570}\text{ of control}} \times 100 \tag{1}$$

### 2.7. Antioxidant efficacy

The antioxidant efficacy of bio-fabricated CdO NPs was determined by two various assays: the DPPH and ABTS radical assay. The entire procedure for the antioxidant capacity of both assays was described in our previous report [78]. This study, used diverse concentrations (20–100 μg/mL) of CdO NPs and positive control (ascorbic acid). The scavenging performance of DPPH and ABTS assays was computed as follows (equation (2)):

$$\text{Scavenging capacity }(\%) = \frac{\text{OD(blank)} - \text{OD(sample)}}{\text{OD(blank)}} \times 100 \tag{2}$$

### 2.8. DNA damage activity

The agarose gel electrophoresis was performed by applying the *E. coli* pBR322 plasmid as a target to assess the DNA cleavage efficiency of the bio-fabricated CdO NPs [78]. The target plasmid was blended with different concentrations of synthesized CdO NPs dissolved in DMSO (dimethyl sulfoxide) solvent. The mixture was then incubated for 30 and 90 min at 37 °C. The tracking dye was mixed with the plasmid and CdO NPs mixture after incubation. After that, it was added to the 0.8% agarose gel. It was then electrophoresed using TAE buffer (pH = 7.8) at 50 V constant voltage. For the analysis, the bands were photographed after being seen by UV light [30,79].

### 2.9. Hemolytic study

The biocompatibility of CdO NPs was ascertained using a red blood cells (RBCs) hemolysis assay [80]. In the experiment, 3 mL of fresh blood was sourced from a healthy volunteer and was collected in an EDTA tube. After collection, 1 mL of the blood was transferred from the EDTA tube into a sterile Eppendorf tube, and erythrocytes were isolated using a centrifuge at 6000 rpm for 10 min. After centrifugation, the pellet obtained was washed thrice with PBS while the supernatant was dispensed. Furthermore, the pre-washed pellet was gently mixed with PBS to prepare RBC suspension. To ascertain the hemolytic nature of both the CdO NPs, the samples were co-incubated in corresponding Eppendorf tubes for 30 min at 37 °C. Following, the Eppendorf tubes were at 8000 rpm for 5 min. Finally, an aliquot of 200 μL from the supernatant from each Eppendorf tube was taken and transferred into a corresponding well in a 96-well plate. The absorption of each concentration was recorded at 540 nm. In the experiment, Triton X-100 (1%) was employed as the positive control while DMSO was the negative control and the RBCs hemolytic percentage was determined employing the following formula (equation (3)),

$$(\%)\text{ Hemolysis} = [(OD_S - OD_{NC})/(OD_{PC} - OD_{NC})] \times 100 \tag{3}$$

Where $OD_S$ depicts the absorbance of the test sample, $OD_{NC}$ shows the absorbance of the negative control, and $OD_{PC}$ displays the absorbance of the positive control, respectively.

## 3. Results and discussion

### 3.1. XRD analysis

XRD profile was applied to analyze the phase, crystal structure, and composition of the as-fabricated CdO NPs. The result is presented in Fig. 3. From the spectra, strong and narrow diffraction peaks may be noticed, which evinces the high crystallinity of the as-synthesized CdO NPs. The diffraction peaks were noticed at diffraction angles (2θ values) of 32.9°, 38.2°, 55.3°, 65.8°, and 69.2° corresponding to the reflection peaks belonging to the (*hkl*) values of (110), (200), (220), (311), and (222) (as marked in Fig. 3), respectively, according to ICDD card no. 05–0640 [76]. Peaks belonging to other crystal phases were not noticed, revealing the high purity of the CdO sample. These indexed peaks affirm the existence of a simple cubic Monteponite phase of CdO NPs. The lattice parameter 'a' was calculated to be 4.71. The mean crystallite size of the as-synthesized CdO NPs was computed employing Scherrer's equation [81], which was calculated to be 46 nm. Therefore, this study obtained information regarding the highly crystalline nature and purity of the as-prepared CdO NPs.

### 3.2. FTIR analysis

It has been well-established through earlier investigations on the bio-fabrication of nanomaterials that plant extracts operate as a reducing and capping agent. Therefore, FTIR analysis needs to be performed to understand the function of the various phytochemicals present in the plant extract. Furthermore, a comparative FTIR analysis of peel extract and biosynthesized nanomaterial is also required to deduce the capping and reducing functions of the plant phytochemicals while producing nanomaterials. Fig. 4 represents the FTIR spectra of *Citrus limetta* peel extract and CdO NPs biosynthesized using the extract of *Citrus limetta* peel. All the prominent peaks have been marked in this figure. The main components of *Citrus limetta* peel extract, which are acidic compounds, show their transmission bands in the FTIR spectrum at ~2924 $cm^{-1}$ and 1730 $cm^{-1}$, respectively [82]. In this case, these bands were noticed at 2925 $cm^{-1}$ and 1745 $cm^{-1}$, respectively, marking the presence of acidic/phenolic –OH and C=O compounds in the biosynthesized CdO NPs. In addition to the phytochemical bands, the Cd–O stretching vibration band was also observed at 450 $cm^{-1}$, consistent with the

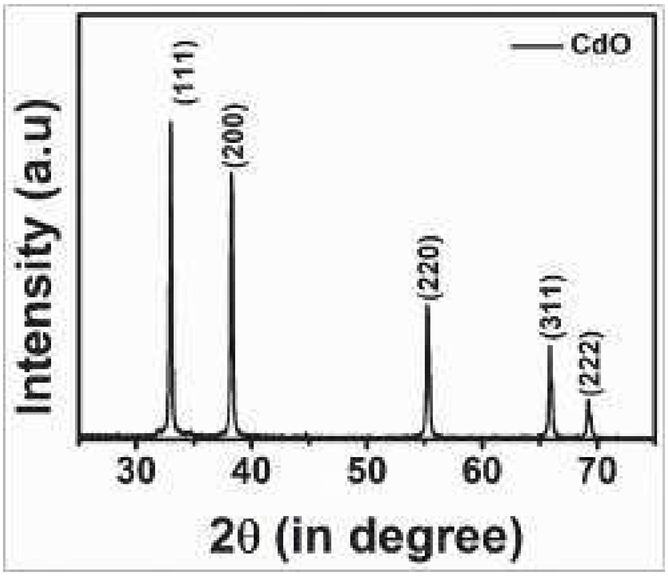


**Fig. 3.** XRD profile of bio-fabricated CdO NPs using *Citrus limetta* peel extract.

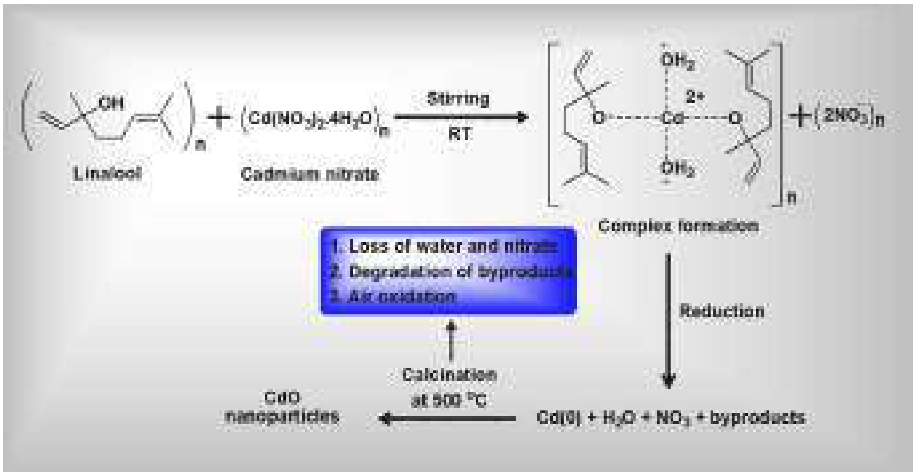
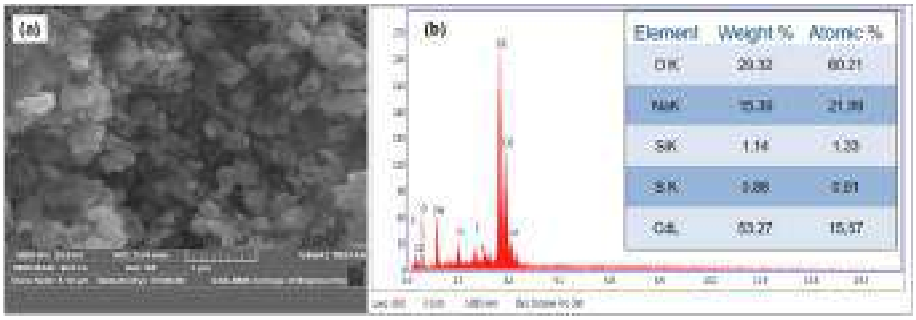


**Fig. 5.** A proposed reaction mechanism for the biogenic formation of CdO NPs.



| Element | Weight % | Atomic % |
|---|---|---|
| O K | 29.32 | 60.21 |
| Na K | 15.39 | 21.89 |
| Si K | 1.14 | 1.33 |
| S K | 0.86 | 0.91 |
| Cd L | 53.27 | 15.57 |

**Fig. 6.** (a) SEM micrograph of CdO NPs, and (b) Elemental information of CdO NPs as obtained through EDX measurements.

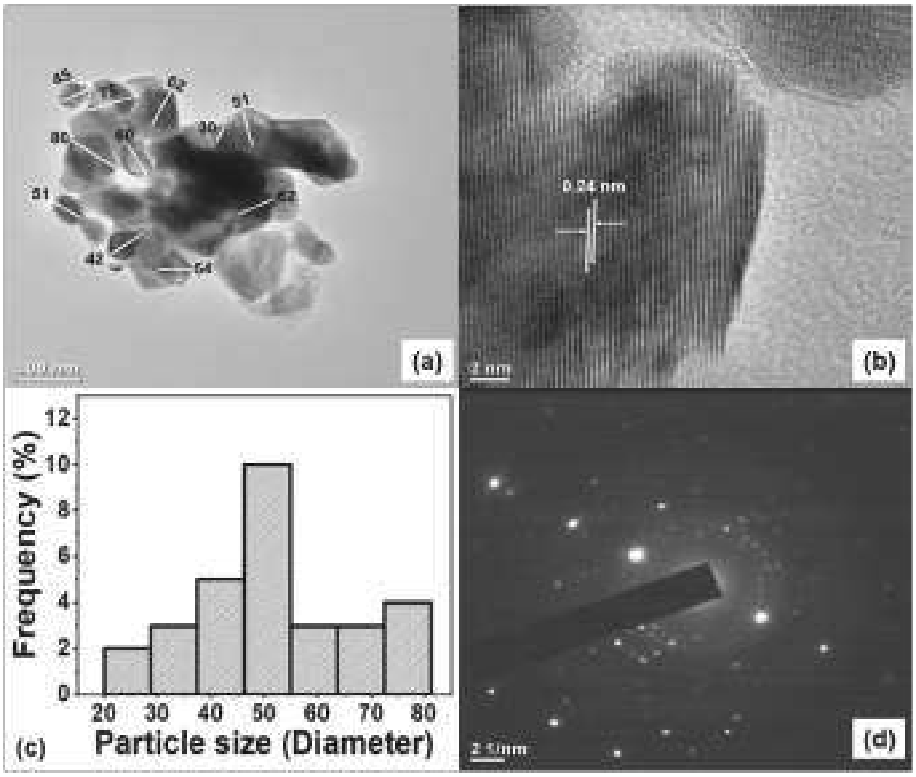


**Fig. 7.** (a) TEM image of CdO NPs, (b) HRTEM image of CdO NPs displaying the lattice fringes, (c) Particle size distribution graph (histogram), and (d) SAED pattern of CdO NPs.

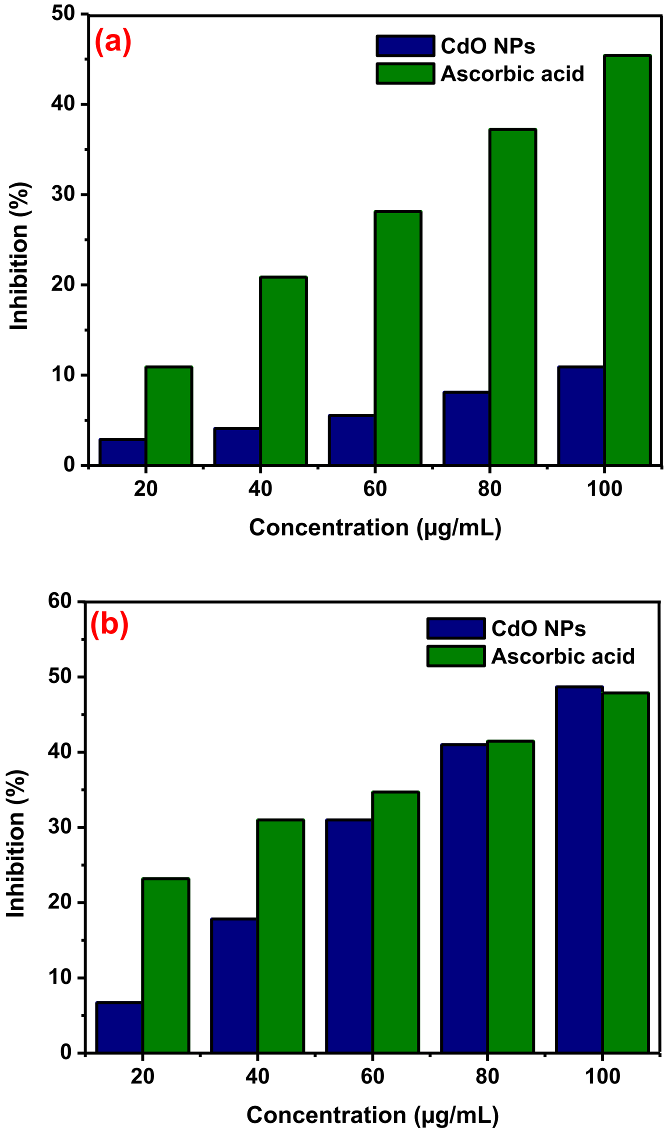


**Fig. 14.** Antioxidant performance of CdO NPs using a) DPPH and b) ABTS assays.

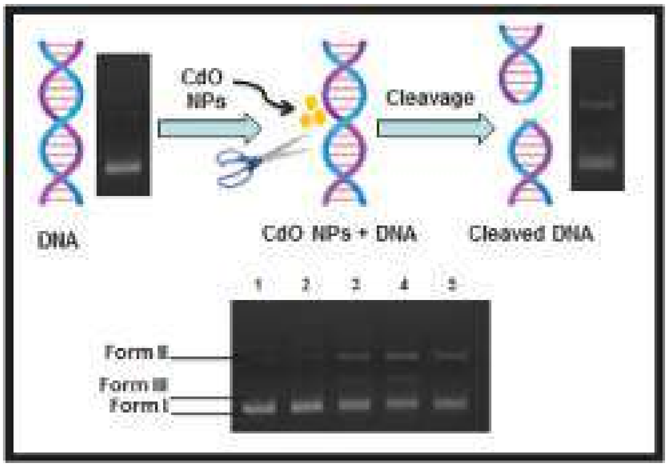


**Fig. 15.** DNA damage study of biosynthesized CdO NPs, Lane 1- DNA (control); Lane 2- DNA + $H_2O_2$ (10 mM); Lane 3- DNA + $H_2O_2$+CdO NPs (1 µL); Lane 4- DNA + $H_2O_2$+CdO NPs (2 µL); Lane 5- DNA + $H_2O_2$+CdO NPs (3 µL).

**Table 5**
% Hemolysis of biogenically produced CdO NPs.

| Concentration (µg/mL) | % Hemolysis of CdO NPs |
|---|---|
| 20 | 1.81 |
| 40 | 2.31 |
| 60 | 2.50 |
| 80 | 2.44 |
| 100 | 2.50 |

## Data availability

Data will be made available on request.

## References

[1] T.V. Tran, et al., Green synthesis of ZrO2 nanoparticles and nanocomposites for biomedical and environmental applications: a review, Environ. Chem. Lett. (2022) 1–23.

[2] A. Rahman, M.A. Chowdhury, N. Hossain, Green synthesis of hybrid nanoparticles for biomedical applications: a review, Appl. Surf. Sci. Adv. 11 (2022), 100296.

[3] H.N. Cuong, et al., New frontiers in the plant extract mediated biosynthesis of copper oxide (CuO) nanoparticles and their potential applications: a review, Environ. Res. 203 (2022), 111858.

[4] V. Aswathi, et al., Green synthesis of nanoparticles from biodegradable waste extracts and their applications: a critical review, Nanotechnol. Environ. Eng. (2022) 1–21.

[5] S. Pansambal, et al., Bioengineered Cerium Oxide (CeO2) Nanoparticles and Their Diverse Applications: a Review, Applied Nanoscience, 2022, pp. 1–26.

[6] M.B. Gawande, et al., Cu and Cu-based nanoparticles: synthesis and applications in catalysis, Chem. Rev. 116 (6) (2016) 3722–3811.

[7] C. Gao, F. Lyu, Y. Yin, Encapsulated metal nanoparticles for catalysis, Chem. Rev. 121 (2) (2020) 834–881.

[8] J. Wang, et al., Synthesis, modification and application of titanium dioxide nanoparticles: a review, Nanoscale 14 (2022) 6709–6734.

[9] X.-Y. Jiang, et al., Tuning Nanostructured CuCo2O4 on 3D Macro-Support for Enhanced Degradation of Carbofuran via Catalytic Activation Monopersulfate: Key Roles of Morphology and Active Species, Separation and Purification Technology, 2022, 122789.

[10] S. Ghotekar, et al., Spinel ZnCr2O4 nanorods synthesized by facile sol-gel auto combustion method with biomedical properties, J. Sol. Gel Sci. Technol. (2022) 1–10.

[11] S. Ghotekar, et al., Recent advances in synthesis of CeVO4 nanoparticles and their potential scaffold for photocatalytic applications, Top. Catal. (2022) 1–15.

[12] G.A. Naikoo, et al., Bioinspired and green synthesis of nanoparticles from plant extracts with antiviral and antimicrobial properties: a critical review, J. Saudi Chem. Soc. 25 (9) (2021), 101304.

[13] C. Pandit, et al., Biological agents for synthesis of nanoparticles and their applications, J. King Saud Univ. Sci. 34 (3) (2022), 101869.

[14] S. AlNadhari, et al., A review on biogenic synthesis of metal nanoparticles using marine algae and its applications, Environ. Res. 194 (2021), 110672.

[15] A.A. Adewunmi, M.S. Kamal, T.I. Solling, Application of magnetic nanoparticles in demulsification: a review on synthesis, performance, recyclability, and challenges, J. Petrol. Sci. Eng. 196 (2021), 107680.

[16] V. Dutta, et al., Bio-inspired synthesis of carbon-based nanomaterials and their potential environmental applications: a state-of-the-art review, Inorg. 10 (10) (2022) 169.

[17] S. Laurent, et al., Magnetic iron oxide nanoparticles: synthesis, stabilization, vectorization, physicochemical characterizations, and biological applications, Chem. Rev. 108 (6) (2008) 2064–2110.

[18] Korde, P., et al., Plant extract assisted eco-benevolent synthesis of selenium nanoparticles-a review on plant parts involved, characterization and their recent applications, J. Chem. Rev., 2(3): p. 157-168.

[19] W. Lin, Introduction: Nanoparticles in Medicine, ACS Publications, 2015, pp. 10407–10409.

[20] Nikam, A., et al., A review on plant extract mediated green synthesis of zirconia nanoparticles and their miscellaneous applications, J. Chem. Rev., 1(3): p. 154-163.

[21] N.K. Ojha, et al., Copper nanoparticles as inexpensive and efficient catalyst: a valuable contribution in organic synthesis, Coord. Chem. Rev. 353 (2017) 1–57.

[22] R.L. Siegel, et al., Cancer statistics, 2022, CA A Cancer J. Clin. 72 (1) (2022) 7–33.

[23] A.J. Siddiqui, et al., Plants in anticancer drug discovery: from molecular mechanism to chemoprevention, BioMed Res. Int. (2022) 2022.

[24] A. Alipour, M.Y. Kalashgarani, Nano Protein and Peptides for Drug Delivery and Anticancer Agents, Adv. Appl. NanoBio-Technol. 3 (1) (2022) 60–64.

[25] A.E. White, et al., Foodborne illness outbreaks reported to national surveillance, United States, 2009–2018, Emerg. Infect. Dis. 28 (6) (2022) 1117.

[26] H. Ge, Y. Wang, X. Zhao, Research on the drug resistance mechanism of foodborne pathogens, Microb. Pathog. 162 (2022), 105306.

[27] S. Guo, Z. Zhang, L. Guo, Antibacterial molecules from marine microorganisms against aquatic pathogens: a concise review, Mar. Drugs 20 (4) (2022) 230.

# A novel approach toward the bio-inspired synthesis of CuO nanoparticles for phenol degradation and antimicrobial applications

Original Article Published: 23 February 2023

(2023) Cite this article

Biomass Conversion and Biorefinery

Aims and scope

Submit manuscript

Harshal Dabhane, Suresh Ghotekar, Manohar Zate, Kun-Yi Andrew Lin, Abbas Rahdar, Balasubramani Ravindran, Dhanraj Bahiram, Chetan Ingale, Bhushan Khairnar, Deepali Sali, Sagar Kute, Ghanshyam Jadhav & Vijay Medhane

363 Accesses 11 Citations Explore all metrics →

## Abstract

Nanotechnology has been a widespread field for the last decade, but the clean and sustainable development of nanomaterials is a stimulating task for researchers in the current situation. The green synthesis of nanomaterial using plant extract is the most practiced chore of researchers, but the use of inorganic and organic bases makes them valueless. Herein, we first report the biogenic synthesis of copper oxide nanoparticles (CuO NPs) using human urine as a reducing agent.

The XRD analysis confirmed the crystalline nature and synthesis of CuO NPs, where the grain size was found to be 6.78 nm. The absorption-desorption study of human urine–mediated synthesized CuO NPs was done with the BET technique, and the pore volume and surface area were found to be 0.06 $cm^3/g$ and 92.64 nm, respectively. Finally, the spherical morphology was confirmed by SEM analysis, and elemental analysis confirmed the formation of CuO NPs using human urine. The well-characterized CuO NPs were used for the eco-friendly degradation of phenol in aqueous media under sunlight, and the removal efficiency was recorded using a spectrophotometer. The antibacterial activity of synthesized CuO NPs was tested against gram-positive and gram-negative pathogenic bacteria. Also, the antifungal activity was verified against different fungal strains.

---

## Abbreviations

---

*BET:* Brunauer-Emmett-Teller

*BJH:* Barrett-Joyner-Halenda

Journal of Sol-Gel Science and Technology
https://doi.org/10.1007/s10971-022-05997-5

ORIGINAL PAPER: SOL–GEL AND HYBRID MATERIALS FOR ENERGY, ENVIRONMENT AND BUILDING APPLICATIONS

# Development of photoactive MgO nanoflakes using the sol–gel method for the removal of organic contaminants

**Harshal A. Dabhane**[1,2] · **Manohar K. Zate**[3] · **Anil Kalyankar**[4] · **Suresh Ghotekar**[5] · **Ghanshyam R. Jadhav**[1] · **Vijay J. Medhane**[1,6]

Received: 22 May 2022 / Accepted: 10 November 2022

## Abstract

Nanotechnology allows synthesizing photoactive materials which are magnificently proficient at photocatalytic remediation of organic pollutant dyes depending upon the bandgap of the synthesized nanomaterial. In the present study, MgO nanoflakes were fabricated via the sol–gel approach. The as-prepared MgO nanoflakes were characterized using various microscopic and spectroscopic techniques. The surface area and basicity were examined employing the BET adsorption-desorption isotherm and $CO_2$-TPD methods. The thickness of MgO nanoflakes was calculated via SEM histogram, where the purity of the sample was confirmed using EDX elemental analysis. The well-characterized photoactive MgO nanoflakes further used photocatalytic remediation of organic dyes like methyl orange and Eriochrome Black T in the presence of sunlight. Moreover, the radical scavenging efficacy was also explored using DPPH and $^{\bullet}$OH assays.

---

✉ Harshal A. Dabhane
hadabhane@gmdcollege.in

✉ Suresh Ghotekar
ghotekarsuresh7@gmail.com

✉ Vijay J. Medhane
vjmedhane1664@gmail.com

[1] Department of Chemistry, K.R.T. Arts, B.H. Commerce, and A.M. Science College, Savitribai Phule Pune University, Nashik 422002 Maharashtra, India

[2] Department of Chemistry, G.M.D. Arts, B.W. Commerce and Science College, Savitribai Phule Pune University, Sinnar 422 103 Maharashtra, India

[3] Department of Physics, G.M.D. Arts, B.W. Commerce and Science College, Savitribai Phule Pune University, Sinnar 422 103 Maharashtra, India

[4] Department of Chemistry, R.B. Narayanrao Borawake College, Savitribai Phule Pune University, Shrirampur 413709 Maharashtra, India

[5] Department of Chemistry, Smt. Devkiba Mohansinhji Chauhan College of Commerce and Science, University of Mumbai, Silvassa 396 230 Dadra and Nagar Haveli (UT), India

[6] Department of Chemistry, S.V.K.T. Arts, Commerce and Science College, Savitribai Phule Pune University, Nashik 422401 Maharashtra, India

## Graphical abstract

In the present study, MgO nanoflakes were fabricated via the sol–gel approach. The as-prepared MgO nanoflakes were characterized using various microscopic and spectroscopic techniques. The surface area and basicity were examined employing the BET adsorption-desorption isotherm and $CO_2$-TPD methods. The thickness of MgO nanoflakes was calculated via SEM histogram, where the purity of the sample was confirmed using EDX elemental analysis. The well-characterized photoactive MgO nanoflakes further used photocatalytic remediation of organic dyes like methyl orange and Eriochrome Black T in the presence of sunlight. Moreover, the radical scavenging efficacy was also explored using DPPH and $^{\bullet}OH$ assays.

**Keywords** Sol–gel method · MgO nanoflakes · Optical properties · Photocatalytic activity · Antioxidant activity

## Highlights

- Sol–gel synthesis of MgO nanoflakes using citric acid as a fuel.
- Synthesis of MgO nanoflakes was confirmed by XRD, FT-IR, SEM, EDX, HR-TEM, UV-DRS, and $CO_2$-TPD analysis.
- MgO nanoflakes exhibited significant photocatalytic activity against EBT and MO dyes under sunlight.
- MgO nanoflakes showed radical scavenging activity using DPPH and $^{\bullet}OH$ assay.

# 1 Introduction

Globalization and the expansion of numerous industrial sectors have made human life easier and faster, creating severe challenges like pollution. The use of organic pollutant dyes in diverse sectors is linked to the discharge of hazardous and non-degradable materials into water resources and harms human and aquatic life [1–3]. This challenge was solved by utilizing an adsorbent to remove organic materials or by using diverse manufactured nanoparticles (NPs) to degrade them [4–6]. Nanotechnology teaches us how to make nanomaterials from the top-down and bottom-up, using the three physical, chemical, and biological synthesis approaches, each with its own set of benefits and drawbacks [7–9]. Researchers reported the synthesis of several nanomaterials based on carbon, silica, graphene, and alumina using the methods mentioned above and using them as photocatalyst degrade various organic dyes [10–16].

Due to their high surface area, MgO NPs have been reported by various researchers for their intriguing applications in the fields of catalysis, photocatalysis, adsorbents, and wastewater removal [17, 18]. However, the photocatalytic efficacy of nanomaterials is determined by their optical bandgaps; materials with a lower bandgap can function as photocatalysts in the visible area, whereas materials with a higher bandgap require ultraviolet light to activate [19]. Nonetheless, numerous research reports have described the fabrication of MgO NPs using diverse methods, with bandgaps ranging from 3.16 to 5.65 eV, indicating that they can effectively act as a photocatalyst in the ultraviolet region for the environmental remediation of inorganic and organic dyes [20–22].

Herein, we report the sol–gel approach for synthesizing MgO nanoflakes using magnesium nitrate and citric acid as precursors. This study focuses on the sol–gel synthesized MgO nanoflakes and their characterization using spectroscopic and microscopic techniques. Furthermore, the photocatalytic efficiency was estimated against methyl orange (MO) and Eriochrome Black T (EBT) dyes, and antimicrobial activity was evaluated using $^{\bullet}OH$ and DPPH assays. The study presents the first effort to investigate the photocatalytic degradation of EBT dye using MgO NPs. The photocatalytic and antioxidant activities of sol–gel synthesized MgO nanoflakes are well explained and compared with the previous report in the result and discussion sections.

# 2 Experimental

## 2.1 Chemicals

All essential AR-grade chemicals and reagents were procured from Sigma-Aldrich in Mumbai, India, and were utilized without additional purification.

**Table 1** Comparative study of sol–gel synthesized MgO NPs with previous reports

| Sr. no. | Magnesium precursor | Gelling agent | Solvent | Calcination temperature (°C) | Morphology | Average size (nm) | Ref. |
|---|---|---|---|---|---|---|---|
| 1 | $Mg(AcO)_2.4H_2O$ | Tartaric acid | Ethanol | 500 | Spherical | 47.9 | [27] |
| | | Citric acid | | 650 | Hexagon | 43.8 | |
| | | Citric acid | | 750 | Rod | 91.2 | |
| 2 | $Mg(AcO)_2.4H_2O$ | Citric acid | Ethanol | Ultra-sonication | Spherical | 19.2 | [28] |
| 3 | $Mg(NO_3)_2$ | Oxalic acid | Ethanol | 550 | Irregular | 105.7 | [29] |
| | | Tartaric acid | | 500 | Spherical | 58.7 | |
| | | Citric acid | | 550 | Irregular | 105.7 | |
| | | Mixture | | 600 | Irregular | 141.8 | |
| 4 | $Mg(AcO)_2.4H_2O$ | KOH | Water and toluene (1:15) | 1000 | Cubic shape | 50–60 | [30] |
| 5 | $Mg(NO_3)_2$ | Citric acid | Ammonia | 600 | Crystalline | 8.9 | [31] |
| 6 | $Mg(NO_3)_2$ | Citric acid | Ethanol | 550 | Spherical | 13–25 | [32] |
| 7 | $Mg(NO_3)_2$ | NaOH | Water | 300 and 500 | Cubic shape | 50–70 | [33] |
| 8 | $Mg(NO_3)_2$ | Citric acid | Water | 400 | Nanoflakes | 14.79 | Present study |

## 2.2 Synthesis of MgO NPs

Magnesium nitrate and citric acid were employed as precursors and fuels, respectively, in the fabrication of MgO NPs employing the sol–gel method. The 0.1 M magnesium nitrate solution was first obtained by dissolving 1.48 g of magnesium nitrate in 100 mL of double-distilled water, then adding 1:5 wt.% citric acid and constantly agitating to achieve a homogenous mixture. Furthermore, the reaction mixture was continuously agitated at 95 °C to obtain a white gel and then dried for 12 h in a hot air oven at 100 °C to make white crystalline powder. Finally, the dry white gel was crushed into powder form and calcinated at 400 °C in a muffle furnace to yield crystalline MgO NPs. The sol–gel synthesized MgO NPs are then used for further processes.

The present study was compared with the previous report in Table 1. The comparative study confirms the first-time report of the nanoflakes morphology of MgO NPs for photocatalytic degradation of organic dyes.

## 2.3 Characterization of MgO NPs

Assorted spectroscopic and microscopic tools were applied to investigate the sol–gel synthesized MgO NPs, including UV-DRS spectroscopy with a JASCO V-770 spectrophotometer, XRD data with a Model-D8 Advance-Bruker, and IR spectra with an FT/IR-4600 type A. Furthermore, the topology of fabricated MgO was investigated employing SEM (JSM-6380), and $CO_2$-TPD was investigated utilizing BELCAT II Version 0.5.1.10.

## 2.4 Photocatalytic activity

Under sunlight, the aqueous phase examined the photocatalytic activity of sol–gel synthesized MgO NPs with organic dyes such as MO and EBT in the aqueous phase. In the experiment, a 10 mL (1 ppm) aqueous solution of the dyes mentioned above was placed in a 50 mL beaker. Various amounts (5, 10, and 15 mg) of sol–gel synthesized MgO NPs were swirled in the presence of UV light. For MO and EBT, the absorbance of dye was measured at a regular interval of 10 min at max = 464 and 535 nm, respectively.

## 2.5 Antioxidant activity

The antioxidant performance of sol–gel synthesized MgO NPs was perused by two various protocols: the hydroxyl ($^{\bullet}$OH) and DPPH radical assay. The entire procedure for antioxidant efficacy is described in our previous report [23].

# 3 Results and discussion

## 3.1 Characterization

The synthesis and a morphological pictogram of sol–gel synthesized MgO NPs were confirmed and understood using spectroscopic and microscopic techniques.

### 3.1.1 XRD pattern of sol–gel synthesized MgO NPs

The crystal structure and grain size of sol–gel synthesized MgO NPs were calculated using the XRD data of MgO NPs. Powder XRD of sol–gel synthesized MgO NPs was done using monochromatic CuKα-1 radiation (wavelength 1.5406 Å), operating at a current of 40 mA and voltage of 40 kV, in the precise range 2θ of 30°–90°. The XRD pattern of MgO NPs shown in (Fig. 1), the planes (111), (200), (220), (311), and (222) confirm the formation of the polycrystalline cubic structure of MgO NPs [24]. The crystallite size of MgO NPs was determined by Scherrer's formula.

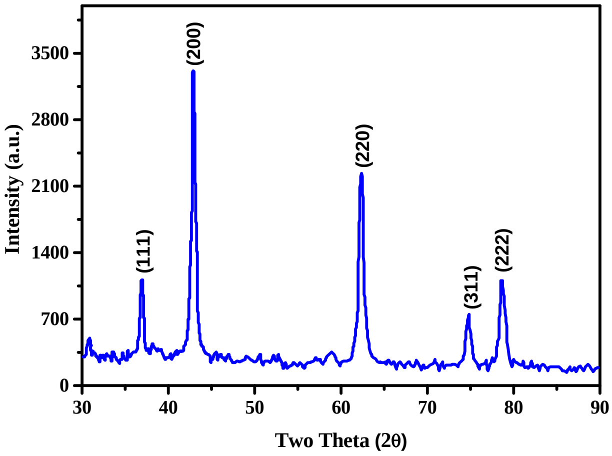


**Fig. 1** XRD pattern of sol–gel synthesized MgO NPs (JCPDS No. 87-0653)

**Table 2** XRD parameter and the average size of sol–gel synthesized MgO NPs

| Entry | 2θ (°) | Crystal plane | FWHM | Crystallite size (nm) | Average size (nm) |
|---|---|---|---|---|---|
| 1 | 36.9 | (111) | 0.5176 | 16 | 15 |
| 2 | 42.9 | (200) | 0.6451 | 13 | |
| 3 | 62.3 | (220) | 0.6528 | 14 | |
| 4 | 74.7 | (311) | 0.6145 | 16 | |
| 5 | 78.7 | (222) | 0.7302 | 14 | |

The corresponding XRD peaks are summarized in Table 2, the calculated average crystallite size of fabricated MgO NPs using Scherrer's equation was found to be 15 nm.

### 3.1.2 FT-IR spectrum of sol–gel synthesized MgO NPs

In sol–gel synthesis of MgO NPs, citric acid was used as a fuel or chelating agent that accumulated all the metal cation to form a gel in the form of metal hydroxide. After calcination of metal hydroxide at 600 °C in a muffle furnace results in crystalline MgO NPs. In this case, the FT-IR spectrum reveals the interaction of the chelating agent and metal ion in a specific region (Fig. 2). FT-IR spectrum sol–gel synthesized MgO NPs confirm the synthesis of the metal-oxygen bond via peak at 448 cm$^{-1}$, whereas the peak present in the functional group region at 3699 cm$^{-1}$, 3433 cm$^{-1}$ may be due to hydroxyl and amine stretch and the peaks around 1446 and 859 cm$^{-1}$ due to carbon-oxygen single bond stretching and bending vibrations. The obtained result was compared and matched with the previous report [25].

### 3.1.3 Adsorption-desorption study

The surface area is one of the key parameters of synthesized NPs, the catalytic and photocatalytic efficiency owing to the surface area, pore size, and volume distribution of NPs. To evaluate the surface properties of NPs, the adsorption-desorption study was carried out under an $N_2$ atmosphere at a certain temperature by the BET method. The BET technique determined MgO NPs under nitrogen gas at 250 °C shown in (Fig. 3a), the surface area was found to be 10.76 m$^2$/g. The pore volume and pore diameters were 0.08 cm$^3$/g and 32.31 nm, respectively (Fig. 3b).

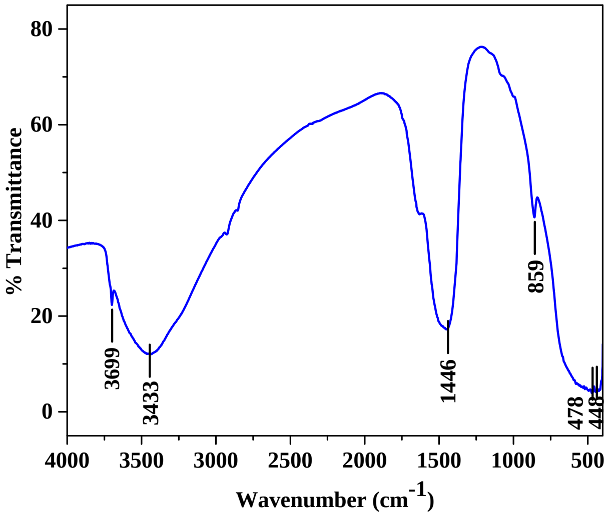


**Fig. 2** FT-IR spectra of sol–gel mediated MgO NPs

### 3.1.4 Morphological and elemental study

The topology of sol–gel synthesized MgO NPs was confirmed by SEM micrographs, Fig. 4 evinces the different micrographs of MgO NPs at a diverse resolution. The SEM micrograph confirms the nanoflakes formation with a thickness of 46 nm. The purity and elemental composition of synthesized MgO NPs were evaluated by the EDS spectrum (Fig. 5). The EDS spectrum evinces the two characteristic peaks at 0.5 and 1.5 eV of O and Mg elements, respectively, which confirm the purity of synthesized MgO NPs.

### 3.1.5 HR-TEM analysis

Figure 6 shows the TEM images of the MgO NPs calcined at 400 °C. It can be seen that all of the MgO NPs were random in size and displayed aggregation in the low magnification image at a scale bar of 500 nm (Fig. 6a, b), whereas under a highly magnified TEM micrograph at a scale bar of 500 nm (Fig. 6a), a reasonably good understanding of shape and thickness can be obtained; the thickness of the NPs is between 10 and 60 nm and irregularly shaped nanoflakes. The white spot array in Fig. 6d, which shows the selective area electron diffraction (SAED) patterns of a single MgO NP, confirms the NPs crystalline nature. As a result, the TEM-SAED findings confirm the XRD findings.

**Fig. 3** **a** Adsorption-desorption study and **b** pore size of sol–gel synthesized MgO NPs

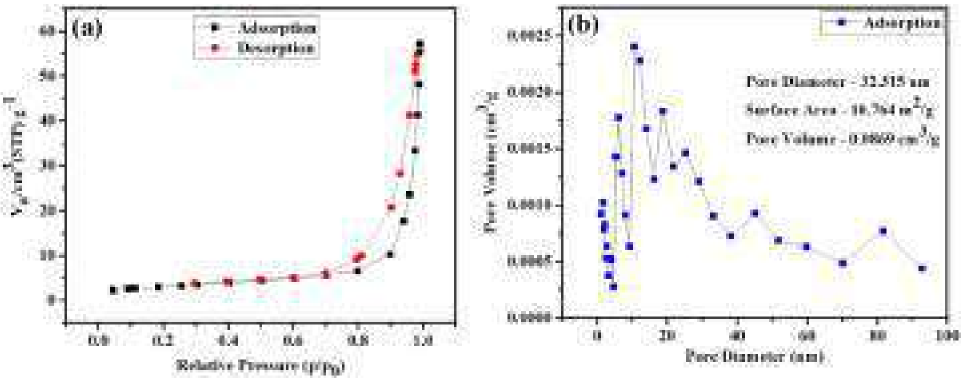


**Fig. 4** SEM images of sol-gel synthesized MgO NPs at different resolutions. **a** 5 μm, **b** 2 μm, **c** 1 μm, and **d** 500 nm

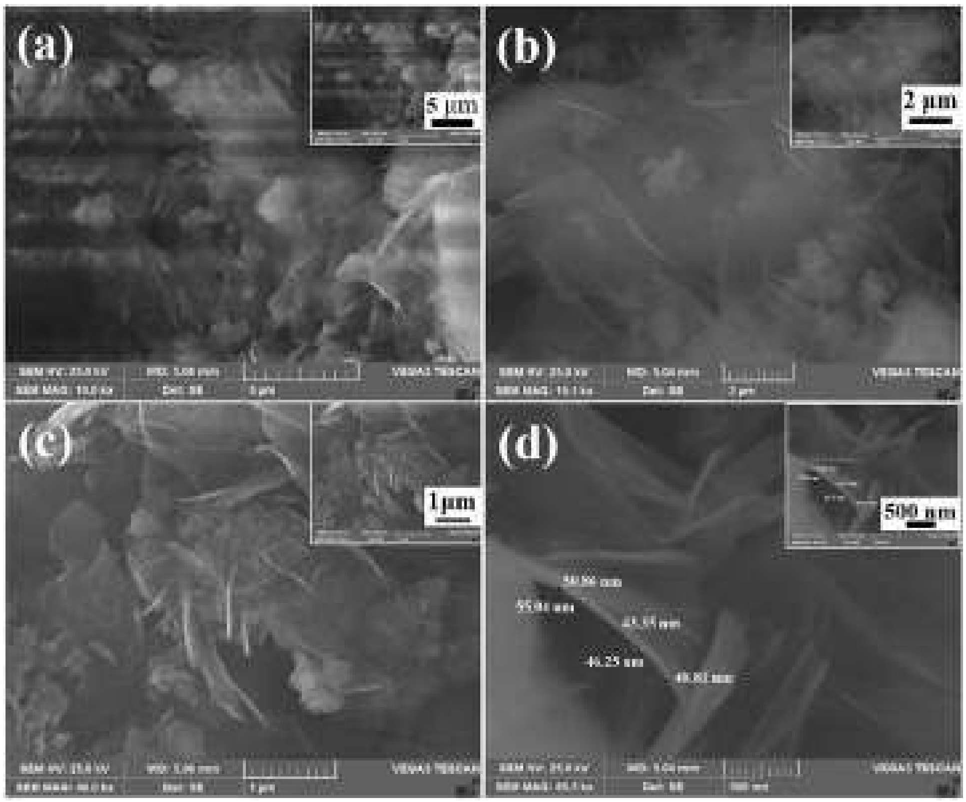
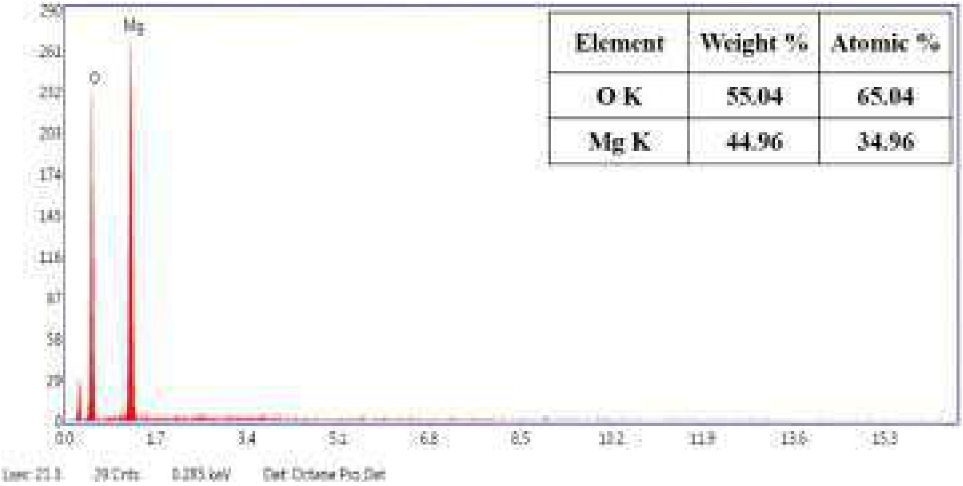


**Fig. 5** EDX spectrum of sol–gel synthesized MgO NPs



| Element | Weight % | Atomic % |
|---|---|---|
| O K | 55.04 | 65.04 |
| Mg K | 44.96 | 34.96 |

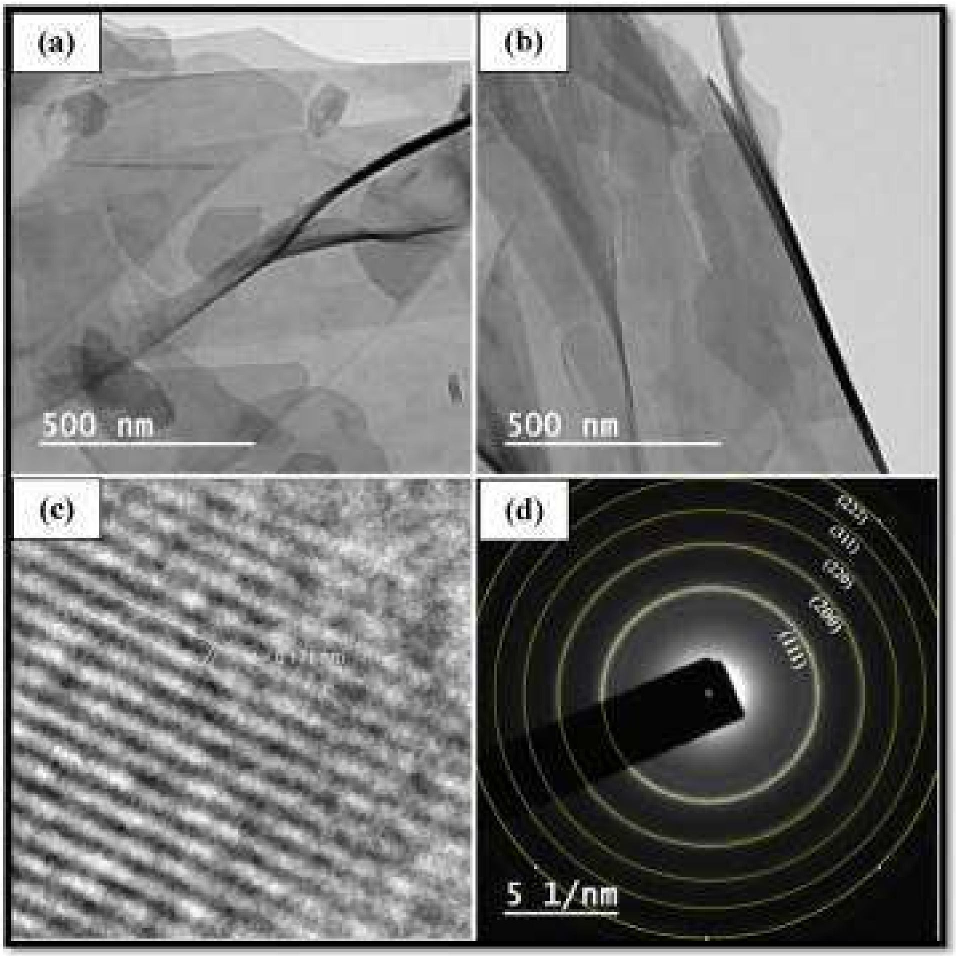


**Fig. 6** **a**, **b** HR-TEM images, **c** lattice-fringe image, and **d** is SAED pattern of sol–gel synthesized MgO NPs

### 3.1.6 $CO_2$-TPD analysis

Metal oxide NPs are naturally basic, and their basicity was assessed using the $CO_2$-TPD method. The $CO_2$-TPD technique's principle was based on the surface characteristics of synthesized metal oxide NPs, and the desorption rate of $CO_2$ gas from the material under investigation was calculated experimentally at temperature increases. The temperature at which the material exhibits high $CO_2$ gas desorption determines whether the synthesized NPs are basic [24]. The $CO_2$-TPD spectrum of MgO NPs synthesized by sol–gel is shown in Fig. 7. The spectrum has two peaks at 180 and 402 °C, suggesting that the material has two different basic sides, with the peak at 180 °C showing mild basic and the peak at 402 °C showing high basic nature of synthesized MgO NPs.

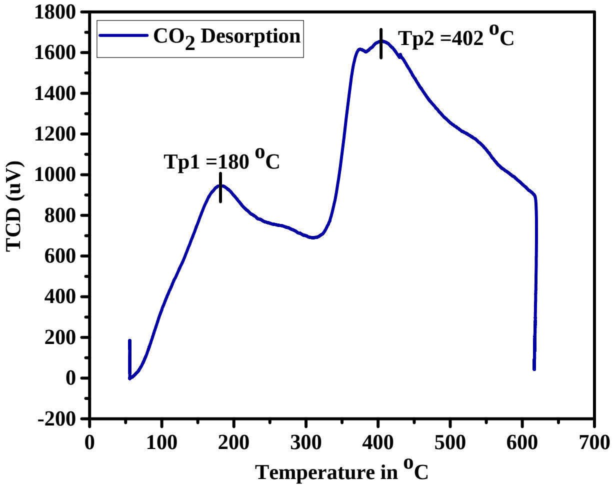


**Fig. 7** $CO_2$-TPD graph of sol–gel synthesized MgO NPs

### 3.1.7 UV-DRS spectra and bandgap of sol–gel synthesized MgO NPs

The initial confirmation of the formation of MgO NPs via the sol–gel method was done with the UV-DRS spectroscopic technique. The absorption spectrum of NPs in the UV-DRS spectrum depends upon the morphology and size of synthesized NPs. The agglomeration of NPs also has a marked effect on the absorption spectra [26]. Here, a single absorption peak at 284 nm was obtained in the UV-DRS spectrum, which affirms the formation of MgO NPs by the sol–gel technique (Fig. 8). The bandgap determines the photocatalytic property of any synthesized NPs, which determines whether the NP material is activated by visible or UV light. The bandgap of sol–gel synthesized MgO NPs was determined with the help of the Tauc Eq. (1).

$$\alpha h\nu = (h\nu - Eg)n \tag{1}$$

where $\alpha$ is the absorption coefficient, $E_g$ is the bandgap of MgO NPs, and $h\nu$ is photon energy. The optical bandgap of sol–gel synthesized MgO NPs was found to be ($E_g = 3.85$ eV) shown in the inset of (Fig. 8). The obtained result was compared and matched with the previous result [25].

### 3.1.8 Photocatalytic activity

Under UV light, the photocatalytic efficacy of sol–gel synthesized MgO NP was investigated using the organic dyes EBT and MO as organic pollutants. The optical bandgap of synthesized MgO NPs was measured using the Tauc equation and was 3.85 eV, as depicted in the inset of (Fig. 8). Their measured bandgap confirms the UV-active nature of MgO NPs. Hence photocatalytic degradation of EBT and MO took place under sunlight. The photocatalysis principle states semiconducting materials absorb visible or ultraviolet light as per the associated bandgap. The absorbed energy is responsible for the excitation of electrons from the valance band to the conduction band, resulting in the generation of an electron-hole pair. Radicals are formed when a water molecule comes into touch with an electron-hole pair, responsible for organic pollutant breakdown. The following equation was used to compute the dye removal efficiency (2):

$$\text{Efficiency}(\%) = C_0 - C_t/C_0 * 100 \tag{2}$$

where $C_0$ is the initial absorbance at $t = 0$, and $C_t$ is the absorbance value at a particular time interval.

Briefly, the absorbance of aqueous solutions of EBT and MO dye at 10 ppm concentration were treated with varying sol–gel synthesized MgO photocatalyst (5 and 10 mg) under sunlight and evaluated at regular time intervals using a double beam UV spectrophotometer at 485 and 464 nm, respectively. Figures 9a and 10a illustrate the decrease in EBT and MO dye absorbance over time and with varying catalyst concentrations. The comparison analysis reveals that a higher rate of decomposition was found in EBT with a catalyst dose of 5 mg, but the dye was completely degraded with a catalyst dose of 10 mg, validating the effect of catalyst dose on dye decomposition performance. However, a significant color change was observed with 5 and 10 mg of catalyst dose in EBT and MO, respectively, as shown in Fig. 9. Figures 10b and 11b explain the percent removal efficiency of MgO NPs in EBT and MO, where the maximum decomposition was noticed in 60 min in the presence of sunlight, and Figs. 10c and 11c exhibit the photocatalytic degradation of EBT and MO via sol–gel synthesized MgO NPs following the principle of first-order kinetics. The various results of the diverse synthetic approaches of photocatalytic MgO NPs for MO dye degradation were discussed in Table 3. However, according to the literature, EBT degradation using MgO NPs has not been reported.

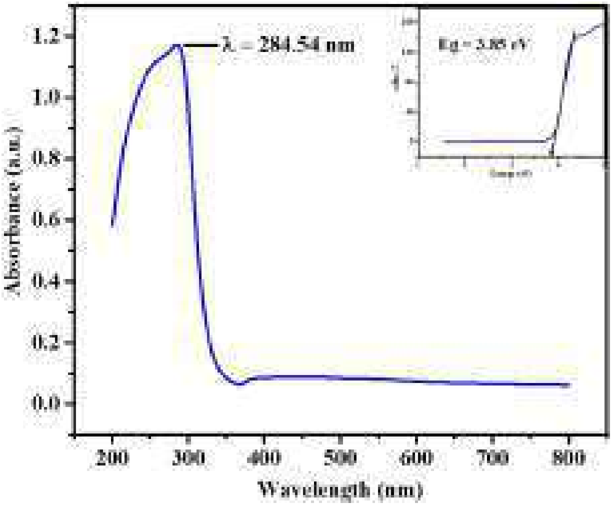


**Fig. 8** UV-DRS spectrum and bandgap of sol–gel synthesized MgO NPs

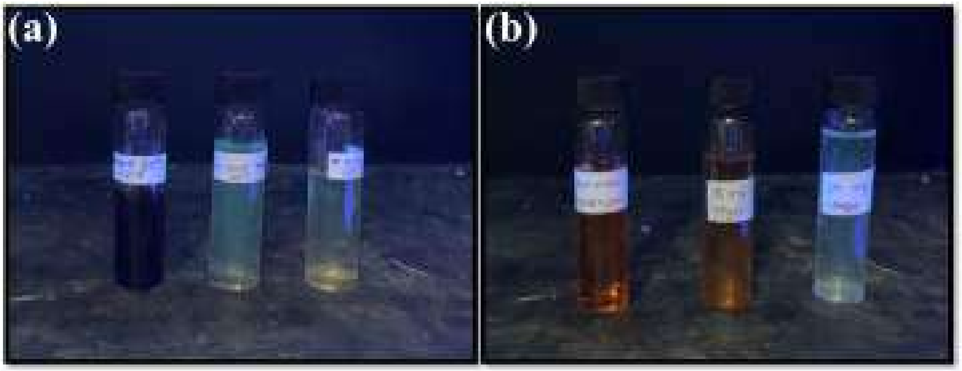


**Fig. 9** Photodegradation of dyes after 60 min under UV light with different concentrations of catalyst. **a** Degradation of EBT dye and **b** degradation of MO dye

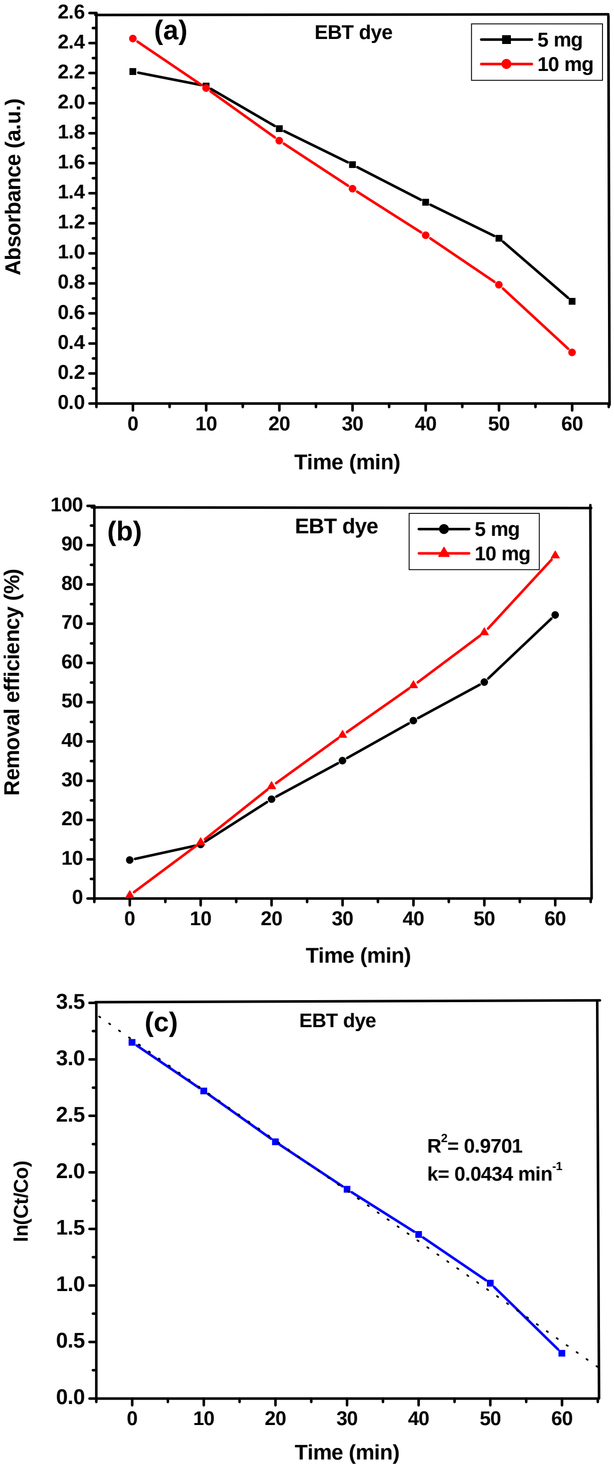


Fig. 10 Photocatalytic activity of sol–gel synthesized MgO NPs. **a** Absorbance with respective to time for the decolonization of EBT dye under sunlight, **b** removal efficiency (%) of EBT dye by MgO NPs, and **c** its first-order kinetics

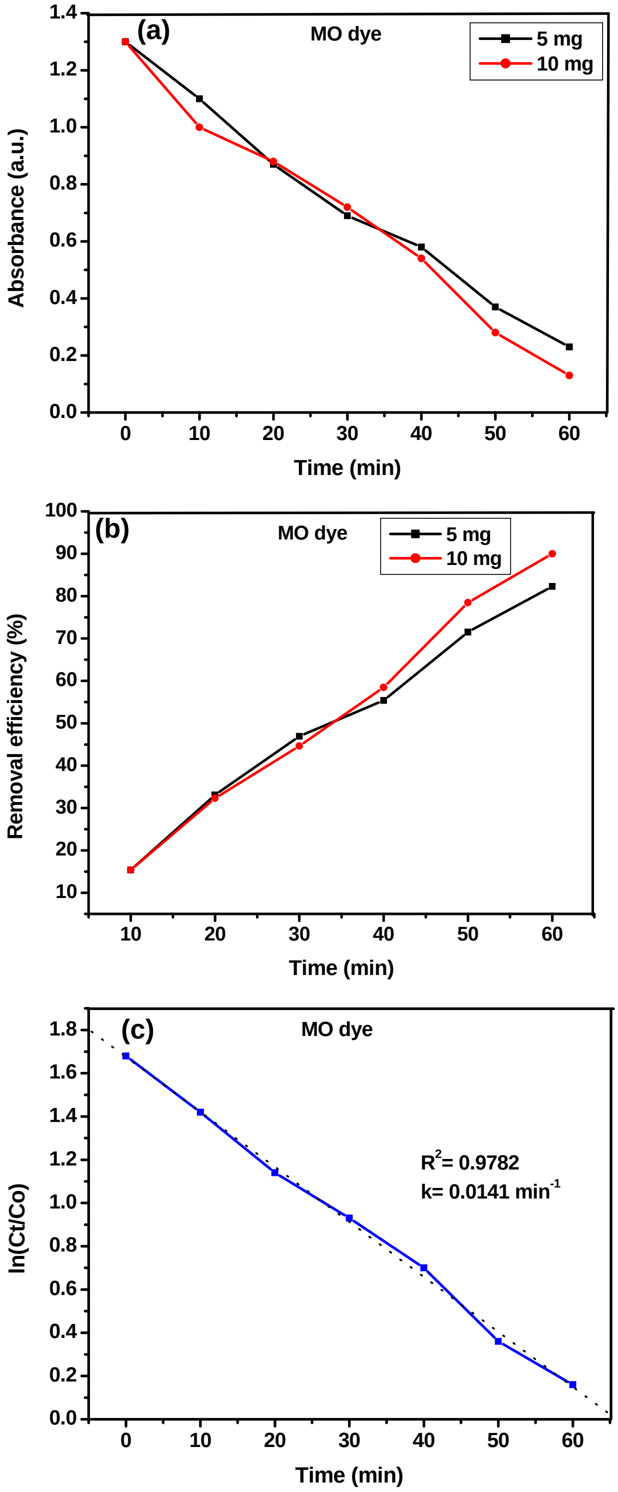


Fig. 11 Photocatalytic activity of sol–gel synthesized MgO NPs. **a** Absorbance with respective to time for the decolonization of MO dye under sunlight, **b** removal efficiency (%) of MO dye by MgO NPs, and **c** its first-order kinetics

### 3.1.9 Antioxidant activity

DPPH and $^{\bullet}$OH tests investigated the radical scavenging efficacy of sol–gel fabricated MgO NPs (Table 4). Due to the transition, DPPH is substantially absorbed at 5at nm. Therefore, the dark violet color of the DPPH was rapidly reduced over time, and the absorbance was gradually

**Table 3** Photocatalytic MO dye degradation using MgO nanomaterials

| S. no. | Fabrication approach | Size (nm) | Shape | Time | Source | Degradation (%) | Ref. |
|---|---|---|---|---|---|---|---|
| 1 | Wet chemical approach | 5.78 | Flakes | 40 min | UV light | 50 | [34] |
| 2 | Co-precipitation | 20 | Spherical | – | UV light | 68.62 | [35] |
| 3 | Molten salt method | 33.3 | Hexagonal plates | 100 min | Sunlight | 80 | [36] |
| 4 | Solvent-assisted synthesis | 11.57 | Flowers | 12 h | UV light | 88.21 | [37] |
| 5 | Sol–gel method | 14.79 | Flakes | 60 min | UV light | 90 | Present work |

**Table 4** Antioxidant activities of sol–gel synthesized MgO NPs

| Entry | Material | Antioxidant activity (%) | |
|---|---|---|---|
| | | $^{\bullet}$OH | DPPH |
| 1 | MgO NPs | 57.1 | 49.8 |
| 2 | Ascorbic acid (standard) | 82.3 | 86.4 |

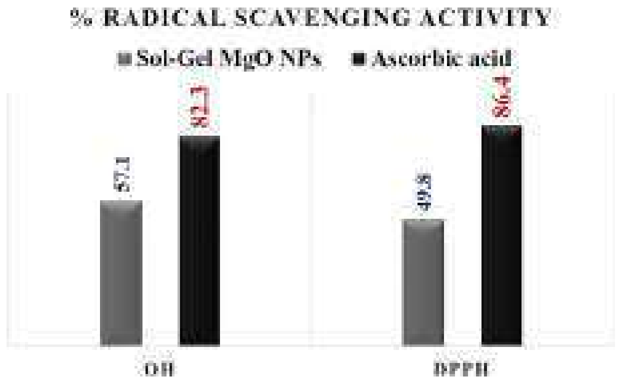


**Fig. 12** Antioxidant activity of sol–gel synthesized MgO NPs

decreased. The decrease in absorption intensity validates the radical scavenging performance of sol–gel synthesized MgO NPs, which was 49.8% compared to 86.4% for ascorbic acid as a control. The $^{\bullet}$OH assay was also used to determine the radical scavenging activity, which was 57.1% using the same standard, with an efficacy of 82.3% (Fig. 12). Previously our study reported the synthesis of MgO NPs using *Trachyspermum ammi* leaf extract and evaluated its antioxidant activities [24]. This result also showed a good agreement with our present work.

## 4 Conclusion

The present study reveals the fabrication of MgO NPs via the sol–gel approach and citric acid as fuel in aqueous media. The preliminary confirmation of the fabrication of MgO NPs was done with the help of the XRD pattern. The crystallite size and flake thickness were determined from Scherrer's equation, and the SEM image was found to be 15 and 46 nm, respectively; the SEM micrograph also confirmed the nanoflakes' morphology. The surface properties were studied via an $N_2$ adsorption-desorption isotherm, showing a high surface area of synthesized MgO nanoflakes with excellent photocatalytic activity. As a result of the findings, MO and EBT dyes were degraded by a significant amount of photocatalytic activity. Finally, our findings may make it more feasible to consider MgO NPs as a potential option for photocatalytic applications to combat water contamination and environmental pollution. Also, MgO NPs show good antioxidant efficacy assessed via DPPH and $^{\bullet}$OH assay.

## Compliance with ethical standards

**Conflict of interest** The authors declare no competing interests.

## References

1. Mydeen SS et al. (2020) Facile synthesis of ZnO/AC nanocomposites using *Prosopis juliflora* for enhanced photocatalytic degradation of methylene blue and antibacterial activity. Optik 224:165426
2. Kumar R et al. (2022) Recent progress in emerging BiPO4-based photocatalysts: Synthesis, properties, modification strategies, and photocatalytic applications. J Mater Sci Technol 108:208–225
3. Van Thuan D et al. (2022) Development of indium vanadate and silver deposited on graphitic carbon nitride ternary heterojunction for advanced photocatalytic degradation of residual antibiotics in aqueous environment. Optical Mater 123:111885
4. Uddin MK, Baig U (2019) Synthesis of Co3O4 nanoparticles and their performance towards methyl orange dye removal: Characterisation, adsorption and response surface methodology. J Clean Prod 211:1141–1153
5. Cuong HN et al. (2022) New frontiers in the plant extract mediated biosynthesis of copper oxide (CuO) nanoparticles and their potential applications: A review. Environ Res 203:111858
6. Kalia R et al. (2022) Photocatalytic degradation properties of Li-Cr ions substituted CoFe2O4 nanoparticles for wastewater treatment application. Phys Status Solidi (A) 219:2100539
7. Dabhane H et al. (2020) Plant mediated green synthesis of lanthanum oxide (La2O3) nanoparticles: A review. Asian J Nanosci Mater 3(4):291–299
8. Kashid Y et al. (2022) Bio-inspired sustainable synthesis of silver chloride nanoparticles and their prominent applications. J Indian Chem Soc 99:100335
9. Pandit C et al. (2022) Biological agents for synthesis of nanoparticles and their applications. J King Saud Univ Sci 34(3):101869
10. Jadhav SA et al. (2019) Recent advancements in silica nanoparticles based technologies for removal of dyes from water. Colloid Interface Sci Commun 30:100181

# Acid-base Modified Biosorbent for Heavy Metal Removal - A Review

**Bharat N. Shelke[1,2], Manohar K. Jopale[2,3], Manoj R. Gaware[4] and Amol H. Kategaonkar[5,*]**

[1]Department of Chemistry, M.V.P. Samaj's Arts, Science and Commerce College, Ozar (Mig) Nashik-422206, India
[2]Department of Chemistry, M.V.P. Samaj's G. M. D Arts, B. W. Commerce and Science College, Sinnar, Nashik-422103, India
[3]Department of Chemistry, M.V.P. Samaj's Arts, Commerce & Science College Jawahar Road, Tryambykeshwar, Nashik-422212, India
[4]Department of Chemistry, M.V.P. Samaj's K. P. G. Arts, Commerce & Science College Takeghoti, Igatpuri, Nashik-422402, India
[5]Post Graduate Department of Chemistry, M.V.P. Samaj's K.S.K.W. Arts, Science and Commerce College, CIDCO, Uttamnagar, Nashik 422008, India

## ABSTRACT

The heavy metals Cu, Cd, Ni, Cr, Pb, As and Bi removal by modified low cost adsorbents were reviewed in the current article. The present study focuses on enhancement of adsorption of metal by acid-base modification of low cost adsorbent. An acid modification were carried out by $H_2SO_4$, $HNO_3$, $H_3PO_4$, citric acid and tartaric acid while base modification were carried out by NaOH, $K_2CO_3$ and KOH. The review represents various parameters such as activation agent of adsorbent by acid-base, type of adsorbent, characterization methods viz. SEM, EDS, FTIR, BET and maximum adsorption capacity of heavy metals. Adsorption method is found superior for removal of pollutant from waste water than any other conventional method. The adsorption of metal on adsorbent surface occurred by physical sorption, chemical sorption, complexation, ion exchange and through pore diffusion process. Agricultural waste adsorbents are found good alternative due its negligible cost, easy availability and maximum adsorption capacity.

**KEYWORDS:** Heavy metals; Adsorbent; Acid-base treatment; SEM; BET

## INTRODUCTION

Heavy metals are major toxic pollutants specially found in waste water discharges from different industries. The process of metal extraction from ore such as mining, roasting, pulverizing, refining greatly contributes the heavy metal accumulation into the waste water while the fertilizer industry, tanneries, pesticides, batteries, electroplating and paper industries also introduces heavy metal into the environment[1]. Heavy metals such as Cadmium (Cd), Chromium (Cr), Copper (Cu), Cobalt (Co), Lead (Pb), Zinc (Zn), Arsenic (As) Vanadium (V) and Nickel (Ni) shows adverse effect on animals as well as aquatic life[2]. The effluent of industrial waste containing large amount of toxic heavy metals without prior treatment causes hazardous effect to aquatic life. Many of the heavy metals are non-biodegradable and hence accumulate in the food chain which reduces the human life[3]. Cadmium (Cd) is carcinogenic and responsible for Itai-Itai disease, anemia, dyspnea, Chromium causes lungs tumor and allergic dermatitis, Copper (Cu) gives liver illness, diarrhea, headache, Mercury affects on kidney, nervousness, unconsciousness, Nickel (Ni) causes anaphylaxis and damages red blood cells, lead (Pb) affects on appetite loss, kidney failure, high blood pressure, anemia and Zinc (Zn) causes restlessness and metal fume fever[4].

Nowdays numerous techniques are available for the removal of heavy metals such as precipitation, oxidation, reduction, ultrafiltration, reverse osmosis, electro dialysis and ion exchangers[5]. Due to increase in processing cost, low efficiency, low sensitivity, all these techniques have certain limitations for heavy metal removal from waste water. Adsorption is an advantageous technique over the all of these methods due to low cost and greater removal efficiency of metal from waste water[6]. An activated carbon adsorbent used for heavy metal removal shows greater removal efficiency and easy operating process but due to its high cost it have some limitation. The adsorbent prepared from fly ash, sludge, industrial waste, zeolites and agricultural waste has great significance for heavy metal removal [7-8].

In the current review article, the surface modification for various low cost adsorbents by acid-base treatment is explored. The absorption efficiency of adsorbent can be enhanced by activation viz. physical method and chemical method[9]. The present work summarizes the effect of modification of various adsorbents by treatment with sulphuric acid, hydrochloric acid, nitric acid, tartaric acid, phosphoric acid while with base sodium hydroxide, potassium hydroxide, potassium carbonate and calcium hydroxide.

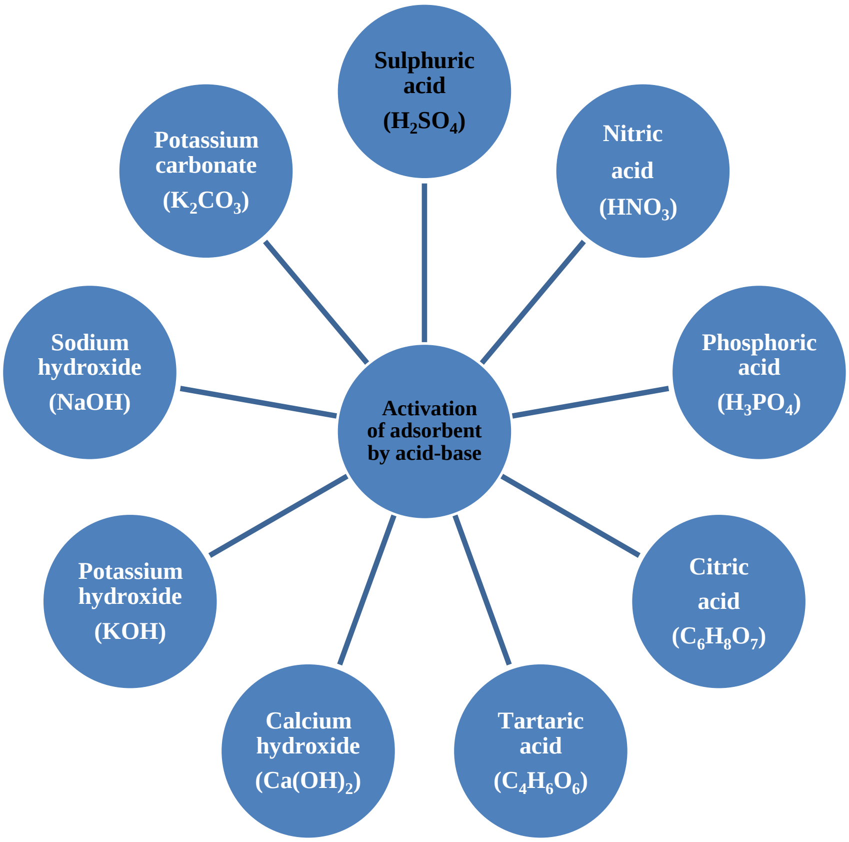


**Figure 1. Activation of adsorbent by various Acid-Base treatment**

**Modification of adsorbent by acid treatment:** The removal of Cu from agricultural waste adsorbent like bagasse on activation with citric acid was investigated by Meenal Gupta et al.[10]. Sulphuric acid treatment for various adsorbents namely areca catechu [11], Cynodon Dactylon [12], Henna leaves [13], Cashew nut[14] were carried out and found maximum adsorption capacity for Cu 1.33 mg/g, 90.35 mg/g, 3.65 mg/g and 406.6 mg/g respectively. An azadirechta indica leaf [26] on phosphoric acid treatment shows higher adsorption capacity 110.9 mg/g for Cr removal while Macadamia activated carbon[15] on treatment with sulphuric acid, phosphoric acid and nitric acid shows 25.75 mg/g, 25.43 mg/g and 38.59 mg/g respectively. Sorghum bicolor [19] and Cassava peel [28] adsorbents on sulphuric acid modification for Cr shows maximum adsorption capacity 25.64 mg/g and 10.07 mg/g respectively. The adsorption efficiency of toxic metal Cd was investigated by sulphuric acid treated cashew nut shell [14], phosphoric acid treated azadirechta indica leaf [26] and sulphuric acid modified cassava peel [28]. Lapsi seed stone [21] on activation with mixture of sulphuric acid-nitric acid shows maximum adsorption capacity 69.49 mg/g for Ni ion while Sorghum bicolor [19], Doam seed coat [20] on sulphuric acid treatment has adsorption capacity 47.62 mg/g and 13.51 mg/g respectively.

Ponnusamy Senthil Kumar et al.[14] studied on removal of Zn by using low cost adsorbent Cashew nut shell. The prepared adsorbent was characterized by FTIR and SEM. The maximum adsorption capacity was found 455.7 mg/g while the Palm midrib [23] on citric acid and tartaric acid treatment and azadirechta indica[26] on phosphoric acid treatment shows 5.72 mg/g and 133.3 mg/g respectively. Sartape Ashish et al. explored the use of coconut shell adsorbent [22] on activation with sulphuric acid for the removal of Bi and the activated adsorbent was characterised by FTIR, SEM and BET surface area analyser. The amount of removal of Pb were investigated on sulphuric acid activated maize tassel [25], phosphoric acid treated azadirechta indica leaf [26], nitric acid activated baggasse, palm pit, saw dust [27], sulphuric acid treated cassava peel [28]. An elemental analysis and Boehm method were applied to characterise the prepared adsorbent.

**Table 1. Biosorption of heavy metals by acid treated low cost adsorbents**

| **Heavy metal** | **Adsorbent** | **Modifying agent** | **Characterizations** | **Maximum adsorption capacity mg/g** | **Ref** |
|---|---|---|---|---|---|
| Cu | Baggasse | Citric acid | FTIR, SEM | 5.35 | 10 |
| Cu | Areca catechu shell | $H_2SO_4$ | FTIR, SEM | 1.33 | 11 |
| Cu | Cynodon Dactylon | $H_2SO_4$ | FTIR, XRD, SEM | 90.35 | 12 |
| Cu | Henna Leaves | $H_2SO_4$ | -- | 3.65 | 13 |
| Cr | Henna Leaves | $H_2SO_4$ | -- | 0.078 | 13 |
| Cu | Cashew nut shell | $H_2SO_4$ | FTIR, SEM | 406.6 | 14 |
| Cd | Cashew nut shell | $H_2SO_4$ | FTIR, SEM | 436.7 | 14 |
| Zn | Cashew nut shell | $H_2SO_4$ | FTIR, SEM | 455.7 | 14 |
| Ni | Cashew nut shell | $H_2SO_4$ | FTIR, SEM | 456.3 | 14 |
| Cr | Macadamia activated carbon | $H_2SO_4$ | FTIR, TGA, EDAX, BET | 25.75 | 15 |
| Cr | Macadamia activated carbon | $H_3PO_4$ | FTIR, TGA, EDAX, BET | 25.43 | 15 |
| Cr | Macadamia activated carbon | $HNO_3$ | FTIR, TGA, EDAX, BET | 38.59 | 15 |
| Cr | Activated carbon | $HNO_3$ | EAS, Boehm method | 13.74 | 16 |
| Cr | Olive stone | $H_2SO_4$ | FTIR | 71 | 17 |
| Ni | Oil palm | $H_3PO_4$ | -- | 19.6 | 18 |
| Cr | Sorghum bicolor | $H_2SO_4$ | BET, FTIR | 25.64 | 19 |
| Ni | Sorghum bicolor | $H_2SO_4$ | BET, FTIR | 47.62 | 19 |
| Ni | Doum seed coat | $H_3PO_4$ | FTIR, | 13.51 | 20 |
| Ni | Lapsi seed stone | $H_2SO_4$ | FTIR, Boehm method | 28.25 | 21 |
| Ni | Lapsi seed stone | $H_2SO_4$ and $HNO_3$ | FTIR, Boehm method | 69.49 | 21 |

| | | | | | |
|---|---|---|---|---|---|
| Bi | Coconut shell | $H_2SO_4$ | SEM, FTIR, BET | 250 | 22 |
| Zn | Palm midrib | Citric acid and tartaric acid | SEM | 5.72 | 23 |
| Cu | Palm | $H_3PO_4$ | FTIR, BET | 21.23 | 24 |
| Pb | Maize Tassel | $H_2SO_4$ | XRD, FTIR | 37.31 | 25 |
| Pb | Azadirechta indica leaf | $H_3PO_4$ | BET | 205.6 | 26 |
| Cu | Azadirechta indica leaf | $H_3PO_4$ | BET | 185.8 | 26 |
| Cd | Azadirechta indica leaf | $H_3PO_4$ | BET | 154.5 | 26 |
| Zn | Azadirechta indica leaf | $H_3PO_4$ | BET | 133.3 | 26 |
| Ni | Azadirechta indica leaf | $H_3PO_4$ | BET | 120.6 | 26 |
| Cr | Azadirechta indica leaf | $H_3PO_4$ | BET | 110.9 | 26 |
| Pb | Baggasse | $HNO_3$ | Element analysis, Boehm method, | 13.7 | 27 |
| Pb | Palm pit | $HNO_3$ | Element analysis, Boehm method | 15.20 | 27 |
| Pb | Sawdust | $HNO_3$ | Element analysis, Boehm method | 17.5 | 27 |
| Pb | Cassava peel | $H_2SO_4$ | Nitroperchloric digestion method, FAAS | 24 | 28 |
| Cd | Cassava peel | $H_2SO_4$ | Nitroperchloric digestion method, FAAS | 7.05 | 28 |
| Cr | Cassava peel | $H_2SO_4$ | Nitroperchloric digestion method, FAAS | 10.07 | 28 |

**Modification of adsorbents by base treatment:** Bagasse [10], green vegetable waste [29], rice husk [30] and orange peel [31] have been used as adsorbent for removal of Cu from its solution. Green vegetable waste was modified by potassium hydroxide while other adsorbents were modified with sodium hydroxide. The author carried out the FTIR, SEM, EDS, TGA and BET characterization for the activated biosorbent material. Green vegetable waste biosorbent shows higher adsorption capacity 75 mg/g in comparison with other adsorbent. The removal of Cd by sodium hydroxide treated biosorbent such as sawdust, wheat straw, corn stalk [32] and rice husk [33] shows adsorption capacity 40.78, 38.75, 30.40, 8.50 mg/g respectively. Rice husk [33] on modification with potassium hydroxide and calcium hydroxide changes adsorption capacity 8.24 mg/g and 10.46 mg/g respectively.

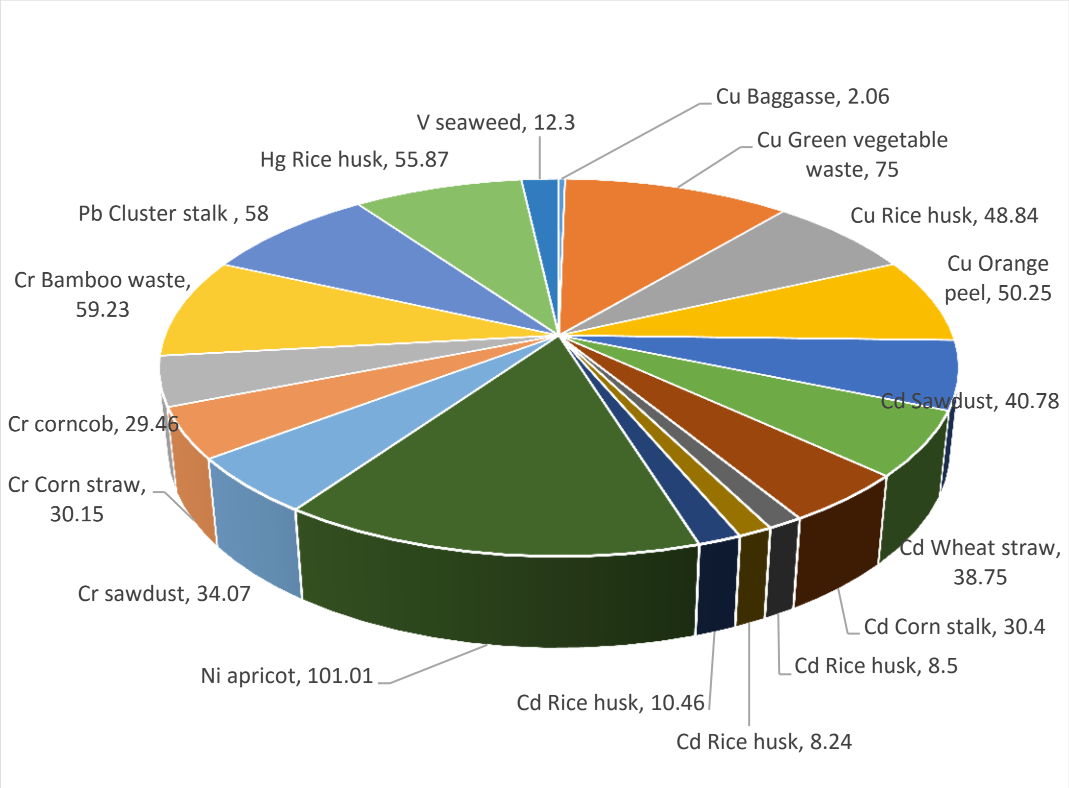


Figure 4. Heavy metal adsorption capacity between 2.06 to 101.01 mg/g by different base treated adsorbents.

S. Erdogan et al. utilised potassium carbonate treated apricot [34] adsorbent for the removal of Ni ion. The prepared biosorbent was characterised by BET and FAAS and shows maximum adsorption capacity 101.01 mg/g. The study of adsorption of Cr by potassium hydroxide activated sawdust, corn straw and corncob [35] were carried out by Shujauddin Khushk et al. The higher adsorption capacity 59.23 mg/g was observed by bamboo waste [36] while corncob shows minimum adsorption capacity 29.46 mg/g. The sawdust and corn straw shows maximum adsorption capacity 34.07 mg/g and 30.15 mg/g respectively. Francisco Jose Alguacil et al. explored the use of cluster stalk [37] on potassium hydroxide activation for Pb ion adsorption.

The poisonous Hg metal adsorption has been investigated by Zhiyuan Liu et al. by rice husk [38] adsorbent on activation with potassium hydroxide. The material was characterised by SEM, FTIR, BET and XPS. The maximum amount of Hg removal by rice husk was found 55.87 mg/g. The seaweed [39] is used as low cost adsorbent on modification with potassium hydroxide and found 12.3 mg/g of maximum adsorption capacity for Vanadium removal.

**Table 2. Biosorption of heavy metals by base treated low cost adsorbent**

| **Heavy metal** | **Adsorbent** | **Modifying agent** | **Characterization** | **Maximum adsorption capacity mg/g** | **Ref.** |
|---|---|---|---|---|---|
| Cu | Baggasse | NaOH | FTIR,SEM | 2.06 | 10 |
| Cu | Green vegetable waste | KOH | SEM, TGA, DSC, FTIR | 75 | 29 |
| Cu | Rice husk | NaOH | FTIR, SEM, EDX | 48.84 | 30 |
| Cu | Orange peel | NaOH | FTIR, SEM, BET | 50.25 | 31 |
| Cd | Sawdust | NaOH | FTIR, SEM, BET, XRD | 40.78 | 32 |
| Cd | Wheat straw | NaOH | FTIR, SEM, BET, XRD | 38.75 | 32 |
| Cd | Corn stalk | NaOH | FTIR, SEM, BET, XRD | 30.40 | 32 |

| | | | | | |
|---|---|---|---|---|---|
| Cd | Rice husk | NaOH | FTIR | 8.50 | 33 |
| Cd | Rice husk | KOH | FTIR | 8.24 | 33 |
| Cd | Rice husk | $Ca(OH)_2$ | FTIR | 10.46 | 33 |
| Ni | apricot | $K_2CO_3$ | BET, FAAS | 101.01 | 34 |
| Cr | sawdust | KOH | SEM, BET, FTIR | 34.07 | 35 |
| Cr | Corn straw | KOH | SEM, BET, FTIR | 30.15 | 35 |
| Cr | corncob | KOH | SEM, BET, FTIR | 29.46 | 35 |
| Cr | Bamboo waste | KOH | FTIR | 59.23 | 36 |
| Pb | Cluster stalk | KOH | FTIR, BET | 58 | 37 |
| Hg | Rice husk | KOH | SEM, FTIR, BET, XPS | 55.87 | 38 |
| V | seaweed | KOH | SEM, EDS, FTIR, BET, XPS | 12.3 | 39 |

From the literature review it is observed that many researchers applied the acid and base activation method to activate the adsorbent. S. Abdic et al. (2018) studied on the heavy metal removal by modified and unmodified tangerine peel adsorbent [40]. The author reported that 40% of adsorption efficiency enhanced by adsorbent modification. The sulphuric acid is most commonly used acid activating agent for activation of adsorbents. An acid and base activation method is simple, effective, time saving and economical than any other chemical method. The activation of functional group on adsorbent surface found successful and which is identified by adsorbent characterization.

## CONCLUSION

In the current review, the biosorption of heavy metal on acid-base treated adsorbents have been studied. Agricultural waste material used as low cost adsorbent for heavy metal removal was found highly efficient and environmental healthy. It was observed that the modified adsorbent by acid-base chemical treatment shows better adsorption efficiency than non-modified adsorbents. An acid-base treatment has been most widely used for surface modification because of its specific impact on surface to adsorb target pollutant. Due to surface modification, the increase in pore volume and pore size generates more active sites for adsorption which is characterized by BET surface area analysis. A new functional group binding sites are formed due to activation which results into more uptake of metal ion from solution. The researcher were studied the presence of different functional groups on adsorbent surface and characterized by FTIR while the surface morphology were studied by SEM analysis. The amount of adsorption of metal ion depends on various factors such as adsorbent dose, pH of the solution, temperature, modifying method and nature of adsorbent. These type of modified adsorbent is helpful for industrial waste water treatment and will used to reduce the environmental pollution.

## ACKNOWLEDGEMENT

We would like to offer special thanks to Dr. Pawan Tambade, who although no longer with us, continues to inspire by his example and dedication to us he served over the course of his career.

## REFERENCES

1. Rajeev Kumar M. A. Laskar, I. F. Hewaidy, M. A. Barakat, *Earth Systems and Environment*, (2019). https://doi.org/10.1007/s41748-018-0085-3
2. Ashutosh Tripathi and Manju Rawat Ranjan, *J Bioremed Biodeg*, **6,** 315 (2015). http://dx.doi.org/10.4172/2155-6199.1000315

Journal of the Indian Chemical Society 99 (2022) 100530

Contents lists available at ScienceDirect

Journal of the Indian Chemical Society

journal homepage: www.journals.elsevier.com/journal-of-the-indian-chemical-society

# Exploration of biomass waste as low cost adsorbents for removal of methylene blue dye: A review

Bharat N. Shelke [a,d], Manohar K. Jopale [b,d], Amol H. Kategaonkar, Ph.D [c,*]

[a] Department of Chemistry, M.V.P. Samaj's Arts, Science and Commerce College, Ozar (Mig), Nashik, 422206, Maharashtra, India
[b] Department of Chemistry, M.V.P. Samaj's Arts, Commerce & Science College, Jawahar Road, Tryambykeshwar, Nashik, 422212, Maharashtra, India
[c] Research Center and Post Graduate Department of Chemistry, M.V.P. Samaj's K.S.K.W. Arts, Science and Commerce College, CIDCO, Uttamnagar, Nashik, 422008, Maharashtra, India
[d] Research Center and Department of Chemistry, M.V.P. Samaj's G. M. D Arts, B. W. Commerce and Science College, Sinnar, Nashik, 422103, Maharashtra, India

ARTICLE INFO

*Keywords:*
Adsorption
Agricultural waste
Fruit peel waste
Low cost adsorbents
Methylene blue
Waste water

ABSTRACT

Biomass waste, which is abundantly available has been studied as low cost biosorbent for dye sequestration from waste water. The present review reports on recent development for remediation of methylene blue dye by agricultural waste and fruit peel waste material. The aim of this study was to revise latest literature in the field of dye adsorption and discuss the dye adsorption capacity of different types of adsorbents. The activated carbon prepared from several types of biomass waste material enhances the adsorption efficiency after modification. The variety of activating agents, method of activation, characterization of biosorbent material like SEM, EDAX, BET surface area and FTIR analysis has been explored in the present review. The dye adsorption factors such as effect of pH, agitation time, temperature, adsorbate and adsorbent dose were discussed. The detailed investigation on applicability of isotherm model, kinetic model and thermodynamic parameters has also been presented. The adsorption kinetics and adsorption isotherm model focus on selectivity of adsorbent. Adsorption mechanism, Influence of surface area, influence of $pH_{pzc}$ and comparative study of biomass waste adsorbent with other adsorbents have been carried out. The use of biomass waste adsorbents is economically feasible, environmental healthy and found to have outstanding removal capacity of dyes.

## 1. Introduction

Dyes are organic aromatic compound having complex structure and soluble in water. Every year dye industry produces $7 \times 10^5$ tons of dyes compound [1]. The industrial effluent contains huge amount of hazardous dyes and it is discarded into the environmental water resources. The presence of even lower amount of dye in water produces colour and which is very harmful to the aquatic life. These dyes prevents the penetration of sunlight into water and disturb the photosynthesis process of aquatic plants, alternately disturb the aquatic life [2]. An approximately 2% dyes from the total present dyes enter into the stream of water through different pathways and pollutes the fresh water. Due to complex structure of dyes, it is difficult to remove it by using chemical reagents and oxidizing agents [3] (see Figs. 1–4).

Most of the dyes are toxic, carcinogenic and cannot be degraded by simple biodegradation technique [4]. Methylene blue is used in great extent in textile industry for colouring the paper, cotton, silk and wool [5]. Different industries like paper, plastic, rubber, leather, textile, cosmetics, food and pharmaceuticals uses large amount of dyes for colouring the material [6].

The traditional methods used for removal of dyes from waste water are physical method, chemical method and biological methods. The physical and chemical methods include precipitation, filtration, flocculation-coagulation and reverse osmosis. The organic chemical compounds converted into mineral material by oxidation process. Chemical method needs specific instruments and chemicals for removal of dyes. It again produces some by-products which create pollution due to its disposal problem. Biological method has limitations for complete removal of dyes. Adsorption is found to be most promising technique for the removal of dyes. The advantage of adsorption techniques are economically feasible, easy handling, availability of adsorbent and better efficiency [7]. Adsorption by low cost adsorbent found most effective for larger scale than other techniques. Activated carbon which is commercially available is a good adsorbent but it increases the cost of

---

* Corresponding author.
*E-mail address:* amol.kategaonkar@gmail.com (A.H. Kategaonkar).

https://doi.org/10.1016/j.jics.2022.100530
Received 29 September 2021; Received in revised form 4 May 2022; Accepted 10 May 2022

dye removal. Nowadays, activated carbon prepared from biowaste, agricultural waste, household waste, industrial waste, clay and minerals found to be most effective adsorbents. These waste materials have disposal problems and do not have as such any appreciable economic value and thus such materials are explored for the removal of dyes from industrial effluent. From environment point of view, low cost adsorbents are ecofriendly, abundant, inexpensive and efficient for dye removal [8].

In recent years, a several type of materials such as agricultural waste, egg shell, coffee waste, nanoparticles, composite material, industrial waste, clay, fly ash and red mud are used for dye removal. Methylene blue has several toxic effects on human body. It causes serotonin toxicity, dizziness, precordial pain and bladder irritation. The researchers carried out the work on methylene blue dye adsorption by pomegranate peel [9], chitosan lignin [10], dragon fruit peel [11], fava bean peel [12], cashew nut shell [13], $H_3PO_4$ activated pomegranate peel [14], coconut leaves [15] and bagasse [16]. A review on methylene blue dye removal by bio-waste material were carried out by A Farhadi et al. [17] and Hamad Noori Hamad and Syazwami Idras [18]. This review summarises the data for methylene blue dye removal by various adsorbents and these cumulative data is advantageous in future research in adsorption.

**Fig. 2.** Factors affecting on adsorption.

## 2. Adsorption mechanism

The amount of dye adsorption depends on the type of adsorption mechanism and interaction between dye and sorbent surface. Ali H. Jawad et al. [19] has investigated surface mechanistic study of MB dye on KOH activated biomass waste. The dye molecule and adsorbent surface has several number of interactions through the functional groups present on surface. The MB dye cations was electrostatically attracted towards negatively charged groups on biomass surface. Adsorption mechanism on orange peel surface for methylene blue dye molecule was reported by Stephanie Giraldo et al. [20]. For mechanism study the author carried out adsorbent surface characteristic study with FTIR spectra and concluded that different type of interactions. The π- π interaction, hydrogen bonding and electrostatic interactions between adsorbent surface and MB dye molecule were stated.

Ali H. Jawad and Ahmed Saudi Abdulhameed [21] studied MB dye

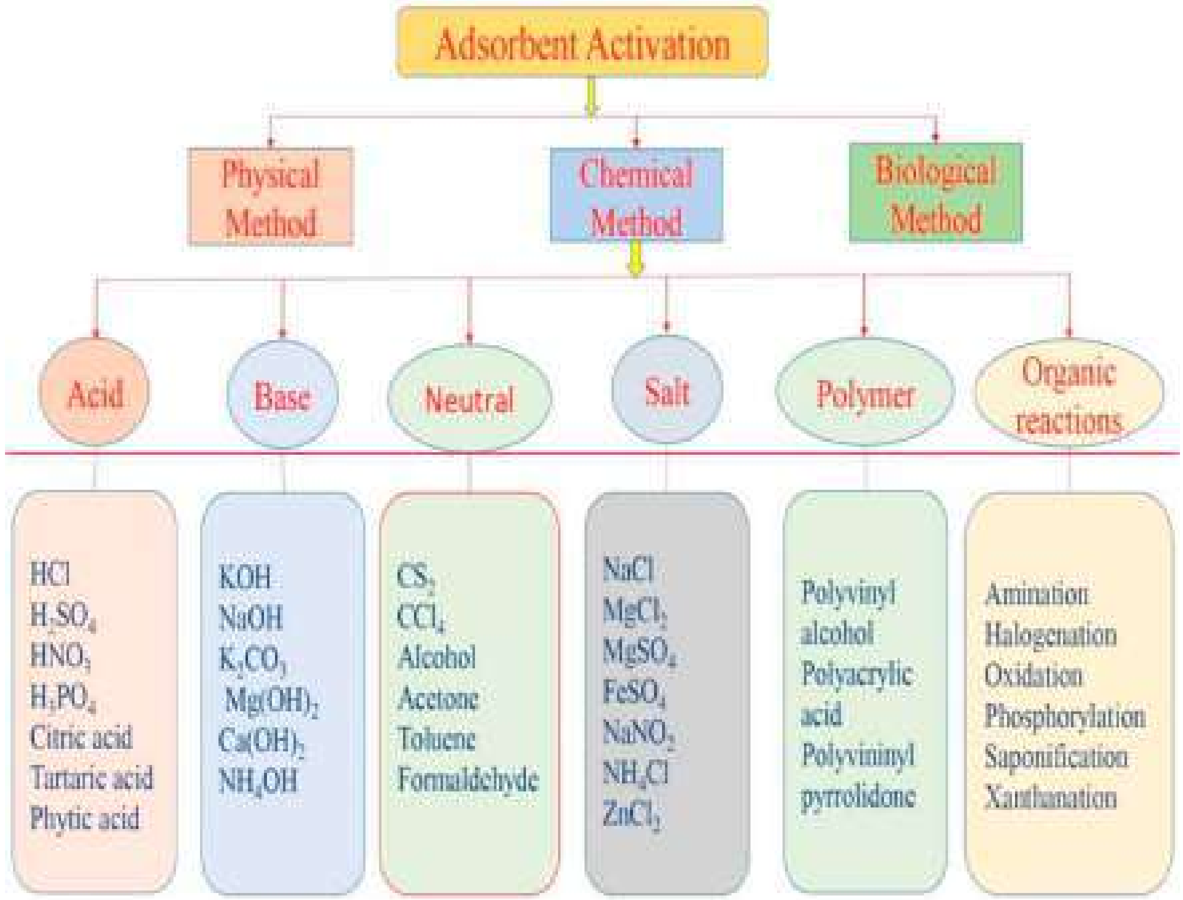


**Fig. 1.** Different methods of adsorbent activation.

removal capacity 84.74 mg/g for untreated bagasse and 35.21 mg/g for $CaCl_2$ treated bagasse. The dye removal capacity of NaOH treated sugarcane bagasse was found to be very high.

Bagasse on treatment with tartaric acid explore their potential for the removal of methylene blue from aqueous solution reported by Ling Wei Low et al. [39]. Adsorbent material was characterized by SEM before and after the treatment with tartaric acid. Initially the surface of adsorbent was smooth with a few tiny pores while after modification it becomes uneven with a few pores. The amount of adsorption increased with increase in dye concentration with optimum pH 9. However, the adsorption phenomenon found to be temperature dependent. The amount of adsorption at 30 °C and 50 °C were found to be 59.88 mg/g and 69.93 mg/g respectively.

Md. Tariqul Islam et al. [40] reported that peanut shell improved its adsorption capacity on refluxing with sulphuric acid. A 5 g of Peanut shell were refluxed with 40 ml conc. $H_2SO_4$ for an hour and then cooled, filtered, washed with distilled water, dried and used for batch experiments. The simulation studies for the effect of initial dye concentration, pH, contact time and temperature were studied. Stronger electrostatic interaction between methylene blue and adsorbent can be achieved due to change in pH from acidic to alkaline. It was found that change in pH from 3.5 to 10 increased the adsorption capacity of adsorbent from 500 mg/g to 810 mg/g. The maximum adsorption capacity of 1250 mg/g was found for an initial dye concentration at 1500 ppm and pH.

10. Langmuir and Freundlich adsorption isotherm were studied to investigate the interaction between adsorbent and adsorbate, Langmuir model was best fitted for these studies. Adsorption kinetics followed pseudo second order kinetic model. The author also studied column adsorption by using 2 g adsorbent with 105 g sea sand packed in column and reported 100% removal efficiency for 36 L of 20 ppm of methylene blue solution at pH 7.

Coconut leaves powder on microwave induced NaOH activation was studied for adsorption of methylene blue dye [41]. The 10 g of coconut leaves impregnated with 40 ml NaOH solution (50%) in the ratio of 1:4. The impregnated mixture was kept in oven 110 °C for 24 h. The prepared material was acid washed and oven dried for batch experiment study. The author investigated different parameters such as adsorbent dose (0.2–1.50 g/l), dye concentration 100 mg/l, contact time (15–90 min), temperature (298–323 K) and pH (3–8). The author reported 99.37% colour removal and 98.27% COD reduction with 87.72 mg/g dye uptake capacity.

Etim U. J. et al. [42] investigated the use of coconut coir dust without any physical and chemical modification for methylene blue dye removal by batch experiment study. The author studied the various parameter like adsorbent dose (0.05–0.2 g), different initial dye concentration, pH (2–10) and contact time (0–35 min). The mechanism and nature of adsorption was studied by Langmuir, Freundlich and Tempkin adsorption isotherm. In a kinetic study, the experimental data well matches with pseudo second order kinetic model with correlation coefficient ($R^2 = 1$). The maximum adsorption was observed for methylene blue dye by coconut coir dust adsorbent was 29.50 mg/g.

An experimental investigation of MB adsorption by response surface methodology through statistical optimization on walnut shell was carried out by Mohammad Kashif Uddin and Abu Nasar [43]. The adsorbent material was characterized by XRD, BET surface area analysis, SEM, FTIR and Thermogravimetric analysis. Adsorption capacity increased from 4.713 mg/g to 18.192 mg/g by increasing the dye concentration 50–200 mg/l. Through the isotherm study it was observed that adsorption process was endothermic and spontaneous in nature. The optimum conditions for better adsorption were adsorbent dose 0.5 g, dye concentration 50 mg/l, pH 8 and temperature 30 °C. The author also carried out desorption study by using 0.1 N HCl and found complete desorption of Methylene blue dye.

N. Ahalya et al. [44] studied various parameters of adsorption on tamarind pod shells for methylene blue dye adsorption. The presence of –COOH, –OH, C–O and C=O groups on adsorbent surface was detected by FTIR frequencies 2924, 3430, 1030 and 1654 $cm^{-1}$ respectively. An element detection of tamarind pod shell adsorbent were carried out and found 46.01% carbon and 6.14% hydrogen with 0.94% of nitrogen. The equilibrium time required for 50 and 100 ppm solution was 70 and 80 min respectively. A total 60.11 mg/g maximum adsorption of methylene blue was found out by tamarind pod shells.

Waste date stone has great potential sorption value due to change in physicochemical characteristics after modification with chemicals. A date stone has lignocelluloses biomass, abundant availability and negligible economic value. Date stone adsorption capacity was improved by modified with 2 N $H_2SO_4$ solution as reported by Noureddine El Messaoudi et al. [45]. The lignocelluloses biomass adsorbent on treatment with $H_2SO_4$ activates the functional adsorption sites and increases binding capacity for adsorbate particle. An acid treated adsorbent material was characterized by FTIR, SEM and thermogravimetric analysis (TGA). SEM analysis shown that acid treated adsorbent has microporous and irregular structure than untreated adsorbent. TGA was studied in the temperature range 25 °C–600 °C with heating rate 10 °C/min for thermal stability of adsorbent. FTIR frequencies depicts that adsorbent have bonded $–OSO_3$ group after modification with acid. During the experiment, methylene blue concentration increased from 100 mg/l to 300 mg/l resulted into increased in amount of adsorption from 98.07 to 280.37 mg/g at contact time 60 min. Langmuir isotherm model was found to be most satisfactory having 515.46 mg/g maximum adsorption capacity. The author tested desorption study and noted that 95.38% of methylene blue desorption was obtained with 0.1 N $HNO_3$.

Adsorption efficiency of rice straw improved by treating with acid-alkali was investigated by Nady A. Fathy et al. [46]. The raw rice straw were treated with citric acid and EDTA separately and dried at 50 °C. In physicochemical analysis bulk density, moisture, iodine number, slurry pH were studied. Adsorption study was carried out by using 20–200 mg/l methylene blue solution (25 ml), adsorbent dose 0.15 g, pH 6 with contact time 2 h. The effect of pH on adsorption rate was studied in the pH range 2–10 and amount of adsorption increased by changing the pH from acid to alkaline. The untreated and citric acid treated rice straw showed maximum adsorption 32.60 mg/g and 62.90 mg/g respectively. Recycling and reusable ability of adsorbent were studied by desorption study which was carried out by treating used adsorbent with 0.1 M HCl and 0.1 M NaOH. A complete removal of methylene blue was observed on treating with 0.1 M HCl.

Hee Jeong Choi et al. [47] studied on agricultural biosorbent corncob for removal of MB. Hauser ratio and porosity analysis showed that corncob has good ability of adsorbent due to number of pores on surface. The corncob adsorbent material was prepared by drying at 70 °C for 72 h and cutted in 0.5 cm thickness and stored in desiccator. Batch studies were carried out by investigating the parameters such as effect of pH, initial MB dye concentration, corncob dosage and temperature. The pH of the solution was adjusted by using the solution HCl or NaOH in between the pH 2 to 10 and effect of temperature was studied in between 10 °C to 30 °C. The elemental analysis of corncob were carried out and showed 57.81% C, 5.41% H, 0.83% N, 0.03% S and analysis of physical properties includes 1.42% moisture, 17.41% volatile matter. 3.23 as h content, 37.63% fixed carbon and 83.51% porosity. The surface characterization carried out by SEM analysis and it showed that corncob surface was very irregular and porous in nature. The surface of corncob was found multiple layers of thin films which adsorb larger amount of dye. The amount of removal of MB in 3 h was found 82.46%, 86.79%, 96.01 and 98.62% at MB concentration 0.02 g/l, 0.01 g/l, 0.005 g/l and 0.0025 g/l respectively. The removal percentage of MB was decreased by increase in initial MB concentration from 0.02 g/l to 0.005 g/l. The effect of pH was observed by maintain pH value at 2,4,6,8 and 10 and removal of MB dye was 11.47%, 38.46%, 99.74%, 99.89% and 99.90 respectively. The maximum adsorption observed at higher pH value due to electrostatic interaction. As the pH increase, the removal rate also increased because of increased in anions in the aqueous solution. The maximum adsorption was found 417.1 mg/g.

Chemically modified cellulose waste prepared from corn cob waste was studied by Jin Yaniqiao et al. [49]. Corn cob waste was treated with citric acid via esterification and used as biosorbent for removal of MB dye. The corncob residue was washed with distilled water and then dried at 60 °C for 24 h. The dried material was filtered to 120–500 mesh size. The powdered residue material was pretreated with 0.1 mol/l NaOH for 2 h and then washed with water to remove excess base. The residue material was treated with 0.6 mol/l citric acid at the ratio 1:10 (w/v) for 1 h and then dry it overnight at 60 °C, then temperature increased up to 120 °C for 3 h. The resultant material was filtered with hot distilled water under vacuum, dried and used it for batch experiment study. Characterization of biosorbent material was carried out by FTIR and XRD study. In XRD study it was observed that the crystallinity of corn waste material is not affected after modification. The biosorbent capacity and removal rate decreased from 124.9 to 121.0 mg/g and 99.95%–96.7% respectively by increasing the temperature from 20 °C to 60 °C which proved that biosorption process was exothermic and favors at low temperature. The adsorption occurred very rapidly in first 10 min and then adsorb slowly, it is due to the more availability of surface function sites at initial stage of adsorption. The maximum MB adsorption 214.5 mg/g was found at the MB concentration 800 mg/l.

Cashew nutshell, a novel adsorbent for removal of MB dye was investigated by Ramlingam Subramanium et al. [50]. The author used the activated carbon prepared from cashew nut and studied different process variable viz. pH, initial dye concentration, adsorbent dose and contact time. The authors carried out several operations for activation of carbon. Initially the material was sieved and dried, then carbonization was carried out at 7000C under $N_2$ atmosphere. The resultant material was soaked in KOH with ratio 1:1 and dehydrated at 105 °C for overnight followed by pyrolysis in stainless steel vertical tubular reactor. The material was activated by placing it in a tube furnace under high purity nitrogen at 850 °C for 2 h. The resultant activated product was cooled to room temperature and washed with deionized water. Finally the acid treatment was given followed by washing with hot distilled water. BET surface area 984 $m^2/g$, average pore diameter 2.52 nm and pore volume 0.552 $cm^2/g$ was found in surface characterization of activated biosorbent. The increase in initial MB dye concentration, the driving force increases and also enhanced the interaction between adsorbent surface and MB dye, which ultimately affects the greater adsorption rate. The author used response surface methodology (RSM) to design the experiment, optimize the variable and model the process.

P. Senthil Kumar et al. [51] studied on removal of MB by cashew nut shell in order to explore their potential use as a biosorbent for MB removal. The characterization of biosorbent was carried out by FTIR, BET and SEM. The BET surface area, average pore diameter, pore volume and bulk density were found 395 $m^2/g$, 5.89 nm, 0.4732 $cm^2/g$ and 0.415 $g/cm^2$ respectively. The author studied the effect of pH on adsorption rate and it was concluded that adsorption of MB increases with increased in solution pH. At lower pH, the adsorption sites are occupied by $H^+$ ions and hence less adsorption occurred while at higher pH the negative ion increased which increases the adsorption through electrostatic attraction. The optimum temperature 30 °C was found for maximum adsorption. The decreased in adsorption from 98.18 to 90.79% was observed by increased in temperature from 30 °C to 60 °C. Thermodynamic parameters such as enthalpy, entropy and free energy change were determined. The Gibbs free energy value found negative which indicated adsorption is feasible and spontaneous. The negative value of enthalpy change indicates exothermic nature and entropy value suggested the randomness at the surface. Langmuir adsorption isotherm best fitted to the experimental values as compared to Freundlich, Tempkin and Dubinin-Radushkevich isotherm model. The pseudo second order kinetic model well fitted than pseudo first order and elovich kinetic model. The maximum adsorption of MB dye was found 5.311 mg/g at pH 10 within contact time 60 min.

An onion skin treated with cold plasma and formaldehyde was investigated for removal of MB dye by Cafer Saka et al. [52]. Onion skin are disposed into the environment in massive amount which causes health issues to the community. The onion skin were collected, dried and removed the adhere impurities. The skins were boiled for 3 h to remove colored material and dried in oven for 24 h at 85 °C. The dried material was sieved and treated with Nitrogen plasma for 30 min. The cold plasma treated material was used for batch experiment study. The author also studied the formaldehyde treated onion skin for adsorption. Formaldehyde (1%) with onion skin in the ratio 1:5 at room temperature for 24 h. The resultant material was filtered with water for several time to remove formaldehyde and dried in oven at 80 °C for 24 h. The prepared biosorbent material were sieved and used for adsorption study. FTIR study were carried out in between 4000 and 400 $cm^{-1}$. Lower adsorption found at acidic pH and it goes on increasing with increased in pH from 2.5 to 10. The cold plasma treated onion skin increased in dye removal from 12.692 mg/g to 120.26 mg/g by increased in dye concentration from 10 to 100 mg/l while the formaldehyde treated onion skin adsorbent showed increased in dye removal from 14.268 to 118.35 mg/g. The author studied pseudo first order and pseudo second order kinetic model and found that pseudo first order kinetic model described best for the uptake of methylene blue. The cold plasma treated onion skin showed maximum adsorption 250 mg/g while formaldehyde treated onion skin showed maximum adsorption 166.67 mg/g.

Somaneh Saber-Samandari and Jalil Heydaripour [53] studied on onion membrane as a biosorbent for MB dye. The maximum adsorption was found 1.055 g/g in first hour with efficiency 84.45% while in 8 h it was 1.202 g/g with efficiency 96.20%. The biosorbent material was characterized by FTIR and SEM. It was found that onion membrane has –COOH and –OH anionic groups which shows electrostatic attraction towards positive charge and hydrogen of MB dye molecule. The author studied three kinetic models such as pseudo first order, pseudo second order and intraparticle diffusion model. Langmuir and Freundlich isotherm model were also studied and found that the Freundlich model well-matched with experimental data. Adsorption process was found exothermic and spontaneous by thermodynamic study.

Mohamad Firdaus Mohamad Yusop et al. [55] explored the physicochemical activation process by KOH treatment to the acacia wood for methylene blue dye adsorption. Due to physicochemical treatment, mesopore surface area increased from 268.40 $m^2/g$ of raw char to 689.77 $m^2/g$ of activated acacia wood carbon. The average pore volume and total pore volume of activated material was found 2.78 nm and 0.5350 $cm^2/g$ respectively. An elemental analysis of material showed 78.60% Carbon, 7.20% Hydrogen, 0.01% Sulphur and 14.19% of Nitrogen and Oxygen. By increasing temperature from 30 °C to 60 °C the adsorption of methylene blue reduced from 210.21 to 179.85 mg/g. Adsorption capacity increased from 256.41 to 279.33 mg/g at pH 8 to 10 respectively. In a thermodynamic study, enthalpy change ($\Delta H^0$) and entropy change ($\Delta S^0$) values were determined as −44.32 kJ/mol and −0.16 kJ/mol respectively.

## 4. Influence of surface area

The BET surface area, pore diameter and pore volume of phosphoric acid activated corn cob carbon powder was studied by Ali H. Jawad et al. [56]. The observed BET surface area was 415.2 $m^2/g$, pore diameter 3.35 nm, volume in pores 95.4 $cm^2/g$ and total volume in pores 0.35 $cm^2/g$. Ahmad Saud Abdulhameed et al. [57] studied the effect of activation of carbon and increase in surface area of adsorbent prepared from biomass green waste. The adsorbent material on activation changes the textural property. The enhancement in surface property such as pore volume from 0.202 $cm^2/g$ to 280.2 $cm^2/g$, total pore volume 0.007 $cm^2/g$ to 0.762 $cm^2/g$ and BET surface area 1.14 $m^2/g$ to 1245.6 $m^2/g$ for raw adsorbent to activated adsorbent respectively. The obtained data indicates that sample was mesoporous in nature. The corn cob was activated with sulphuric acid and used for methylene blue dye adsorption studied by Ali H. Jawad et al. [58]. The mean pore diameter and BET surface area was found 11.534 nm and 1.653 $m^2/g$ respectively.

Mondira Bardhan et al. [59] worked on betel nut husk carbon activated with sodium hydroxide for MB dye removal. The textural property was studied with BET surface area analysis. The obtained pore diameter 3.533 nm depicts mesoporous properties. The author reported that BET surface area 81.73 $m^2/g$ was found longer in comparison with areca husk. The activated adsorbent showed maximum adsorption capacity 381.6 mg/g at temperature 30 °C. The acid treated rubber leaf shows maximum adsorption capacity 263.2 mg/g reported by Ali H Jawad et al. [60]. Due to acid activation with high concentration of sulphuric acid, the decrease in surface area was observed, alternatively increase in sulphur and oxygen content on adsorbent surface. The BET surface area and total pore volume for activated carbon of rubber leaf were found 1.65 $m^2/g$ and 0.00342 $cm^2/g$ respectively.

## 5. Fruit peel waste

Fruits contain noteworthy ingredients which are useful to maintain good health. Day by day demand of fruits goes on increasing due to rise in population and health issues. During the fruit processing, 20–30% materials are discarded as waste. The fruit waste includes seed, peel and pomace which contain dietary fibers, carotenoids, polyphenols and other fibers [61]. The use of proper fruits in diet reduces the risk of diseases such as cancer and cardiovascular diseases [62]. Fruit seeds can be preserved and used but fruit peels are generally of no use and discarded as waste. Different organic and inorganic pollutants were successfully removed by using fruit peel biosorption process. Fruit peel based adsorbents are explored for the removal of methylene blue dye [63], the various fruit peels used are summarized in Table 2.

Ali H. Jawad et al. [64] investigated mango peel as an adsorbent for removal of methylene blue dye from its aqueous solution. Mango fruit found to be one of the most consumable fruit in the entire world. The 35% to 60% mass from the mango fruit considered to be the byproduct and discarded as a waste material into the environment. The mango peel contained carotenoids, vitamin E, vitamin C, polyphenols, lactic acid and dietary fibers. The author utilized sulphuric acid to activate and modify the mango peel waste. At first, the mango peels were collected from local fruit juice center and then washed with water. Afterwards, dried in oven at 105 °C for 24 h for removal of moisture content. The material was grinded, sieved and treated with acid in proportion of 1 g powder with 1 ml sulphuric acid. Activated material was examined to ash content, moisture content and micropore content. Surface morphology was characterized by SEM-EDAX. The change in surface topography of the adsorbent indicated that, reduction in pore structure and the surface became smoother after adsorption. In FTIR spectra study, shifting in frequency before and after adsorption of methylene blue dye proved the methylene blue interaction with functional groups of activated mango peel adsorbents. Adsorption kinetics were studied by using pseudo first order and pseudo second order kinetic model. Maximum adsorption by pseudo first order and pseudo second order were found 241.94 mg/g and 256.41 mg/g respectively. It was found that pseudo second order kinetic model is well fitted to the adsorption kinetics. In adsorption thermodynamic study, the entropy change positive value indicated that adsorption process was endothermic and follows chemisorption mechanism through strong forces of attraction. The author reported that maximum adsorption capacity for sulphuric acid treated mango peel was found 277.8 mg/g. Methylene blue adsorption by $H_3PO_4$ treated and activated orange peel has been investigated by Maria Emilia Fernandez et al. [65]. For activation of carbon content within orange peel, the powdered material with diameter 500–1000 μm was treated with 50% $H_3PO_4$. Elemental analysis of untreated orange peel showed 43% Carbon, 5.9% Hydrogen, 50.2% Oxygen while treated orange peel material showed 82% Carbon, 2.5% Hydrogen, 14% Oxygen and 0.9% Nitrogen. Batch and continuous experiments were carried out for adsorption study. For continuous adsorption experiment, acid activated orange peel powdered material was packed into the column having internal diameter 1.6 cm, height 36 cm and diameter of particles used in between 105 and 250 μm. Adsorption capacity found 0.131 mmol/g by using pseudo second order kinetic model at pH 7, initial concentration 0.21 mmol/g and adsorbent dose 0.29 mmol/100 ml. By using Langmuir adsorption isotherm 1.00 mmol/g adsorption capacity was achieved.

Lina B. L. Lim et al. [66] utilized breadnut peel as adsorbent for its ability to remove methylene blue dye. Artocarpus camansi commonly known as breadnut belongs to Artocarpus of the Moraceae family. Breadnut peels are inedible, having no economic value and thus discarded as waste. The author studied different experimental parameters such as effect of pH, contact time and adsorbent dose. The prepared and dried breadnut peel powder was characterized for element content in which 41.1% carbon was found by elemental analysis. In general characterization, the adsorbent contain 21% fiber which is beneficial for adsorption of dye molecule. SEM characterization point up that, after methylene blue treatment, roughness of adsorbent surface was changed and reduced in number of pores due to packing with methylene blue molecules. The author noted that, high removal efficiency of dye molecule was due to fibrous and porous surface of adsorbent. The calculated specific surface area 1519 $m^{2}$ $^{g-1}$ was found to be higher than

**Table 2**
Various fruit peel waste used as low cost adsorbents.

| Fruit peel adsorbents | Activating agent | pH | Temp (°C) | Contact Time (min) | Max. Adsorption (mg/g) | Ref. |
|---|---|---|---|---|---|---|
| Mango | Sulphuric Acid | 5.6 | 30 | 60 | 277.8 | 64 |
| Breadnut | – | 6 | 25 | 60 | 409 | 66 |
| Banana | $H_2SO_4$ | 11 | 30 | 1440 | 250 | 67 |
| Banana | Carbonization | 6.3–6.9 | 25 | 150 | 1263 | 68 |
| Pomegrana te | – | 7 | 30 | 150 | 36.36 | 69 |
| Pomegrana te | – | 11 | 30 | 30 | 102.25 | 70 |
| Citrus | – | 6.4 | 24 | – | 185.83 | 71 |
| Citrus | Calcium alginate | 6.4 | 24 | – | 964.54 | 71 |
| Citrus Lanatus | $ZnCl_2$ | 5.45 | 25 | – | 231.48 | 72 |
| Citrus Lanatus | $H_2SO_4$ | 5.6 | 30 | 0-300 | 200 | 73 |
| Kendu | Ammonium carbonate | 6 | 25 | 100 | 144.9 | 75 |
| Pomelo | — | 10 | 30 | 180 | 81.71 | 76 |
| Pomelo | Citric acid | 10 | 30 | 180 | 199.29 | 76 |
| Pomelo | – | 10 | 30 | 150 | 218.5 | 77 |
| Pumpkin | Beetroot Extract | 7 | 50 | 180 | 198.15 | 78 |
| Bean | Microwave induced KOH | 9 | 25 | 30 | 45.45 | 79 |
| Acron | Microwave induced KOH | 9 | 25 | 30 | 17.54 | 79 |
| Dragon | – | 4.7 | 20-25 | 60 | 640 | 81 |
| Apple | – | 6 | 20 | 360 | 107.52 | 82 |
| Durian | NaOH | – | – | – | 235.80 | 83 |
| Orange | Carbonization | 6 | 30 | 180 | 476 | 85 |
| Banana | Carbonization | 8 | 30 | 180 | 390 | 85 |

other relevant adsorbents. The equilibrium time found 60 min to achieve maximum adsorption and further increased in time does not show any more adsorption. Spontaneous biosorption process was studied by using energy and entropy factors. At temperature 25 °C Gibbs free energy change −6.25 kJ mol$^{-1}$ indicated that adsorption process was exothermic and spontaneous. The author also reported that increased in temperature, negative value of $\Delta G^0$ increases, which proved that adsorption occurred at lower temperature and maximum adsorption capacity $q_{max}$ decreased with increased in temperature. The maximum adsorption 409 mg/g was found at temperature 25 °C.

Banana peel is the most wasted peel among the other fruit peels. It contains cellulose, lignin, starch, protein and hemicelluloses but these peels have no economic value and considered to be waste material. However, preparation of activated carbon from banana peel as an adsorbent found to be most attractive alternative for commercial activated carbon. Ali H. Jawad et al. [67] reported the acid treated banana peel as adsorbent for methylene blue removal. Raw banana peels were washed, dried, grinded, sieved and impregnated with concentrated $H2_SO_4$ for activation purpose. Elemental analysis showed Carbon 55.54%, Oxygen 37.95% and Hydrogen 4.24%. Due to activation by sulphuric acid, the $SO_3$ group bonded on adsorbent surface group which creates negative charge on surface for maximum adsorption. It has been reported that, the amount of adsorption depends on initial dye concentration, as the initial concentration increased from 10 mg/l to 300 mg/l, then removal of methylene blue increased from 16.63 to 259.70 mg/g. Higher methylene blue concentration creates large driving force which determines more probability of collision between adsorbent and methylene blue molecule. From the calculated data of adsorption isotherm, author noted that Langmuir isotherm model best fitted with larger $R^2$ value (0.990) than Freundlich (0.703) and Tempkin model (0.922). The monolayer and homogeneous adsorption occurred on the surface of adsorbent. Batch experiment study were carried out between the pH 3–12, contact time 0–1440 min, methylene blue concentration 10–300 mg/l and adsorbent dose 0.02–0.30 g. At temperature 30 °C, the maximum adsorption capacity 250 mg/g was found in batch experiment study. Adsorption was spontaneous and endothermic in nature. The adsorption efficiency of banana peel has been improved by carbonization process at temperature 500–750 °C reported by Jian Feng Ma et al. [68]. Pyrolysis of volatile matter occurred during carbonization which changes the original surface morphology. A numerous micropores formed on the surface and a high surface area 1950 m$^{2\ g\text{-}1}$ was found. The pore volume was 1.071 cm$^2$g$^{-1}$ while 0.869 cm$^3$g$^{-1}$ micropore volume observed. According to adsorption kinetic study, 87–95% adsorption was found in the first 10 min due to the high driving force on methylene blue molecule for migration towards adsorbent surface. The maximum uptake of methylene blue 1263 mg/g was observed which is higher than any treated and activated banana peel for methylene blue dye.

Fuat Guzel et al. [69] reported pomegranate peel as an adsorbent with adsorption capacity of 36.36 mg/g for removal of methylene blue. Punica granatum commonly known as pomegranate is found to be most popular and nutritional fruit. Pomegranate peel becomes thick and hard carries 5–15% of total weight. A huge amount of pomegranate peel discarded as waste from fruit juice industry. The authors prepared fine powder from the peel by washing, grinding, sieving and drying methods. The resultant material was studied without any further physical or chemical treatment. The batch experiments were carried out at different pH values between 2 and 12 with proper addition of 0.1 M NaOH or 0.1 M HCl solution. The amount of adsorption increased from 5.36 to 20.68 mg/g with increase in pH from 2 to 7. This is due to decrease in electrostatic repulsion between the positively charged surface and methylene blue molecule. The pH 7 was found to be suitable for better adsorption. Equilibrium time 150 min was found but initial adsorption occurred very rapidly within first 60 min and then adsorption capacity became slower. The variation in biosorbent dose from 0.1 g/l to 1 g/l enhances the methylene blue removal from 38.6 to 94.0%. The author studied the effect of salt ionic strength on removal of methylene blue dye and reported that adsorption decreased by increased in NaCl salt concentration. The salt cations occupied the surface of adsorbent rather than methylene blue. Furthermore, author worked on desorption study of dye from adsorbent surface. They utilized HCl, $HNO_3$, $CH_3COOH$, $H_3PO_4$ Citric acid and water as desorbing agents. The desorption efficiency with various materials were found as with citric acid 78.25%, HCl 57.81%, $HNO_3$ 55.73%, $H_3PO_4$ 68.64% and with water 3.29%. Citric acid showed maximum desorption of methylene blue while water showed minimum desorption. It was due to more binding cites of carboxyl group in citric acid molecule.

An investigation on pomegranate peel was carried out by Nur Dini Daud et al. [70] to evaluate the removal efficiency for methylene blue dye from its aqueous solution. They found the adsorption capacity 102.25 mg/g and dye removal percentage 99.8%. The batch experiments were carried out with pH 11, adsorbent dose 1.0 g, contact time 120 min, dye concentration 10 mg/l and temperature 30 °C.

Application of citrus peel encapsulated with calcium alginate and unmodified citrus peel as ecofriendly and effective biosorbent for removal of methylene blue was reported by Amina Aichour et al. [71]. Fine fractions of citrus peel were prepared by washing, crushing, sieving and drying. One fraction of the prepared material was added into 2% sodium alginate and stirred for 10 h. Then added into 4% calcium chloride to form beads, it was washed repeatedly to remove excess sodium chloride and dried. The author studied both batch and continuous adsorption methods. Plastic column with diameter 1.9 cm and length 20 cm was used in continuous method. Several parameters such as adsorbent flow rate, effect of bed height, and effect of initial concentration of dye were studied. The total amount adsorbed, effluent volume, adsorption at equilibrium and amount of dye spent in the column were determined by using breakthrough curve. The batch study showed that 93% of methylene blue was removed by using calcium alginate encapsulated citrus peel. The high correlation coefficient ($R^2$) showed Langmuir model well fitted and proved monolayer adsorption. The maximum amount of methylene blue adsorbed was 185.83 mg/g on citrus peel and 964.54 mg/g over encapsulated citrus peel. For an initial concentration of methylene blue 200 mg/l with flow rate 2 ml/min and bed height 3.5 cm, the amount of methylene blue obtained 93.6% having bed capacity of 31.45 mg/g. Thomson and Yoon-Nelson model best fitted by the breakthrough curves.

Activated carbon prepared from citrullus lanatus rind was found efficient for the removal of methylene blue reported by Osman Umer et al. [72]. The rind of citrullus lanatus commonly known as watermelon considered to be waste and no economic value. On treatment with chemicals and carbonization process, the rind produced highly efficient activated carbon. The watermelon rind were collected, washed and cleaned with distilled water, cutted into small pieces, dried in sunlight for 2 days and then crushed and sieved (50 $^{mesh).}$ The dried powder impregnated with $ZnCl_2$ in the ratio of 2:1 with refluxing condition for an hour. The resultant material was dried for 24 h at 105 °C in an incubator. Then carbonization was carried out in furnace at 700 °C for 60 min. For removal of chloride and zinc compound from the surface of adsorbent, it was treated with 0.1 N HCl followed by hot water, dried in incubator at 105 °C and used for adsorption study. Thermal behavior of the prepared material during the carbonization and activation was studied by using thermogravimetric analysis. The carbon content analysis of raw material and treated material found to be 38.57% and 60.42% of respectively. Effect of temperature on adsorption of methylene blue was found to be significant. The amount of methylene blue adsorbed was 231.48, 243.90, 244.50 and 259.74 mg/g at temperature 25 °C, 35 °C, 45 °C and 55 °C respectively. The author utilized Langmuir, Freundlich, Tempkin and Dubinin-Radushkevich model to explain adsorption mechanism. The correlation coefficient value from Langmuir isotherm was found to be closer to 1, suggested that the Langmuir model best fitted for adsorption study. Pseudo-first order, pseudo second order and Elovich model were examined for kinetic study. The correlation coefficient value was in the range of 0.995–1.000 proved to be the best fitted pseudo second order kinetic model. Thermodynamic study revealed that adsorption was endothermic in nature, spontaneous and feasible.

Ali H. Jawad et al. [73] used sulphuric acid for activation of citrus lanatus rind. One step chemical activation by sulphuric acid at temperature 110 °C for 24 h was used for activation to adsorbent material. The effect of different system variables such as contact time, pH, initial dye concentration and adsorbent dose were studied in batch experiments. Elemental analysis of adsorbent material showed 41.06% carbon, 52.25% oxygen, 5.12% hydrogen and 1.57% nitrogen. Adsorption capacity increased at equilibrium from 60 mg/g to 300 mg/g with increased in methylene blue concentration from 50 to 400 mg/l. The increased in amount of adsorption was observed due to increase in collision rate between methylene blue molecule and adsorbent surface. The calculated and measured quantity of adsorbed value in pseudo second order kinetic model was closer than the values obtained from pseudo first order model, indicated that pseudo second order kinetic model satisfied the adsorption kinetics. The author reported that the adsorption mechanism on the adsorbent surface was occurred due to electrostatic attraction between positively charged methylene blue molecule and negatively charged functional group on adsorbent surface and also due to the hydrogen bonding and π- π stacking interaction between surface framework of adsorbent and aromatic rings of methylene blue molecule. The maximum adsorption capacity 200 mg/g at 30 °C was found and well described by Langmuir isotherm model.

Similarly, batch and fixed bed column studies were carried out on watermelon rind by Lakshmipathy and N. C. Sarada [74]. Batch studies were performed with different parameters like adsorbent dose, pH, contact time and initial dye concentration while fixed bed column studies were carried out with parameters such as bed height, flow rate and initial inlet concentration. Thomas and Yoon- Nelson and Adams-Bohart model were studying for analyzing the breakthrough curve. Glass column having length 15 cm with diameter 1 cm packed by adsorbent material was used for fixed bed column adsorption process. The physicochemical characteristics of watermelon rind showed 61.47% carbon and 30.31% oxygen. By increasing the temperature 30 °C–50 °C, the amount of adsorption changed from 44.5 to 46.1 mg/g, shows no appreciable change in adsorption with increase in temperature.

Sumanta Sahu et al. [75] investigated the use of kendu fruit peel as low cost adsorbent for the removal of methylene blue. Kendu is popular fruit belongs to Ebenaceae family known to be coromandel ebony. In order to improve the adsorption efficiency the chemical treatment was done by ammonium carbonate followed by carbonization to the biosorbent material. The washed, dried fruit peel powder carbonized in furnace at 400 °C for 2 h. The carbonized biomaterial was modified by mixing 20 g powder with 250 ml 0.05 M ammonium carbonate and then stirred it for 24 h on magnetic stirrer. The resultant material was filtered, dried in oven at 100 °C for 2 h and then in muffle furnace at 400 °C for 2 h. The prepared material was known to be modified biosorbent and used for batch experiment study. Biosorbent material was characterized by SEM, FESEM and FTIR. The surface area and pore size were calculated from BET and BJH method respectively. Thermogravimetric analysis was performed to study thermal stability of material. The pore volume and specific surface area were determined by using Quantachrome model. The SEM micrographs showed that modified biosorbent material surface was fully porous with different sizes. The modified biosorbent surface area 249 $m^{2\ g^{-1}}$, pore volume 0.133 $cm^3g^{-1}$ and pore size 3.09 nm were found from BET characterization. The author noted that temperature has no effect on adsorption capacity. The maximum adsorption of 144.9 mg/g was found for the batch study. The adsorption energy value (E) 10.42 KJmol-1 indicated that it was chemical adsorption.

Pomelo is largest fruit from citrus belongs to Rutaceae family. Approximately 15% weight out of the fruit is discarded as peel waste. Pomelo peel was found to be attractive biosorbent for dye removal from its aqueous solution. Yimei Ren et al. [76] studied pomelo peel as an adsorbent and improved its removal efficiency by modifying with citrate. The grinded small particles (60–80 mesh) were prepared from pomelo peel by washing, grinding and drying at 60 °C. 5 g Pomelo peel powder and 150 ml citric acid (0.6 mol/l) was stirred at room temperature, filtered, dried at 55 °C for 20 h and then heated for 90 min at 120 °C. After cooling the mixture was filtered and added into 100 ml NaOH solution (0.1 mol/l), material was washed with hot water (70 °C) and dried in oven for 24 h at 60 °C. The increased in adsorption was found with increased in initial concentration of methylene blue. The maximum adsorption occurred within first 30 min and then adsorption equilibrium achieved after 3 h. Removal rate of methylene blue increased from 46.22% to 90.51% and adsorption capacity increased from 38.52 mg/g to 75.43 mg/g with increased in pH 2.57 to 4.1. The author reported that below the pH 5.3, the surface of adsorbent was positively charged, which decreased the electrostatic attraction between adsorbent surface and methylene blue molecule. The pH value more than 5.3 makes the surface negatively charged and increased in electrostatic attraction which ultimately increased in adsorption capacity. The correlation coefficient value of pseudo second order model was found to be higher than pseudo first order model. The adsorption capacity value of calculated and experimental analysis found closer which indicated that pseudo second order kinetic model well fitted than pseudo first order kinetic model. From thermodynamic study it was observed that increased in temperature has no effect on adsorption. Negative value of $\Delta H^0$ indicated that adsorption process was exothermic. The increased in $\Delta G^0$ with rise in temperature proved that maximum adsorption occurred at lower temperature. From the obtained values it was concluded that, adsorption process was exothermic, spontaneous and entropy decreased process.

The internal interaction relationship during adsorption process was studied by Van Phuc Dinh et al. [77] using pomelo peel adsorbent. Computer simulation by ab initio model was applied to simulate the IR spectra of pomelo peel biosorbent material. The combination of FTIR measurement with ab initio model was found to be effective to understand the adsorption mechanism. By using such combination author concluded that methylene blue adsorption on biosorbent took place due to electrostatic attraction and hydrogen bonding. The author studied four kinetic model such as pseudo first order, pseudo second order, intraparticle diffusion and Elovich model having correlation coefficient value 0.6183, 0.9282, 0.8422 and 0.9671 respectively. From the calculated values it was indicated that adsorption kinetics followed pseudo second order kinetic model. To estimate adsorption, the author utilized five adsorption isotherm models such as Langmuir, Freundlich, Tempkin, Sips and Dubinin-Radushkevich. The Langmuir isotherm model well fitted with maximum adsorption capacity 218.5 mg/g.

Jamshaid Rashid et al. [78] utilized pumpkin peel by modifying with beetroot extract as novel adsorbent for decolorization of aqueous solution of methylene blue. Beetroot extract was selected due to presence of its natural antioxidant activity and explored a greener approach towards the waste water treatment. The collected pumpkin peels were washed, dried in sunlight for 30 days, then in oven dried at 100 °C for 18 h, finally grinded and sieved. The carbonization treatment was given to the peel at various temperature 250, 350, 450 and 550 °C for 1 h in muffle furnace and prepared material was known to be activated carbon namely $AC_{250}$, $AC_{350}$, $AC_{450}$ and AC550 respectively. Then all these activated carbon were tested for adsorption capacity of methylene blue. It was observed that $AC_{250}$ found to be most efficient adsorbent than other carbonized activated carbon. For further activation, $AC_{250}$ was treated with oxalic acid, nitric acid and citric acid. SEM images of beetroot extract activated carbon material showed that adsorbent surface contained high pore volume, different sizes of pores and well distributed pore structure, which facilitates higher adsorption than acid treated activated carbon. FTIR spectra showed that $AC_{250}$ has varieties of functional group than $AC_{350}$, $AC_{450}$ and $AC_{550}$. Adsorption capacity enhanced from 147.5 mg/g to 198.15 mg/g by increased in temperature 30 °C–50 °C. The temperature dependent adsorption process was found to be endothermic in nature. The author studied in recycling of adsorbent and it was found that adsorption efficiency reduced from 198.15 mg/g to 149.12 mg/g after third cycle. Total 12% reduction in adsorption efficiency was observed due to the blockage of micropore on adsorbents. Methylene blue adsorption decreased with rise in carbonization temperature from 250 °C to 550 °C ($AC_{250}$ to $AC_{550}$) of an adsorbent due to sintering effect which destroyed the pore wall. Extent of adsorption was found to depend on methylene blue concentration and it was observed that increased in methylene blue concentration, the adsorption capacity increased. The highest adsorption capacity was found 198.15 mg/g at methylene blue concentration 200 mg/l.

Microwave induced KOH chemical activation for bean peel and acron peel was investigated by Ibtissem Kahoul et al. [79] and applied for removal of methylene blue dye from aqueous solution. Been peel and acron peel were cutted, washed, dried and crushed to fine powder. They were carbonized at temperature 623 °C and 923 °C respectively in oven for 1 h. The produced biochar were impregnated with KOH solution in the ratio 1:1. The microwave activation to biosorbent were carried out in microwave oven with microwave power 800 W, irradiation time 7 min with stirring speed 600 rpm. The produced material was further washed with 0.1 M HCl and then with water to achieve neutral pH and finally dried in oven at 60 °C for 12 h. The author investigated thermogravimetry and it was observed that, been peel loses its mass in four stages while mass of acron peel drops in three stages. The weight loss was observed due to release of adsorbent water and decomposition of cellulose, hemicelluloses and lignin. Calculated qe value was found in good agreement with experimental qe value and higher coefficient value proved that adsorption process followed pseudo second order kinetics. Bean peel and acron peel showed maximum adsorption capacity 45.45 mg/g and 17.54 mg/g respectively at pH 9.

M. F. Abdullah et al. [80] investigated dragon fruit peel as a biosorbent for decolorisation of methylene blue aqueous solution. The dragon fruit peel extracted pectin was polymerized with acrylic acid to produced hydrogel by using gamma and microwave radiation. In the first step the dried powder of dragon fruit peel was treated with acid at pH 1.5 and 3.5 and stirred the solution for 120 min at 70 °C. An isopropanol solution (85%) was mixed into the pectin solution in the proportion of 1:2 and coagulated at room temperature for 24 h. The formed precipitate was filtered, centrifuged, rewashed with isopropanol and dried it for 24 h at 37 °C. In the second step, 1% pectin solution was mixed with acrylic acid at different ratio (1:4), (2:3), (3:2), and (4:1) by adding 5% N–N’ bisacrylamide for crosslinking. The resultant material was stirred for 2 h at room temperature. The solution were taken in Petri dish with parafilm covering and exposed to gamma radiation. Similar process was performed and additionally 5% sodium persulphate was added as initiator and resultant mixture was radiated to microwave radiation at different doses. The prepared hydrogel material was used as biosorbent for methylene blue removal from aqueous solution. Gamma ray radiated hydrogel adsorbent showed 45% of methylene blue removal while microwave radiated hydrogel adsorbent showed 35% removal of methylene blue from 20 mg/l initial dye concentration at pH 8. According to adsorption kinetics, the correlation coefficient value by pseudo first order model for gamma and microwave radiated hydrogel adsorbents were found 0.9979 and 0.9933 respectively which was very closer to 1 while by pseudo second order kinetic model the value were 0.9811 and 0.8667 respectively. The author claimed that adsorption kinetics followed pseudo first order kinetic model.

Priyantha et al. [81] also utilized dragon fruit skin for removal of methylene blue and studied effect of different parameters such as pH, contact time and initial dye concentration. The dragon fruit skin was oven dried at 88 °C, blended and sieved to obtained smaller particles. The equilibrium was reached within 1 h and initial adsorption was occurred very rapidly. The adsorption process was described by using three kinetic models such as Lagergren first order, pseudo-second order and Weber–Morris intraparticle diffusion order model. It was observed that adsorption kinetics followed pseudo second order model which indicated the chemisorption nature in which exchange of electrons occurred between methylene blue molecule and biosorbent functional groups. Langmuir model well fitted with high correlation coefficient value 0.972. Maximum adsorption 640 mg/g was observed by dragon fruit peel adsorbent.

Adsorption of methylene blue onto biosorbent prepared from apple peel was investigated by I. Enniya and A. Jourani [82]. Dried apple peel were grounded, sieved and preserved for adsorption studies. The resultant material was characterized by adsorption spectra. The author noted that functional groups OH, C═O, C–O and C–O–C were disappeared after adsorption of methylene blue. Adsorption is found to be optimum between the pH range 3–6. Adsorption process was found to be slightly temperature dependent. By increased in temperature from 10 to 40 °C, the adsorption capacity was decreased from 9.08 to 8.56 mg/g. It was showed that adsorption process was exothermic in nature. The author also studied thermodynamic parameters such as Gibbs free energy ($\Delta G^0$), change in enthalpy ($\Delta H^0$) and change in entropy ($\Delta S^0$). All the three factors were showed negative value which indicated that adsorption process was spontaneous, feasible and exothermic in nature. Furthermore, the data obtained from Langmuir, Freundlich and Tempkin isotherm model, the adsorption capacity was found to be 107.52 mg/g showed that Langmuir adsorption isotherm best fitted than other isotherm models.

Durian peel, an fruit peel waste available abundantly was studied as low cost adsorbent for removal of methylene blue dye by Nguyen Thi Thoung et al. [83]. Only 40% part of fruit is edible while remaining part is discarded as a waste. The collected durian peels were extensively washed with distilled water to remove any dirt and adhering particles, then cutted, dried at 80 °C for 48 h and grounded. The powdered material treated with 0.01 M NaOH, isopropanol and repeatedly washed with distilled water to maintained pH 6–7, then oven dried at 80 °C for 12 h and used for fixed bed column adsorption study. Fixed bed column adsorption method was studied with three factors such as bed height, flow rate and initial concentration of methylene blue dye. For column study, a plastic column was used with diameter 2 cm and height 15 cm. Specific amount of durian peel powder (3.5g) was packed into the column with average packed density 322 $g/cm^2$. Methylene blue with varied concentration was allowed to flow down through the column bed during adsorption study. Flow rate changed from 5 to 20 ml/min with different bed height 2, 4 and 6 cm. The amount of adsorption was found to depend upon initial methylene blue concentration. It was observed that with increased in methylene blue concentration from 200 ppm to 600 ppm, increased in adsorption amount from 196.60 mg/g to 235.80 mg/g. Adsorption occurred faster by increased in flow rate. The adsorption capacity was found 110.96, 196.60 and 201.95 mg/g with increased in flow rate 5, 10 and 20 ml/min respectively. The author found that, increased in bed height by 2, 4 and 6 cm, the adsorption capacity increased to 166.15, 196.60 and 242.09 mg/g respectively. Dye molecule diffuse completely on adsorbent surface due to longer breakthrough time. The author also studied adsorption through batch experiment and it was found that initial methylene blue concentration 50, 100, 200 and 400 ppm showed adsorption capacity 23.84, 43.17, 74.12 and 102.59 mg/g respectively. Fixed bed column adsorption is found to be superior on batch experiments.

Erny Haslina Abd Latib et al. [84] studied $H_2O_2$ treated and carbonized durian peel for sequestration of methylene blue dye. The activation of durian shell was carried out by physical and chemical activation process. Dried powder of durian peel was immersed in 100 ml $H_2O_2$ solution. Then it was filtered, washed to maintained pH 6–7. Afterwards, dried overnight at 80 °C and then carbonized in tube furnace. The sample was characterized using Field Emission Scanning Electron Microscopy (FESEM) and elemental analyzer. The percentage of carbon in activated biomass was found 62.58%. Effect of adsorbent mass on adsorption capacity was compared with treated and untreated durian shell. The removal efficiency for untreated shell increased from 62%, 85% and 86% for adsorbent dose 0.2g, 0.4 g, and 0.6 g respectively while for the same biomass, treated shell showed removal efficiency 35%, 96% and 95% respectively. The author reported the maximum removal efficiency for methylene blue was 99% by using 0.6 M $H_2O_2$ treated durian peel.

A comparative study on banana peel and orange peel prepared biochar was carried out by Amin M. T. et al. [85]. The collected material was washed, dried, grinded and then pyrolised in a box furnace for 3 h at 800 °C. The biochar material was characterized by using SEM, EDX, and FTIR spectra. The biochar produced having particle size less than 75 μm was used for adsorption study. The surface area of orange peel and banana peel decreased from 90% to 83% and from 80% to 73% respectively by increased in the initial methylene blue concentration 50–150 mg/l. This was observed due to larger surface area, active functional groups and more adsorption sites in orange peel adsorbent as compared to banana peel adsorbent. The author studied initial rate of adsorption by second order kinetic model and it was observed that, with increased in initial concentration from 50 to 150 mg/l adsorption increased from 12 to 31 mg/g and 10–42 mg/g respectively for banana peel and orange peel. Effect of pH and effect of adsorbent dose were investigated through batch experiments. Result showed that removal efficiency increased to 30% for banana peel adsorbent and 15% for orange peel adsorbent by changing the pH value 2 to 8 and 2 to 6 respectively. The change in adsorbent dose of an orange peel from 0.1 to 0.4 g and banana peel from 0.1 to 0.5 g, the adsorption capacity increased from 350 to 500 mg/g and 250–390 mg/g respectively. For adsorption isotherm study, six isotherm models were studied such as Langmuir, Freundlich, Tempkin, Dubinin-Radushkevich (D-R), Harkin-Jura (H-J) and Hasley model. A high correlation coefficient value and closer agreement to the experimental values indicated that Langmuir isotherm model is well fitted. The adsorption capacity of sorbent banana peel and orange peel increased from 390 to 430 mg/g and 476–526 mg/g respectively with increased in temperature from 30 °C to 60 °C. Total 7% increase in removal indicated that adsorption was endothermic in nature. Negative value of Gibbs free energy suggested the non-spontaneous nature of adsorption of dye on adsorbent.

## 6. Influence of $pH_{pzc}$

Orange peel biochar by acid activation shows MB adsorption 208.3 mg/g was investigated by Jawad Ali H. et al. [86]. The point of zero charge analysis was carried out by authors and found that $pH_{pzc}$ for orange peel biochar was 4.80. The point of zero charge for physically and chemically modified coffee husk were evaluated at pH 4.35 and pH 6.95 respectively by T. P. Krishna Murthy and B·S.Gowrishankar [87]. The maximum methylene blue dye adsorption efficiency achieved at pH greater than $pH_{pzc}$. At alkaline pH, the surface of adsorbent becomes negatively charged and creates attractive force to the cations of methylene blue dye. The chemically treated coffee husk adsorbent shows higher dye uptake capacity (199.73 mg/g) than physically treated material (129.43 mg/g) at pH 7.9 and 7.6 respectively.

Watermelon rinds prepared from biosorbent shows $pH_{pzc}$ at 4.3 [88]. Below the $pH_{pzc}$ anion adsorption was more favourable while above the $pH_{pzc}$ cation adsorption was more suitable. The $ZnCl_2$ treated edible fungus residue studied for influence of point of zero charge by Hongyan Li et al. [89]. The evaluated $pH_{pzc}$ value for prepared adsorbent material was found at pH 6.93. The $pH_{pzc}$ value was determined through solid addition method using pH meter for pomegranate peel by Ali H. Jawad et al. [90]. The maximum dye adsorption was found 200 mg/g and pH at point of zero charge was 5.4 which indicate acidic surface of biosorbent. The adsorption of methylene blue dye was increased up to pH 5 and after that no further increase in dye adsorption. At very acidic pH, the amount of adsorption was lower due to higher concentration of $H^+$. Syringa vulgaris leaves investigated by Giannin Mosoarca et al. [91] got dye adsorption capacity 188.2 mg/g at pH > pHpzc (5.77).

Ramlah Abd Rashid et al. [92] was explored coconut leaves for MB dye remediation. The adsorption capacity was 151.5 mg/g with adsorbent dose 0.02–0.25 g and pH 3–11. The point of zero charge was estimated for adsorbent surface and found at pH 4.2. The carbonized coconut leaves on KOH activation was investigated by Ramlah Abd Rashid et al. [93]. The authors studied the effect of pH in the range 3–11 for the amount of dye adsorption. The point of zero charge for prepared adsorbent was obtained at pH 4.2.

## 7. Comparative study with other adsorbents

The zeolite activated carbon composite on sodium hydroxide treated palm oil was explored for MB dye adsorption by W. A. Khanday et al. [94]. The composite was prepared in two steps, the NaOH fusion with palm oil was carried out in first step by heating at temperature 800 °C for 90 min. The hydrothermal treatment then processed by mixing material with kaoline in the ratio 1:0.2 and heated at 100 °C for 8 h in autoclave. The prepared composite material was characterized by XRD, scanning electron microscopy, BET surface area analysis and FTIR. The larger BET surface area 615.406 $m^2/g$ with pore diameter 3.048 nm was evaluated for composite biosorbent. The adsorption of dye was found temperature dependent and increased the amount of adsorption 143.47 mg/g, 199.6 mg/g and 185.71 mg/g with temperature 30 °C, 40 °C and 50 °C respectively.

Md Azharal Islam et al. [95] utilized sodium hydroxide activated rattan hydrochar for MB dye sequestration. The collected mass was hydrothermally carbonized to prepare activated carbon. The morphological and textural properties of biosorbent surface was examined. Due to carbonization and activation of prepared carbon material, the surface area increased to 1135 $m^2/g$ with pore size distribution 35.5 $A^0$. Authors studied the different adsorption variables such as dye concentration 25 mg/l, temperature 30 °C, contact time 8 h and pH 7 which shows 96% of MB removal efficiency. The Langmuir isotherm show the best fitted isotherm with maximum adsorption capacity 359 mg/g.

Karanj fruit hulls activated carbon on KOH activation produced large surface area and found efficient biosorbent for methylene blue removal reported by Md. Azharul Islam et al. [96]. The author carried out detailed study of adsorption isotherm, kinetic modelling, thermodynamic property and adsorption mechanism. The adsorption process such as monolayer, multilayer, dye-adsorbent interaction were evaluated by studying the langmuir, freundlich and tempkin isotherm model respectively. The MB dye uptake capacity through Langmuir isotherm model were 154.8 mg/g, 203.4 mg/g and 239.4 mg/g at temperature 30 °C, 40 °C and 50 °C respectively. The experimental thermodynamic parameter value denotes that dye adsorption was favourable at higher temperature. The authors carried out the comparative study with apricot stones, coffee grounds, peach stone which has lesser dye uptake capacity than karanj fruit hull activated carbon.

F. Marrakchi et al. [97] worked on MB removal by chitosan flakes with NaOH treatment. The activated carbon material was prepared from chitosan and NaOH with different impregnation ratio such as 1:1, 2:1, 3:1 and 4:1. The impreganated samples were treated under $N_2$ flow at 800 °C. The available functional groups, pore size, pore diameter, surface morphology were studied by using FTIR, BET surface area and SEM analysis. The FTIR spectra clearly depicts the presence of –OH, C–H, N–H, C–O, C–N functional groups on the surface of sorbent material. Due to sodium hydroxide impregnation with applied temperature 800 °C, there was change in surface chemistry and shifting of peaks at different frequencies. The influence of MB initial concentration was evaluated with concentration 25–400 mg/l with contact time 60–120 min. The authors demonstrated the adsorption mechanism by using Weber-Morris and Boyd model. The maximum dye uptake 143.53 mg/g with solution pH 11 evaluated by Langmuir adsorption isotherm.

W A Khanday et al. [98] utilized phosphoric acid treated chitin for removal of cephalexin antibiotic having adsorption capacity 245.13 mg/g. Low rank coal, a waste material converted into activated carbon with greater dye removal efficiency was explored for MB dye adsorption by Ali H Jawad et al. [99]. Due to KOH activation, the sorbent material increased the surface area from 1.23 $m^2/g$ to 1094.3 $m^2/g$. The enhancement in surface area was responsible for higher percentage of MB dye uptake. The author studied the influence of adsorbent dose, dye concentration, contact time and solution pH to investigate the adsorption properties. The maximum removal of MB dye low rank coal adsorbent was found 491.7 mg/g. The regression coefficient value ($R^2$) for langmuir, freundlich and tempkin model were found 0.99, 0.93 and 0.97 respectively indicates adsorption system follows langmuir model. The author has carried out comparative study with several adsorbent and concluded that selantik coal shows more dye adsorption capacity than other adsorbents. S N Surip et al. [100] used sulphuric acid activated Merit Kapit Coal for decolorisation of MB dye. The coal material was impregnated with $H_2SO_4$ and dried in oven at 110 °C for 24 h. The elemental analysis shows 48.78% C, 22.35% N, 3.26% H and 25.61% O. The acid treated coal has low surface area (0.59 $m^2/g$) with pore diameter 16.4 nm. Box-Behnken design was used to optimized decolorisation and COD reduction of methylene blue dye. The optimum obtained results were 78.5% decolorisation and 63.3% COD reduction. The freundlich model shows best regression coefficient ($R^2 = 0.99$) than langmuir model ($R^2 = 0.87$) but maximum dye uptake capacity of langmuir (421.1 mg/g) was greater than freundlich model (123.7 mg/g).

Merit Kapit coal on activation with KOH used for MB dye sequestration was investigated by Ali H Jawad [101]. However, change in surface area 332.61 $m^2/g$ of raw adsorbent to 1100.18 $m^2/g$ of KOH treated adsorbent material. In the adsorption isotherm study, langmuir model shows 200 mg/g MB dye uptake by KOH activated adsorbent.

## 8. Conclusion

The aim this research work is to compile and present the data of various low cost adsorbents for removal of methylene blue dye. Many researcher modified the adsorbent by various physical and chemical treatments and found superior improvement in dye adsorption. Agricultural waste and fruit peel waste materials are readily available with negligible cost and show greater dye adsorption capacity. The amount of adsorption depends on various parameters viz. Dye concentration, adsorbent dose, contact time, solution pH and temperature. The maximum amount of dye adsorbed at higher quantity of adsorbent dose. The adsorbent prepared from agricultural waste shows the same amount of dye removal efficiency as like activated carbon.

Agricultural waste adsorbents found outstanding dye removal efficiency and promising result with minimum processing cost is advantageous and good alternative as adsorbent in adsorption technology for industrial waste water treatment. Many of the low cost adsorbent can be recycle and reuse. All the researcher used batch experiments for adsorption study therefore again further study and experiments need to be performed for larger scale so this can be used in industry for commercial level.

## Declaration of competing interest

The author declare no conflict of interest.

## Acknowledgement

We would like to offer special thanks to Dr. Pawan Tambade, who although no longer with us, continues to inspire by his example and dedication to us he served over the course of his career.

## References

[1] Vanitha Katheresan, Jibrail Kansedo, Sie Yon Lau, Efficiency of various recent wastewater dye removal methods: a review, J. Environ. Chem. Eng. 6 (2018) 4676–4697, https://doi.org/10.1016/j.jece.2018.06.060.

[2] Kayode Adesina Adegoke, Olugbenga Solomon Bello, Dye sequestration using agricultural wastes as adsorbents, Water Resources and Industry 12 (2015) 8–24, https://doi.org/10.1016/j.wri.2015.09.002.

[3] K.S. Bharathi, S.T. Ramesh, Removal of dyes using agricultural waste as low- cost adsorbents: a review, Appl. Water Sci. 3 (2013) 773–790.

[4] Mohammad Malakootian, Mohammad Reza Heidari, Reactive orange 16 dye adsorption from aqueous solutions by psyllium seed powder as a low cost biosorbent: kinetic and equilibrium studies, Appl. Water Sci. 8 (2018) 212, https://doi.org/10.1007/s13201-018-0851-2.

[5] Sana Dardouri, Jalila Sghaier, Adsorptive removal of methylene blue from aqueous solution using different agricultural wastes as adsorbents, Kor. J. Chem. Eng. 34 (4) (2017) 1037–1043, https://doi.org/10.1007/s11814-017-0008-2.

[6] Maryam Khodaie, Nahid Ghasemi, Babak Moradi, Mohsen Rahimi, Removal of Methylene Blue from Wastewater by Adsorption onto ZnCl $_2$ Activated Corn Husk Carbon Equilibrium Studies, Hindawi Publishing Corporation Journal of Chemistry, 2013, 383985, https://doi.org/10.1155/2013/383985. Article ID.

[7] Tabrez A. Khan, Momina Nazir, Enhanced adsorptive removal of a model acid dye bromothymol blue from aqueous solution using magnetic chitosan-bamboo sawdust composite: batch and column studies, Environ. Prog. Sustain. Energy 34 (5) (2015), https://doi.org/10.1002/ep.12147.

[8] Sulyman Mohamed, Jacek Namiesnik, Andrzej Gierak, Low-cost adsorbents derived from agricultural by-products/wastes for enhancing contaminant uptakes from wastewater: a review, Pol. J. Environ. Stud. 26 (2) (2017) 479–510, https://doi.org/10.15244/pjoes/66769.

[9] Ali H. Jawad, Ahmed Saud Abdulhameed, M.A.K.M. Hanafiah, Zeid A. ALOthman, Mohammad Rizwan Khan, S.N. Surip, Numerical desirability function for adsorption of methylene blue dye by sulfonated pomegranate peel biochar: modeling, kinetic, isotherm, thermodynamic, and mechanism study, Kor. J. Chem. Eng. 38 (7) (2021) 1499–1509, https://doi.org/10.1007/s11814-021-0801-9.

[10] Shivani S. Vedula, Ganapati D. Yadav, Wastewater treatment containing methylene blue dye as pollutant using adsorption by chitosan lignin membrane: development of membrane, characterization and kinetics of adsorption, J. Indian Chem. Soc. 99 (2022), 100263, https://doi.org/10.1016/j.jics.2021.100263.

[11] Ali H. Jawad, Ahmed Saud Abdulhameed, Lee D. Wilson, Syed Shatir A. Syed-Hassan, Zeid A. ALOthman, Mohammad Rizwan Khan, High surface area and mesoporous activated carbon from KOH-activated dragon fruit peels for methylene blue dye adsorption: optimization and mechanism study, Chin. J. Chem. Eng. 32 (2021) 281–290, https://doi.org/10.1016/j.cjche.2020.09.070.

[12] Omar S. Bayomie, Haitham Kandeel, Tamer Shoeib, NohaYoussef HuYang, M. H. Mayyada, El-Sayed Novel approach for efective removal of methylene blue dye from water using fava bean peel waste, Sci. Rep. 10 (2020) 7824, https://doi.org/10.1038/s41598-020-64727-5.

[13] Nguyen Hoc Thang, Dinh Sy Khang, Tran Duy Hai, Dinh Thi Nga, Phan Dinh Tuan, Methylene blue adsorption mechanism of activated carbon synthesised from cashew nut shells, RSC Adv. 11 (2021) 26563–26570.

[14] Ali H. Jawad, Muna Hasoon Sauodi, Mohd Sufri Mastuli, Mohammed Ajah Aouda, Khairul Adzfa Radzun, Pomegranate peels collected from fresh juice shop as a renewable precursor for high surface area activated carbon with potential application for methylene blue adsorption, Desalination Water Treat. 124 (2018) 287–296.

[15] Ali H. Jawad, Ramlah Abd Rashid, Khudzir Ismail, S. Sabar, High surface area mesoporous activated carbon developed from coconut leaf by chemical activation with $H_3PO_4$ for adsorption of methylene blue, Desalination Water Treat. 74 (2017) 326–335.

[16] Kamal Al-Mokhalelati, Iman Al-Bakri, Nesrin Al Shibeh Al Wattar, Adsorption of methylene blue onto sugarcane bagasse-based adsorbent materials, J. Phys. Org. Chem. (2021) 4193. https://www.researchgate.net/publication/349477013.

[17] A. Farhadi, A. Ameri, S. Tamjidi, Application of agricultural wastes as a low-cost adsorbent for removal of heavy metals and dyes from wastewater: a review study, Phys. Chem. Res. 9 (2) (2021) 211–226. https://www.researchgate.net/publication/349701980.

[18] Hamad Noori Hamad, Syazwani Idrus, Recent developments in the application of bio-waste-derived adsorbents for the removal of methylene blue from wastewater: a review, Polymers 14 (2022) 783, https://doi.org/10.3390/polym14040783.

[19] Ali H. Jawad, Ahmed Saud Abdulhameed, Noor Nazihah Bahrudin, Nurul Nadiah Mohd Firdaus Huma, S.N. Surip, Syed Shatir A. Syed-Hassan, Emad Yousif, S. Sabar, Microporous activated carbon developed from KOH activated biomass waste: surface mechanistic study of methylene blue dye adsorption, Water Sci. Technol. 84 (8) (2021) 1858.

[20] Stephanie Giraldo, Irma Robles, Luis A. Godínez, Nancy Acelas, Elizabeth Flórez, Experimental and theoretical insights on methylene blue removal from wastewater using an adsorbent obtained from the residues of the orange industry, Molecules 26 (2021) 4555, https://doi.org/10.3390/molecules26154555.

[21] Ali H. Jawad, Ahmed Saud Abdulhameed, Statistical modeling of methylene blue dye adsorption by high surface area mesoporous activated carbon from bamboo chip using KOH-assisted thermal activation, Energ. Ecol. Environ 5 (2020) 456–469, https://doi.org/10.1007/s40974-020-00177-z.

[22] Jacob J. Salazar-Rabago, Roberto Leyva-Ramos, Jose Rivera-Utrilla, Raul Ocampo-Perez, J. Felipe, Cerino-cordova, biosorption mechanism of methylene blue from aqueous solution onto white pine (pinus durangensis) sawdust: effect of operating conditions, Sustainable Environment Research 27 (2017), 32e40.

[23] Ali H. Jawad, Ahmed Saud Abdulhameed, Mohd Sufri Mastuli, Acid-factionalized biomass material for methylene blue dye removal: a comprehensive adsorption

# Biodiversity of Cyanophyceae from Amaravati Dam of Dhule district (Maharashtra)

**V.P. Patil[*] and S.N. Nandan**

P.G. Department of Botany, S.S.V.P.'s L.K. Ghogrey Science College, Dhule – 424 005

**ABSTRACT**: In aquatic ecosystems the flora and fauna interact with the biotic and abiotic factors in their habitat. Therefore flora and fauna are called biological indicators. Man made reservoirs like Dam reflect both terrestrial and aquatic environment as their construction involves superimposition of lentic water body on flowing water mass on the terrain. Algae constitute the main autotrophic component of the aquatic ecosystems. Change in algal community severely affect the species diversity. Biodiversity is greater in fresh water than in the most affected terrestrial ecosystem. So the present study shows biodiversity of Cyanophyceae from Amaravati Dam. Total 35 taxa belonging to 15 genera are discussed in present paper. The genera viz. Microcystis, Chroococcus, Gloeocapsa, Aphanocapsa, Synechococcus, Merismopedia, spirulina, Oscillatoria, Phormidium, Lyngbya, Nostoc, Anabaena, Plectonema, Homoethrix and calothrix.

**Key words:** Taxonomy, Algae, Cyanophyceae, Ecobiodiversity

## Introduction

In India the pioneer work was done on Cyanophyceae (Kamat and Patel, 1973; Marathe, 1965 ; Nandan and Borse 1996; Mahajan and Nandan, 2004).

The region Dhule district though rich in large number of fresh water bodies has so for not been explored as its biotic diversity of algal flora. The present investigation is done on Amaravati dam, which is the main resource of Shindkheda Taluka of Dhule dirstict for drinking and irrigation purpose. In present study three group of algae wiz. Cyanophyceae, Chrorophyceae and Bacillaciophyceae were studied but present communication deals with taxonomy of 35 algal taxa of cyanophyceae group only. All blue green algal taxa were identified with the help of monograph (Desikachary 1959).

## Methodology

The Amaravati dam is located near the village Malpur, taluka Sindkheda in Dhule district (Maharashtra, India). The main sources of amaravati dam are Amaravati river, Nai river & Ghusri nala. The dam is situated at 70 $^0$ 30′ S longitude and 20 $^0$ 30′ N latitude.

The sample were collected in the morning from different habitats of station 1st, 2nd, 3rd and preserved in 4% formalin. For identification line drawings were made with the help of camera lucida.

## Results and Discussion

During the present investigation following Blue green algae have been observed.

**1. Microcystis flos-aquae (Wittr.) Kirchner ( PL-1 Fig.1 )**
Desikachary, 1959, P-94, PI-17, F-11
Colonies roughly spherical, ellipsoidal, or somewhat elongate or often squarish in optical section, not clathrate, with indistinct colonial mucilage; cells 4 µm in diameter spherical, with gas vacuoles, nannocytes present.
**Habitat:- Amaravati Dam Station-ADS-III, November,2006.**

**2. Chroococcus tugidus (Kuets) Nag. (PL-1 Fig.2 )**
Desikachary, 1959, P-101, Pl-26, F-6
Cells spherical or ellipsoidal single, or in group of mostly 2-4 without sheath 30 µm, with sheath 13-25 µm, diameter, rarely 40 µm, sheath colourless, not distinctly lamellated.
**Habitat:- Amaravati Dam Station-ADS-I, May,2007.**

**3. Chroococcus cohaerens (Breb.) Nygaard (PL-1 Fig.3)**
Desikachary, 1959, P-111, Pl-26, F-3
Thallus slimy, or gelatinous, dark green; cells single or up to 2-8 in group without envelope 2 µm diameter, and with sheath 2.5 µm diameter, sheath thin, colourless; unlamellated.
**Habitat:- Amaravati Dam Station-ADS-II, July,2007.**

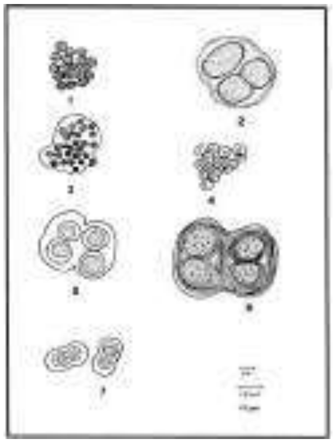
**4. Gloeocapsa punctata Nag. (PL-1 Fig.4)**
Desikachary, 1959, P-115, Pl-23, F-2
Thallus gelatinous, light blue-green, cell without sheath 0.7-1.5 µm diameter with sheath 4 µm broad blue green, sheath thick, clolurless, unlamellted or scarcely lamellated, cells 2-16 in groups or colonies about 25 µm diameter.
**Habitat:- Amaravati Dam Station-ADS-II, February, 2007.**

**5. Gloeocapsa nigrescens Nag. (PL-1 Fig.4)**
Desikachary, 1959, P-117, Pl-24, F-17
Thallus crustaceous, light blue-green, cell without sheath 3.3 µm diameter, with sheath thick, colourless, lamellated , cells 4 in groups or colonies about 32 µm diameter.
**Habitat:- Amaravati Dam Station-ADS-II, July, 2007.**

**6. Gloeocapsa pleurocapsoides Novacek (PL-1 Fig.6)**
Desikachary, 1959, P-118, Pl-24, F-3
Colony microscopically small, more or less roundish or irregular, dull olive green, cells olive coloured or pale blue-green, homogenous, granular; cells 5-10 µm in diameter, elongated, closely arranged, sheath thin, simple coloured yellowish in the peripheral the part, 2-3 µm thick and lamellated, 3-4 lamellae.
**Habitat:- Amaravati Dam Station-ADS-I, March, 2007.**

**7. Gloeocapsa Stegophila var. crassa Rao, C.B. (PL-1 Fig.7)**
Desikachary, 1959, P-119, Pl-25, F-3
Cells spherical, subspherical or elongated, 14 µ broad commonly single or in colonies of 2.4; sometime striated; colony with sheath 14 broad and 9.6 – 19.2 µm long, sheath up to 3.2 µm thick.
**Habitat:- Amaravati Dam Station-ADS-I, July, 2007.**

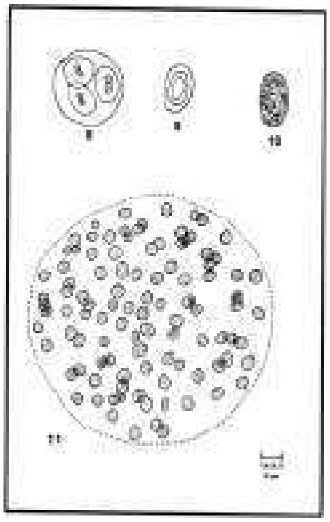
Plate 1



1. Microcystis flos-aquae (Wittr.) Kirchner
2.Chroococcus turgidus (Kuetz) nag.
3.Chroococcus cohaerens (Breb.) Nygaard
4.Gloeocapsa puntata

5. Gloeocapsa nigrescens Nag.
6.Gloeocapsa pleurocapsoides Novacek.
7. Gloeocapsa stegophila var.crassa Rao, C.B.

Plate 2



8. Gloeocapsa coracina kutz.
9. Gloeocapsa Samoensis Wille. v. major Wille
10. Aphanocapsa grevillei (Hass.) Rabenh.
11. Synechocccu aeruginousus Nag.

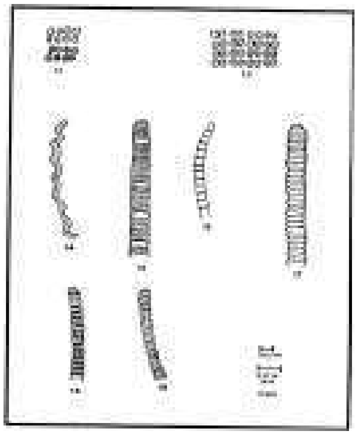
**8. Gloeocapsa coracina kutz. C.B. ( PL-2 Fig.8)**
Desikachary, 1959, P-121, Pl-24, F-11
Thallus crustaceous, lubricous, cells single, round small, with sheath 7.3 μm and without sheath about 4 μm broad, single or in group of 28 μm diameter laterally uniting; distinctly lamellated, contents homogeneous, blue-green.
**Habitat:- Amaravati Dam Station-ADS-III, March, 2007.**

**9. Gloeocapsa Samoensis Wille. v. major Wille (PL-2 Fig.9)**
Desikachary, 1959, P-128, Pl-23, F-6
Cells without envelop 5 μm broad and 10 μm long on the inner walls of a well, sheath hyaline.
**Habitat:- Amaravati Dam Station-ADS-I, August, 2007.**

**10. Aphanocapsa grevillei (Hass.) Rabenh. (PL-2 Fig.10)**
Desikachary, 1959, P-134, Pl-21, F-9
Thallus gelatinous, spherical or hemispherical, light blue green; cells spherical, 3.3. diameter. Contents finely granular, blue-green, closely arranged in a homogeneous mucilage; individual envelopes not distinct.
**Habitat:- Amaravati Dam Station-ADS-II, November,2006.**

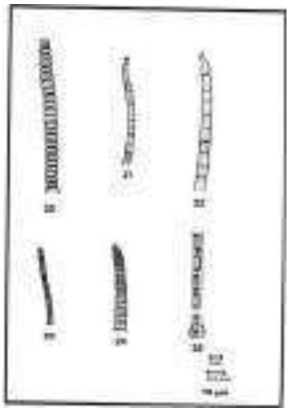
**11. Synechocccu aeruginousus Nag. (PL-2 Fig.11)**
Desikachary, 1959, P-143, Pl-25, F-6,12
Cells cylindrical, 15 μm broad up to 30 μm long, single, pale blue green.
**Habitat:- Amaravati Dam Station-ADS-I, February,2007.**

Plate 3



**12.** Merismopedia punctata Meyen
**13.** Merismopedia glauca (Ehrenb.) Nag.
**14.** Spirulina meneghiniana Zanard. ex. Gomont
**15.** Oscillatoria subbrevis Schmidle
**16.** Oscillatoria subtilssima Kutz.
**17.** Oscillatoria corallinae (Kutz.) Gomont
**18.** Oscillatoria tenuis Ag. ex. Gomont

Plate 4



20. Oscillatoria formosa Bory ex. Gomont
21. Oscillatoria splendida Grev. ex. Gomont
22. Oscillatoria acuminata Gomont
23. Phormidium angustissimum W.et.G.S. West.
24. Phormidium autumnale (Ag.) Gomont.
25. Lyngbya mesotricha Skuja.

**12. Merismopedia punctata Meyen ( PL-3 Fig.12)**
Desikachary, 1959, P-155, Pl-29, F-6
Colonies small, 16 cells, about 60 μm broad; cells not closely packed, spherical or avoid, 2.7 μm broad, pale blue green. Plankton found in stagnant and flowing water and among other algae.
**Habitat:- Amaravati Dam Station-ADS-II, Deceber,2006.**

**13. Merismopedia glauca (Ehrenb.) Nag. (PL-3 Fig.13)**
Desikachary, 1959, P-155, Pl-29, F-5
Colonies Mostly small with 32 cells, Cells oval or spherical, closely arranged, 3.3. μm broad, pale blue green. In plankton in standing water and among algae, in irrigation channels.
**Habitat:- Amaravati Dam Station-ADS-III, May,2007.**

**14. Spirulina meneghiniana Zanard. ex. Gomont (PL-3 Fig.14)**
Desikachary, 1959, P-195, Pl-36, F-8
Trichome 1.9 μm broad, flexible irregularlyspirally coiled, bright blue-green, forming a thick blue-green thallus, spiral 3.2-5 broad and 3.5 μm distant from each other.
**Habitat:- Amaravati Dam Station-ADS-III, August,2007.**

**15. Oscillatoria subbrevis Schmidle (PL-3 Fig.15)**

not attenuated not constricted at the cross-wall, cross walls marked with one or two larger granules on either side; cells 1-2 time longer than broad, 4-8 µm long, content pale blue-green; homogeneous; apical cell rounded conical.
**Habitat:- Amaravati Dam Station-ADS- II, December,2007.**

**26. Nostoc ellipsosporum (Desm.) Rabenh. ex.Flah. ( PL-5 Fig.26)**
Desikachary, 1959, P-383, Pl.69, F. 5
Thallus gelatinous, irregularly expanded, attached by the lower surface, radish brown, filaments flexuous; loosely entangled; trichome about 4 µm broad, light blue-green, cells cylindrical 6-14 µm long; heterocysts subspherical, or o b long, 6-7 µm long; spore ellipsoidal to ablong cylindrical, 6-8 µm broad, 14-19 long, epispore smooth, hyaline.
**Habitat:- Amaravati Dam Station-ADS- II, September,2007.**

**27. Nostoc muscorum Ag.ex Bron et Flah. (PL-5 Fig.27)**
Desikachary, 1959, P-385, Pl.70, F. 2
Thallus gelatinous – membranous, irregularly expanded, attached by the lower surface, tuberculate, dull olive or brown, 2-5 cm diameter; filaments densely entangled; sheath disrinct only at the periphery of the thallus, yellowish brown trichome 3-4 µm broad; cells short barrel-spaped to cylindrical, up to twice as long as broad; heterocysts nearly spherical, 6-7 µm broad; spores oblong, many in series, 4-8 µm broad, 8-12 µm long.
**Habitat:- Amaravati Dam Station-ADS- III, November,2006.**

**28. Nostoc piscinale Kuetzing ex Born. et Flah. (PL-5 Fig.28)**
Desikachary, 1959, P-377, Pl.69, F. 3
Filaments flexuous, loosely entangled; sheath distinct at the periphery of the thallus, trichome 3-7 µm broad; cells shorter or longer than broad up to nearly twice as long as broad; heterocysts subspherical, 4.5-6 µm broad; spore globose, 6-7 µm broad, in long chains.
**Habitat:- Amaravati Dam Station-ADS- I, November,2006.**

**29. Anabaena orientalis Dixit (PL-5 Fig.29)**
Desikachary, 1959, P-405, Pl.77, F. 6
Thrichome single, straight or slightly curved, 2.5-4 µm broad cells quadrate or cylindrical, rarely slightly barrel shaped, upto twice as long as broad, 3.7-4.8 µm long, end-cell conical with rounded apex; heterocysts single, intercalary, cylindrical or slightly ellipsoidal with rounded end walls, 4.8-5.5 µm broad, and 7.4-9.2 µm long; spore one on each side of a heterocyst, ellipsoidal, 7.4-9.2 µm broad and 14.8 – 16.6 µm long.
**Habitat:- Amaravati Dam Station-ADS- I, August,2007.**

**30. Anabaena ballyganglii Banerji. (PL-5 Fig.30)**
Desikachary, 1959, P-409, Pl.77, F. 4
Thrichome fragile, circinate, never straight, forming a thin pale blue green stratum over the surface of a small water pond, cells compressed, spherical as long as broad or slightly shorter or longer than the diameter, 7-8.5 µm broad and 6.5-13.5 µm long, content franular, heterocyst some what spherical with homogenous contents, single or in pairs; hetrocyst 7.5-10 µm broad and 7.5-11 µm long; spore single; ellipsoidal, younger ones somewhat spherical remote from the heterocyst, wall of the spore thick, smooth colourless content granular.
**Habitat:- Amaravati Dam Station-ADS- II, February,2007**

**31. Anabaena doliolum Bharadwaja (PL-5 Fig.31)**
Desikachary, 1959, P-410, Pl.78, F. 3
Plant mass mucilagenious, pale blue green; trichome single, free swimming, straight, curved or slightly coiled, 3.6-4.2 µm broad, slightly tapering at the ends, with conical apical cell, possessing almost pointed apex; cells barrel-shaped as long as broad or a little longer or shorter than broad; hetro cyst barrel shaped, 5.2-6.3 µm broad and 6.3-9.4 µm long; spore ellipsoidal with almost pointed apices in short or long chain, adjoining the heterocyst but developed centrifugally, epispore thick, smooth and hyaline or yellow-brown, 4.2-6.2 µm broad and 6.3-11.5 µm long.
**Habitat:- Amaravati Dam Station-ADS- III, May,2007**

**32. Anabaena circinalis Rebenhorst ex Born. et Flah. (PL-6 Fig.31)**
Desikachary, 1959, P-414, Pl.77, F.2
Thallus forthy, floating, trichome mostly circinate, seldom straight, mostly without a sheath, 8-14 µm broad. Cells barrel shaped or spherical, somewhat shorter than broad, with gas-vacuole; heterocyst subspherical, 8-10 µm broad; spore cylindrical sometime curved, end rounded, 16-18 µm broad, ordinarily away from the heterocyst, epispore smooth and colourless.
**Habitat:- Amaravati Dam Station-ADS- III, July,2007**
**Family:- Scytonemataceae.**

**33. Plectonema notatum Schmidel (PL-6 Fig.33)**
Desikachary, 1959, P-440, Pl.83, F.5
Filaments variously bent, not forming any distinct thallus, 1.7-2 µm broad; false branching sparse, single or geminate; sheath thin, colourless; cells cylindrical, 2-3 time as long as broad; with two granule at the cross-walls not constricted, plae blue-green, end cell rounded.
**Habitat:- Amaravati Dam Station-ADS- II, July,2007**
**Family:- Rivulariaceae.**

**34. Homoeothrix juliana ( Menegh.) Krichn. (PL-6 Fig.34)**
Desikachary, 1959, P-519, Pl.107, F.7
Filaments single or many together forming a olive coloured thallus, when dried amethyst coloured erect, rigid, unbrached, 10-15 µm broad, up to 2 mm long, thickened at the base sheath thin close to the trichome, colourless, not lamellated; trichome 9-12.5 µm broad, produced into a long hair and fragile; cells discoid harmogones 4-5 time as long as broad 30-60 µm long.
**Habitat:- Amaravati Dam Station-ADS- III, August,2007**

**35. Calothrix thermalis (Schwabe) Hansg. (PL-6 Fig.34)**
Desikachary, 1959, P-533, Pl.114, F.10
Thallus expanded mucilaginous, soft blue-green or olive green, filaments intricate, flexuous, up to 3 mm long, densely arranged, 8-10 µm broad, swollen at the base, sheath thick, homogenous hyaline or yellowish at the base; unlamellated; cells 5-8 µm broad, 1/3 to as long as broad seldom longer, blue-green.
**Habitat:- Amaravati Dam Station-ADS- III, May,2007**

## Acknowledgement

One of the author (VPP) is thankful to the Principal Dr. S.N. Nandan and Shri. A.C. Patil Head of the Department of Botany for providing necessary laboratory and library facilities.

## Reference

Desikachary, T.V. 1959 cyanophyta I.C.A.R, - New Delhi.

Kamat, N.D. and Patel, M.Z. 1973 Soil algae of rice filed at different depts. Botanique 4:101-106.

Mahajan, S.R. and and S.N. Nandan, 2004 Blue green algae of Hartala lake of Jalgaon, Maharashtra. J. Aquatic Biology 19(1) : 11-12

More, Y.S. and Nandan S.N. 2000, Hydrobiological study of Algae of Panzara dan (MH) Eclo. And Cons. 6(1) : 99-103

Ganpati, S.V. 1940 The ecology of the temple tank containing a permanent bloom of Microcystis. J. Bomb. Nat. Hist. Soc, 42(1) : 65-77

Nandan S.N. and D.S. Jain 2006. Biodiversity of cyanophyceae in Sonvad Project dam and Devbhane dam of Dhule (MH): Biodiversity assessment and conservation-PP.107-138.

**International Journal of Advance and Applied Research**
www.ijaar.co.in
**ISSN – 2347-7075** **Impact Factor – 7.328**
**Peer Reviewed** **Bi-Monthly**
**Vol.4 No.24** **July-Aug 2023**

# Characterization of Biologically Synthesised Copper Oxide Nanoparticle Thick Film

**Seema V. Gharate[1], Chandrakant L. Sasle[2]**
[1]Department of Microbiology, S.V.K.T.College,Nashik (M.S.)
[2]Department of Physics. K.A.A.N.M.S.College,Satana (M.S.)
**Corresponding Author- Seema V. Gharate**

**DOI- 10.5281/zenodo.8242553**

The Present paper deals with the characterization of biologically synthesisednanoparticlesfor fabrication of Thick films.Nanoparticles over bulk equivalents have found wide application in number of fields including, optics, electronics, sensor technology etc. Of the various methods, chemical ones are expensive and use toxic chemicals for synthesis of nanoparticles that result in environmental pollution. .“Green Synthesis “ of nanoparticle production has found a sound solution for this .Microbes like bacteria , fungi, diatoms ,actinomycetes and cells of higher plants serve as Living Machines to generate nanoparticles. Through their metabolic pathways, they reduce salts in to nanoparticles .Present work deals with synthesis of nanoparticles using simple cost effective eco-friendly microbial enzymes. The nanoparticles synthesised were characterised by XRD, S EM, EDS, Spectrophotometric analysis etc. Attempts were made to fabricate thick films.

**Keywords;** Thick films, Nanoparticles, Biogenic, Enzym

## Introduction:

Today Nano science is most fascinating field of technology. Metal nanoparticles are different from those of bulk materials made from same atom. Because of their size nanoparticles exhibit larger surface area than micro sized material and hence fore possess improved physical and chemical properties bearing unique optical, electronic, mechanical and magnetic characteristics, different from bulk materials and find applications in catalysis, photonics and electronics e.g. silver nanoparticles possess diverse properties and uses like magnetic and optical polarizability, electrical conductivity catalysis, surface enhanced Raman scattering.

Recently higher integrated density of electronic components (small size and precision of electronic components) greatly demands thin conductive films and reduction in printed circuits. Films made from nanoparticles reduce dimensions of PCBs. Secondly large surface area makes material more chemically reactive affecting their strength and electrical properties. Quantum effects begin to dominate behaviour of matter at Nano scale at lower end and affect optical, electrical, magnetic behaviour of materials. When a nanoparticle is much smaller than the wavelength of light, coherent oscillation of the conduction band electrons are induced by interaction with an electromagnetic field. This resonance is referred as surface Plasmonwithin resonance. The surface Plasmon resonance charge, its own dielectric constant and environment includes substrate, sorbates and solvents. High sensitivity of surface Plasmon resonance of noble metal nanoparticles in response to adsorbate induced changes in dielectric constant of environment is used in chemo sensing and bio sensing. Advent of nanotechnology has introduced diverse methods for generation of Nanoparticles, physiochemical methods for synthesis of nanoparticles are proved to be undesirable due to expensiveness, toxicity and hazardous properties which cause threatening environmental risks. Whereasbiologically synthesized nanoparticles are inexpensive and find applicability in enviro-friendly sustainable biomimetic approaches.

Battery of all these femes of nanoparticles attracted the researcher for production of nanoparticle coated films to make the process more enviro-friendly. Present investigation was undertaken to synthesise biogenic nanoparticles using microbial enzymes .Synthesised nanoparticles were characterised by techniques like UV-Visible spectroscopy, XRD, EDS, SEM etc.

Attempts were made to prepare thick films for gas sensing application.

## Materials and Methods:

1. All the chemicals required for biosynthesis were purchased from S.D. Fine chemicals and Qualigen Fine chemicals. The glass wares all used wereeither chemically clean and/or sterilized in hot air oven wherever necessary.
2. Cultivation of bacterial culture: Bacterial culture Bacillus spp**.** was inoculated in small250 ml conical flask containing sterile Nutrient Broth and incubated on rotary shaker at 120 rpm for 24 hours .After24 hours culture was centrifuged at 5000rpm for 10 min to separate bacteria.
3. Biofabrication of copper oxide nanoparticle: the supernatant obtained was added in equal volume with 1mM copper acetate Solution. The pH of mixture was maintained to neutrality .Detection of copper oxide nanoparticles was carried out in reaction mixture by observing color change , optical density at various time intervals using UV –VIS Spectrophotometer. The solution was stored in dark for 24-48 hours at room temperature so as to settle nanoparticles. The reaction mixture was centrifuged at 10000 rpm for 10 min. The supernatant was discarded and suspension was concentrated by repeated centrifugation. It was freeze dried and used for further analysis. Suitable controls weremaintained throughout the experiment.
4. Characterization method: UV-VIS Spectrophotometer, XRD, SEM, EDSanalysis.
5. Thick Films of biogenic copper oxide nanoparticles were prepared by Screen Printing technique.

## Characterization of Nanoparticles

UV –VIS Spectrophotometer analysis: Biosynthesis of CuO nanoparticle was detected by UV- VIS Spectrum at different time intervals using distilled water as a blank.

**XRD analysis:** The CuO nanoparticles obtained were purified by repeated washing and centrifugation at 10000 rpm for 10 min and subsequent freeze drying. These nanoparticles were characterised by XRD. Fig.1 Shows XED pattern of CuO nanoparticles. The nature of these nanoparticles can be deducted from XRD pattern obtained. The peaks of X-ray diffraction are broad at their bottom indicating that they are of Nano size. Thus the confirmation of Biosynthesis of nanoparticle was proved by XRD analysis of freeze dried CuO nanoparticles generated in this work.

**SEM analysis:** SEM analysis was carried out for morphological characterization of nanoparticles synthesised. The freeze dried powder was put in to the sample well and dried in mercury lamp. To analyse an electron beam was focussed into a fine probe that was subsequently scanned over small sample area. The interacting beam with sample generated various signals.

**EDS analysis:** Energy Dispersive Spectroscopic analysis indicates the presence of Copper element. For EDS analysis sample subjected to SEM analysis was used. The SEM instrument was equipped with thermos EDS attachment.

## Results and Discussion

Culture supernatant of Bacillus specieswas used for biogenesis of CuO nanoparticles. Biosynthesis was indicated by browning of reaction mixture that could be visually inspected. Visual inspection of nanoparticle synthesis was confirmed by UV-VIS spectrum analysis.The XRD spectrum pattern of freeze dried CuO particles was found to show broadening of different peaks at the base confirming the Nano size of particles.

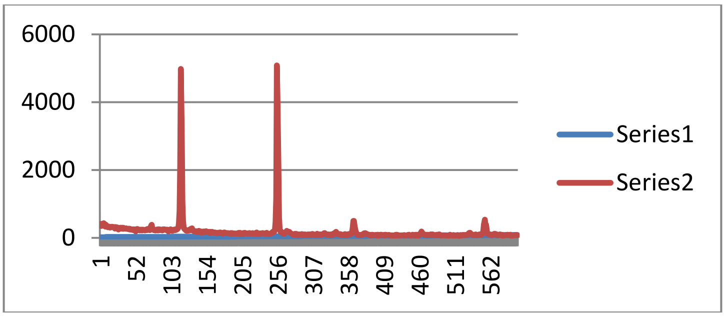


**Fig.1 XRD pattern of CuO Nanoparticles synthesised by Bacillus spp.**

EDS analysis supported the elemental confirmation of particles showing peak in copper region

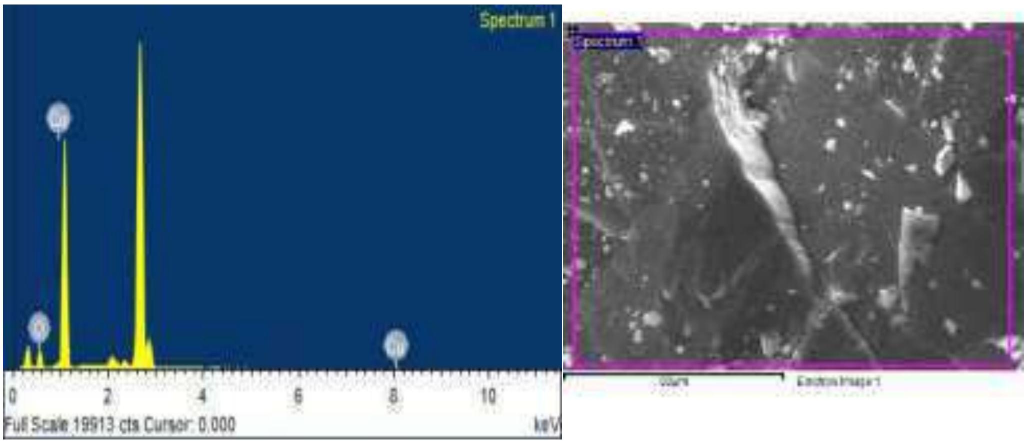


**Fig.2 EDS analysis shows peak in copper region confirming presence of elemental copper.**

**SEM:** The Scanning Electron microscopy was conducted to study morphological features of CuO nanoparticles. The images are shown in figure 3a and 3b respectively. Images indicate that the morphology of iron nanoparticle is roughly spherical. Also the nanoparticles are covered by biomolecules which indicated in the image thatlarge organic biomolecules are seen attached to small copper nanoparticles (Figure3)

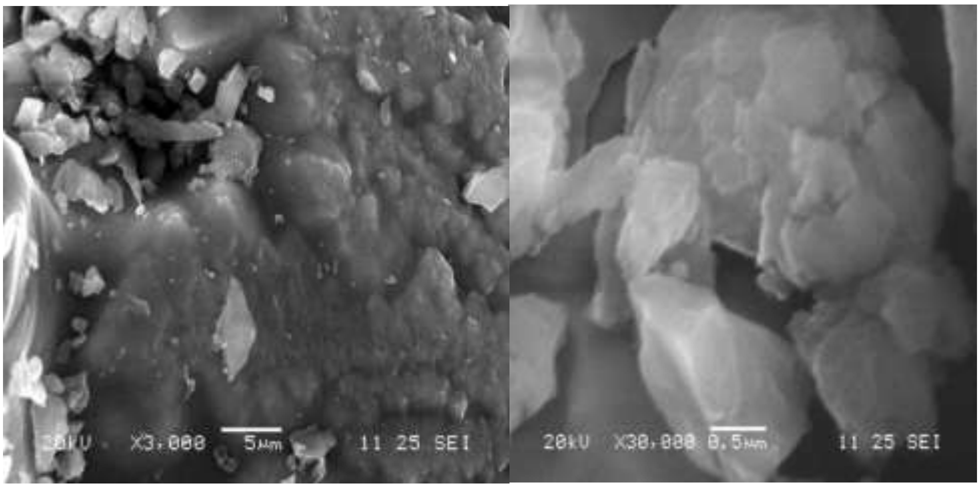


**Fig.3 SEM images of sample showing morphology of copper nanoparticles.**

## Conclusion

Present studyhas developed simple, green and eco-friendly biogenic fabrication of copper oxide nanoparticle by Bacillus spp.Extracellular synthesis of nanoparticles byBacillus spp.was confirmed in terms of colour change by visual observation. The nanoparticles synthesised were characterised by UV-VIS spectrophotometer. The XRD pattern revealed that particles were of Nano size. EDS analysis confirmed elemental nature of nanoparticle especially in copper region. SEM micrograph showed morphologyof nanoparticle. Successful attempts were made to fabricate thick films using biogenic copper oxide nanoparticles by screen printing technique. The present method of synthesis of copper oxide nanoparticle is free from toxic chemicals and hence enviro-friendly. It is simple economically feasible and willfind wide potential for future application in various fields.

## References:

1. Sensors and transducers – Dr. R.Y. Borase

2. Handbook of thick film technique – P.J. Holmels & R.G. Loasby
3. Thick film screen printing solid state technique – Austin
4. Ahmed, P. Mukherjee, S. Senapati et al., "Extracellular biosynthesis of silver nanoparticles using the fungus Fusariumoxysporum, " colloids and surfaces B, vol.28, no.4 pp. 313-318,2003.
5. M. gericke and A. Pinches, "Biological synthesis of metal nanoparticles" Hydrometalurgy, vol.83, no. 1-4, pp. 132-140, 2006.
6. P. Mohanpuria, N.K. Rana, and S.K. Yadav, " Biosynthesis of nanoparticles: technological concepts and future applications," Journal of nanoparticle research, vol.10, no.3, pp. 507-517, 200.
7. M. gericke and A. Pinches, "Biological synthesis of metal nanoparticles" Hydrometallurgy, vol.83, no. 1-4, pp. 132-140, 2006.
8. P. Mohanpuria, N.K. Rana, and S.K. Yadav, "Biosynthesis of nanoparticles: technological concepts and future applications," Journal of nanoparticle research, vol.10, no.3, pp. 507-517, 2008.
9. Ritu shah ,goldie oza ,Sunil Pandey,Madhuri sheron,J. Microbial .Biotech.Res,2012, 2 (4); 485-492
10. Seema Garg, International Journal of Innovations in biological and chemical sciences, Vol, 3-5-10-2012.
11. Sangeetha. N. Sarvanan.K. Journal of nanoscience and nanoitechnology.Vol.2/Issue1/Pp99-102 (Feb 2014).
12. Pooja Bansal ,Joginder Singh Duhan , Suresh Kumar Gahlawat African J. of Biotechnol,Vol13 (28)July 2014 2778-2785.
13. Kaido Tammeveski. Main Research Developments in the chair of Collide and Environmental Chemistry.(2007-2012)
14. A.K.Suresh, Metallic Nanocrystallites and their interaction with microbial systems ,Spriger Briefs in Biometals,DOI; 10,1007/9768-94-007-4231-4-2.(2012).

International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075
Peer Reviewed
Vol.4 No.16
Impact Factor – 7.328
Bi-Monthly
March – April 2023

# An Epidemiological survey on dietary changes during COVID – 19 Pandemic in Nashik,Maharashtra, India

V.E. Sonawane[1], A.J. Kharat[2]
[1]MVP's S.V.K. Tejookaya Arts, Science and Commerce College, Deolali College
[2]MGV's LVH Arts, Sci. & Com. College Panchavati Nashik
*Corresponding Author*- V.E. Sonawane
Email : agneskharat@gmail.com

DOI- 10.5281/zenodo.7939911

**Abstract:**

The COVID-19 pandemic has affected all aspects of human life including their food consumption. The changes in the food production and supply processes introduce changes to the global dietary patterns. Survey approach was used for gathering primary data from Nashik City. According to the present survey it is noted that during first wave of COVID-19 many families were shifted to vegetarian diet. During second wave consumption of foods like chicken and fish along with green vegetables and chickpeas which are rich in vitamins and proteins has increased. People have emphasized on eating *chavanprash* twice a day with warm water and turmeric milk on an empty stomach to boost immunity due to Corona.

Home-based treatments, including self-care, self-medication, were found to be thefirst line of action for prevention of COVID-19. There has been gradual shift in diet from vegetarian to non-vegetarian which has resulted in minimizing the vitamin B12 deficiency.

**Key words:** COVID-19 pandemic, Dietary pattern, vegetarian diet, non-vegetarian diet

## Introduction:

The recent outbreak of COVID-19 began in Wuhan, a city in the Hubei province of China. Very soon after this it spread into many countries of the world. In India, the first case of the COVID-19 virus was detected in Thrissur, Kerala on January 30th, 2020. In the first wave, the death rate was approximately 3-4 lakhs and in the second wave, the death rate was approximately 9-9.4 lakhs. The severe symptoms observed in both waves includes: Coughing, Headache, Fever, Chills, Common cold. The COVID-19 symptoms, including dyspnea, fever, non-productive cough, pneumonia, fatigue, and myalgia emerge following an incubation stage of 2–14 days. The COVID-19 pandemic had affected all aspects of human life including their food consumption. The changes in the food production and supply processes introduce changes to the global dietary patterns.

The World Health Organization (WHO) declared COVID-19 as a global pandemic on January 30, 2020, in response to the global spreading of this dangerous virus. Millions of people have already affected due to COVID-19. Due to this pandemic the world has experience lockdown situations during last two years which has several limitations on daily living such as isolation, social distancing, home confinement etc. The COVID-19 pandemic represents a massive impact on human health, causing sudden lifestyle changes, through social distancing and isolation at home, with social and economic consequences. (Di Renzo *et.al.* 2020)

The COVID-19 pandemic has affected all aspects of human life including their food consumption. The changes in the food production and supply processes introduce changes to the global dietary patterns. This study is intended to understand the changes in eating habits promoted during the first and second wave of COVID-19.

## Material and Method:

Survey approach was used for gathering primary data from Nashik City. The questionnaire was created, designed and circulated by using the non-digital platform. Participants were encouraged to fill up the form. This survey was conducted with the help of student volunteers during 4th December 2022 to 10th January 2023. Students were requested for sharing the questionnaire with their family members, friends, relatives and neighbors in their areas. Individuals were asked to declare their consumption of certain foods and food groups, and lifestyle habits comparing before and during the pandemic period. (Alzhrani, A *et.al.* 2021)

We have received 2875 responses during this survey. All the interested participants were included in the survey. Exclusion criteria for the survey was age bellow 18, pregnant and lactating women and duplicate response. After exclusion final data set included 2657 participants. Identity of all the participants and their personal data collected was keptanonymous.

**Result and discussion:**

The first wave of the COVID-19 pandemic commenced with increased detection of cases in January-March 2020, and after the September 2020 peak, cases declined by the endof October 2020.

According to the present survey it is noted that during first wave of COVID-19poultry business was in danger due to fear of Corona. During this time number of people eating chicken has decreased greatly, causing a great crisis to the poultry industry. Many families were shifted to vegetarian diet during this phase. It was found that during first outbreak of COVID -19 about 40% of the participants were vegetarian and 60% participants were non-vegetarian.

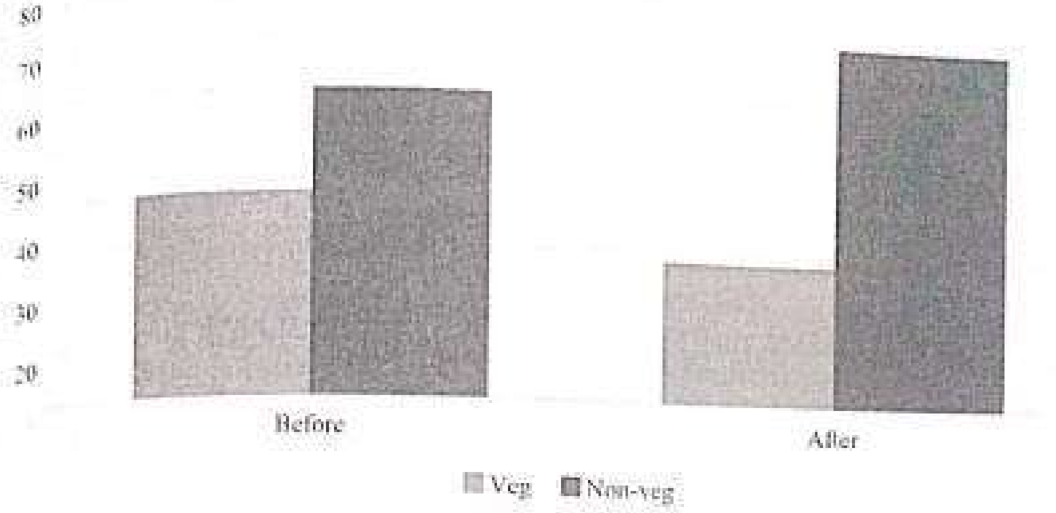
The second wave of the COVID-19 pandemic began on March 13, 2021, peaked on April 23 (17,937 cases), and ended on June 19, 2021. This is the most crucial phase where we have noted vast dietary changes. Our survey shows that many citizens who used to prefer fast food, oily food are now opting for immunity boosting foods. Consumption of vegetables, fruits and pulses which have nutrients that increases immunity has increased by rejecting the fast food made in the family. It is seen that the amount of fruit and leafy vegetables has increased a lot during this phase. In order to increase immunity, there have been a lot of changes in the home kitchen and now raw vegetable, pulses and salad is being emphasized in every household. Most frequently used home remedies were decoction of herbs including ginger, Tinosporacordifolia, turmeric, black pepper, carom seeds. Turmeric milk was also popular choice. (Ayalur Gopalakrishnan *et.al.*, 2021) Consumption of "Golden Milk" which is turmeric powder in hot milk once or twice a day for boosting immunity and help fight against COVID illness. (Gupta *et.al.*, 2020) Increase use of Indian gooseberry (amla) is noted whichis being eaten to boost immunity. Consumption of foods like chicken and fish along with green vegetables and chickpeas which are rich in vitamins and proteins has increased. People are emphasizing on eating *chavanprash* twice a day with warm water and turmeric milk on an empty stomach to boost immunity (Motiwala, *et.al.*, 2023)

It was observed that during second wave 72% of participants were non vegetarian, there was about 12% in non-vegetarian diet. It was also observed that due to increase in non- vegetarian diet there is considerable decrease in vitamin B12 deficiency.

There was considerable increase in maintenance of hygienic condition that had resulted in considerable decrease in common microbial infections.

**Table 1: Proportion of changes in the consumption of Vegetarian diet before and afterpandemic**

| **Consumption of Vegetarian and non-vegetarian diet Before and After pandemic** | | |
|---|---|---|
| Diet | Before Pandemic | After Pandemic |
| Vegetarian | 40% | 28% |
| Non-Vegetarian | 60% | 72% |
| Total | 100 % | 100% |



**Graph 1: Proportion of changes in the consumption of Vegetarian diet before and after pandemic**

## Conclusion:

According to the present survey it is noted that during first wave of COVID-19 many families were shifted to vegetarian diet. During second wave consumption of foods like chicken and fish along with green vegetables and chickpeas which are rich in vitamins and proteins has increased. Home-based treatments, including self-care, self-medication, were found to be the first line of action for prevention of COVID-19. There has been gradual shift in diet from vegetarian to non-vegetarian which has resulted in minimizing the vitamin B12 deficiency.

## References:

1. Di Renzo L, Gualtieri P, Pivari F, Soldati L, Attinà A, Cinelli G, Leggeri C, Caparello G, Barrea L, Scerbo F, Esposito E, De Lorenzo A. Eating habits and lifestyle changes during COVID-19 lockdown: an Italian survey. J Transl Med. 2020 Jun 8;18(1):229. doi: 10.1186/s12967-020-02399-5. PMID: 32513197; PMCID: PMC7278251.
2. Alzhrani, A., M.H. Alhussain, and A. Bahammam. "Comparison of Dietary Intake, Physical Activity, and Sleep before and during Ramadan among Saudi Adults." Clinical Nutrition ESPEN 46 (2021): S600. Web.
3. Gupta H, Gupta M, Bhargava S. Potential use of turmeric in COVID-19. Clin Exp Dermatol. 2020 Oct;45(7):902-903. doi: 10.1111/ced.14357. Epub 2020 Jul 27. PMID: 32608046; PMCID: PMC7361299.
4. Motiwala, Zainab Y.; Khan, Isna R.; Ahmad, Sameena[1]; Abedi, Ali J.[1]. Dietary Changes among the Indian Population during the Covid-19 Pandemic: A Cross-Sectional Study. Indian Journal of Community Medicine 48(1):p 137-141, Jan–Feb 2023. | DOI: 10.4103/ijcm.ijcm_521_22
5. Ayalur Gopalakrishnan Radhika, Himani Malik:
6. Fight against COVID-19: Survey of Spices & Herbs Used in North IndiaOpen Journal of Epidemiology, Vol.11 No.3, 2021
7. Singh, Birgurman1; Jain, Srishti2; Rastogi, Ashu3. Effects of nationwide COVID-19
8. lockdown on lifestyle and diet: An Indian survey. Journal of Family Medicine and
9. Primary Care 10(3): p 1246-1250, March 2021. | DOI: 10.4103/jfmpc.jfmpc_2046_20

Indian J Med Res 156, October & November 2022, pp 640-647
DOI: 10.4103/ijmr.IJMR_208_20

Quick Response Code:

# Polyalanine polymorphism in the signal peptide of *Glutathione peroxidase 1* (*GPX1*) gene & its association with osteoporosis

Soni Ghumnani Ahuja[1], Arjun Shahu[1], Subrata Rath[2], Neeraj Adkar[3], Yogesh Shouche[4], Saroj Ghaskadbi[1] & Richa Ashma[1]

*[1]Department of Zoology, Savitribai Phule Pune University, [2]Division of Statistical Quality Control and Operations Research, Indian Statistical Institute, [3]SaiShree Hospital & Joint Replacement Center & [4]National Centre for Microbial Resource, Microbial Culture Collection, National Centre for Cell Science, Pune, Maharashtra, India*

Received January 28, 2020

***Background & objectives*: Osteoporosis is a systemic skeletal disease, characterized by a low bone mass leading to increased bone fragility and hence, a greater susceptibility to the risk of fracture. Since age-related oxidative stress is one of the factors that has been implicated in developing low bone mineral density (BMD), leading to osteoporosis, this study wanted to explore the expression of antioxidant enzymes in individuals with osteoporosis. The present study focused on mapping polymorphism in an important antioxidant enzyme glutathione peroxidase 1 (GPx1) among osteoporosis and healthy Asian Indians.**

***Methods*: Dual-energy X-ray absorptiometry was used to assess BMD of individuals and was classified into normal (n=96) and osteoporotic (n=88) groups. Biochemical parameters such as vitamin D, total oxidant status (TOS), and GPx1 enzyme activity were estimated from plasma samples of recruited individuals. Quantitative real-time qRT-PCR was carried out using GAPDH as an endogenous control. Genomic DNA was isolated from whole blood, and polymorphisms were evaluated by sequencing.**

***Results*: The BMD was lower in osteoporotic individuals, and further analysis of biochemical parameters indicated significantly low 25-hydroxy vitamin D and GPx1 with higher TOS levels in osteoporotic as compared to healthy individuals. Furthermore, qRT-PCR revealed low expression of *GPX1* in osteoporotic individuals. *GPX1* sequence analysis of the promoter and two exons revealed the lower frequency of five alanine repeats in the osteoporotic individuals.**

***Interpretation & conclusions*: In this study, the *in silico* analysis revealed the lower frequency of five alanine repeats in exon 1 of *GPX1* and high TOS to be associated with osteoporosis. However, no polymorphism was found in exon 2 of *GPX1* among the two study groups.**

**Key words** Glutathione peroxidase 1 - osteoporosis - oxidative stress - polyalanine repeat - SNP - total oxidative stress

Osteoporosis is a multifactorial, systemic skeletal disease, characterised by deterioration of bone tissue and low bone mass with a consequent increase in bone fragility and susceptibility to fracture. It is associated with an increase in bone resorption by osteoclasts, a decrease in bone formation by osteoblasts[1] and an increase in oxidative stress (OS) within osteoblasts[2]. More than 61 million Indians have been estimated to have osteoporosis, out of which 80 per cent are reportedly females[3]. Studies have also reported that older men and women with osteoporosis have lower plasma antioxidants and reduced bone mineral density (BMD)[4]. Decreased levels of antioxidants are known to elevate the level of reactive oxygen species (ROS) within osteoclasts which may further lead to bone resorption[5,6].

Cellular OS refers to the excess production of free radicals compared to the antioxidant capacity of the cell[7]. The impairment caused by an increased concentration of ROS damages macromolecules such as proteins, lipids and DNA. In addition, it constitutes a stress signal that activates specific redox-sensitive signalling pathways which potentially have protective functions[7]. Evidence suggests that OS is responsible for the pathophysiology of ageing[8] and may participate in the pathogenesis of diabetes[9], atherosclerosis[10], cancer[11] and osteoporosis[12]. It has been demonstrated that free radicals modulate the differentiation of osteoblasts[13] and intervene in bone resorption, thereby promoting osteoclastic differentiation in such a manner that bone resorption increases with OS[14,15]. One of the key enzymes of the antioxidant defence of a cell is glutathione peroxidase 1 (GPx1) encoded by *GPX1* (Gene ID: 2876), located on the p arm of chromosome 3.

GPx1, a soluble selenoprotein (located in mitochondria) is one of the most abundant antioxidant enzymes found in humans. It is ubiquitously expressed in many tissues where it protects cells from OS[16]. This enzyme uses reduced glutathione as an essential co-substrate and reduces hydrogen peroxide ($H_2O_2$) and organic hydroperoxide to water ($H_2O$) and corresponding alcohols[16]. The *GPX1* coding for this enzyme has two exons which together code for 203 amino acids. Two polymorphisms in this gene have been associated with osteoporosis[17]. One of these is a GCG repeat polymorphism in exon 1 coding for five to seven alanine repeats, a part of signal peptide present from positions 7th to 13th nucleotide[17]. The second exon consists of CCC/CTC polymorphism coding for proline/leucine at 198th position[17]. Variation in the number of polyalanine repeats has been reported in Slovenian osteoporotic individuals[17]. In the same population, polyAla and Pro198Leu polymorphisms, individually and in combination, were found to be associated with BMD and therefore are proposed as useful genetic markers for osteoporosis[17]. The present study focused on the association of polymorphisms present in the antioxidant gene *GPX1* with osteoporosis in the Asian Indian population. Genetic variants in the promoter and the two exons of this gene were screened by sequencing. Furthermore, transcript levels of GPx1 were evaluated in healthy and osteoporotic individuals. The association between biochemical parameters (total oxidant status [TOS], 25-hydroxy vitamin D and GPx1) and *GPX1* polymorphism among healthy and osteoporotic groups was also investigated.

## Material & Methods

This study was conducted over a period of two years in Pune district of Maharashtra, India, after approval by the Institutes Human Ethics Committee of Saishree Hospital, Pune, which follows the guidelines of the Indian Council of Medical Research. A written consent was obtained from all the participants.

*Study design*: A priori power analysis was carried out for two-tailed t test using G*Power 3.1.9.2 software, (Heinrich Heine University, Düsseldorf, Germany) with the α-error set at 0.05 (statistical power of 95%), to have large effect size ($P$=0.50). The total sample size (n) was calculated to be 42 with the allocation ratio N2/N1. Both males and females were recruited for this study and belonged to the age group of 45-75 yr.

*Inclusion and exclusion criteria*: Before inclusion of the individuals in the study, a stringent exclusion criterion was followed. Individuals visiting multi-speciality Saishree Hospital, Aundh, Pune, as outpatients willing to participate in this study were asked to fill a questionnaire-based history form. Individuals having secondary osteoporosis or any major OS-related diseases such as cardiovascular disease, diabetes mellitus, hyper/hypotension, thyroid deficiency, bone-related diseases such as rheumatoid arthritis, bone fracture were excluded from the study. Personal and family medical histories were also obtained with relevant clinical details such as age, gender, body mass index, ethnicity, physical activity, medications and food habits (such as dietary calcium intake). Individuals with a daily non-vegetarian diet, smokers, alcoholics and those on steroid intake were excluded from the study.

*Bone mineral density (BMD) estimation*: The BMD was measured from the proximal femoral neck or spine in both study groups using a bone mineral densitometer known as dual-energy X-ray absorptiometry (QDR 4500 C, Hologic, Inc., Bedford, MA, USA).

Hologic's system automatically calibrates by using internal reference standards and scans the spine phantom to confirm system stability and performance and gives maximum accuracy and precision. Assuming a normal distribution of T-scores using estimated BMD, unrelated participants were classified as healthy group (n = 96) with T score > −1.1 standard deviations, or osteoporotic group (n=88) with a T score ≤ −2.5 standard deviation.

*Biochemical estimation*: Peripheral blood (5 ml) was collected in vials containing EDTA (ethylenediaminetetraacetic acid) or sodium heparin sulphate as an anticoagulant. Plasma was separated from the peripheral blood centrifuged within 2 h of collection and the plasma aliquots were frozen at –80°C until use.

Vitamin D levels were estimated using the COBAS e411 instrument (Roche Diagnostics, Germany) at Genesys Laboratories, Pune, India, following Electro-Chemi Luminescence ImmunoAssay method[18]. The reference range of vitamin D used for healthy individuals was 20-50 ng/ml. TOS estimation was carried out using Erel's assay[18] and the results were expressed as µmol $H_2O_2$/L (Merck Millipore, India). GPx1 enzyme levels were estimated using the Glutathione Peroxidase Activity Colorimetric Assay Kit (Cayman Chemicals, USA) as per the manufacturer's instructions. The reference range of GPx1 enzyme activity was 5.3-11.5 µmole NADPH oxidised /min/g of Hb[19].

*RNA extraction and cDNA synthesis*: Peripheral blood mononuclear cells (PBMCs) were isolated from 5 ml blood using Histopaque (Sigma-Aldrich, USA), which facilitates the recovery of a large number of viable mononuclear cells by density gradient centrifugation. Isolated PBMCs were washed twice with ice-cold phosphate-buffered saline and then frozen in TRIzol (Invitrogen, Massachusetts, USA) within 3 h of phlebotomy. Total RNA was isolated from the PBMCs of both the study groups according to the protocol developed by Chomczynski[20]. Isolated RNA was then quantified using a NanoDrop 1000 spectrophotometer (BioSpec-nanodrop, USA). Complementary DNA (cDNA) was synthesised by reverse transcription from total RNA (1 µg) with a Verso cDNA Synthesis Kit (Thermo Scientific, USA).

*Quantitative real-time (qRT) PCR*: The qRT-PCR was performed (Applied Biosystems, USA) in triplicate using cDNA and gene-specific primers for *GPX1* and glyceraldehyde-6-phosphate dehydrogenase (GAPDH) was used as a reference endogenous control. Primer sequences for *GPX1* were as follows: forward (5′-CAGTCGGTGTATGCCTTCTCG-3′) and reverse (5′-GAGGGACGCCACATTCTCG-3′) and GAPDH were as follows: forward (5'-GAAGGTGAAGGTCGGAGTCAAC-3') and reverse (5'-CAGAGTTAAAAGCAGCCCTGGT-3'). PCR reaction was set using 50 ng cDNA, 10 µl SyBr® Green Premix Ex Taq™ II (Tli RNaseH Plus) (Clonetech, Japan) and 10 pmol each of forward and reverse primers in 20 µl reaction volume. For amplification of both genes, the following cycle was used: denaturation at 95°C for 30 sec, annealing at 58°C for 30 sec and extension at 60°C for 1 min. Forty cycles of amplification were performed. ΔΔCt-based fold-change calculations were carried out from raw threshold cycle data.

*DNA extraction and sequencing*: Genomic DNA was extracted directly from blood samples (700 ml) by standard procedures of phenol–chloroform extraction and ethanol precipitation[21]. DNA samples were used for PCR-based sequencing for which primers were designed using Primer3 (version 0.4.0)[22]. The first primer was designed for a part of a promoter sequence (-365 bps) and exon 1 (136 bps) and the second primer for exon 2 (545 bps) of *GPX1*. Primer sequences for the promoter and exon 1 were as follows: forward (5′-GCCAAACCCCACATCCTAACTCAG-3′) and reverse (5′-CCACATTCTCGATAAGTAGTACCT-3′) and those for exon 2 are as follows: forward (5′-CGTTTCTCTCCTCCTCTTGAC-3′) and reverse (5′-CATCTCGAGGTGGTATTTTCTGTAAG-3′). GAPDH was used as endogenous control[12]. Aligned DNA sequences were converted to amino acid sequences using six frames of references and the one matching the amino acid sequence of GPx1 protein from the database was selected. Amino acid sequences were aligned for osteoporotic and healthy individuals using ClustalW algorithm (BioEdit software version 7.0, Informer Technologies Inc., Los Angelas. CA, USA).

*In-silico analysis*: The polyalanine repeat found in GPx1 is a part of the signal peptide, which is cleaved before it is translocated to mitochondria. To check whether variation in the polyalanine repeat number had any effect on signal peptide cleavage, *in silico* analysis was carried out using Signal P 4.1 servers (*http://www.cbs.dtu.dk/services/SignalP*). The first 40 amino acids in our amplicons were compared with the reference amino acid sequence from UniProt (*GPX1* ID: P07203) in osteoporotic and healthy individuals.

*Statistical analysis*: Mann-Whitney U test was performed for the biochemical parameters that were not normally distributed and a two-sample t test was carried out for biochemical parameters found to be normally distributed in the study groups using Minitab® 17.1.0 software, Pennsylvania USA. Pairwise correlation coefficient test between the biochemical parameters was performed to check the correlation between GPx1 enzyme activity, 25-hydroxy vitamin D, TOS and BMD among healthy and osteoporotic groups. Since individuals of two groups belonged to a common geographical area, the effects of admixture and mixed ancestry on the allele frequencies could not be ruled out, and hence for inferring population structure, STRUCTURE programme version 2.3[23] was employed, keeping 10000 burn-in periods and 10000 repetitions. The chromatogram quality of sequence obtained and trace score of the sequences was confirmed using ABI Seq Scanner (ver. 2.0) software (Applied Biosystems, USA). The alignment of the multiple sequences was carried out using ClustalW algorithm of the BioEdit software version 7.0 (Informer Technologies) and sequences were scanned for the presence of single-nucleotide polymorphism (SNPs)[24]. The presence of polymorphism was verified with the reference sequence of the National Centre for Biotechnology Information and the variation in the alanine repeat number between osteoporotic and healthy individuals was calculated by direct counting[12]. The reference sequence identifier used for the wild-type gene sequence was NM_001329502.1, *Homo sapiens GPX1*, transcript variant 3, mRNA. Pearson's Chi-square test was carried out to assess the significant difference in the distribution of polyalanine repeat variation among healthy and osteoporotic groups. Odds ratio (OR) was estimated using McNemar 2 × 2 contingency test to assess the risk conferred by polyalanine repeat variation towards osteoporosis[25]. OR of 1.00 denoted no risk associated with that factor while OR more than 1.00 indicated excess risk and OR less than 1.00 a decreased risk[26].

## Results

*Population structure and admixture*: The mean alpha value of admixture in this study was estimated to be 0.071, indicating that the individuals of the study groups (both healthy and osteoporotic) belonged to an admixed population, *i.e.* they were of mixed ancestry (Fig. 1). The genetic distance, $F_{ST}$, calculated between the two populations ranged from 0 to 1.

*Analysis of biochemical parameters*: Biochemical parameters were analysed for both healthy (mean age = 59 yr; comprising 67.7% of males) and osteoporotic (mean age = 58 yr; comprising 43.2% of males) groups. BMD was found to be lower in osteoporotic individuals as compared to healthy individuals as shown in Table I for age-matched groups belonging to the same geographical area, homogeneous ethnicity and food habits. Likewise, the osteoporotic group had significantly lower circulating 25-hydroxy vitamin D, GPx1 enzyme levels and higher TOS, as compared to a healthy group (Table I).

*Association analysis of biochemical parameters with osteoporosis risk*: Healthy group showed a high GPx1 activity and significantly correlated with high femoral BMD (*P*=0.026) when compared to osteoporotic group (Table II). However, the osteoporotic study group did not show any significant correlation between GPx1 and femoral BMD (Table II).

*Analysis of GPx1 transcript and polymorphism*: The analysis of GPx1 transcripts by qRT-PCR showed a 3.5-fold decrease in the expression of GPX1 in osteoporotic as compared to healthy individuals (T=2.893, *P*<0.05) (Supplementary Fig. 1).

Single Nucleotide Polymorphisms (SNPs) in two regions of the *GPX1*, one spanning part of promoter and exon 1 region and second spanning exon 2 was checked. As per the dbSNP (SNP database), there are 66 SNPs reported in each of these two exonic regions. Of the 132 SNPs reported in dbSNP *(https://www.ncbi.nlm.nih.gov/SNP/snp)* in the studied exon 1 and 2 regions, four SNPs were detected in our samples (*viz.*, rs17838762, rs1800668, rs3210019 and rs1050450) with a significant difference in their allele frequency distribution (Supplementary Figs 2 and 3). It was observed that variation was found only in the length of polyalanine repeat in the first amplicon spanning selected promoter and exon 1 region.

*Polyalanine repeat variations in the first exonic region of GPx1 among the study groups*: Compared to the reference sequence, four alanine repeats were found in 37, five in 57, six in two healthy individuals (n=96) and four alanine repeats in 76, five in eight, six in two and seven in two osteoporotic individuals (n=88).

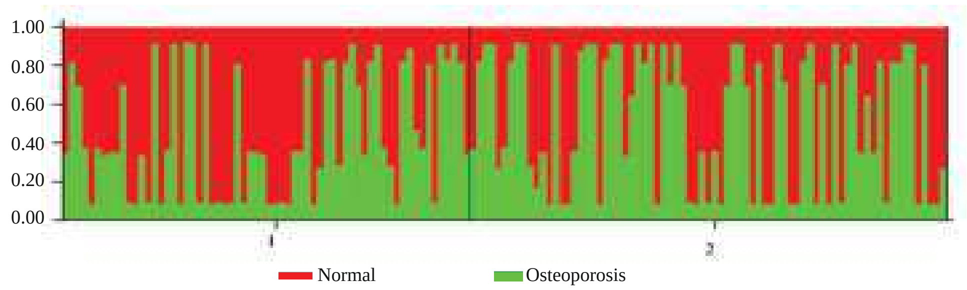


**Fig. 1.** Bar plot showing admixture for the two population clusters in the sampled population. Red: healthy individuals, Green: osteoporotic individuals. (STRUCTURE programme version 2.3 was employed, keeping 10000 burn-in periods and 10000 repetitions. The analysis is based on SNP allele frequency data of the two study groups for understanding population structure, identifying migrants and admixed individuals).

**Table I.** Analysis of bone mineral density, 25-OH vitamin D, total oxidative stress and glutathione peroxidase 1 (GPx1) enzyme activity between healthy and osteoporotic individuals

| Biochemical parameters | 25-OH vitamin D (ng/ml) | TOS (µmol $H_2O_2$/l) | GPx1 (µmole/min/g) |
|---|---|---|---|
| Healthy (n=96), *T* score=−0.16±0.66 | | | |
| Mean±SD | 24.78±7.29 | 27.45±18.36 | 0.693±0.078 |
| Median | 24.00 | 23.37 | 0.693 |
| CI for median | 21.775-26.087 | 21.523-32.531 | 0.683-0.707 |
| Osteoporotic (n=88), *T* score=−3.18±1.25 | | | |
| Mean±SD | 18.16±6.90$^{***}$ | 35.54±9.61 | 0.401±0.032$^{***}$ |
| Median | 16.93 | 35.80 | 0.409 |
| CI for median | 15.671-20.229 | 25.028-40.571 | 0.398-0.409 |

$P$ $^{***}$<0.001 considered as significant. TOS, total oxidative stress; NS, non-significant; SD, standard deviation; CI, confidence interval; 25-OH vitamin D, 25-hydroxy vitamin D; $H_2O_2$, hydrogen peroxide

**Table II.** Pairwise correlation coefficient test between glutathione peroxidase 1 (GPx1) and 25-OH vitamin D with total oxidative stress and bone mineral density amongst the healthy and osteoporotic groups

| Condition | Biochemical parameters | GPx1 | | 25-OH vitamin D | |
|---|---|---|---|---|---|
| | | Correlation coefficient | *P* | Correlation coefficient | *P* |
| Healthy (n=96) | TOS | −0.112$^{*}$ | 0.276 | 0.168 | 0.103 |
| | BMD | 0.227 | 0.026 | 0.043 | 0.677 |
| Osteoporotic (n=88) | TOS | 0.086 | 0.428 | 0.03 | 0.784 |
| | BMD | −0.128$^{*}$ | 0.232 | −0.162$^{*}$ | 0.132 |

$^{*}$The inverse relationship between biochemical parameters. BMD, bone mineral density; TOS, total oxidative stress; 25-OH vitamin D, 25-hydroxy vitamin D

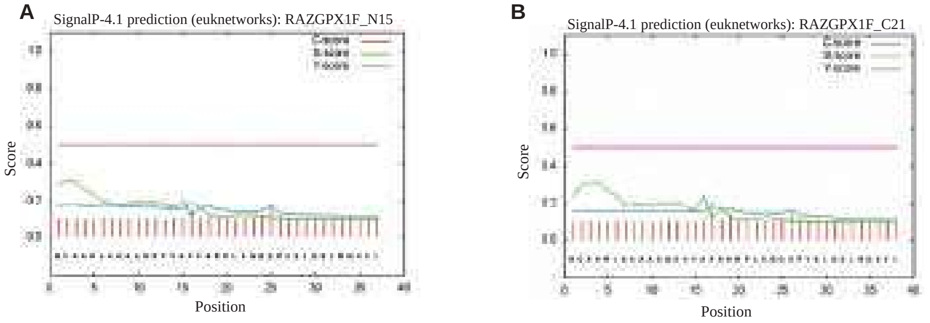
Lower frequency of five alanine repeats was found in osteoporotic individuals (0.09) as compared to the healthy group (0.59) ($P$<0.001). Pearson's Chi-square test confirmed that variation in five alanine repeats was less prevalent in the osteoporotic group ($\chi^2$ = 50.81, df = 1; $P$<0.001) than the healthy group (Table III). Odds ratio analysis (OR) showed that five alanine repeat variation in *GPX1* was associated with excess risk for osteoporosis (OR =14.62, OR >1, 95% confidence interval: 6.35-33.62). Correlation of association Phi (Φ) was estimated to be +0.53, suggesting a positive association between five alanine repeat variations in *GPX1* and osteoporosis condition.

*In silico* analysis of polyalanine repeats revealed that the combined cleavage score (Y-score) was comparable between osteoporotic (0.200) and healthy (0.191) individuals. Signal peptide cleavage site was also observed to be located at the same position at 19th 'F' phenylalanine (Fig. 2), as per the reference

**Table III.** Polyalanine repeat variation amongst healthy and osteoporotic individuals with 2×2 contingency Chi-square tests for genetic association analysis

| Condition | Prevalence of five alanine repeats | OR | 95% CI | |
|---|---|---|---|---|
| | | | Lower limit | Upper limit |
| Healthy (n=96) | 57/96 | 14.62 | 6.35 | 33.62 |
| Osteoporotic (n=88) | 8/88 | | | |

Data are represented as McNemar 2×2 contingency test, where $\chi^2$=50.81, *P*<0.0001, Φ=+0.53 represents positive association between alanine repeat variation in *GPx1* and osteoporosis condition. OR >1 (14.62) indicates excess osteoporosis risk. OR, odds ratio



```
# Measure    Position    Value    Cutoff    Signal peptide?
  max. C     25          0.168
  max. Y     16          0.191
  max. S      2          0.311
  Mean S      1-15       0.217
       D      1-15       0.205    0.450     NO
Name=RAZGPX1F_N15    SP='NO'   D=0.205   D-cutoff=0.450   Networks=SignalP-noTM
```

```
# Measure    Position    Value    Cutoff    Signal peptide?
  max. C     17          0.175
  max. Y     17          0.200
  max. S      4          0.314
  Mean S      1-16       0.226
       D      1-16       0.214    0.450     NO
Name=RAZGPX1F_C21    SP='NO'   D=0.214   D-cutoff=0.450   Networks=SignalP-noTM
```

**Fig. 2.** Signal peptide cleavage site prediction in the protein sequence of (**A**) healthy, and (**B**) osteoporosis Individuals. Signal P 4.1 servers were used for the first 40 amino acids in our amplicons to compare with the reference amino acid sequence from UniProt (GPX1 ID: P07203) between osteoporotic and healthy individuals. C-score: raw cleavage site score; S-score: signal peptide score; D-score: Discrimination score; Y-score: Combined cleavage site score that predicts true cleavage. Y-score was comparable amongst osteoporotic (0.200) and healthy (0.191) individuals. GPX1, glutathione peroxidase 1

sequence. Further, the probability of localization of GPx1, predicted by Target P 1.1 servers *(http://www.cbs.dtu.dk/services/TargetP)*, was found to be similar between our amplicons and reference sequence.

## Discussion

Osteoporosis is an age-related disease with preponderance in females[27]. Ageing along with OS is involved in the pathogenesis of osteoporosis[27]. Antioxidant enzymes play a major role in overcoming OS[28]. Glutathione peroxidase is an important antioxidant enzyme expressed ubiquitously in many tissues[29]. Different forms of GPx exist, of which GPx1 localises in both cytoplasm and mitochondria and functions in the reduction of $H_2O_2$ using glutathione as a reductant[29].

In the present study, age-matched healthy and osteoporotic individuals of homogenous ethnicity (Asian Indian Origin) belonging to the same geographical area, food habit and lifestyle were evaluated for population admixture. The admixture model for population ancestry was evaluated based on allele frequencies which indicated the degree of admixture within the two populations[23]. The model for correlated allele frequencies states that the allele frequencies between the two population clusters may be similar due to migration or recent shared ancestry[23]. High $F_{ST}$ typically indicates a high degree of differentiation among the populations. However, in this study, a low mean value of $F_{ST}$ (0.3191 ± 0.047) was obtained which indicated a recent common ancestry due to high gene flow and heterozygosity in the studied population. The two groups were compared for BMD, vitamin D, TOS and GPx1 activity. A significantly lower BMD, vitamin D and GPx1 levels and higher TOS was observed in the osteoporotic group as compared to healthy individuals supporting our hypothesis that OS contributes to the occurrence of osteoporosis. Our results are in corroboration with the previous studies[4,5,12,13,30], which indicated a significant increase in the values of plasma TOS and OS index and a decrease in total antioxidant status in patients with post-menopausal osteoporosis than those of healthy individuals. Moreover, similar to our findings, these studies also reported a significant negative correlation between OS index, TOS and BMD estimated from the femoral neck region and spine[4,5,12,13,30]. Correlational studies using biochemical parameters suggested that the high level of GPx1 activity was significantly associated with high femoral BMD in healthy individuals, as compared to osteoporotic individuals. In addition, a 3.5-fold decrease in the expression of *GPX1* and a significant decrease in plasma GPx1 activity were observed in osteoporotic individuals corroborating their involvement in the development of osteoporosis.

In the present study, polymorphism in *GPX1* was screened to check for the possible association with lower enzyme activity in osteoporotic individuals. GPx1 being a cytosolic protein requires translocation to mitochondria *via* signal peptide. The reference peptide sequence of *GPX1* consists of seven alanine repeats from positions 7th to 13th constituting part of the signal peptide[17]. A previous study on the Slovenian population showed that polymorphisms polyAla and Pro198Leu of the *GPX1*, individually and in combination, were associated with BMD and hence can be used as genetic markers for bone disease[17]. They found the highest values of BMD in 7/7 Ala group followed by individuals having 5/5 genotype and the lowest BMD values in the group carrying 6/6 genotype which implies that 7/7 Ala group might protect against osteoporosis. In the present study, we found the lower frequency of five alanine repeats in *GPX1* of the osteoporotic group as compared to a healthy group. Pearson's Chi-square test determined that five alanine repeat variation in *GPX1* was associated with excess osteoporosis risk. This demonstrates that genetic variability in *GPX1* and low GPx1 enzyme expression with high TOS is involved in the development of osteoporosis. Bioinformatics analysis of the signal peptide of GPx1 was carried out to understand its cleavage site and subcellular localization to mitochondria in osteoporotic and healthy individuals. *In silico* analysis revealed that signal peptide cleavage site did not change in either study group implying that variation in the number of alanine repeats in the N-terminal region of GPx1 protein sequences, did not affect cleavage of a signal peptide. Furthermore, Signal P 4.1 analysis confirmed that subcellular localization of GPx1 to mitochondria was also not influenced; indicating that deletion of the alanine residues from the signal peptide in the osteoporotic group may not influence subcellular localization of the protein to mitochondria. However, these findings need to be confirmed experimentally through biological and functional evidence in future studies. Moreover, we did not find Pro198Leu polymorphism (rs758910873) in the *GPX1* which is contrary to a previous report[17] or other SNPs reported in dbSNP (*https://www.ncbi.nlm.nih.gov/SNP/snp*).

The present study was not without certain limitations. This study could not infer causality between the biochemical parameters and osteoporosis. Although the healthy and osteoporotic groups belonged to the same environment, similar ethnicity and lifestyles, larger sample size will be required to increase the significance of the present association analysis.

Overall, in this study of Asian Indian population, low *GPX1* expression, high TOS and lower frequency of five alanine repeats was observed in the osteoporotic group which was found to be associated with excess osteoporosis risk. However, in addition to *GPX1*, there is a need to study the genetic variants of coding and non-coding regions of other antioxidant genes and their isoforms to understand their importance in OS-induced pathogenesis of osteoporosis. These results further emphasise our understanding of genetic variation in the pathogenesis of osteoporosis.

***Acknowledgment***: The authors acknowledge volunteers and patients for their active participation in this study.

***Financial support & sponsorship***: The study was funded by the Department of Biotechnology, Government of India, and RUSA (Rashtriya Uchchtar Shiksha Abhiyan), Savitribai Phule Pune University, Pune. Author (SG) and AS received Junior Research Fellowship from University Grant Commission and department of Biotechnology, New Delhi, respectively.

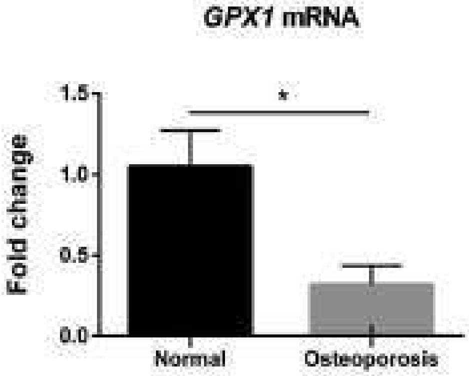
***Conflicts of Interest***: None.

## References

1. Raisz LG. Pathogenesis of osteoporosis: Concepts, conflicts, and prospects. *J Clin Invest* 2005; *115* : 3318-25.
2. Rached MT, Kode A, Xu L, Yoshikawa Y, Paik JH, Depinho RA, *et al.* FoxO1 is a positive regulator of bone formation by favoring protein synthesis and resistance to oxidative stress in osteoblasts. *Cell Metab* 2010; *11* : 147-60.
3. Aggarwal N, Raveendran A, Khandelwal N, Sen RK, Thakur JS, Dhaliwal LK, *et al.* Prevalence and related risk factors of osteoporosis in peri-and postmenopausal Indian women. *J Mid-Life Health* 2011; *2* : 81-5.
4. Lee YJ, Hong JY, Kim SC, Joo JK, Na YJ, Lee KS. The association between oxidative stress and bone mineral density according to menopausal status of Korean women. *Obstet Gynecol Sci* 2015; *58* : 46-52.

5. Baek KH, Oh KW, Lee WY, Lee SS, Kim MK, Kwon HS, *et al.* Association of oxidative stress with postmenopausal osteoporosis and the effects of hydrogen peroxide on osteoclast formation in human bone marrow cell cultures. *Calcif Tissue Int* 2010; *87* : 226-35.
6. Srinivasan S, Koenigstein A, Joseph J, Sun L, Kalyanaraman B, Zaidi M, *et al.* Role of mitochondrial reactive oxygen species in osteoclast differentiation. *Ann N Y Acad Sci* 2010; *1192* : 245-52.
7. Liguori I, Russo G, Curcio F, Bulli G, Aran L, Della-Morte D, *et al*. Oxidative stress, aging, and diseases. *Clin Interv Aging* 2018; *26* : 757-72.
8. Kregel KC, Zhang HJ. An integrated view of oxidative stress in aging: Basic mechanisms, functional effects, and pathological considerations. *Am J Physiol Regul Integr Comp Physiol* 2007; *292* : R18-36.
9. Houstis N, Rosen ED, Lander ES. Reactive oxygen species have a causal role in multiple forms of insulin resistance. *Nature* 2006; *440* : 944-8.
10. Kondo T, Hirose M, Kageyama K. Roles of oxidative stress and redox regulation in atherosclerosis. *J Atheroscler Thromb* 2009; *16* : 532-8.
11. Visconti R, Grieco D. New insights on oxidative stress in cancer. *Curr Opin Drug Discov Devel* 2009; *12* : 240-5.
12. Botre C, Shahu A, Adkar N, Shouche Y, Ghaskadbi S, Ashma R. Superoxide dismutase 2 polymorphisms and osteoporosis in Asian Indians: A genetic association analysis. *Cell Mol Biol Lett* 2015; *20* : 685-97.
13. Arai M, Shibata Y, Pugdee K, Abiko Y, Ogata Y. Effects of reactive oxygen species (ROS) on antioxidant system and osteoblastic differentiation in MC3T3-E1 cells. *IUBMB Life* 2007; *59* : 27-33.
14. Bai XC, Lu D, Bai J, Zheng H, Ke ZY, Li XM, *et al.* Oxidative stress inhibits osteoblastic differentiation of bone cells by ERK and NF-kappaB. *Biochem Biophys Res Commun* 2004; *314* : 197-207.
15. Lee NK, Choi YG, Baik JY, Han SY, Jeong DW, Bae YS, *et al.* A crucial role for reactive oxygen species in RANKL-induced osteoclast differentiation. *Blood* 2005; *106* : 852-9.
16. Hamanishi T, Furuta H, Kato H, Doi A, Tamai M, Shimomura H, *et al.* Functional variants in the glutathione peroxidase-1 (GPx-1) gene are associated with increased intima-media thickness of carotid arteries and risk of macrovascular diseases in Japanese type 2 diabetic patients. *Diabetes* 2004; *53* : 2455-60.
17. Mlakar SJ, Osredkar J, Prezelj J, Marc J. The antioxidant enzyme *GPX1* gene polymorphisms are associated with low BMD and increased bone turnover markers. *Dis Markers* 2010; *29* : 71-80.
18. Erel O. A novel automated method to measure total antioxidant response against potent free radical reactions. *Clin Biochem* 2004; *37* : 112-9.
19. Gümüşlü S, Bilmen S, Korgun DK, Yargiçoğlu P, Ağar A. Age-related changes in antioxidant enzyme activities and lipid peroxidation in lungs of control and sulfur dioxide exposed rats. *Free Radic Res* 2001; *34* : 621-7.
20. Chomczynski P, Sacchi N. Single-step method of RNA isolation by acid guanidinium thiocyanate-phenol-chloroform extraction. *Anal Biochem* 1987; *162* : 156-9.
21. Sambrook J, Fritsch EF, Maniatis T. *Molecular cloning: A laboratory manual*, Vol. 16. Plainview, New York: Cold Spring Harbor Laboratory Press; 1989. p. 66.
22. Untergasser A, Cutcutache I, Koressaar T, Ye J, Faircloth BC, Remm M, *et al*. Primer3—new capabilities and interfaces. *Nucleic Acids Res* 2012; *40* : e115.
23. University of Chicago. *Documentation for structure software : Version 2.3.4*, Vol. 6. Available from: *http://pritch.bsd.uchicago.edu/software/readmestructure2.pdf*, accessed on January 20, 2020.
24. Hall TA. BioEdit: A user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symp Ser* 1999; *41* : 95-8.
25. Lewis CM. Genetic association studies: Design, analysis and interpretation. *Brief Bioinform* 2002; *3* : 146-53.
26. Knol MJ, Le Cessie S, Algra A, Vandenbroucke JP, Groenwold RH. Overestimation of risk ratios by odds ratios in trials and cohort studies: alternatives to logistic regression. *Cmaj* 2012 ; *184* : 895-9.
27. Manolagas SC. From estrogen-centric to aging and oxidative stress: A revised perspective of the pathogenesis of osteoporosis. *Endocr Rev* 2010; *31* : 266-300.
28. Birben E, Sahiner UM, Sackesen C, Erzurum S, Kalayci O. Oxidative stress and antioxidant defense. *World Allergy Organ J* 2012; *5* : 9-19.
29. Brigelius-Flohé R, Maiorino M. Glutathione peroxidases. *Biochim Biophys Acta* 2013; *1830* : 3289-303.
30. Altindag O, Erel O, Soran N, Celik H, Selek S. Total oxidative/anti-oxidative status and relation to bone mineral density in osteoporosis. *Rheumatol Int* 2008; *28* : 317-21.

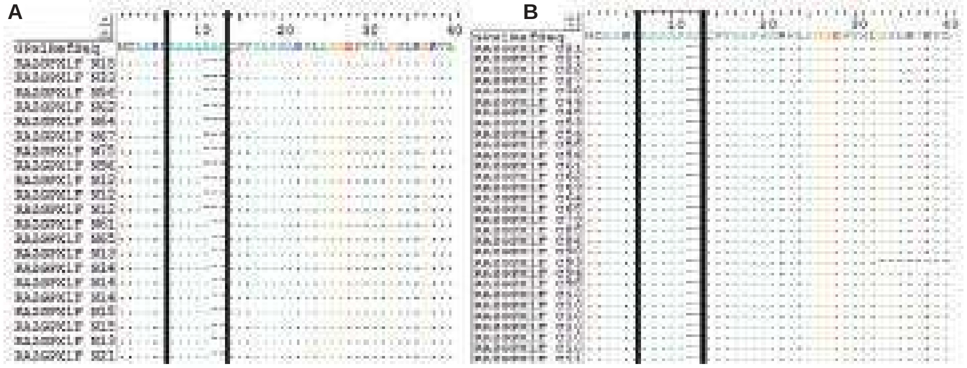
*For correspondence*: Dr Richa Ashma, Department of Zoology, Savitribai Phule Pune University, Pune 411 007, Maharashtra, India
e-mail: richaashma@unipune.ac.in



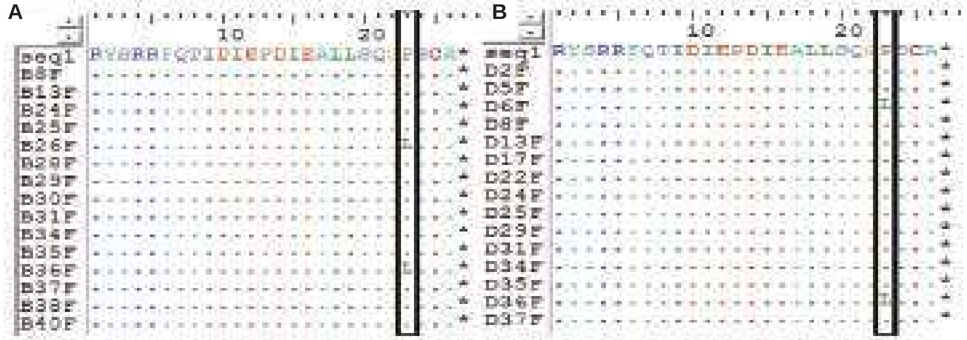
* = significant; P=0.0444

| Normal | osteoporosis | T-value | p-value |
|---|---|---|---|
| 1.048± 0.2240 | 0.3190±0.1158 | 2.893 | 0.0444 |

**Supplementary Fig. 1.** Bar graph of qRT-PCR of GPX1 from PBMCs of healthy and osteoporosis individuals. RNA was isolated from PBMCs of healthy and osteoporotic individuals and cDNA synthesis was carried out. cDNA was subjected to qRT-PCR for GPX1 expression analysis. Statistical analysis using unpaired Student's t test. Error bars indicate mean ± SEM. $P^*$ <0.05. GPX1, glutathione peroxidase 1; qRT-PCR, quantitative real-time polymerase chain reaction; PBMCs, peripheral blood mononuclear cells; SEM, standard error of the mean



**Supplementary Fig. 2.** Polyalanine repeat variation in (**A**) healthy and (**B**) osteoporotic individuals. DNA sequencing and sequence analysis were done using BioEdit software version 7.0. The results are expressed as the aligned sequence of amino acids and variation of polyalanine repeat shown for the individuals among healthy (a) and osteoporotic groups (b). Rows include amino acid sequences of individuals and columns are the specific amino acid position.



**Supplementary Fig. 3.** Pro198Leu polymorphism in exon 2 of *GPX1* in (**A**) healthy, and (**B**) osteoporotic individuals. The aligned nucleotide sequences were converted to amino acid sequence and variation of proline to leucine shown for the individuals amongst healthy (a) and osteoporotic groups (b) was analysed. Rows include amino acid sequences of individuals and columns are the specific amino acid position. A significant difference was not found across proline to leucine among osteoporotic and healthy individuals. GPX1, glutathione peroxidase 1.

# The `luatruthtable` LaTeX package

Chetan Shirore, Ajit Kumar

## Abstract

This paper describes the development and usage of the *luatruthtable* package in LaTeX. It is developed to generate truth tables of boolean values in LaTeX documents. The package provides an easy way of generating truth tables in LaTeX. There is no need of a special LaTeX environment for generation of truth tables with the package. It is written in Lua and the TeX document is to be compiled with the LuaLaTeX engine.

## 1 Introduction

The Lua [1] programming language is a scripting language which can be embedded across platforms. With LuaTeX [4], it is possible to use Lua in LaTeX. TeX or LaTeX has scope for programming in themselves. However, with the internals of TeX there are several limitations especially for performing calculations on numbers in LaTeX documents. There are packages like *pgf* [5] and *xparse* [9] in LaTeX which provide some programming capabilities inside LaTeX documents. However, such packages are not meant to provide the complete programming structure that in general other programming languages (like Lua) provide.

The generation of truth tables with these packages in LaTeX gets complicated [7] and probably without using Lua it can't be done in an easier way in LaTeX. The programming facilities of Lua are effectively used in the *luatruthtable* package. The *xkeyval* package is used in its development, in addition to the *luacode* package [2]. The time for generation of truth tables using the package and compilation of TeX document with LuaTeX is not an issue.

## 2 Installation and inclusion

The installation of the *luatruthtable* package is similar to any LaTeX package, where the `.sty` file is placed in the LaTeX directory of the texmf tree. The package can then be used by including the usual command `\usepackage{luatruthtable}` in the preamble of the LaTeX document. The document is to be compiled using LuaLaTeX.

## 3 Core ideas used in the development of the package

Lua [1] is an extensible language that can be embedded in LaTeX. The TeX [8] language has indirect support for scripting languages [6].

The *luatruthtable* function `toBinary(x,y)` is used to produce a sequence of *True* and *False* values

doi.org/10.47397/tb/43-2/tb134shirore-luatruthtable

of boolean variables. This function converts the decimal number `x` to a binary number by adding `y` number of leading zeroes. The result of this is stored in a table in Lua. Here `y` corresponds to the number of boolean variables. As $2^y$ permutations of boolean variables are to be produced, the function `toBinary(x,y)` runs inside a loop where `x` takes values from 1 to $y$. The splitting of variables and expressions is done using string methods available in Lua. The nested *metamethods* in Lua are used to define several logical operators. The *load* function in Lua is used to evaluate logical expressions.

## 4 The `\luaTruthTable` command in the `luatruthtable` package

The `\luaTruthTable` command is the main command in the *luatruthtable* package which generates truth tables. It has the following syntax.

```
\luaTruthTable[⟨trtext⟩,⟨fltext⟩]
  {⟨list of boolean / logical variables⟩}
  {⟨list of expressions⟩}
```

The command has two mandatory arguments:

i) ⟨*list of boolean / logical variables*⟩: The list of boolean or logical variables should be separated by commas.
ii) ⟨*list of expressions*⟩: The list of logical expressions that are to be evaluated should also be separated by commas.

And the command has two optional arguments:

i) ⟨*trtext*⟩: the display value for the boolean value *True*. It has the default value `$T$` in the package. It can be any string or number, although assigning the value 0 would not make sense.
ii) ⟨*fltext*⟩: the display value for the boolean value *False*. It has the default value `$F$` in the package. It can be any string or number, although assigning the value 1 would similarly not make sense.

The `\luaTruthTable` command should be used within `\begin{tabular} ... \end{tabular}` environment or any other environment in LaTeX for tables. The sequence of column heads should be the same as the sequence of *list of boolean / logical variables* and *list of expressions*. Without these correct inputs, `\luaTruthTable` cannot produce the desired output.

## 5 Operations in the `luatruthtable` package

a) *not*: The value of *not* $p$ is False when $p$ is True and it is True when $p$ is False.

| $p$ | not $p$ |
|---|---|
| $T$ | $F$ |
| $F$ | $T$ |

The command `lognot*` is used in the package to generate a truth table for the *not* operation.

b) *and*: The value of $p$ *AND* $q$ is True if and only if both $p$ and $q$ are True.

| $p$ | $q$ | $p$ and $q$ |
|---|---|---|
| $F$ | $T$ | $F$ |
| $T$ | $F$ | $F$ |
| $T$ | $T$ | $T$ |
| $F$ | $F$ | $F$ |

The command `*logand*` is used in the package to generate a truth table for the *and* operation .

c) *or*: The value of $p$ *or* $q$ is False if and only if both $p$ and $q$ are False.

| $p$ | $q$ | $p$ or $q$ |
|---|---|---|
| $F$ | $T$ | $T$ |
| $T$ | $F$ | $T$ |
| $T$ | $T$ | $T$ |
| $F$ | $F$ | $F$ |

The command `*logor*` is used in the package to generate a truth table for the *or* operation.

d) *implies*: The value of $p$ *implies* $q$ is False if and only if $p$ is True and $q$ is False.

| $p$ | $q$ | $p$ implies $q$ |
|---|---|---|
| $F$ | $T$ | $T$ |
| $T$ | $F$ | $F$ |
| $T$ | $T$ | $T$ |
| $F$ | $F$ | $T$ |

The command `*imp*` is used in the package to generate a truth table for the *implies* operation.

e) *if and only if*: The value of $p$ *if and only if* $q$ is True if and only if both $p$ and $q$ have same truth values.

| $p$ | $q$ | $p$ iff $q$ |
|---|---|---|
| $F$ | $T$ | $F$ |
| $T$ | $F$ | $F$ |
| $T$ | $T$ | $T$ |
| $F$ | $F$ | $T$ |

The command `*iff*` is used in the package to generate a truth table for the *if and only if* operation.

f) *NAND*: The value of $p$ *NAND* $q$ is 0 if and only if both $p$ and $q$ have value 1.

| $p$ | $q$ | $p$ NAND $q$ |
|---|---|---|
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |
| 0 | 0 | 1 |

The command `*lognand*` is used in the package to generate a truth table for the *NAND* operation.

g) *XOR*: The value of $p$ *XOR* $q$ is 0 if and only if $p$ and $q$ have same values.

| $p$ | $q$ | $p$ XOR $q$ |
|---|---|---|
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |
| 0 | 0 | 0 |

The command `*logxor*` is used in the package to generate a truth table for the *XOR* operation.

h) *NOR*: The value of $p$ *NOR* $q$ is 1 if and only if both $p$ and $q$ have value 0.

| $p$ | $q$ | $p$ NOR $q$ |
|---|---|---|
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |
| 0 | 0 | 1 |

The command `*lognor*` is used in the package to generate a truth table for the *NOR* operation.

i) *XNOR*: The value of $p$ *XNOR* $q$ is 1 if and only if both $p$ and $q$ have same values.

| $p$ | $q$ | $p$ XNOR $q$ |
|---|---|---|
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |
| 0 | 0 | 1 |

The command `*logxnor*` is used in the package to generate a truth table for the *XNOR* operation.

Table 1 summarises logical operators in the package.

## 6 Examples and usage

The *luatruthtable* package accepts a finite number of variables. It supports any finite number of variables that one would need in practice. A few examples of usage are given here.

The following example involves three variables, `p`, `q`, and `r`.

```
\begin{tabular}{|ccc|c|}
\hline
\(p\) & \(q\) & \(r\) &  \((p \land q)\)
    \rightarrow \(\neg r\) \\
\hline
\luaTruthTable{p,q,r}{(p*logand*q) *imp*
    (lognot*r)} \\
\hline
\end{tabular}
```

The output from the above is shown in Table 2.

Here *lognot*r* is enclosed in parentheses to produce correct results in the generated truth table.

**Table 1**: Operations in the `luatruthtable` package, given boolean variables $p$ and $q$.

| Command | Description |
|---|---|
| `lognot*p` | Negates the boolean variable $p$. |
| `p*logand*q` | Truth table for the expression *$p$ and $q$*. |
| `p*logor*q` | Truth table for the expression *$p$ or $q$*. |
| `p*imp*q` | Truth table for the expression *if $p$ then $q$*. |
| `p*iff*q` | Truth table for the expression *$p$ if and only if $q$*. |
| `p*lognand*q` | Truth table for the expression *$p$ NAND $q$*. |
| `p*logxor*q` | Truth table for the expression *$p$ XOR $q$*. |
| `p*lognor*q` | Truth table for the expression *$p$ NOR $q$*. |
| `p*logxnor*q` | Truth table for the expression *$p$ XNOR $q$*. |

The following is the code generated by the command `\luaTruthTable` in the above code.

```
$F$ & $F$ & $T$ & $T$\\
$F$ & $T$ & $F$ & $T$\\
$F$ & $T$ & $T$ & $T$\\
$T$ & $F$ & $F$ & $T$\\
$T$ & $F$ & $T$ & $T$\\
$T$ & $T$ & $F$ & $T$\\
$T$ & $T$ & $T$ & $F$\\
$F$ & $F$ & $F$ & $T$
```

With the use of optional arguments *[trtext=True, fltext=False]* in the previous example, one gets the following output:

| $p$ | $q$ | $r$ | $(p \land q) \rightarrow \neg r$ |
|---|---|---|---|
| False | False | True | True |
| False | True | False | True |
| False | True | True | True |
| True | False | False | True |
| True | False | True | True |
| True | True | False | True |
| True | True | True | False |
| False | False | False | True |

**Table 2**: Example output from the `\luaTruthTable` command.

| $p$ | $q$ | $r$ | $(p \wedge q) \to \neg r$ |
|---|---|---|---|
| *F* | *F* | *T* | *T* |
| *F* | *T* | *F* | *T* |
| *F* | *T* | *T* | *T* |
| *T* | *F* | *F* | *T* |
| *T* | *F* | *T* | *T* |
| *T* | *T* | *F* | *T* |
| *T* | *T* | *T* | *F* |
| *F* | *F* | *F* | *T* |

It is possible to give *trtext* and *trfalse* values that are TeX math text. So with the use of optional arguments `[trtext=$T$, fltext=$F$]` in the previous example, one gets the following output:

| $p$ | $q$ | $r$ | $(p \wedge q) \to \neg r$ |
|---|---|---|---|
| $F$ | $F$ | $T$ | $T$ |
| $F$ | $T$ | $F$ | $T$ |
| $F$ | $T$ | $T$ | $T$ |
| $T$ | $F$ | $F$ | $T$ |
| $T$ | $F$ | $T$ | $T$ |
| $T$ | $T$ | $F$ | $T$ |
| $T$ | $T$ | $T$ | $F$ |
| $F$ | $F$ | $F$ | $T$ |

Since the luacode* environment is used, the backslash is to be escaped in setting *trtext* and *trfalse*. For example: `[trtext=\\(True\\), fltext=\\(False\\)]`.

## 7 Known issues, limitations and scope of the package

The associativity and precedence of operators is not yet supported. Thus the package can give appropriate results only when parentheses are used for each of the operations, and gives erroneous results when parentheses are not used. This point is of utmost importance in using the package.

There is no native way of defining a custom operator in Lua [3]. However, some metamethods can be nested in a way to replicate an operator. All operators defined in this package are instances of such nesting. The question may be raised that are there better ways of accomplishing these in Lua. The answer is yes. The alternative ways may be better in one way or another. For example, instead of defining *logand* operator and using it in the fashion p*logand*q, one could define function *logand* that takes two arguments and use it in a way *logand(p,q)*. But when it comes to embedding in LaTeX, one has to use more and more nested parentheses as the number of statements and operations increases. This is the exact reason why this approach was not used in the development of the package. Instead of using *implies(logand(p,logor(q,r)),s)* it seems more natural to use (p *logand* (q*logor*r) )*implies* s.

Also, there is no error handling mechanism used in the package. It relies on the error handling of Lua and TeX itself. The package currently supports the nine listed operations, viz. *not, and, nand, or, xor, implies, iff, nor, xnor.* Error handling and extending the number of operations may be considered in future versions of the package.

The package, including source code, is released through CTAN (`ctan.org/pkg/luatruthtable`), and in the usual TeX distributions.

## References

[1] Lua 5.4 reference manual. `https://www.lua.org/manual/5.4`

[2] Luacode package page, 2012. `https://ctan.org/pkg/luacode`

[3] Lua custom operators. `http://lua-users.org/wiki/CustomOperators`

[4] Luatex package page. `https://ctan.org/pkg/luatex`

[5] PGF package page. `https://ctan.org/pkg/pgf`

[6] W.M. Richter. TeX and scripting languages. *TUGboat* 25(1):71–88, 2004. `https://tug.org/TUGboat/tb25-1/richter.pdf`

[7] StackExchange. Macro for automating truth tables. `https://tex.stackexchange.com/questions/505994`

[8] Wikipedia. TeX. `https://en.wikipedia.org/wiki/TeX`

[9] Xparse package page. `https://ctan.org/pkg/xparse`

◇ Chetan Shirore
Department of Mathematics,
K.T.H.M. College, Nashik
422002, Maharashtra, India
`chetanshirore (at) kthmcollege dot ac dot in`

◇ Ajit Kumar
Department of Mathematics,
Institute of Chemical Technology, Mumbai
400019, Maharashtra, India

# The `luamodulartables` and `luaset` LaTeX packages

Chetan Shirore, Ajit Kumar

## Abstract

The `luamodulartables` package was developed by us to generate modular addition and multiplication tables for positive integers, for use in LaTeX documents. The commands in the package have optional arguments for formatting of tables. These commands can be used in an environment similar to the `tabular` and `array` environments. The commands can also be used with the `booktabs` package to provide better formatting of tables in LaTeX.

Similarly, the `luaset` package is developed by us to define finite sets and perform different operations on them inside LaTeX documents. There is no special environment in the package for performing set operations. The package commands can be used in any environment (including mathematics environment).

These packages are written in Lua, and the TeX source is to be compiled with the LuaLaTeX engine. There is no need to install Lua on users' systems as TeX distributions (TeX Live and MiKTeX) come bundled with LuaLaTeX. The packages can be modified or extended by writing custom Lua programs.

## 1 Introduction

The Lua [1] programming language is a scripting language which can be embedded across platforms. With LuaTeX [3], and more easily with the `luacode` [2] package, it is possible to use Lua in LaTeX. The TeX [9] and LaTeX languages provide for programming [8]. However, with the internals of TeX there are several limitations, especially for performing calculations on numbers in LaTeX documents. There are packages like `pgf` [7] and `xparse` [10] in LaTeX which provides some programming capabilities inside LaTeX documents. However, such packages do not provide the complete programming structure that general programming languages, such as Lua, provide. The `luacode` [2] package is used in development, in addition to the `xkeyval` package.

The modular addition (multiplication) of integers with respect to a positive integer $n$ is obtained by taking the remainder of the usual addition (multiplication) after dividing it by $n$. There is no easy way in LaTeX to do modular addition and multiplication [4]. With Lua, it can be achieved easily in LaTeX. Also, non-Lua ways of doing modular arithmetic in LaTeX are more complicated [5].

The time required for the LuaTeX compilation to generate modulo addition and multiplication tables with the `luamodulartables` package, or to perform different operations on sets with the `luaset` package, is not an issue.

## 2 Installation and license

The installation of `luamodulartables` and `luaset` package is similar to simple LaTeX packages, with a `.sty` file in the LaTeX directory of a `texmf` tree. The packages can be loaded with `\usepackage{luaset}` and `\usepackage{luamodulartables}` commands in the preamble of a LaTeX document. The TeX file is to be compiled using the LuaLaTeX engine.

`luamodulartables` and `luaset` packages are released under the LaTeX Project Public License v1.3c or later. The complete license text is available at `latex-project.org/lppl.txt`. The packages are developed in Lua. Lua is available as certified open source software. Its license is simple and liberal, compatible with the GNU GPL. A small part of the development of these packages was inspired by questions on `https://tex.stackexchange.com`. The content on this site is available under the CC BY-SA license.

## 3 The `luamodulartables` package

`\luaModularMult` and `\luaModularAdd` are the two basic commands in the `luamodulartables` package, to generate modular multiplication and addition tables, respectively. The command `\luaModularMult` has the following syntax and it is used to generate modular multiplication tables for positive integers.

```
\luaModularMult
  [multlabel=⟨text⟩,
   headline=⟨text⟩,midline=⟨text⟩]
  {⟨n⟩}
```

The command has one compulsory argument $\langle n\rangle$, and three optional arguments `multlabel`, `headline` and `midline`. The compulsory argument denotes the positive integer $n$ with respect to which modular multiplication is to be carried out.

The `multlabel` string denotes the label to be printed as the entry in the first row and first column of the generated `tabular` environment. Its default value is `$\times$`. The `headline` refers to the style of horizontal line after first row in tabular or table environment. The `midline` refers to the style of horizontal lines after second row till the second last row. The `headline` and `midline` strings are both empty by default.

The formatting of the top line (before the beginning of the first row) and the bottom line (after the end of the last row) are defined in the user's LaTeX document. The alignment of columns and use of vertical lines for columns are likewise specified in the document.

doi.org/10.47397/tb/43-3/tb135shirore-luamath

| $\mathbb{Z}_4$ | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 2 | 3 |
| 2 | 0 | 2 | 0 | 2 |
| 3 | 0 | 3 | 2 | 1 |

**Table 1**: Illustration of `\luaModularMult`

An example of using the `\luaModularMult` command follows, specifying the optional arguments `multlabel` and `headline`. It requires the `amsmath` and `amssymb` packages.

```
\begin{tabular}{r|rrrr} \toprule
\luaModularMult[multlabel=$\mathbb{Z}_4$,
                headline=\midrule]
               {4} \\
\bottomrule \end{tabular}
```

This generates the output shown in Table 1.

Similarly, the command `\luaModularAdd` is used to generate addition modulo tables for positive integers. It has the following syntax:

```
\luaModularMult
  [addlabel=⟨text⟩,
   headline=⟨text⟩,midline=⟨text⟩]
  {⟨n⟩}
```

The `addlabel` argument denotes the label to be printed as the entry in the first row and the first column of tabular environment. Its default value is `$+$`. The optional parameters `headline` and `midline` are exactly the same as in the `\luaModularMult` command.

## 4 The `luaset` package

### 4.1 Defining and displaying sets

A set can be defined with the `\luaSetNew` command:

```
\luaSetNew{⟨name⟩}{⟨set⟩}
```

For example, the following defines sets $A$ and $B$:

```
\luaSetNew{A}{a,b,c,10,d,10,a,30}
\luaSetNew{B}{d,e,f,10,20}
```

The set can be output with `\luaSetPrint`:

```
\luaSetPrint{⟨name of set⟩}
```

Continuing our example, the commands

```
\(A = \luaSetPrint{A}\) \\
\(B = \luaSetPrint{B}\)
```

generates this output (notice that duplicate elements have been removed, this being a set):

$A = \{10, 30, a, b, c, d\}$
$B = \{10, 20, d, e, f\}$

The command `\luaSetPrint` parses, sorts and prints all elements by using the `parsers.iterator` [6] function in `lualibs`.

### 4.2 Commands in the `luaset` package

These commands are available in the `luaset` package to perform various operations on finite sets in LaTeX documents.

`\luaSetUnion{C}{A}{B}` Defines new set $C$ as union of sets $A$ and $B$.

`\luaSetIntersection{C}{A}{B}` Defines new set $C$ as intersection of sets $A$ and $B$.

`\luaSetDifference{C}{A}{B}` Defines new set $C$ as difference of sets $A$ and $B$.

`\luaSetCardinal{A}` Gives cardinality of set $A$.

`\luaSetBelongsto{x}{A}` Returns true if $x$ is in set $A$, otherwise returns false.

`\luaSetSubseteq{A}{B}` Returns true if set $A$ is a subset of set $B$, otherwise returns false.

`\luaSetSubset{A}{B}` Returns true if set $A$ is a proper subset of set $B$, otherwise returns false.

`\luaSetEqual{A}{B}` Returns true if set $A$ is equal to set $B$, otherwise returns false.

## References

[1] Lua 5.4 reference manual. `lua.org/manual/5.4`

[2] Luacode package page. `ctan.org/pkg/luacode`

[3] LuaTeX package page. `ctan.org/pkg/luatex`

[4] Modular arithmetic in LaTeX. `mathoverflow.net/questions/18813`

[5] Modular arithmetic in LaTeX. `tex.stackexchange.com/questions/34424`

[6] parsers.iterator function in lualibs. `github.com/latex3/lualibs/blob/main/lualibs-util-prs.lua`

[7] PGF package page. `ctan.org/pkg/pgf`

[8] W.M. Richter. TeX and scripting languages. *TUGboat* 25(1):71–88, 2004. `tug.org/TUGboat/tb25-1/richter.pdf`

[9] Wikipedia. TeX. `en.wikipedia.org/wiki/TeX`

[10] Xparse package page. `ctan.org/pkg/xparse`

◇ Chetan Shirore
Department of Mathematics,
Institute of Chemical
Technology, Mumbai - 400019,
Maharashtra, India

◇ Ajit Kumar
Department of Mathematics,
Institute of Chemical
Technology, Mumbai - 400019,
Maharashtra, India

The Electronic Journal of Mathematics and Technology, Volume 17, Number 1, ISSN 1933-2823

# Basic Mathematical Computations inside LaTeX using Lua

*Chetan Shirore*
mathsbeauty@gmail.com
Department of Mathematics
Institute of Chemical Technology
Mumbai, India

*Ajit Kumar*
a.kumar@ictmumbai.edu.in
Department of Mathematics
Institute of Chemical Technology
Mumbai, India

**Abstract**

*LaTeX is one of the most widely used typesetting systems for scientific publications. Lua programming language is a scripting language which can be embedded across platforms. We have developed Lua-based packages to perform basic mathematical computations inside LaTeX documents. The main aim of this paper is to introduce Lua-based LaTeX packages developed by us. The* **`luamaths`**, **`luacomplex`**, **`luatruthtable`**, **`luaset`** *and* **`luagcd`** *packages are introduced in this paper with their applications in LaTeX. These packages are designed from a pedagogical perspective. We have built time-saving macros that can assist in the creation of teaching notes.*

## 1 Background and Introduction

There is a good scope to perform basic mathematical computations in LaTeX using Lua. This approach is suitable for performing standard operations on real and complex numbers, sets, integers, vectors, and matrices. It involves some complex intermingling of Lua and TeX. No particular environment in LaTeX is required to use the developed packages. The core part of programming is done in Lua, and the tex file is to be compiled with the LuaLatex engine. The time required for performing operations in LaTeX documents is not an issue while compiling with LuaLaTeX. There is no need to install Lua on the users' systems as TeX distributions (TeXLive or MikTeX) come bundled with LuaLaTeX.

With LuaTEX [9] and Luacode [3] packages, it is possible to use Lua in LaTeX. TeX or LaTeX has scope for programming [12]. However, with the weird internals of TeX, there are several limitations, especially for performing calculations on numbers in LaTeX documents. The `luacode` [3] package is used in development of packages apart from the `xkeyval` [15] package. Various packages and commands introduced in the paper can further be extended or modified by writing custom Lua programs.

This paper is organized into different sections. The second section summarises the key features of developed packages. The third section discusses the advantages of techniques and methods used in the development of packages. The fourth section describes some limitations of the approach used in the development of packages. The fifth section discusses the prospects of the research work. Applications and usage of developed packages are given in the sixth section.

## 2 Lua-based packages in LaTeX

This section provides brief information on **luamaths**, **luacomplex**, **luatruthtable**, **luaset**, and **luagcd** packages, along with their key features.

### 2.1 The luamaths package

The **luamaths** package [6] provides commands to evaluate trigonometric, inverse trigonometric, logarithmic, and exponential functions. The random numbers can be generated by using commands in the package. There are functions in the package to find the maximum and minimum of finite subsets of real numbers. The greatest and nearest integer to a real number can be determined, and rounding off real numbers is also possible. Numbers can also be entered in scientific notation. For example, the number 1230000 can be entered as $1.23e6$, and the number 0.000123 can be entered as $1.23e-4$. The package provides the standard constant $\pi$ and the Euler number $e$. These constants can be used with other commands of the package. The package can also deal with $\infty$. Table 1 in subsection 6.1 illustrates some commands in **luamaths** package.

### 2.2 The luacomplex package

The **luacomplex** package [4] is developed to define complex numbers and perform basic arithmetic operations on complex numbers in LaTeX. It is built over the **luamaths** package. The package provides commands to find modulus, principal arguments, complex conjugates, and real and imaginary parts of complex numbers. The package can be modified or extended by adding custom Lua programs. Subsection 6.2 illustrates some commands of the **`luacomplex`** package.

There are a few limitations of the **`luacomplex`** package. Complex numbers are to be defined explicitly by listing real and imaginary parts. It does not support symbolic calculations on complex numbers. These issues can be addressed in future package updates.

### 2.3 The luatruthtable package

The **`luatruthtable`** package [10] is designed to generate truth tables of logical operators. The package supports nine operations: *not, and, nand, or, xor, implies, iff, nor, xnor*. There is no in-built function in Lua to convert decimal numbers to binary numbers. The function **`toBinary(m,n)`** is constructed in Lua and used to produce a sequence of *True* and *False* values of boolean variables. This function converts a decimal number $m$ to a binary number, say $b$. If the number of digits in $b$ is less than $n$, then ($n$ - no. of digits in $b$) leading zeroes are added to $b$. Each digit is stored in a table in Lua. This function runs inside a loop where $m$ takes values from 1 to $2^n$; $n$ is the number of truth variables. It produces $2^n$ combinations of $n$ truth variables. Subsection 6.4 illustrates some commands of the **`luatruthtable`** package.

The associativity and precedence of operators still need to be supported. The package can produce correct results only when parentheses are used for each operation. This point is of utmost importance in using the package. There is no native way of defining custom operations in Lua [2]. However, some metamethods can be nested in a way to replicate the operators. All operators defined in this package are instances of such nestings. The question may be raised about a better way of accomplishing this in Lua. There are alternative ways of doing it. For example, instead of defining **logand** operator and using it in the fashion *p*logand*q*, one could define the function *logand* that takes two arguments and use it in a way *logand(p, q)*. However, when it comes to embedding it in LaTeX, one has to use more and more nested parentheses as the number of statements and operations increase. This is the exact reason why such an approach is not used in the package. It sounds more natural to use *(p *logand* (q*logor*r) )*implies* s* instead of using *implies(logand(p, logor(q, r)), s)*.

### 2.4 The luaset package

The **`luaset`** package [8] is developed to define finite sets and perform operations on them in LaTeX. There is no particular environment in the package for performing set-operations. The package supports the nesting of commands for multiple set operations. Sets need to be defined explicitly. There are commands to determine the cardinal number of sets and check whether two sets are equal. It is also possible to check whether the specified element is in a set. Subsection 6.3 illustrates some commands of the **`luaset`** package.

### 2.5 The luagcd package

The **`luagcd`** package [5] is designed to find the **greatest common divisor (gcd)** of integers in LaTeX. The package also provides a command to obtain the step-by-step computation of gcd of two integers (Table 4) by the Euclidean algorithm [13]. In addition, the package also has the command to express the gcd of two integers as an integer linear combination (Table 5) and thus verify Bezout's identity. It also provides a step-by-step solution to find integers $a$ and $b$ such that $am+bn=d$, where $d$ is gcd of $m$ and $n$ (Table 6). Subsection 6.5 illustrates some commands of the **`luagcd`** package.

## 3 Techniques and Methods Used

- The techniques and methods used in developing packages do not need any special resources. All the techniques are platform-independent and work on most standard operating systems, including Microsoft Windows, Linux and its derived versions, and Macintosh. The technique mainly uses Lua and LaTeX, which are platform-independent and do not need strong hardware resources.
- No proprietary software and tools are used in the development of the packages. All tools are freeware and open source. The developed packages are made available as freeware and open source. This is important as the research work can further be extended without any restrictions. This is within the philosophy of open source and freeware tools that are available for the mathematics community.

## 4 Known Issues and Limitations

The error-handling mechanism in developed packages is not robust. Some error-handling mechanisms for input values are available in packages. If something absurd is entered in a command, it converts it into *nil* through the *table.pack* function in Lua and processes the rest of the input, or it throws an appropriate error through functions in the package or through inbuilt functions of Lua. The error-handling mechanism of the package can be strengthened in future updates.

The number of operations in each of the packages is limited. Also, symbolic calculations still need to be supported. More operations and symbolic calculations can be supported in future updates.

## 5 Future Plans and Prospects of the Research Work

The approach of embedding Lua in LaTeX can be extended in several other ways. With `luamplib` [7] and `metapost` [11] libraries, it is possible to plot graphs of functions in LaTeX in a native way. This sort of package can be developed in the future to extend the series of Lua-based packages in LaTeX.

There is wide use of linear algebra in several fields and often a need to type vectors and matrices inside LaTeX documents and perform different operations on them. The linear algebra specific packages of LaTeX can be developed using Lua. These packages will be developed in the next part of the research work.

The powerful programming capabilities of Lua can also be used to produce customized documents from LaTeX files. This approach can further be extended to produce Web Apps and Android Apps from LaTeX files. The mathematical content in LaTeX files can be pre-processed and pre-compiled in Web and Android Apps using Lua. We will develop Lua-based techniques to create custom documents and produce Web and Android Apps from LaTeX files. This approach is very innovative and can have several benefits over other techniques of creating Web and Android Apps for mathematical content. One of the android applications developed by us based on this technique is available on the Google play store: “Sequences of Real Numbers” [14]. The technique can be refined to automate the creation of Android applications from LaTeX files. The sample web application produced from LaTeX file can be found on this link [1].

## 6 Applications and Usage of Developed Packages

The various commands in **`luamaths`**, **`luacomplex`**, **`luaset`**, **`luatruthtable`**, and **`luagcd`** packages are illustrated in subsections of this section.

### 6.1 Illustrations of commands in the luamaths package

Table 1 illustrates various operations in the **`luamaths`** package.

| LaTeX input | Output |
|---|---|
| `\mathOp{(3+3)^4-4}` | 1292.0 |
| `\mathAbs{-6.96}` | 6.96 |
| `\mathFloor{-6.9}` | $-7$ |
| `\mathFloor{9.9}` | 9 |
| `\mathCeil{-9.9}` | $-9$ |
| `\mathCeil{6.3}` | 7 |
| `\mathRound{9.678884}{3}` | 9.679 |
| `\mathMax{20, 30, 100}` | 100 |
| `\mathMin{20, 30, 100}` | 20 |
| `\mathSqrt{9}` | 3.0 |
| `\mathRound{\mathPi}{6}` | 3.141593 |
| `\mathInf` | $Inf$ |

| LaTeX input | Output |
|---|---|
| `\mathOp{\mathInf/2}` | $Inf$ |
| `\mathPi` | 3.1415926535898 |
| `\mathLog{2}` | 0.69314718055995 |
| `\mathExp{3}` | 20.085536923188 |
| `\mathRad{1800}` | 31.415926535898 |
| `\mathSin{0}` | 0.0 |
| `\mathCos{0}` | 1.0 |
| `\mathTan{0}` | 0.0 |
| `\mathAsin{0}` | 0.0 |
| `\mathAcos{0}` | 1.5707963267949 |
| `\mathAtan{0}` | 0.0 |
| `\mathOp{9+\mathCos{0}}` | 10.0 |

Table 1: Illustrations of commands in the luamaths package

The package can be extended to define new functions. For example, the code in listing 1 output to 0.5.

Listing 1: Extending luamaths package

```
\documentclass{article}
\usepackage{luamaths}
\begin{luacode}
function avgMinMax(...)
avg = (math.min(...) + math.max(...))/2
return avg
end
\end{luacode}
\newcommand\mathAvgMinMax[1]{\directlua{tex.sprint(avgMinMax(#1))}}
\begin{document}
\mathAvgMinMax{\mathCos{0},\mathSin{0}}
\end{document}
```

### 6.2 Illustrations of commands in the the luacomplex package

The latex document (Listing 2) uses various commands from the `luacomplex` package.

Listing 2: LaTeX document with luacomplex package

```
\documentclass{article}
\usepackage{luacomplex}
\begin{document}
\cpxNew{a}{3, 4}
\cpxNew{b}{1, 3}
\(a=\cpxPrint{a}\) \\
\(b=\cpxPrint{b}\) \\
\cpxAdd{c}{a}{b}
\(c=a+b=\cpxPrint{c}\) \\
\cpxSub{d}{a}{b}
\(d=a-b=\cpxPrint{d}\) \\
\cpxMul{e}{a}{b}
\(e=a. b=\cpxPrint{e}\) \\
\cpxDiv{f}{a}{b}
\(f=\frac{a}{b}=\cpxPrint{f}\) \\
\cpxInv{g}{a}
\(g=\frac{1}{a}=\cpxPrint{g}\) \\
\cpxRe{h}{a}
\(h=Re(a)=\cpxPrint{h}\) \\
\cpxIm{j}{a}
\(j=Im(a)=\cpxPrint{j}\) \\
\cpxMod{m}{a}
\(m=|a|=\cpxPrint{m}\) \\
\cpxOp{n}{a+b*c-d}
\(n=\cpxPrint{n}\) \\
\luaexec{tex. sprint(string. format('\%. 10f', math. pi))}
\end{document}
```

The latex document (Listing 2) outputs the following on compiling with LuaLaTeX engine.

$a = 3+4i$
$b = 1+3i$
$c = a+b = 4+7i$
$d = a-b = 2+i$
$e = a.b = -9+13i$
$f = ab = 1.5-0.5i$

$g = a1 = 0.12-0.16i$
$h = Re(a) = 3$
$j = Im(a) = 4$
$m = |a| = 25$
$n = -16+22i$
3.1415926536

### 6.3 Illustrations of commands in the the luaset package

The latex document (Listing 3) uses various commands from the `luaset` package.

Listing 3: LaTeX document with luaset package

```latex
\documentclass{article}
\usepackage{luaset,parskip}
\begin{document}
\luaSetNew{A}{a,b,c,\mathCos{0},d,10,a,30}
\luaSetNew{B}{d,e,f,10,20}
\luaSetUnion{C}{A}{B}
\luaSetIntersection{D}{A}{B}
\luaSetDifference{E}{A}{B}
\luaSetDifference{F}{B}{A}
\(A = \luaSetPrint{A}\) % printing set A
\(B = \luaSetPrint{B}\) % printing set B
\(C = A \cup B = \luaSetPrint{C}\) % printing set C
\(D = A\cap B = \luaSetPrint{D}\) % printing set D
\(E = A-B = \luaSetPrint{E}\) % printing set E
\(F = B-A = \luaSetPrint{F}\) % printing set F

The Cardinality of set \(A\) is \luaSetCardinal{A}.
It is \luaSetSubseteq{A}{B} that \(A \subseteq B \).

It is \luaSetSubseteq{A}{C} that \(A \subseteq C \).

It is \luaSetSubset{A}{B} that \(A \subset B \).

It is \luaSetSubset{A}{C} that \(A \subset C \).

\setIntersection{G}{C}{A}
\(G = C \cap A = \luaSetPrint{G}\) % printing set G

It is \luaSetEqual{A}{B} that \(A=B \).

It is \luaSetEqual{G}{A} that \(G=A \).

It is \luaSetBelongsto{z}{A} that \(z \in A \).

It is \luaSetBelongsto{10}{A} that \(10 \in A \).

\luaSetNew{S}{a, 10, b, x, y, z, 100, 200}
\(S = \luaSetPrint{S}\) % printing set S

\luaSetIntersection{H}{C}{S}
\luaSetUnion{I}{D}{S}
\(H = C \cap S = \luaSetPrint{H}\) % printing set H

\(I = D \cup S = \luaSetPrint{I}\) % printing set I
\end{document}
```

The latex document (Listing 3) output the following.

$A = \{10, 30, 1.0, a, b, c, d\}$
$B = \{10, 20, d, e, f\}$
$C = A \cup B = \{10, 20, 30, 1.0, a, b, c, d, e, f\}$
$D = A \cap B = \{10, d\}$
$E = A - B = \{30, 1.0, a, b, c\}$
$F = B - A = \{20, e, f\}$
The Cardinality of set $A$ is 7.
It is false that $A \subseteq B$.
It is true that $A \subseteq C$.

It is false that $A \subset B$.
It is true that $A \subset C$.
$G = C \cap A = \{10, 30, 1.0, a, b, c, d\}$
It is false that $A = B$.
It is true that $G = A$.
It is false that $z \in A$.
It is true that $10 \in A$.
$S = \{10, 100, 200, a, b, x, y, z\}$
$H = C \cap S = \{10, a, b\}$
$I = D \cup S = \{10, 100, 200, a, b, d, x, y, z\}$

## 6.4 Illustrations of commands in the luatruthtable package

The *luatruthtable* package can accept a finite number of variables. It supports a finite number of variables that one would need.

Listing 4: LaTeX document with luatruthtable package

```
\begin{tabular}{|cc|c|c|c|c|c|c|c|c|c|}
\hline
\(p\) & \(q\) & \(\neg p\) & \(p \land q\) & \(p\lor q\) & \(p \rightarrow q\)
 & \(p \leftrightarrow q\) & \( p\) nand \(q\) & \(p\) xor \(q\) & \( p\) nor
    \(q\) & \(p\) xnor \(q\) \\
\hline
\luaTruthTable{p, q}{lognot*p, p*logand*q, p*logor*q, p*imp*q, p*iff*q,
p*lognand*q, p*logxor*q, p*lognor*q, p*logxnor*q } \\
\hline
\end{tabular}
```

The LaTeX code (Listing 4) generates the output shown in Table 2.

| $p$ | $q$ | $\neg p$ | $p \land q$ | $p \lor q$ | $p \rightarrow q$ | $p \leftrightarrow q$ | $p$ nand $q$ | $p$ xor $q$ | $p$ nor $q$ | $p$ xnor $q$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $F$ | $T$ | $T$ | $F$ | $T$ | $T$ | $F$ | $T$ | $T$ | $F$ | $F$ |
| $T$ | $F$ | $F$ | $F$ | $T$ | $F$ | $F$ | $T$ | $T$ | $F$ | $F$ |
| $T$ | $T$ | $F$ | $T$ | $T$ | $T$ | $T$ | $F$ | $F$ | $F$ | $T$ |
| $F$ | $F$ | $T$ | $F$ | $F$ | $T$ | $T$ | $T$ | $F$ | $T$ | $T$ |

Table 2: The luatruthtable command

### 6.5 Illustrations of commands in the luagcd package

The command `\luagcd` is illustrated in Table 3.

| LaTeX input | Output |
|---|---|
| `\luagcd{20,30,60,70}` | 10 |
| `\luagcd{0,10,75,90}` | 5 |
| `\luagcd{-30,45,-90}` | 15 |

Table 3: The luagcd command

The command `\luagcdwithsteps{-20}{-6008}` generates the output shown in Table 4.

Step 1: Apply the division algorithm to 6008 and 20.
$6008 = 20(300) + 8$
Step 2: Apply the division algorithm to 20 and 8.
$20 = 8(2) + 4$
Step 3: Apply the division algorithm to 8 and 4.
$8 = 4(2) + 0$
The gcd of -20 and -6008 is the last non-zero remainder and it is 4.

Table 4: The luagcdwithsteps command

The command `\luagcdlincomb{10011}{210}` generates the output shown in Table 5.

The gcd of 10011 and 210 is 3 and the equation $-10011x + 210y = 3$ and has a solution $(x, y) = (3, -143)$.

Table 5: The luagcdlincomb command

The command `\luagcdlincombwithsteps{-10011}{210}` generates the output shown in Table 6.

Step 1:10011 is written as a linear combination of 10011 and 210.
$10011 = (1)(10011) + (0)(210)$
Step 2:210 is written as a linear combination of 10011 and 210.
$210 = (0)(10011) + (1)(210)$
Step 3: The equation in Step 2 is multiplied by 47 and subtracted from the equation in Step 1.
$141 = (1)(10011) + (-47)(210)$
Step 4: The equation in Step 3 is multiplied by 1 and subtracted from the equation in Step 2.
$69 = (-1)(10011) + (48)(210)$
Step 5: The equation in Step 4 is multiplied by 2 and subtracted from the equation in Step 3.
$3 = (3)(10011) + (-143)(210)$
The gcd of -10011 and 210 is 3 and the equation $-10011x + 210y = 3$ and has a solution $(x, y) = (-3, -143)$.

Table 6: The luagcdlincombwithsteps command

## 7 Acknowledgements

Authors wish to thank the editors for their valuable feedback. We also are immensely grateful to the Institute of Chemical Technology, Mumbai, and K.T.H.M. College, Nashik, for their constant support. These institutes provided excellent infrastructure and unique facilities to conduct our research and supported us in several other ways.

## References

[1] *Android applications from LaTeX files using Lua* (visited on 2022-02-22). https://play.google.com/store/apps/details?id=com.unimaths.realseq

[2] *luacustomoperator* (visited on 2022-02-22). http://lua-users.org/wiki/CustomOperators

[3] *Luacode package page* (visited on 2022-03-10). Comprehensive TeX Archive Network. https://ctan.org/pkg/luacode

[4] *luacomplex package page* (visited on 2022-12-29). https://ctan.org/pkg/luacomplex

[5] *luagcd package page* (visited on 2022-12-30). https://ctan.org/pkg/luatruthtable

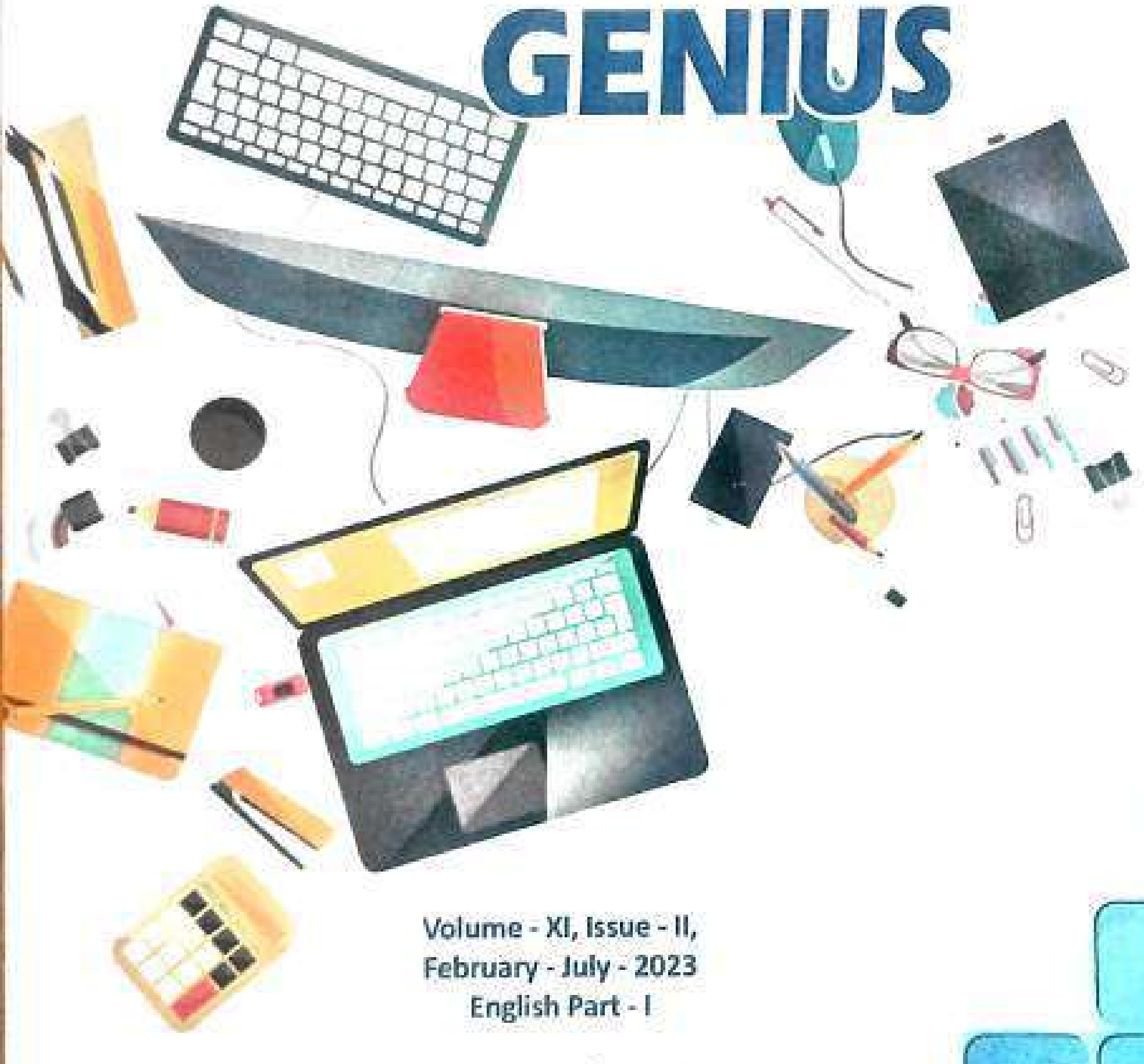
[6] *luamaths package page* (visited on 2022-12-27). https://ctan.org/pkg/luamaths

[7] *Luamplib package page* (visited on 2022-12-22). https://mirror.kku.ac.th/CTAN/macros/luatex/generic/luamplib/luamplib.pdf

Peer Reviewed
Refereed and
UGC Listed
Journal No. 47100

ISSN - 2279 - 0489
AN INTERNATIONAL MULTIDISCIPLINARY
HALF YEARLY RESEARCH JOURNAL

# GENIUS



Volume - XI, Issue - II,
February - July - 2023
English Part - I

Impact Factor / Indexing
2023 - 7.508
www.sjifactor.com

Ajanta Prakashan

Dr Urmila Y. Gite
Prof. S.E.Kardak
Dr. S. S. Saundankar
Dr. S. S.

# 9. National Education Policy 2020 : Few Initiatives in Higher Education in India

**Dr. Urmila Y. Gite**
Assistant Professor, MVPs S. V. K. T. College, Deolali Camp, Nashik.

In January 2015, a committee under former Cabinet Secretary T. S. R. Subramanian started the consultation process for the New Education Policy. Based on the committee report, in June 2017, the draft NEP was submitted in 2019 by a panel led by former Indian Space Research Organisation (ISRO) chief Krishnaswamy Kasturirangan. The Draft New Education Policy (DNEP) 2019, was later released by Ministry of Human Resource Development, followed by a number of public consultations.

### Introduction of New Education Policy

The NEP 2020 replaces the National Policy on Education of 1986.

### Vision of National Education Policy

National Education Policy 2020 envisions an India-centric education system that contributes directly to transforming our nation sustainably into an equitable and vibrant knowledge society by providing high quality education to all.

### The Primary Objective

It aims to increase state expenditure on education from around 4% to 6% of the GDP.

### Implementation of NEP-2020 by the State Government

**Oct. 2020**

Committee under the President-ship of Dr. Raghunath Mashelkar for designing basic plan of Action for NEP implementation NEP

**June-2021**

Committee Proposed Course of Action-Work to the State Government.

**Jan. - 2022**

Acceptance of Proposed Course of Action-Work by the State Government

**Apr-2022**

Committee formed under the President-ship of Dr. Ravindra Kulkarni for Designing Academic Programmes as per NEP

**Oct.-2022**

Committee Submitted Reformed Structure of Academic Programmes to the State Government

**Nov.-2022**

Acceptance of Reformed Structure Academic Programmes by the State Government

**Dec.-2022**

Instructions to All State Universities, Deemed Universities and Autonomous Colleges to implement the Revised Structure from Academic Year 2023-24

**Few Initiatives in Higher Education in India**

**Uchhatar Avishkar Yojana (UAY)**

UAY promotes industry sponsored, outcome oriented research projects with an outlay of Rs. 475.00 crore for a period of two years beginning 2016-17. The project cost is met to the extent of 50% by the Ministry of Human Resource Development (MHRD) and 25% each by the Industry. The objectives of UAY scheme are to promote innovation in IITS addressing issues of manufacturing industries to spur innovative mindset to co- ordinate action between academia & industry to strengthen labs & research facilities.

**Margdarshan**

This scheme allows Institutions of repute to act as Hub to guide Disperse knowledge to and between technical institutions to encourage best practices. The selected public universities/institutions will be eligible to receive Rs. 1000 crores over a span of 5 years to develop into a world class university.

**SWAYAM**

An indigenous On-line Education platform, launched on 9th July 2017. Through this platform courses in teachers training and other subjects both at the graduate and post-graduate level are offered. There are 837 courses and 16, 83, 828 people are registered in the SWAYAM platform. Access to SWAYAM is also being widened by linkage with DTH channel, SWAYAMPRABHA, dedicated to education.

QIP and Joint Research Programmes in countries USA, UK, Israel and African Counteris are being implemented

**Beginning of ICT Initiatives in India**

- The Online learning was mainly imitated through E- PG Pathshala
- Later on MOOCs through SWAYAM were introduced.
- Also the National Digital Library (NDL) is established.

- The UGC formulated Regulations for Online Programmed in 2018. The Certificate, Diploma and Degree programmers are allowed for eligible institutions in online mode.

**Action plan of UGC**

- All universities to adopt SWAYAM courses for credit transfer
- HEIS - Students and Faculty may be encouraged to use SWAYAM Platform.
- UGC to develop 100+ MOOCs every year

**National Resource Centres (NRCs)**

- NRCS notified in 75 specific disciplines for online refresher courses for 15 lakh faculty through MOOCs(SWAYAM)
- Develop the Refresher Module and upload the training materials on SWAYAM w.e.f. 1" October each year
- Highly flexible and can be done at one's own pace and time.
- NRCS publish list of faculty who have completed the refresher course

**E-Content vs MOOCs**

E-PG Pathshala provides e-content in four quadrants. It can be accessed as Open Educational Resource (OER) where no teacher support/hand-holding for students is available.

MOOCs has teacher-student groups where MOOC coordinator/teacher interacts with the learner. A learner can earn certificate/credit on successful completion of MOOCs course on SWAYAM

**ICT Initiatives in India**

The use of Information and Communication technology (ICT) has great potential in improving the quality of education imparted and widening the access of education throughout the country. For this purpose, the Department of Higher Education, Ministry of Human Resource Development (MHRD) has undertaken many initiatives under 'National Mission on Education through Information and Communication Technology'.

The students as well as teachers across India in their up-skilling as well providing them quality educational resources. In addition, these efforts will be leading to a great repository of knowledge, tools and enablers that can not only impart quality education and accessibility but also excite creativity and innovation in a billion minds, particularly young students, catalyzing them to attain their true potential in building the nation.

The MOOCs are now an integral part of Higher Education in India.

# 20. SWAYAM Education: An Opportunity for E - Learning

**Mr. Kardak Santosh Eknath**
Assistant Professor, SVKT College Deolali Camp, Nashik.
**Dr. Pradeep S. Jadhav**
Associate Professor, Bahirji Smark Mahavidyalay, Basmathnagar, Hingoli.

## Abstract

Considering the rapid change in technology, inevitable changes in education sector are going to happen. A lot or research is taking place to understand the pros and cons of online education in comparison to face to face education. In India, there are a lot of challenges and opportunities for online education. With a comprehensive literature review, in this paper, we have identified key factors which will boost online education in India. We have identified internet penetration; low cost of online education, ease of doing course, initiative by government, employer's recognition and bridging gap are the key factors the growth of online education. There are certain factors which are creating a hindrance in the growth which include insufficient digital infrastructure, credibility and language used in online education. With the increase in number of internet users in India, the paper also looks into what opportunities are there in future in education sector.

**Keywords:** Online Education; Face to face Education; Challenges and opportunities; Digital infrastructure.

## Introduction

A literacy system grounded on formalized tutoring but with the help of electronic coffers is known as E-learning. While tutoring can be grounded in or out of the classrooms, the use of computers and the Internet forms the major element of E-learning. E-learning can also be nominated as a network enabled transfer of chops and knowledge, and the delivery of education is made to a large number of donors at the same or different times. Before, it wasn't accepted wholeheartedly as it was assumed that this system demanded the mortal element needed in literacy. Still, with the rapid-fire progress in technology and the advancement in learning systems, it's now embraced by the millions. The preface of computers was the base of this revolution and with the passage of time, as we get hooked to smartphones, tablets, etc, these bias now have a significance place in the classrooms for literacy. Books are gradationally getting replaced by electronic educational accoutrements like optic discs or pen drives. Knowledge can also be participated via the Internet, which is accessible24/7, anywhere, anytime.

Description E-learning has proved to be the stylish means in the commercial sector, especially when training programs are conducted by MNCs for professionals across the globe and workers are suitable to acquire important chops while sitting in a board room, or by having forums, which are conducted for workers of the same or the different associations under one roof. The seminaries which use E-learning technologies are a step ahead of those which still have the traditional approach towards literacy. No doubt, it's inversely important to take forward the conception of non-electronic tutoring with the help of books and lectures, but the significance and effectiveness of technology- grounded literacy cannot be taken smoothly or ignored fully. It's believed that the mortal brain can fluently flash back and relate to what's seen and heard via moving film land or vids. It has also been set up that illustrations, piecemeal from holding the attention of the pupil, are also retained by the brain for longer ages. Colorful sectors, including husbandry, drug, education, services, business, and government setups are conforming to the conception of E-learning which helps in the progress of a nation.

## Objective of the Study

1. To Study the Concept of E- Learning.
2. To Study the Growth drivers of online education.
3. To study the Challenges in Online Education.

## Research Methodology

Research methodology not only talks about the research methods but also consider the logic behind the method used in the context of the research study. Research methodology is away to systematically study and solve the research problems.

## Research design used in the Study

Descriptive research design is used in this study. The researcher had to use fact and information already available in order to study the Opportunities in online Education.

## Data Collection Method

The Process of data collection begins after a research problem has been defined. For the present study researcher only collect secondary data, in order to find the Opportunities in online Education.

## Secondary Data

It is the data which is already collected someone else. Researcher to analyze the data and interprets the results. Researcher collected the secondary data through various books, authorized websites.

## Growth Drivers

### 1. Low- Cost Action

Online skill improvement courses are more affordable than offline druthersfor numerous families, especially since utmost of them are freely available. Numerous prestigious universities and institutes similar as Harvard University, Berkeley University of California, and Boston University grease online courses on multitudinous subjects. These courses are generally available on Massive Online Open Courses (MOOCS) which can be bought for free or with a minor figure.

### 2. Offers Quality Education

The registrations for open courses and distance literacy in India are anticipated to increase +to around 10 million by 2021 according to Netscribes. Areas that warrant acceptable options to pursue traditional education, substantiation advanced relinquishment of online courses. States similar as Bihar, Kerala, and Jammu and Kashmir regard for 0.4mn distance literacy enrolments.

### 3. Government Enterprise

Government enterprise similar as SWAYAM,E-Basta, Rashtriya Madhyamik Shiksha Abhiyan ( RMSA), Skill India and Digital India will make way for the structure demanded by scholars to study online. The government is also working on a National Open University for the dispersion of education to the millions. Piecemeal from this, it's laboriously promoting digitization of education and ease of internet access.

### 4. Adding Internet Penetration

Presently, 409 million Indians have access to the internet but its steady growth, especially insemi-urban and pastoral areas, provides high eventuality for the proliferation of online education. Netscribes estimates nearly 735 million internet druggies in India by 2021. This internet penetration will enable reach and increase business for online education players.

**5. Increase in Disposable Income and a Large bit of the Youthful Population**

Growing disposable income is herding the youthful population to enhance their chops for advanced career and payment growth. Employment openings encyclopedically are tensing their qualifications, performing in violent competition. This makes the youthful population with high bournes but lower income, a good target request for online education. Further, the adequacy of online channels is also advanced in the youngish demographic.

**6. Bridge the Gap between Education Position and Assiduity Prospects**

According to a report in The World Employment and Social Outlook – Trends, there were18.3 million Indians jobless in 2017 and it's projected to increase by18.9 million by the time 2019. According to a report, India's working age population is adding and is anticipated to reach 64% of the population by 2021. Do you suppose it's because of sufficient job openings are not available in India? Nascom says 6 million people will be needed in cyber security by 2022. According to Tech Mahindra CEO C P Gurnani, 94% of IT graduates aren't fit for hiring. According to opinion given by Sanjay Bansal, 58% of jobless graduates and maturity of the jobless post-graduates (62%) states that jobs matching their skill and education are not available and this is the primary reason for their severance. So online education is one of the druthers to ground the gap between what diligences anticipate and what the educational institutes are delivering. Online education offers an occasion to enhance chops through advance courses available in different disciplines.

**Challenges in Online Education**

**1. Cornucopia of Free Content and Multiple Influencers in decision Making**

YouTube tutorials and other fluently accessible content make it harder for online paid courses to access to request. Free or affordable educational content gets further traction from eager scholars. Likewise, buying opinions are told in course descriptions, parents, and peers. There are numerous institutes and channels that allow druggies to grasp the essential understanding of the course. Still, they're impelled to pay in order to continue into more advanced literacy stages. Some druggies aren't comfortable investing their plutocrat given the lack of trust in online channels, egging them to subscribe up for offline courses rather.

### 2. Lack of mindfulness, slow Internet connectivity, and value of the immolations

Lack of mindfulness of online offers and monolingual tutorials or language hedge proves to inhibit the rapid-fire growth of the assiduity. The value offered for numerous courses can feel relatively precious to numerous druggies due to low per capita income of the Indian millions. Also, numerous areas in the country, still fall under internet-deficient regions or areas equipped with only 3G connectivity. This hinders the growth of the online education request in India.

### 3. Familiarity with Offline Education

Largely, online education is considered as a supplement to education from offline channels. A primary partiality for offline education systems poses a major hedge to the growth and demand of this request.

### 4. Inadequate Digital Structure

Although Government of India is taking action to develop digital structure but a lot need to be done in this direction. High speed internet and stable power force are the biggest problem. India stands 89th worldwide on internet speed and stability. According to the report of World Economic Forum, only 15 percent of the homes have access to the Internet, and mobile broadband remains accessible to veritably many i.e. only5.5 subscriptions for every 100 people. Farther, presently reach of broadband is just about 600 corridors, largely in and around the top 50 to 100 Indian metropolises, leaving pastoral areas with poor connectivity. 5G networks technology is the demand of moment's which will increase the speed of downloading the data.

### 5. Limited Social Commerce

Since online education can be penetrated at home or any other accessible place, there's veritably limited direct commerce with the schoolteacher and other people doing the course. According to Dhirendra Kumar (2010), especially those courses which are tone paced, there's veritably lower discussion among the peers. Utmost of the discussion takes place through e correspondence, converse room or discussion groups. There isn't any lot atmosphere to ameliorate social commerce. So you are not suitable to develop any social links which do help in the career growth.

### 6. Language of the Course

India is amulti-linguistic country, and a vast maturity of the population comes from pastoral areas. The content offered by utmost of the online courses is in English. Hence, those scholars who are not suitable to speak English struggle with the vacuity of language content.

Hence, it's the duty of computer professionals, preceptors, directors, language content generators, and content disseminators, to sit together and give a feasible frame and standard result to the learners knowing only Indian languages.

## Conclusion

Online education can change the whole future scenario in education if it can be implemented in joint collaboration with industry, universities and government. Drastic changes in course curriculum are required to bridge the gap so that students are industry ready after passing out. Education process needs to be changed by making it more practical with the use of technology. Also course should be designed in different language to increase their reach and more opportunities for youth of rural India. Innovations are required to design ways to increase the social skills of online learners.

## References

1. https://www.netscribes.com/online-education-market-in-india-growth-drivers-challenges-and-key-trends/
2. https://www.pramanaresearch.org/gallery/prj_c_ap_12.pdf
3. https://economictimes.indiatimes.com/definition/e-learning

# 19. A Study on Role of SWAYAM Education in Competitive Examination in India

**Dr. Gaikwad Vijay Ganpat**
Associate Professor of Commerce, S. V. K. T. Arts, Science and Commerce College, Deolali Camp, Nashik.

## Abstract

The number of students preparing for the competitive exam from the various states of India is huge. The Day by day the cost of preparation competitive study is increased, considering the rising cost of competitive exam preparation, it has become difficult for common students to prepare for the competitive exam. It is impossible to qualify the competitive exam without the guidance from the expert and use of various books. The cost of coaching and books purchased for competitive examination is not affordable to every student in that filed so number of student's deprivation from the competitive examination. Swayam: Stands for "Study Webs of Active learning for the Young Aspiring Minds" started by the Government of India specially designed for free online education in India. Swayam platform covered syllabus of competitive examination which are general english, history, geography, mathematics etc. covered from class ninth class to till post-graduation and these things in his competitive exam preparation. Swayam online education is available free of charges. Each student would find this article very helpful while preparing for the civil service examination. Students should begin their preparation of the competitive examination with the help of Swayam platform.

## 1. Introduction

SWAYAM is a free online education program started by the Government of India and designed by Ministry of Human Resource Development Department of India. Swayam is a Massive Open Online Courses (MOOCs) platform, which has been offer free online courses in disciplines such as Science, Engineering and Technology, Humanities and Social Science, Law, Management etc. The study material on this E-learning platform is available into eight regional languages with English language; these are Marathi, Bengali, Gujarati, Hindi, Kannada, Malayalam, Tamil and Telugu. The Massive Open Online Courses (MOOCs) platform has offered 521 courses. SWAYAM was started to achieve three important principles of education policy i.e. Access, Equity and Quality, these principles of education policy is the roadmap for the success in Competitive Examination. Syllabus of competitive examination covered from class 9 to till post-graduation and SWAYAM platform covered these things in his courses. These courses can be accessed anyone, anywhere at any time in form of video lectures, printed/downloaded material. On this platform competitive examination learner prepared through self-assessment quizzes, test and online discussion with faculty for clearing doubts.

## 2. Objective of the Study

1. To Take the Overview of SWAYAM Education
2. To Know the platform of Online Education(SWAYAM: MOOCs)
3. To Study the Overview of Competitive Examination
4. To Study the importance of SWAYAM Education in Competitive Examination

## 3. Research Methodology

This study is based on secondary data, secondary data which has been collected from books, periodical journals and newspapers, websites of SWAYAM, use of internets etc. The data and information have been arranged logically in order to draw certain conclusions about the use of SWAYAM education in competitive examination.

## 4. Overview of SWAYAM Education

SWAYAM is an online e-learning initiative of the government of India. The full form of SWAYAM is "Study Webs of Active learning for the Young Aspiring Minds". The SWAYAM portal was started by The Ministry of Education on 9th July 2017 to achieve three important principles of education policy i.e. Access, Equity and Quality. The aim of this education is to provide a quality education through e-learning courses to millions of students throughout the country.

## 5. Platform of Online Education (SWAYAM: MOOCs)

SWAYAM E learning platform provides three modes of learning all over of India by name of SWAYAM Portal, SWAYAM App and SWAYAM Prabha DTH channels. There are nine national coordinators appointed for various courses and education levels these are NPTEL, AICTE, UGC, NCERT, NIOS, IGNOU, IIM-B, CEC, NITTTR. The SWAYAM portal implements a four quadrant approach for the betterment; these quadrants of SWAYAM are, video lectures, specially prepared reading material, self-assessment tests and online discussion forum.

### 6. Overview of Competitive Examination:

A Competitive Examination is an examination intended to measure the students through exam takes knowledge, aptitude, reasoning or any other skills based on the topic of the exam and ranked according to their grades and percentiles then top rank holders are selected for the specific job. The preliminary exam is the first stage of the competitive examination and Mains exam is the second stage of the competitive examination. These competitive exams can be of state level and national level namely Civil Service Exam. The civil services examination is a national level competitive examination in India and it is conducted by the Union Public Service Commission. At state level state government conduct the examination for recruitment in the state government department by the Maharashtra Public Service Commission. The various name of competitive exam given below.

1. Indian Administrative Service (IAS)
2. Indian Police Service (IPS)
3. Indian Forest Service (IFS)
4. Indian Foreign Service (IFS)
5. Indian Audit and Account Services (IA&AS)
6. Indian Civil Accounts Service (ICAS)
7. Indian Corporate Law Service (ICLS)
8. Indian Defense Accounts Service (IDAS)
9. Indian Defense Estate Service (IDES)
10. Indian Information Service (IIS)
11. Indian Ordnance Factories Service (IOFS)
12. Indian Communication Finance Services (ICFS
13. Indian Postal Services (IPOS)
14. Indian Railway Accounts Service (IRAS)
15. Indian Railway Personnel Service (IRPS
16. Indian Railway Traffic Service (IRTS)
17. Indian Revenue Service (IRS
18. Indian Trade Service (ITS)

19. Railway Protection Service (RPF)

In India there are around 300 entrance exams are conducted by the state and central government for securing jobs at state level and at national level.

## 7. Importance of SWAYAM Education in Competitive Examination

1. SWAYAM Education provide free and quality education to students who appeared for competitive examination
2. SWAYAM Education covers all the subjects from $9^{th}$ class to post graduation which is framed in competitive examination.
3. SWAYAM Education provides online education which is helpful to the remote area students who willing to prepared for competitive examination.
4. SWAYAM Education provides online free e-learning education, all the study material are available online. This education is affordable to the point of reduced the cost of private coaching, reduced the cost of purchasing textbooks, cost of notes/prints etc. Online education is helpful to the middle class and poor family students.
5. SWAYAM Education eliminates the cost in points of student's transportation, student's meals, hostel/rooms expenditure etc.

## 8. Conclusion

The various courses from SWAYAM portal cover wide range of subjects like humanities, science commerce and management and engineering which helps to participants to develop their various skills free of cost particularly those who are planning to appear for Competitive Examination.

## References

1. www.swayam.gov.in.
2. https://testbook.com
3. https://iimskills.com
4. www.nptel.ac.in

# 5. An Opportunity for a New National Education Policy

**Dr. Jayashri Pandharinath Jadhav**
Head Department of Economics, MVP's S. V. K. T. Art's, Science
and Commerce College Deolali Camp, Nashik.

## Introduction

The main objective of the new National Education Policy is to "Build a Society Based on Knowledge and Equality in All Forms." The first educational reform of the 21st century was carried out in 2020. On July 29, 2020, the Cabinet approved a new National Education Policy aimed at bringing several changes to the existing Indian education system. India has completed 73 years since its independence. Many education commissions were appointed during the pre-independence period and even after India's independence. In this 1854 Woods Report, 1882 Hunter Report, 1902 Reilly Commission etc. Radhakrishnan Commission, Kothari Commission came after the independence of India. He discussed the exact changes required in the education system and prepared a draft for the government. The same education system was in operation till now. After that almost 34 years later there has been a change as per the National Education Policy 2020. This is a historic event and decision. A commission appointed under the chairmanship of former ISRO chief Dr. KasturiRangan had suggested some changes. The result of this change is the new National Education Policy 2020. The motto of the new Education Policy 2020 is "Educate, Anchor, and Enlighten". This education policy seems to give a new hope to our nation. Some of the decisions in this policy are very well taken and can benefit our education system and students in the future. The important decisions taken in this are increasing expenditure on education, emphasis on education through mother tongue, new stratification emphasis on professional education, increasing skill level, freedom of subject choice, it is felt that the new education policy will give a new direction to Indian education. Mr. Dharmendra Pradhan has also emphasized that this policy will help make education inclusive, cost-effective, affordable and equitable. How has there been progress in this field so far? Is this policy really progressing? What are the challenges facing this policy in the coming decades? A study has been done in this aspect in the present research paper.

## Objectives

1. To study the New National Education Policy
2. To Study School Education and New Educational Policies
3. To Study Higher Education and New Educational Policies

## Research Methods

Secondary data collection method has been used for this research paper. Research essays of various experts and websites have been used for this.

## New National Education Policy 2020

In the new education policy, the previous structure of 10+2+3 has been changed to 5+3+3+4. It covers education from primary level to graduation. It is important to understand the changes that are structured in four phases in the new education policy. Because before taking admission in the college, what the student is going to acquire is mainly:-

**Phase I –** Three years of pre-primary education and the first five years of class I and II is the phase.

**Phase II –** Action and play based interactive interaction during these three years from class III to V Intellectual development of students will be achieved by developing Curriculum.

**Phase III –** Action based experiential curriculum for classes VI to VIII over the next three years.

The scheme is designed to develop professional craft and skills to the students Education will be provided.

**Phase IV**- Study of a total of 40 different subjects in four years from class IX to XII in the fourth Phase.

Students will get an opportunity to do Board Exams of Class X and XII.

Unreasonable importance is being reduced. Student can should take subjects as per their interest. In the higher secondary class, without branching into Arts, Science and Commerce Subjects of interest can be selected.

**Phase V**- The fifth stage is to pursue higher education. Here is the choice of subjects in college. Education given Students get freedom. Freedom of subject choice for students in higher education. One can choose different subjects at the branch for education. Several streams of thought are evident here. For example, it has been debated that a science student can take a music subject of choice but an arts student thinks he wants to specialize in chemistry or pursue a degree in engineering. At that time his intellectual development will be complete. By the time a student enters the stream of higher education, it will be fully developed as the new education policy 2020 is mainly based on five pillars.

**The National Education Policy 2020 is based on the following five pillars**

- Assess
- Equity
- Quality
- Affordability
- Accountability

The above five pillars enable students to study in class XII and beyond.

The planning for the implementation of the new National Education Policy 2020 is as follows-

**New National Education Policy Administrative Responsibility**

New National Education Policy 2020 all information (SARTHAQ)'Students' and Teachers' Holistic Advancement through Quality Education' is given in the book. National Educational Research and Training Council, State Educational Research and Training Council Maharashtra, Pune will do the work of creating new curriculum. Similarly, the responsibility of teacher training is with the State Educational Research and Training Council, Maharashtra, Pune. The Department of School Education and Sports is functioning as a coordination mechanism (nodal) for effective implementation of NEP 2020 in all schools of the state.

**National Education Policy Teacher Training**

For the new National Education Policy 2020, quality promotion will be promoted by organizing training to empower teachers along with the development of students. Due to the inclusion of multidisciplinary curriculum, the teachers will be trained accordingly from time to time.

**New Education Policy Evaluation**

The new National Education Policy Review is going to be multi-faceted. By reducing the importance of marks in the assessment of students, the concept of multi-dimensional assessment has been adopted in the National Education Policy 2020, in which students will be assessed consistently based on emotional, social, cognitive and functional progress along with self assessment, peer assessment, learning assessment.

This collaboration with the school education department of the state along with other departments will be important for the concept of National Education Policy 2020 mainly in that -

- Department of Women and Child Development
- Department of Social Justice and Special Assistance
- Department of Other Backward Bahujan Welfare
- Department of Skill Development and Entrepreneurship

The National Education Policy 2020 provides an important opportunity to shift Indian education from "classification and selection" to "human development", enabling each student to maximize his or her potential. Although the NEP focuses on basic literacy and numeracy, and early childhood education is welcome. , requires constant attention to execution to deliver on its promise.

**Three principles are very important for implementation**

1. Focus on independent and reliable measurement of results
2. Rigorous evaluation of policy and program effectiveness
3. Careful cost-effectiveness analysis of alternative policy proposals

The education sector has been disrupted to a large extent due to the COVID-19 pandemic. A special focus on involving parents in education and using technology effectively (while bridging the digital divide) will be important.

The global expansion of schooling over the past three decades has been unprecedented. Primary school enrollment is nearly universal, expected years of schooling have increased rapidly, and the number of out-of-school children has fallen sharply. Yet one of the biggest challenges for the global education system, the "learning crisis" according to the World Bank, is that these gains in schooling are not being translated into equivalent gains in educational outcomes. India, which has the largest education system in the world, is a good example of this crisis. More than 95 percent of children between the ages of 6 and 14 are in school, but nearly half of Grade 5 students in rural areas cannot read at a Grade 2 level, and less than a third can do basic segmentation. India's new National Education Policy 2020 (NEP) (the first major reform since 1986) recognizes the centrality of achieving universal basic literacy and numeracy. Whether India succeeds in this goal is fundamentally important because of the impact on more than 200 million children, and will have lessons for other low- and middle-income countries in well. The NEP's discussion of schooling is being reviewed in light of the accumulated research evidence relevant to the successful implementation of this ambitious goal.

**New India and Future**

India announced the first and most comprehensive education policy of the 21st century. For the first time since 1986, such an education policy has been announced. In this policy, an attempt was made to suggest solutions to eight different challenges faced by the education system of India.

Speaking on the anniversary of the announcement of this new education policy, Hon'ble Prime Minister said that we are entering the 75th year of independence, in a way the implementation of the new education policy has now become a very important part, this policy plays an important role in creating a new India and future ready youth generation will play. Education Minister Dharmendra Pradhan has expressed the view that this is the most visionary policy of the 21st century. This will lead to proper utilization of every student's potential, universalization of education, capacity development and transformation in the medium of education.

Since the announcement of the new National Education Policy 2020, some important milestones in the policy have been completed in the face of the Corona epidemic. Most importantly, the government has done a good job in creating awareness and interest among the public about the goals and vision of the new education policy.

The New Education Policy 2020 is certainly a guiding document. Considering the new challenges of the new era, the policy aims to address various educational needs, structural disparities and prepare students for the future. Along with this, the most challenging task of facing many crises in the education system is also to be completed through this policy.

The implementation of this policy will depend on mainstreaming India's vast population into education and thereby creating numerous employment opportunities. The Center has demonstrated the ability to take difficult decisions and implement them quickly during the COVID-19 pandemic. The benefit of this skill will also be in the field of education. Some states have implemented the new education policy while others are going through the process. Still, there is a long way to go.

Engaging the various stakeholders at the state, district, taluka level as well as the private sector in the implementation of this policy is a difficult task. Along with this, there are challenges such as lack of capacity, financial resources and a conducive environment for generating new ideas. But the most difficult task of all is to create public opinion in various states. In short, the success of the implementation of the new education policy depends on the cooperative federal system and the ability of the states to contribute to reforms.

## Conclusion

The new education policy has made comprehensive provisions keeping in mind the rapidly changing future. But how will it be implemented? How to spread technology to the common elements of our country? The new education policy bodes very well for a self-reliant India. But the time to come will decide how much it will be beneficial for the youth class.

## References

1. National Education Policy 2020 Ministry of Education Government of India https://en.wikipedia.org/wiki/National_Education_Policy_2020
2. https://www.orfonline.org/marathi/five-challenges-that-would-shape-the-outcome-of-nep-96761-2020
3. https://www.mainsa.in/new-national-education-policy-/2020
4. https://riseprogramme.org/publications/indias-new-national-education-policy-evidence-and-challenges

**International Journal of Advance and Applied Research**
www.ijaar.co.in
**ISSN – 2347-7075** **Impact Factor – 7.328**
**Peer Reviewed** **Bi-Monthly**
**Vol.4 No.6** **Jan – Feb 2023**

# New Education Policy 2020 and Agriculture Sector

**Dr.Jayashri Pandharinath Jadhav**
Head of Department (Economics)
MVP's S.V.K.T.Art's ,Science and Commerce College Deolali Camp, Nasik.
***Corresponding Author*- Dr.Jayashri Pandharinath Jadhav**
Email: -jayashriskadam@gmail.com
**DOI- 10.5281/zenodo.7663268**

## Introduction

India is known in the world for its population. According to the statistics of January 2023, the population of India has increased to 1.417 billion i.e. more than 140 crores. Out of the 121 crore youth in the world, 16% of the youth population is in India. More than 250 million youth i.e. 27% of the total population of India is youth. The percentage of youth in the total population is higher than any other country in the world. The country's education system has emerged as the largest system in the world in terms of number of universities, Affiliated Colleges, Faculty and Students Currently India is considered to be the fifth largest economy in the world. But in terms of quality of education it does not compete with the education system of developed countries. It was planned to bring something new to India to compete effectively with the world. To improve the quality of education in the education system, the central government has brought a new education policy 2020. Indian students lack education like foreign students. Indian students have enormous potential. This is the ability of the youth to be utilized in the development of the country and to create opportunities for employment. To revolutionize the structure of the Indian education system based on knowledge and life skills through a new education policy to positively impact the agricultural sector. In the research paper, it is reviewed that the change in the new education policy can be a kind of revitalization to accelerate the development of the agricultural sector.

### Research Objectives:

- To study the impact of new education policy on agriculture sector.
- To study the impact on regional imbalance in agriculture sector.

### Research Hypotheses:

1) Agriculture sector is important in new education policy.
2) There is an opportunity for the development of agriculture sector in the new education policy.

### Research Methods:

Secondary sources have been used for the present research.

### New Education Policy 2020:

Since the establishment of the first agricultural university at Pantnagar in Uttarakhand in 1960, agricultural education in the country has expanded tremendously, both quantitatively and qualitatively. The education system in the country is based on the National Education Policy of 1986. The National Education Policy 1986 was reviewed for a more comprehensive, sustainable and comprehensive roadmap to transform the education system of the country. Every country in the world needs an education policy for a better and brighter future. Because education is a major threat to economic and social progress. Different countries have adopted different education systems keeping in mind their traditions and culture. India has also ushered in an educational innovation by announcing the new National Education Policy 2020. The new education policy is a positive aspect of the existing education system of India and contains some very effective and commendable aspects. This policy lays the foundation for a model of inclusive education that is integrated, engaging as well as scientifically sound. Arts, Science, Physical Education and other co-curricular activities are included and students can choose the subject according to their interest. The new education policy will move towards holistic education and be equipped with 21st century skills. The National Education Policy 2020 which includes comprehensive reforms in the fundamental design of education, curriculum, pedagogy and teaching learning process. Incorporating technology into education, incorporating traditional knowledge and culture, leveraging skills and employability through professional learning and assessment, the National Education Policy 2020. It is expected to bring qualitative transformation in the education sector by making it internationally competitive. The new education policy will give importance to the agriculture sector and develop agriculture in terms of research. This will create new opportunities in the agriculture sector.

The new education policy calls for structural changes in agricultural teaching methods. Keeping in view the broad mandate of the New Education Policy 2020. Agriculture to focus more on multi-disciplinary and holistic education, the structure of higher education institutions in agriculture has to be rethought. This is necessary to meet the needs of large multidisciplinary universities offering holistic education. These Higher Education Institutions (HEIs) will have to redesign their curriculum and make teaching technology more inclusive and equity-oriented by making it more enabling, skills-oriented and culturally integrated.

According to the provisions of the New Education Policy 2020, the prevailing fragmentation in higher agricultural education in the country must be ended by converting agricultural universities or colleges into large multidisciplinary universities, colleges and HEIs into clusters or knowledge hubs. Another important provision in the new education policy is to make agricultural HEIs multi-disciplinary. Therefore, multidisciplinary in higher education in agriculture must include academic programs in basic sciences, social sciences and agricultural sciences.

### Impact of New Education Policy on Agricultural Education:

As this policy will lead to major changes in the education sector, some of the positive effects on the agriculture sector in India are as follows:-

### Changes in Agricultural Education :-

Emphasis is placed on adopting multi-disciplinary education in agricultural education and thus it will benefit these students by having a positive effect on the education in this sector and also in terms of employment it can help in the development of this sector. As students studying agriculture can study in other disciplines, acquiring knowledge in agriculture and other subjects can boost their overall development.

### Help to increase agricultural productivity:

Farmers in India will benefit from the new education policy as it will change agricultural education with emphasis on maximum use of technology for agricultural production. As a result, it can greatly help in increasing the productivity of agriculture. Under the implementation of this policy, priority will be given to the discovery of innovative and improved seed species and its direct use, increasing the production of agriculture will be speeded up, and attention will also be given to quality production.

### Increase in export of agricultural produce:

In the present situation, the quality of Indian agricultural production in the international market is low compared to that of developed countries, so the export volume is low. As a result, the agricultural income is decreasing day by day and the proportion of agricultural sector in the national income has decreased. The implementation of the new education policy will focus on agricultural production research to identify better yielding seed species in the Indian natural environment. This will improve the quality of agricultural crops. As a result, Indian products can compete with agricultural products of other countries in the international market, which can help increase agricultural exports if demand increases and sales are increased.

### Promotion of agro processing industries:

In order to develop the Indian agricultural sector, it is necessary to expand the processing industries based on it more and more In India, if the population dependent on agriculture for employment increases in the agro processing industry, the agricultural sector can grow on a large scale. Due to the change in agricultural education in the new educational policy, more importance will be given to agricultural research, so the development of processing industries based on the study of crops and their needs in various parts of the country can be promoted. Therefore, more emphasis will be placed on doing research on agriculture, and the establishment of processing industries in various parts of India will help in the development of these industries.

**Help to reduce regional imbalance in agricultural development:**

There is a huge disparity in development in India. As a result there has been an imbalance in terms of agricultural development across states in India and reducing this imbalance has become an urgent need of the moment. The number of agricultural universities in India is 64. The number of Central Agricultural Universities in India recognized by ICAR is 3 and these universities are located in Manipur, Uttar Pradesh, Bihar. Total Number of State Agricultural Universities Recognized by ICAS 64. Agricultural Universities are currently functioning in India, state-wise the number of State Agricultural Universities is 6 in Karnataka and Rajasthan, 5 in Gujarat and Maharashtra, 5 in Andhra Pradesh, Haryana, Kerala, Madhya Pradesh, Tamil Nadu, Telangana and West Bengal respectively. 3 each, Bihar, Chhattisgarh, Janmu Kashmir, Punjab, Uttarakhand 2 each and Assam, Orissa 1 each. There are 4 deemed agricultural universities in India and these universities are located in New Delhi, Karnal, Bareilly, Mumbai. Establishing new agricultural universities in states where there is a regional balance in terms of agricultural universities in the country will reduce this imbalance. The implementation of the new educational policy will have a positive impact on the development of agriculture as there will be a lot of changes in the form of education in agriculture. As more priority will be given to research and other skill development in agricultural education, the quality of agricultural production can also be improved by increasing it. Similarly, since agriculture-based processing industries will get an indirect boost under this educational policy, if the agro-processing industries are started in the states which are lagging behind in terms of development, keeping in mind the local needs, the people there will get employment and help increase their income. As a result the per capita income of the state may also increase to some extent and the regional imbalance between the states in the country will accelerate.

**Vocational Education**

Vocational education is going to be a mandatory and integral part of the higher education system. Universities of Technology which are Universities of Health Sciences, Universities of Law and Universities of Agriculture will now aim to become multi-purpose institutions. Central and state governments will work together to increase public investment in education sectors. The objective is to raise this investment to 6 percent of GDP as soon as possible.

Vocational education can be increased through agricultural colleges to develop rural areas. To provide investment opportunities to agriculture based industries on a priority basis. There should be more research based education in agricultural universities. So that the objectives of professional education can be achieved quickly.

**Help to increase share of agriculture sector in national income:**

Since 1991 when India embraced globalization, the share of agriculture in gross national income was 18.8% in year 2021-22. The growth rate of agriculture sector was 3.6 percent in 2020-21 and 3.9 percent in 2021-22. But the proportion of people dependent on agriculture is still 57% directly and indirectly and more people are working in agriculture sector for livelihood. The new education policy is likely to indirectly benefit agriculture. Through research, agricultural productivity, agro processing industry as well as the quality of agricultural products can be increased by increasing exports and increasing the income of farmers. This may increase the share of agriculture in the total national income to some extent. With the increase in agricultural income, agriculture will gain importance and more new schemes can be planned by the government for the development of agriculture. Also, since the development of the industrial sector is dependent on the development of agriculture, if the development of agriculture is given a boost, it will also help in the industrial development in good measure.

**Conclusion:**

From the above point it can be seen that the implementation of the new education policy can have an effect on the agriculture sector. The current condition of agriculture in the country is not satisfactory, but this policy will bring various changes, so the agriculture sector can benefit from it to a large extent. Also, if this education policy is successful in reducing the regional imbalance in the country through the development of agriculture, the country can be boosted to achieve the goal of sustainable development. So the new education policy can be a kind of revival to accelerate the development of agriculture sector.

**Reference :**

1. New Education Policy. 2020
2. Dholakia,R. H. (2003). 'Regional Disparity In Economic and Human Development In India'. Economic and Political Weekly 4166-4173.
3. Suryanarayana,M.H.(2014). 'How Inclusive Is India's Reform (ed)Growth' , Economic and Political Weekly, 44-56.
4. Kurian, N. J. (2000a). 'Widening Regional Disparities In India: SomeIndicators', Economic and Political Weekly, 538–550.
5. Agarwalla, A., &amp; Pangotra, P. (2011). 'Regional Income Disparities in Indiaand Test for Convergence–1980 to 2006'. Indian Institute of ManagementAhmedabad, Research
6. https://www.worldometers.info/world-population/india-population/
7. https://mr.vikaspedia.in/education/policies-and-schemes/93093e93794d91f94d93094092f-93693f91594d937923-92794b930923-2020

# EDUCATION FOR SUSTAINABLE DEVELOPMENT

**Dr. Rekha S. Jadhav**
Shrimati.Vimlaben Khimji Tejookaya Arts, Science and Commerce College, Deolali Camp. Nashik.
**Corresponding Author- Dr. Rekha S. Jadhav**

DOI- 10.5281/zenodo.7264557

Abstract:

Education for sustainable development (ESD) leads to the development of the knowledge, skills, understanding, values and actions required to create a sustainable world, which ensures environmental protection and conservation, promotes social equity and encourages economic sustainability. Sustainability education encompasses all school subjects and extends far beyond the classroom. It gives students actual skills they can use to improve the world. It provides today's children with the independent they must for tomorrow. The purpose of this paper is to discuss The sustainable development goals and some pedagogy and tools of surrounding e-learning systems.

**Keywords**: sustainable development goals; education; E-Learning, etc.

## Introduction:

### Sustainable Development:

Sustainable means "able to be sustained"; that is, to be maintained indefinitely, and is contracted with "unsustainable", referring to what cannot be maintained (Martinez-Alier 2002; Wackernagel and Rees 1995). Sustainable development means having a different vision of the world. Sustainable development a constantly evolving concept, is thus the will to improve everyone's quality of life, including that of future generations, by reconciling economic growth, social development and environmental protection (UNDESD, 2005)

### Objectives of the study:

1) **To Study The Goals Of Sustainable Development.**
2) **To Study The Pedagogy And Tools Of Education.**

### Research Methodology:

The present study paper is mainly based on secondary data which is collected from periodicals, books, websites research articles and Internets.

The following figure shows United Nations Sustainable Development Goals:

Source-http://www.aproms.ap.gov.in/SDG/

The concept of sustainability has undergone notable developments over the past few years. In its beginnings, the report "Our Common Future" [1]Education is most important and top priority goal because it is a basic human right and the bottom on which to build peace and drive sustainable development. Education is both a goal in itself and a means for attaining all the other SDGs. It is not only an essential part of sustainable development, but also a key supporter for it. That is why education represents an essential strategy in the pursuit of the sustainable development goals..Education for Sustainable Development – a key instrument to achieve the SDGs "A basic change is needed in the way we think about education's role in global development, because education has a responsibility to be in gear with 21st century challenges and aspirations, and foster the right types of values and skills that will lead to sustainable and inclusive growth, and peaceful living together. " Irina Bokova, Director-General of UNESCO Sustainable means "able to be sustained"; that is, to be maintained indefinitely, and is contracted with "unsustainable", referring to what cannot be maintained (Martinez-Alier 2002; Wackernagel and Rees 1995). Sustainable development means having a different vision of the world. Sustainable development a constantly evolving concept, is thus the will to improve everyone's quality of life, including that of future generations, by reconciling economic growth, social development and environmental protection (UNDESD, 2005) T

### Definitions:

"Education for Sustainable Development allows every human being to acquire the knowledge, skills, attitudes and values necessary to shape a sustainable future"(UNESCO, 2014)

."Education can, and must, contribute to a new vision of sustainable global development." (UNESCO, 2015)

Education for Sustainable Development aims at developing proficiency that empower individuals to reflect on their own actions, taking into account their current and future environmental, economical, cultural and social impacts, from a local and a global perspective. It helps students to acquire new concepts and critical thinking abilities, which are learned in application to real life situations. Students obtain information and gain knowledge, while getting familiar with the dilemmas faced when applying or producing innovative solutions for interdisciplinary sustainability issues Individuals should also be empowered to act in complex situations in a sustainable manner, which may require them to strike out in new directions; and to participate in socio-political processes, moving their societies towards sustainable development. UNESCO coordinates the international community to achieve the education goals of SDG-4 through partnerships, policy guidance, capacity development, monitoring and advocacy with the Education 2030 Framework for Action as roadmap Emphasis on upgrading learning resources and facilities to make access to information easier or instruction more engaging has led to the formation.

### Sustainable Development Goal (EDUCATION) through E- Learning Pedagogy-

According to Naidu (2006), the term E-learning comprises more than online learning, but incorporates all educational activities that are carried out by individuals or groups working online or offline.

E-learning is "utilizing electronic technologies to access educational curriculum outside of a traditional classroom."

In a modern world, higher education has an obligation and central in redefining education for the case of sustainability surpassing its two traditional functions of research and teaching.Nowadays, higher education and sustainability are widely recognized as interlace concepts.

### Smart classroom:

Smart Classroom is a setting that incorporates electronic devices and software into the learning environment. Typically, it is a digital classroom where a physical classroom extends into a digital space. This digital environment makes it possible for users to collaborate or continue their work outside the classroom.Students find it engaging and easy to access learning resources, networks and track their learning progress. teacher also find it resourceful in focus on students' work in a smart classroom.Smart classroom facilitates customization of feedback based on student, lesson, group and more.

### Digital Education:

Digital Education is broder than what we see in today's world.

Digital Education is consisting of 3 elements.

1.Technology-
2.Digital content-
3.Instruction-

**1.Technology-** It is tools by which used the the digital content transmitted from source to recipient that is the student communicating Bluetooth,laptop,camera,3D printing machine, these are used for education.

**2. Digital content-** digital content is all enriched and quality content that is mid available to students through this technologies, channel. it can be regular online platform, PDF file, multimedia presentation, PPT Presentation etc. which deals with the transmission of information from sources to recipient.

**3.Instruction-**

Who is going to handed to the digital content process to trend teacher to the quality teacher are in separable part of entire part of digital content system. because this trained teacher get to now how aware to transmit information or knowledge to students to this technologies. These three elements makes digital education.

**Learning Management System (LMS)-**We need technology in every classroom and in every student and teachers' hand, because it is the pen and paper of our time, and it is the lens through which we experience much of our world. A Learning Management System (LMS) is an online accommodates software to address the dramatic changes in all aspects of life generated by the emergence of information technology, particularly given its presence in higher education as sustainability. Technology has also helped to improve the simplest of practices, such as the development of traditional learning as sustainability techniques. Alias and Zainuddin define LMS as a web-based framework designed to promote the learning as sustainability process in educational institutions by properly planning, implementing and updating it. A methodology that falls under the umbrella of e-learning as sustainability has made it possible to resume the learning as sustainability process after lockdown This technology is known as a Learning Management System (LMS), the use of LMS in the learning as sustainability process helps to encourage e-learning as sustainability by offering instructional material without constraints on time or place. LMS nowadays have turned out to be a standard tool in higher education to facilitate interaction, communication, and collaboration with and among each other. Thus, LMS have grown into an indispensable tool for facilitating teaching and learning in higher education. Besides cropping and improving students' communication skills and assisting teaching in general, studies also found that the implementation of LMS contributes to sustainability by significantly reducing the production of materials and conserve resources.

MOOCs are another prominent development as part of the ramified E-Learning universe. The basic idea of MOOCs is to educate a massive amount of students online and free of charge. The term MOOC was first introduced by Dave Cormier from the University of Prince Edward Island in 2008 to describe a course about Connectives and Connective Knowledge . MOOCs can bring knowledge to students who may not have access otherwise, and be of use to learners who can't afford the costs of higher education. Non-traditional

to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity.

**References:**

1. Education: An Essential tool for Sustainable Development (Pawan Deep Singh, Research Scholar, Department of Economics, H.N.B.Garhwal University, Uttarakhand).
2. Martinez- Alier.j. 2002. The Environmentalism of the poor: A Study of Ecological Conflicts and valuation, Cheltenham, Edward Elgar.
3. " Irina Bokova, Director-General of UNESCO.
4. Article Sustainable Development Goals and Education: A Bibliometric Mapping Analysis Esther Prieto-Jiménez 1,* , Luis López-Catalán 2 , Blanca López-Catalán 3 and Guillermo Domínguez-Fernández..
5. Anyim, W. O. (2018). E-Library Resources and Services: Improvement and Innovation of Access and Retrieval for Effective Research Activities in University E-libraries in Kogi State Nigeria. Library Philosophy and Practice. Retrieved April 11 2021 from Retrieved April 12, 2021 from Brundiers, K.; Wiek, A.; Redman, C.L. Real-world learning opportunities in sustainability: From classroom into the real world. Int. J. Sust. Higher Ed. 2010, 11, 308–324. [**Google Scholar**] . Wiek, A.; Xiong, A.; Brundiers, K.; van der Leeuw. Integrating problem- and project-based learning into sustainability programs: A case study on the School of Sustainability at Arizona State University. Int. J. Sust. Higher Ed. 2014, 15, 431–449. [**Google Scholar**].
6. Biggs, John. (2002, January) The reflective institution: Assuring and enhancing the quality of teaching and learning. Higher Education Academy. Retrieved April 20, 2021 from http://www.heacademy.ac.uk/embedded_o

# भारतातील नक्षलवादी चळवळ

**डॉ.रमेश जगन्नाथ निकम**

सहाय्यक प्राध्यापक,राज्यशास्त्र विभाग प्रमुख, मराठा विद्या प्रसारक समाजाचे
श्रीमती विमालाबेन खिमजी तेजोकाया कला, वाणिज्य आणि विज्ञान
महाविद्यालय,देवळाली कॅम्प,नाशिक

---

## प्रस्तावना

सध्याच्या काळात भारतासमोरील अनेक समस्यांपैकी नक्षलवाद ही एक समस्या आहे. भारताच्या राष्ट्रीय सुरक्षा ते समोरील नक्षलवाद एक मोठे आव्हान आहे. भारतातील मोठा भूभाग नक्षलग्रस्त आहे. बिहार महाराष्ट्र झारखंड छत्तीसगड पश्चिम बंगाल, आंध्र प्रदेश या घटक राज्यांमध्ये नक्षलवाद प्रामुख्याने आढळून येतो. देशामध्ये एकूण 76 जिल्ह्यांमध्ये नक्षलवादी चळवळ सक्रिय असल्याचे गृह खात्याने मान्य केले. इतर घटक राज्यांमध्ये ही आपला प्रभाव वाढविण्यासाठी नक्षलवादी चळवळ प्रयत्न करत आहे. भारत सरकारने देखील नक्षलवादी चळवळीच्या वाढीबद्दल चिंता व्यक्त केले आहे. देशाच्या अंतर्गत सुरक्षिततेला नक्षलवादाच्या रूपाने मोठा धोका निर्माण झाला असल्याचे पंतप्रधानांनी मान्य केले.

## भारतातील नक्षलवादी चळवळ समस्या :

नक्षलवादी चळवळीची सुरुवात सर्वप्रथम पश्चिम बंगाल राज्यातील नक्षलवारी गावातून सुरू झाली. या गावात काही ठराविक जमीनदारांचे प्राबल्य होते. येथील बरीचशी जमीन जमीनदारांच्या ताब्यात होती. त्या जमिनीवर आदिवासी शेतमजूर काम करत असत. या जमीनदारांनी या शेतमजुरांचे आर्थिक शोषण केले. त्यामुळे आदिवासी बांधवांमध्ये जमीनदारांविषयी चीड निर्माण झाली. या अन्यायाच्या भावनेतूनच 1967 मध्ये नक्षलबाडी गावातील शेतमजूर तरुणांनी जमीनदारा विरोधात लढा पुकारला. या शेतमजुरांना बांगला काँग्रेस, कम्युनिस्ट पार्टी ऑफ इंडिया, इत्यादी राजकीय पक्षांनी पाठिंबा जाहीर केला. या घटनेतूनच 22 एप्रिल 1969 रोजी भारतीय कम्युनिस्ट पार्टी ( माओवादी ) ही संघटना

अस्तित्वात आली. जमीनदारी व्यवस्था नष्ट करणे, शेतकऱ्यांना लढ्यासाठी तयार करणे, माओ वादी विचारसरणीचा प्रसार करणे. ही या संघटनेचे महत्त्वाची उद्दिष्टे होती. चळवळीचा विस्तार :

1. पश्चिम बंगाल - नक्षलवादाची सुरुवात पश्चिम बंगाल राज्यात सुरु झाली . चारू मुजुमदार यांनी सुरुवातीच्या काळात या चळवळीचे नेतृत्व केले. चारू मुजुमदार यांनी नक्षलवादी चळवळीचा विस्तार व्हावा यासाठी अनेक लेख लिहिले. त्यातून माओवादी विचाराचा प्रसार करण्याचे काम काम सुरू केले.1972 मध्ये चारू मुजुमदार यांना अटक करण्यात आली. त्यानंतर थोड्याच दिवसात पोलीस कोठडीमध्ये त्यांचा मृत्यू झाला.मुजुमदार यांच्यानंतर कान्हू संन्याल यांनी पश्चिम बंगालमध्ये नक्षलवादी चळवळीचे नेतृत्व केले,2006 मध्ये टाटा मोटर्स कंपनीला जमीन संपादन करण्यास विरोध केला. पश्चिम बंगाल मध्ये नक्षलवादी चळवळीचा विस्तार थांबविण्यासाठी भारत सरकारने ' ऑपरेशन बरगा' सुरू केले. या ऑपरेशन अंतर्गत जवळपास 11 लाख एकर जमिनीचे तुकडे करून ती शेती कसण्यासाठी आदिवासींना परवानगी देण्यात आली. त्याचप्रमाणे 1.5 लाख एकर बेवारस जमीन सरकारने ताब्यात घेऊन ती 25 लाख अल्पभूधारक आणि भूमिहीन मजुरांना कसायला दिली. यामुळे नक्षलवादी चळवळीचा प्रभाव काहीसा कमी होताना दिसतो.

आंध्र प्रदेश - 1968 आंध्र प्रदेश राज्यांमध्ये नक्षलवादी चळवळीने जोर पकडला. नक्षलवाद्यांनी या भागातील जमीनदारांची हत्या केली. देशातील नक्षलवादी चळवळीचे एक केंद्रबिंदू म्हणून आंध्रप्रदेश ला ओळखले जाते. डिसेंबर 2000 मध्ये नक्षलवादी चळवळी विषयी जनतेत जागृती करण्यासाठी पीपल्स वॉर ग्रुप या संघटनेची स्थापना केली. या संघटनेने 2003 मध्ये आंध्र प्रदेशचे मुख्यमंत्री चंद्रबाबू नायडू यांच्यावर हल्ला केला. मात्र या हल्ल्यातून मुख्यमंत्री बचावले.

मध्य प्रदेश - मध्यप्रदेश मध्ये बालाघाट मंडला दिंडोरी आणि सोदी या जिल्ह्यांमध्ये नक्षलवादी कारवाया घडून येतात. 1999 मध्ये मध्य प्रदेशचे परिवहन मंत्र्यांची नक्षलवाद्यांनी हत्या केली.

छत्तीसगडमध्ये बस्तर, राज नांदगाव, सरगुजा या जिल्ह्यांमध्ये नक्षलवाद्यांनी हिंसाचार सुरू केला.2006 मध्ये सरकारला सहकार्य केल्यामुळे 27 आदिवासींची नक्षलवाद्यांकडून हत्या करण्यात आली. बिहार आणि झारखंड राज्यांमध्ये देखील नक्षलवाद्यांकडून हिंसाचार होताना दिसून येतो.

महाराष्ट्र - महाराष्ट्रात गडचिरोली गोंदिया भंडारा या जिल्ह्यांमध्ये नक्षलवाद यांचा प्रभाव आढळतो. या भागात नक्षलवादी डोंगराळ आणि दुर्गम भागात बास्तव्य करून राहतात. पोलीस शासकीय अधिकारी कर्मचारी यांना ते आपले लक्ष्य बनवितात. शासकीय कामात अडथळा आणून अधिकारी कर्मचारी यांना धमकावून शासकीय कामात अनेक वेळा अडथळा आणला जातो, या भागात आदिवासींसाठी नक्षलवाद्यांचा शब्द प्रमाण मानला जातो. विशेषता गडचिरोली जिल्ह्यातील अनेक आदिवासी लोकांची पोलिसांना मदत केल्याच्या संशयावरून हत्या करण्यात आली.2005 मध्ये महाराष्ट्र सरकारने नक्षलवाद्यांसाठी आत्मसमोर पण योजना जाहीर केली. ही योजना जाहीर झाल्यापासून आतापर्यंत अनेक नक्षलवाद्यांनी आत्मसमर्पण केले आहे.

उपाय :

नक्षलवादी भागात असलेले कुपोषण, बेकारी या समस्यांवर लोकप्रबोधन व शिक्षण हाच उपाय आहे. नक्षलवाद नियंत्रीत करायचा असेल तर नक्षलवाद्यांना ही जाणीव करून द्यायला हवी की आपल्या देशात सशस्त्र क्रांतीला थारा नाही. लोकशाही प्रक्रियेत भाग घेऊन छत्तीसगड किंवा झारखंड यासारख्या आदिवासी बहुल राज्यांत नक्षलवादी सत्तेत येऊ शकतात. सनदशीर मार्गाने सत्ता मिळवून त्यांना अभिप्रेत असलेली धोरणे ते राबवू शकतात. त्यांना या मार्गावर आणण्याकरिता नक्षलवाद्यांना नि:शस्त्र करणे हाच उपाय आहे. नक्षलवादी व सरकारच्या या संघर्षात आदिवासी भरडले जाण्याचा धोका आहे. त्यावर उपाय म्हणजे नक्षलवाद्यांपासून आदिवासींना अलग केले पाहिजे . यासाठी आदिवासींपर्यंत पोहोचणे गरजेचे आहे. आदिवासांचे राजकीय नेतृत्व यात मोठी भूमिका बजावू शकते.

यावरोबरच नक्षलग्रस्त भागात कार्यरत असणाऱ्या सशस्त्र दलांनी आपली वागणूक कायद्याच्या चौकटीत ठेवून सूड म्हणून आसपासच्या आदिवासींवर अत्याचार करता कामा नयेत. नक्षलवादाची समस्या ही केवळ लष्करी समस्या नव्हे. या समस्येचे आर्थिक, सामाजिक, मनोवैज्ञानिक व राजकीय, असे अनेक पैलू आहेत. परंतु हे सर्व उपाय करण्याआधी हिंसाचारावर अंकुश ठेवणे गरजेचे आहे.

गरिब आणि श्रीमंत यांना समान न्याय प्रशासनामध्ये मिळाला तर, नक्षलवाद कमी होऊ शकतो. अर्थात, बंदुकीच्या गोळीचं उत्तर बंदुकीच्या गोळीनं पूर्णपणे सुटणार नाही. सरकारकडून नक्षलवादाच्या बंदोबस्ताकरिता जो पैसा वापरला जातो. या सर्व पैशाचा वापर शेवटच्या माणसाच्या विकास करण्यासाठी झाला पाहिजे. त्यातला पैसान् पैसा ज्या कारणासाठी आला आहे, त्या कारणासाठीच वापरला गेला पाहिजे. मार्क्सवादी विचारसरणीला लोकशाहीने उत्तर देताना ग्रामीण आणि दुर्गम भागाचा वेगाने विकास करणे, हेच खरे उत्तर आहे. त्यामुळे, नक्षलवादाच्या या प्रश्नाचे उत्तर हे मंत्रालयात शोधले पाहिजे. याबरोबरच ज्या-ज्या राज्यात नक्षलवादाचा प्रभाव आहे, त्या-त्या सर्व राज्यांबरोबर योग्य असा समन्वय साधून, नक्षलवादाच्या समूळ बंदोबस्ताची कृती करण्याची इच्छाशक्ती सरकारने दाखवायला हवी. कधी-कधी पोलीसांना शहीद व्हावं लागते. ही एक लढाई आहे. त्यामुळे, पोलीसांचे मनोधैर्य कमी होणार नाही, याची काळजी घेण्याची आवश्यकता आहे.

नक्षलबरोबर अनेक बाजूनी लढावे लागेल. तो कायदा-सुव्यवस्थेचा प्रश्न आहे, पण, तो गृह खात्याचा विषय आहे, तसाच तो सामाजिक, राजकीय व आर्थिक प्रश्नही आहे. गडचिरोली जिल्हा भौगोलिकदृष्टया राज्यातील संपन्न जिल्हा आहे. बारमाही वाहणा-या नद्या, उंचच उंच झाडांचे जंगल, कसदार जमीन, कष्ट करणारी माणसं गडचिरोली जिल्ह्यात आहेत. पण, एवढी नैसर्गिक सुविधा, असूनही निरक्षरतेत महाराष्ट्रात प्रथम जिल्हा, दारिद्र्य रेषेखाली जीवन जगणा-या लोकांची टक्केवारी सर्वाधिक, मानवी विकास निर्देशांकात सर्वात शेवटी, रोजगाराशिवाय उपाशी रहाणारी माणसं, रस्ते, पाणी, आरोग्य, ज्ञान, उद्योग यांची वाणवा यातूनच

नक्षलवादाला बळ मिळतं. याबरचा उपाय म्हणून सर्वांनीच उठावं लागेल व युध्द म्हणून कार्यरत व्हावे लागेल. नक्षलवादाचे खरे उत्तर हे विकासाच्या माध्यमातूनच सापडू शकेल. आज त्यासाठी मोठ्या प्रमाणात पायाभूत सुविधा निर्माण करणे आवश्यक आहे. जमीन ओलिताखाली आणणे, पिढ्यान् पिढ्या ज्या जमिनी आदिवासी कसत आहेत, त्या जमिनी त्यांच्या नावावर करणे व बेकार हातांना काम देणे, चांगले शिक्षण, चांगले आरोग्य व दारिद्र्य निर्मूलन हा त्याच्यावरील खरा उपाय आहे.

संदर्भ :

1. व्ही.बी.चांदजकर, 'नक्षलवाद आव्हान आणि आवाहन', आर.आर.ग्राफिक्स,वाशिम.
2. राम सातपुते, 'नक्षलवाद', भारतीय विचार साधना प्रकाशन,पुणे.
3. योजना ,फेब्रुवारी २००७
4. महाराष्ट्र टाइम्स १२ मे २०१०
5. नक्षलवाद व भारत ,व्ही.पी.एम.दिशा,मार्च २०१७

# 23. SWAYAM and MOOCs: An Opportunity for E-Learning

**Dr. Shraddha A. Raravikar**
Asst. Professor, M. V. P. Samaj's S. V. K. Tejookaya A. S. C. College, Deolali Camp, Nashik.

## Abstract

The digital revolution has changed the lives of countless people. It touched all aspects of our lives including the Education. The efforts of Government of India to reach to most disadvantaged and provide them with the finest teaching learning resources turned into a massive project of online education courses designed to achieve the three cardinal principles of Education Policy of that assures access, equity and quality. The freely available courses can bridge the knowledge gap between privileged and disadvantaged students. Most importantly, the courses provide opportunities for self-paced learning. SWAYAM and MOOCS are the platforms that can drastically change the dynamics of learning and take it to another level provided that the internet and data facilities reach to remote areas too and the information about the platforms reach to all who need it.

**Key words:** SWAYAM, MOOCs, eLearning, Self-paced Learning.

## Introduction

The digital revolution has changed the lives of countless people. It touched all aspects of our lives including the education. The Covid-19 pandemic took eLearning to almost every home. The students from K. G. to P. G. learnt to learn online. The picture seems very optimistic as eLearning can literally teach you anything, from languages, science, data science, management to personal development.

Nonetheless many people are still untouched by the revolution. They don't know where to find the authentic knowledge in a particular subject. Even the certification they get after completing an online course may be questioned by concerned authorities. But Government of India came up with an answer i.e., SWAYAM. The effort to reach to most disadvantaged and provide them with the finest teaching learning resources turned into a massive project of online education courses designed to achieve the three cardinal principles of Education Policy of that assures access, equity and quality. The freely available courses can bridge the knowledge gap between privileged and disadvantaged students. Being true to its name 'Study Webs of Active-Learning for Young Aspiring Minds' the platform provides enormous opportunities to learn.

Most importantly, the courses provide opportunities for self-paced learning; the courses are designed in a way that permit learning at the student's own pace. They are not limited to fix days and time as the actual, physical classrooms.

MOOCs i. e. Massive Open Online Courses is the online platform where people can enrol freely learn new skills and educate themselves. People use MOOCs for varied resond from career development, changing careers, college preparations, supplemental learning, lifelong learning, corporate eLearning & training, and more. MOOCs have dramatically changed the way the world learns.

**Objectives**

- To discuss the advantages of SWAYAM and MOOCs
- To deliberate on the challenges in using the eLearning platforms

**Discussion**

1. A major advantage of SWAYAM and MOOCS is the availability of quality knowledge. The well qualified and experienced faculties with appropriate skills prepare the courses that provide knowledge and skills. This help learners to get authentic information in a concerned area.
2. The platforms offer this authentic knowledge at no cost. Many learners interested in gaining new knowledge had to stay away from it due to unaffordability of quality online courses. But SWAYAM and MOOCs allows to flow knowledge towards every interested learner, rich or poor.
3. The platforms provide an opportunity for self-paced learning. A learner can pick up at his own schedule and time. Many students as well as professionals have their own schedule of work and part-time jobs. So it becomes difficult for them to learn at fixed schedule designed by educational institutes that offer offline, physical classroom

education. So, they previously had to stay away from education. But such learners can now easily enrol in self-paced online classes.

4. The rehearsal or revision of learnt material is crucial in learning process. It is comparatively very easy to revise material taught in online classes as the students can view videos of the online course for as much as time he prefers. This facility was missing in offline physical classes. Students need to rely on teachers, fellow students or self-made notes for revision in such classes.
5. The learner can frequently check his progress in MOOCs as he needs to complete assessments very frequently. Most of the courses provide instant feedback that is very necessary to keep the learner motivated and engaged.
6. Though the advantages of these online platforms seems very appealing, there is a flip side too. One of the challenges to spread the knowledge through such platforms is the internet connectivity in remote locations and uninterrupted availability in connected areas.
7. Also, learners may find it difficult to purchase data needed. Though the courses are free, the purchasing of data can be a problem.
8. It also increases the screen time of learners. It is creating many physical as well as mental issues. The learner may face vision issues, concentration problems and other related issues. The immobility for long hours also contributes in physical and mental health concerns.
9. Similarly, the online classes lack the human touch that is provided in face-to-face classes. The doubts can be cleared immediately in such classes. The social dynamics of face-to-face classes make the interaction even more fruitful as it adds up in a socialization process. All these communication opportunities and social dynamics are missing in online platforms. Some learners may find it uninteresting and mechanical.
10. So, considering all these issues, it's challenging to make these online platforms popular and common way of learning. The educators, technicians and policy makers need to come together to intensify the advantages and de-intensify the problems.

# 24. Role of SWAYAM and MOOC's in National Education Policy

**Dr. S. V. Shrimali**
Assistant Professor, S. V. K. T. College, Deolali Camp, Nashik.

## Abstract

Swayam is the online platform of online learning provided by MHRD in India. Swayam is known for Study Webs of Active-Learning for Young Aspiring Minds) and under that MOOC has been provided the Platform for online courses. It was developed by AICTE in 2016 to facilitate hosting of online courses which could be accessed by anyone, anywhere at any time free of cost to achieve three cardinal principles of Education Policy viz.

## Introduction

The formation of New Education Policy comes under the control of MHRD. They formed a Committee headed by Dr. K. Kasturirangan for preparing draft and forming structure of the National Education Policy. In June 2017 the Committee was constituted. and they submitted their report on May 31, 2019. NEP (National Education Policy) was approved by the Union Cabinet on July 1, 2020. In addition to renaming the Ministry of Human Resource Development as the Ministry of Education, this policy ensures changes to the country's education policy. Several changes have been introduced in the Indian education system, from school to college, with the new National Education Policy 2020 by replacing the old education policy of 1986 approved by the Union Cabinet. This new policy has covered primary and university education in urban and rural areas of India. SAWYAM in this regards plays a vital role to provide a ready platform to conduct online courses in the various field. It has 3 core plus registered members as of now. India's SWAYAM portal is the 3rd largest online Education portal in the world.

**Key Words:** The Ministry of Human Resource Development (MHRD), Higher Education Institutes (HEI'S).

## Objectives

- To provide 24*7 e-learning opportunity for the learner.
- To increase the Gross Enrollment Ratio of the students.
- To acquaint the student in the use of digital platform.

- To facilitate the implementation of NEP.

**National Education Policy an Overview**

- In 1968 the first education policy was formed followed by second education policy in 1986.
- In 1964-1966 on the recommendations of the Education Commission the first NPE was formed.
- To accomplish national integration and better economic and cultural development, the policy sought to restructure India's education system and provide equal access to education for all.
- In accordance with the Indian Constitution, the NPE also called for compulsory education for all children until the age of fourteen.
- Furthermore, the program provided enhanced training to teachers and improved their qualifications

**Features of new NEP: 2020**

- India's first education policy of the 21st century is NEP 2020.
- National Education Policy 2020 emphasizes the development of each student's creative potential.
- In the NEP 2020, ancient scholars such as Charaka and Susruta, Aryabhata, Bhaskaracharya, Chanakya, Madhava, Patanjali, Panini and Thiruvalluvar were mentioned.
- According to the government, National Education Policy 2020 includes the following principles:
    - Adaptability
    - There are no hard distinctions between subject areas, curricular activities, and extracurricular activities
    - Education that integrates multiple disciplines
    - Conceptual understanding
    - Critical thinking
    - Ethical motives
    - Teachers known as the heart of the learning process.

**Key aspects of New Education Policy: 2020**

- **Reformation of school curriculum**: The existing structure of 10+2 has been abolished and new structure of 5+3+3+4 has been designed covering age 3 to 8 as foundational stage, age 8 to 11 as preparatory stage, ages 11 to 14 as middle stage and age 14 to 18 as secondary stage. The new structure will be more appropriate by considering the needs of students.
- **Early Childhood Care and Education (ECCE):** This new education system also deals with early childhood education which should consist of brain storming activities while learning like puzzles, quiz, paintings, alphanumeric games and music for students of early age. As per the research early age children has huge grasping power till the age of 6 years.
- **Modifications in curriculum:** The existing curriculum is further modified to reduce the burden on students and to develop the habit of critical thinking, analytical thinking-based learning. The students have given flexibility for making choice of their subjects.
- **Medium of instruction:** Till grade 5 the instructions should be in local language of the child. The states have to implement three language formulas for schools which should include Hindi, English and regional language.
- **Foreign universities:** Best performing universities will get freedom to expand their level from national to international level. They can set up their universities in other countries. On the other hand forign universities will be permitted to operate in India.
- **Multidisciplinary education:** For all HEI's Multidisciplinary education is recommended. For undergraduates also flexibility will be provided with multiple certifications and exit options. Academic bank credit is given to store credits earned at different stages by the students.
- **Regulatory structure:** To regulate the eductyaion system 4 independant regulatory bodies will be set up i) The National Higher Education Regulatory Council ii) The National Accreditation Council iii) Higher Education Grants Council iv) General Education Council.
- **Improving research:** The NEP has announced the setting up of National Research Foundation in regards with funding and enhancing quality research and innovations in the country.

- **Technology in education:** The setting up of National Education Technology Forum is recommended under this policy to increase and develop the technology used in higher education. New techno based systems are suggested to used for teaching learning purposes.
- **Digital education:** Digital education by training the teachers for using various online teaching platforms and teaching mechanisms will be undertaken.

**Benefits Derived**

- **Comprehensive**: SWAYAM coverers the whole education right from preschool to doctoral studies, and from professional degrees to vocational training.
- **Early Childhood Education**: In adopting a 5+3+3+4 model for school education starting at age 3, the New education Policy recognizes the primacy of the formative years from ages 3 to 8 in shaping the child's future.
- **Easy to enroll:** NEP 2020 will make the regulations at minimum level and will provide independency for self-assessment to the universities so any one from anywhere can register under SWAYAM free of cost to meet the requirements maid under NEP.
- **Complete:** The policy, inter alia, aims to eliminate problems of pedagogy, structural inequities, access asymmetries and rampant commercialization.
- **Increase Insertion:** The Policy proposes the creation of 'inclusion funds' to help socially and educationally disadvantaged children pursue education.

## Conclusion

The New Education Policy with SWAYAM and MOOC's provides comprehensive platform to increase the learning potential of the students from vernacular backgrounds. It is in itself a model of overall development of student's right from the age of 3 years to higher studies. The effective implementation of NEP with the help of MOOC's will provide great opportunities for all categories of students.

## References

- Singh, J. D. (2011). Higher education in India–Issues, challenges and suggestions. Higher education, 93-103, ISBN: 978-3-8465-1753-6.
- Devi, S., Rizwaan, M., & Chander, S. (2012). ICT for Quality of Education in India. International Journal of Physical and Social Sciences, 2(6), 542-554.
- National Education Policy 2020.
- Ranganathan, S. 2007. Educational Reform and Planning Challenge. Kanishka Publishers. New Delhi.

# Recent Advancement in Genetic engineering using DNA manipulating enzymes

Darshana Dhokane[1], Dipali Girase[2], Ashwini Kadbhane[3]
[1]*K.T.H.M. College of Arts, Commerce and Science Nashik, Maharashtra, India*
[2]*S.S.V.P.S Science, College, Dhule, Maharashtra, India*
[3]*S.V.K.T. Arts, Science, and Commerce. College, Devlali Camp, Nashik, Maharashtra, India*

***Abstract*: The development of molecular genetics as well as genetic manipulation are leading to innovative changes in the field of life science. Genetic engineering is an accurate technique of gene manipulation at the molecular level. Several enzymes play an important role in genetic engineering like restriction endonuclease, ligase, Alkaline phosphatase as well as DNA polymerase. The importance of genetic engineering in medical science consists of the formation of vaccines, growth hormones including proteins along with the treatment of various diseases. Genetic engineering has several applications in agriculture, research, medicine as well as industrial biotechnology. CRISPR/Cas9 is the new genome editing technique with excellent advantages. The fast advancement in CRISPR/Cas9 system greatly revolved around genetic engineering, particularly modifications of the Cas9 as well as sgRNA to attain proper editing.**

***Index Terms*— Genetic Engineering, CRISPR-Cas9, DNA Manipulation, Genome**

## INTRODUCTION

Genetic engineering provides a great advantage in the research area begins to be developed in 1973 by Stanley Cohen with Herbert Boyer [1]. Gene manipulation including genetic engineering is in used for a very long time. Genetic engineering (GE) also known as gene manipulation as well as recombinant DNA technology (RDT) three are used as a conversely-intimate of manipulation as well as interchange the genetic constituents of the organism by introducing some traits of the interest [2]. This is the combination of methods that are useful for the recognition, replication, modification as well as transfer of genetic material. The methods specified above are through including great in the area since the 1970s with various importance in areas such as pharmaceuticals, industry, health, the environment in addition to agriculture. With the development of genetic engineering, its importance field is expanded that provide benefit to humans several genetic disorders is nowadays curable with the help of this technique it is not available before time. The importance of genetic engineering in medical science consists of the formation of vaccines, growth hormones including proteins along with treatment of various diseases including genetic disorders like Cancer, Down’s syndrome, Alzheimer’s disease, cystic fibrosis including Huntington’s disease with the help of gene therapy. The Transgenic plants the useful traits like resistance to pests, herbicide tolerance, stress tolerance as well as increased nutrients. In the agriculture field which importance of GE is main apparent in developing genetically modified (GM) foods [3]. Genetic engineering is also used to enhance milk as well as meat this is the “values added” initiative in the area of animal agriculture that is enhanced the number of existing proteins by developing completely new ones [4]. Genetic engineering is the main important technique for the study of genomes, the formation of genetically modified (GM) organisms is formed by proteins of biotechnological importance and advancements of the transgenic organisms by new characteristics [5]. CRISPR/Cas9 is the growing essential technique for genome engineering because of its great efficiency as well as simplicity [6]. The rapid advancement in CRISPR/Cas9 technology greatly revolved around genetic engineering, particularly modifications of the Cas9 as well as sgRNA to attain proper editing [7].

## ENZYMES IN DNA MANIPULATION

Nucleic acids are widely manipulated, to obtain particular attributes as well as features. The modifications are mainly catalyzed with the enzymes like polymerases, and ligases including nucleases. The DNA polymerase enzyme synthesizes DNA molecules from deoxyribonucleotides. The various types of DNA polymerase are useful for gene manipulation. DNA polymerase I involved 3'-5' as well as 5'-3' exonuclease both actions including 5'-3' polymerase action. Reverse transcriptase synthesizes DNA from RNA. Taq DNA polymerase is a heat-stable DNA polymerase and is mainly extracted with Thermus aquaticus. That work at 72°C with slightly stabilized over 90°C and it mainly functions in PCR. Nucleases are enzymes that degrade nucleic acids by breaking the phosphodiester bonds. Ribonucleases (generally abbreviated RNases) mainly catalyzed the degradation of RNA including deoxyribonucleases (generally abbreviated DNases) that mainly catalyzed the degradation of DNA. Nucleases consist of two different types such as exonucleases as well as endonucleases. Exonucleases that cleave off nucleotides one at a time from 3'or 5' ends of DNA as well as RNA chains. The endonucleases cleave the phosphodiester bonds within a nucleic acid. Mung bean nucleases are the endonuclease particular from single-stranded DNA including RNA. The S1 nuclease is the endonuclease that degrades ssDNA and RNA. RNase H is an enzyme that cleaves the RNA of an RNA-DNA duplex [8]. The restriction-modification system consists of a modification enzyme (DNA methylase) that identifies the recognition regions including modifying the regions with the addition of a methyl group. The bacteria produce restriction enzymes as well as modification enzymes that modify their DNA because of that it will not be cleaved with a restriction endonuclease. The reason for modification is enzyme modifies the recognition sites, due to that restriction enzymes are incapable to cut those sites. So, with the help of modification systems protect host cell DNA from restriction enzymes [9]. Hamilton discovered the first restriction enzyme Hind III in 1970 from the Haemophilus influenza. Restriction enzymes is identifying a particular sequence and cut the DNA strand. Enzymes are classified into various types that are different primarily on the cofactor demands, structure, activity, and recognition as well as cleavage sites. The three different types of restriction endonucleases like Type I, II including III. The Type II enzyme performs an important function in Recombinant DNA Technology which consists of the simple structure of the protein, and for the cleavage of DNA, ATP is not necessary [10]. Table [11]. End modification enzymes make changes to the ends of DNA molecules. Enzyme terminal deoxynucleotidyl transferase addicts the series nucleotides onto 3'OH termini of dsDNA molecule [12]. Alkaline phosphatase was found in E. coli as well as calf intestinal tissue, which catalyzed the removal of phosphate groups of 5'ends of the DNA strand [13]. T4 polynucleotide kinase, which is mainly isolated from the E. coli cells infected by the T4 phase, carries out a reverse reaction of the alkaline phosphatase, the addition of phosphates to the 5' ends [14].

## ADVANCEMENTS IN GENETIC ENGINEERING OF CRISPR/CAS9 SYSTEMS

The Genetic engineering technique is greatly involved in the area of life sciences research as well as numerous importance. In 1987, CRISPR first identified in E. coli. The term "CRISPR" was introduced in 2002 [15]. CRISPR is greatly developing in recent times it is majorly useful for life sciences [16]. The recent advancements of the CRISPR-Cas9 system are very useful as well as easy-to-used editing techniques They play great importance in the research area [17]. CRISPR-Cas9 is the newly developed genome-editing system. CRISPR-Cas9 technology is the latest genetic manipulation technique, it is recently used all over the world. The enzymes that act on DNA are crucial for genetic manipulation technologies [18]. The CRISPR system provides adaptive immunity to bacteria including archaea [19]. The CRISPR/Cas9 system involved two important components like Cas9 including sgRNA. Cas9 is obtained from Streptococcus pyogenes. Cas9 involved two domains as HNH domain including a RucV-like domain. Synthetic sgRNA with a length of about 100 nt [20]. CRISPR systems are majorly divided into two main classes. Class I consist of (type I, III, I) with class II including (type II, V, VI) [21]. The Class I CRISPR-Cas systems included multisubunit complexes. The class II systems involved a single Cas protein [22]. CRISPR-Cas9 system was obtained from type II systems [23]. Type II CRISPR/Cas9 systems are relatively simplest, they are studied properly and are majorly useful for genetic engineering. The sgRNA including CRISPR-associated (Cas-9) proteins are two important components of the CRISPR/Cas9 system [24 ,27]. Studies that invented enzymes related to the CRISPR family, involved enzymes it encoded Cas genes smaller than SpCas9 (4.2 kb), such as SaCas9 (3.2 kb), NmCas9 (3.2 kb) including St1Cas9 (3.4 kb). These enzymes assist in the packaging of viral vectors. The newly identified enzyme called Cpf1 and shorter crRNA sequences uses an alternative for SpCas9. Moreover, newly developed C2c2 (Cas13a) including C2c6 (Cas13b) it degrades RNA [25]. Newly, CRMAGE that combines to CRISPR/Cas9 system including MAGE technique, is established it allows effective as well as fast genome engineering. In an earlier study, the CRMAGE technology used, recombineering efficiency extended by around 90% including protein synthesis modulation efficiency extended by 64%. The newly, identified CRISPR-Cas13 is the capability to knock down RNAs use of RNA-guided RNA-targeting CRISPR-Cas effector Cas13a from Leptotrichia wades (LwaCas13a) although most effective in an E. coli [26].

## CONCLUSION

Genetic engineering is used in the formation of transgenic organisms it is the new main advancement in agriculture, medical sciences as well as biotechnological applications. This technique is mainly useful for human purposes. This is a great time its awareness with the education of genetic engineering is assisting. The researchers are generally to coordinate with discussing development in the field of Genetic engineering. The fast advancement in CRISPR/Cas9 system greatly revolved around genetic engineering, particularly modifications of the Cas9 as well as sgRNA to attain proper editing.

## REFERENCE

[1] Au, R. (2015). From Genetic Engineering to Genome Engineering: What Impact Has Made on Science and Society? Advances in Biology, Biotechnology, and Genetics. 02(01):1-8.

[2] Begna, T and Okonkwo, J.C. (2020). Role of Recombinant DNA Technology in Agriculture. International Journal of Agriculture and Biosciences. 9(5):

[3] Muntaha, S.T., Ahmed, A., Ahmed, K., Mukhtar, N., Naureen, U., Murtaza, M., and Hussain, T. (2016). Application and prospects of genetic engineering: A new global perspective. 6(2):201-209.

[4] Asaye, M., Biyazen, H. and Girma, M. (2014). Genetic engineering and animal production: Applications and prospects. 2(2):12-22.

[5] Singh, H. P., and Singh, B.P. (2014). Genetic Engineering of Field, Industrial and Pharmaceutical Crops. 05(26):3974-3993.

[6] A., Edraki, A., Lee, J., & Sontheimer, E.J. (2018). Type II-C CRISPR-Cas9 Biology, Mechanism, and Application. DOI: 10.1021/acschembio.7b00855

[7] Mei, Y., Wang, Y., Chen, H., Sun, Z.S. and Ju, X.D. (2016). Recent Progress in CRISPR-Cas9 Technology.

[8] Rittie, L. and Perbal, B. (2008). Enzymes used in molecular biology: a useful guide. 2(1-2):25-45. DOI: 10.1007/s12079-008-0026-2

[9] Ershova, A.S., Rusinov, I.S., Spirin, S.A., Karyagina, A.S. and Alexeevski, A.V. (2015). Role of Restriction-Modification Systems in Prokaryotic Evolution and Ecology. 80(10): 1373-1386. DOI:10.1134/S0006297915100193

[10] Agresti, P.M., Carmo, F.L.S., Carvalho, R.D.O., Azevedo, M.S.P., Silva, A. and Azevedo, V. (2015). DNA Technology, Genes and Genetic Engineering.

[11] Maurya, G.K. (2019). Restriction Enzyme. DOI: 10.1007/978-3-319-47829-6_210-1

[12] Sarac, I. and Hollenstein, M. (2018). Terminal deoxynucleotidyl transferase in synthesis and modification of nucleic acids.

[13] Sharma, U., Pal, D. and Prasad, R. (2013). Alkaline Phosphatase: An Overview. DOI: 10.1007/s12291-013-0408-y

[14] Lian, S., Liu, C., Zhang, X., Wang, H., and Li, Z. (2014). Detection of T4 polynucleotide kinase activity based on cationic conjugated polymer-mediated fluorescence resonance energy transfer.

[15] Ishino, Y. (2020). Studies on DNA-related enzymes to elucidate molecular mechanisms underlying genetic information processing and their application in genetic engineering. DOI: 10.1080/09168451.2020.1778441

[16] Lomov, N.A., Borunova, V.V., & Rubtsov, M.A. (2015). CRISPR/Cas9 technology for targeted genome editing. 31(4), 243-248. DOI:10.7124/bc.0008E7

IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

# Isolation and characterization of urease producing bacteria from different soil types.

**P.S.Rayate[1, 2], Dr.S.S.Ghumare[3]**

[1]*Department of Microbiology, S.V.K.T College, Deolali Camp, Nashik.*

[2]*Department of Environmental Science, K.T.H.M College, Nashik.*

[3]*Principal, S.S.S.M ,College, Saikheda.*

## Abstract:

Urea is hydrolyzed by means of urease enzyme with production of ammonia and carbonic acid. It provides an alkaline pH, and leads to $CaCO_3$precipitation.This are one of the mechanism for microbially induced calcium carbonate precipitation (MICP).For this study, ureolytic bacteria capable of precipitating calcium carbonate were isolated from different types of soil samples and were tested for their urease activity. Each isolate were identified morphologically and using basic biochemical tests.Isolates were also further tested for their ability to grow in extreme environment such as high pH, high salt concentration and low nutrient availability.16 out of 28 isolates showed positive results for urease production. Hydrolysis of urea was examined using Christensen's urea agar base. Conductivity method was used to assay urease activity and it was in the range of 0.009-0.051 mS/min.Calcium carbonate precipitation via urea hydrolysis was investigated in both solid and broth media. $CaCO_3$crystals in the precipitation agar media were imaged.The present experimental approach can be potentially useful for a variety of environmental bioremediation applications such as heavy metal removal, self-healing concrete etc.

***Keywords:*** Urease, calcium carbonate precipitation, electric conductivity, soil bacteria.

## INTRODUCTION:

Soil is loose surface material and contains inorganic matter, organic matter, gases and different kinds of micro-organisms. These microorganisms present in soil play a very vital role in different biogeochemical cycles, in degradation of various pollutants, biomineralization process etc.

Urease (urea amidohydrolase: EC3.5.1.5) is an enzyme that hydrolyzes urea into one mole of carbonate and two moles of ammonia per mole of urea, resulting in an increase of the pH and carbonate concentration in the bacterial environment, which induces the formation of calcium carbonate. This enzyme is widespread in plants, bacteria algae , fungi etc.

Calcium carbonate ($CaCO_3$) is a widely distributed mineral in nature. Production of calcite by bacteriais general phenomenon which occurs under appropriate conditions.(Bouquet etal, 1973).Calcium carbonate is widely spread in nature and has major applications in construction industry. Bio mineralization is the science of precipitation of minerals by living organisms. Both eukaryotic and prokaryotic organisms deposit minerals.Most crystals formed by biomineralization consisted of inorganic minerals, which may contain trace organicelements, that can regulate the process of biomineralization. (Yoshida *et al*. 2010).This property was explored by various scientists worldwide and its application in bioengineering field.(Dhami, etal (2013d)).There are different parameters that govern the induction of calcium carbonate precipitation which are; (a) calcium concentration, (b) carbonate concentration, (c) pH of the environment, and (d) presence of nucleation sites.(Hammes and Verstraete (2002)).

The microbial induction mechanism for the precipitation of calcium carbonate is called Microbially Induced Calcite Precipitation (**MICP**). Biologically controlled or biologically inducedis some mechanism by which CaCO3 is precipitated(Lowenstan and Weiner, 1988).

In this study the isolation of ureolytic bacteria is carried out from different soil samples.Urease activity of the isolates is done using conductivity method. Further isolates are tested for calcium carbonate precipitation in both broth and agar state.

## MATERIALS AND METHODS:

### *Sample collection and preparation:*

Soil samples from alkaline locations were used for this study. A total of 3samples were aseptically collected randomly using sterile spatula and put in a sterile zipper bag. The samples were transported to the laboratory and stored at $4^0$C till use.

### *Study area/ location:*

The samples were collected from various locations as follows:

1. Alkaline soil: Niphad
2. Tulsi plant rhizosperesoil:Dindori
3. Cementous soil: Mhasrul, Nashik

### *Enrichment and Isolation of microorganisms:*

All soil samples were enriched by inoculating samples in 50ml sterile nutrient broth pH-9 containing 2% urea and incubated at $37^0$c.For isolation and enumeration of cultivable bacteria, all the samples were serially diluted in saline (NaCl, w/v 0.85%) and plated on alkaline nutrient agar having pH 9), and the plates were incubated at 37°C. Viable bacterial count: Viable bacterial count was done and TVC(cfu/ml) was calculated by usin formula as follows:

TVC (cfu/ml) =Avg. no. of colonies ×dilution factor

Volume plated

The grown bacterial colonies from the plates were sub cultured several times on the same medium from where it was picked.

***Preliminary Screening:***

This screening was mainly based on tolerance of organism against high pH levels and high salt concentrations and growth at minimum nutrient availability. Nutrient broth with varying pH concentrations (pH 8, 9, 10, 11) was prepared. Nutrient broth with varying salt concentrations (NaCl 0.5%, 1%, 1.5%, 2% per 100 ml) was prepared. Each isolate were aseptically inoculated incubated at $37^0$C for 24 – 48 hrs. Growth of organisms was monitored. Half strength Nutrient broth was prepared (i.e. keeping the volume same adding half the amount of component that are added normally). Isolates were aseptically inoculated and incubated at $37^0$C for 24 – 48 hrs. Tubes were monitored for the growth of the isolates.

***Morphological and Biochemical analysis for identification of the isolate:***

All isolates were identified using following tests:

Gram staining, motility test , Indole test Catalase test, Oxidasetest, MR-VP test, urease test ,Starch hydrolysis test, Sugar fermentation test.

***Qualitative urease assay:***

All the isolates were tested for urease activity. This was done by streaking the purified cultures on Christensen's Urea Agar Base which is used for rapid screening of urease enzyme(Himedia)(Dhami et al., 2013d)It composed from (g/l); urea , 20.0; NaCl, 5.0; peptone, 1.0; glucose, 1.0; KH2PO4, 2.0; phenol red, 0.012 and agar, 15.0; (pH 6.5). All components of media were autoclaved except urea which filter-sterilized then added after autoclaving. CUAB were inoculated with isolates, and then kept at 37°C for incubation and were examined continually to record the pink color development.

***Quantitative urease assay by electric conductivity:***

Conductivity method for urease activity assay in the absence of calcium ionswas used in thestudy((Al-Thawadi, 2008, Whiffin, 2004)). For enzyme assay, 1.0ml of bacterial broth culture (NB-U) was added to 9.0 ml of 1.11 M urea solution (Harkes et al., 2010). The urease reaction involves the hydrolysis of non-ionic substrate urea to ionic products thus generating a proportionate increase in conductivity under standard conditions. Final conductivity record could be taken after 5 minutes of incubation at 20ºC by electric conductivity meter (EQUIP-TRONICS NO. EQ-660A).

Urease activity is presented by the rate of conductivity increase as mS/min.

### *Calcium carbonate precipitation test:*

B4 medium(Yeast extract-0.4 gm., glucose 0.5gm, calcium acetate-0.25 gm) (Marvasi.M et al,2012)was used for test.Both broth and agar medium were used for the study. Broth was for tube test were the broth wasaseptically inoculated with test isolates and incubated at $37^0$C for 2-3 weeks and was monitored for formation of precipitates of calcium carbonate (calcite) at the bottom of the tube. While the test isolates were aseptically spot inoculated on the medium plates and incubated at $37^0$C for 2 weeks plates were monitored for observation of accumulation crystals on the colonies of the organism.

### *Confirmatory test for Calcite:*

"Acid test" was used as a confirmatory test for acid production which involves use of 5% of concentrated acid solution which is placed on the surface of the colony present on B4 medium plates. Later the colonies of organism submerged in the drop of 5% acid were monitored for observation of emission of $CO_2$ in the form of effervescences. Colonies showing effervescences showed positive test.

## RESULTS AND DISCUSSION:

### *Preliminary Screening:*

All isolates showed growth in the nutrient broth having pH range from 8-10 and were able to grow in low nutrient availability.

In **sample 1**, 4 out of 7, in **sample 2** , 4 out 0f 8 and in **sample 3** all isolates showed growth in nutrient broth having salt concentration from 0.5% -5%.

### *Morphological and Biochemical analysis for identification of the isolate:*

**Table No.1: Morphological and biochemical identification of isolates.**

| Sample | Code no. | Gram character | Catalase | Oxidase | Indole | MR | Citrate | Urease | glucose | Lactose | Maltose | Nitrate | VP | Starch hydrolysis | CaCO3pptn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | A1 | +ve rods | + | + | + | + | + | ++ | + | + | + | - | - | + | ++ |
|  | A2 | +ve rods | + | + | + | + | + | ++ | + | + | + | + | - | + | ++ |
|  | A3 | +ve rods | + | + | + | + | + | ++ | + | + | + | + | - | + | ++ |
|  | A4 | +ve rods | + | + | + | + | + | ++ | + | + | + | + | - | + | ++ |
|  | A5 | -ve rod | + | + | + | + | - | - | + | + | - | - | - | - | - |
|  | A6 | +vecocci | + | + | - | + | + | - | + | + | + | - | - | + | - |
|  | A7 | +vecocci | + | + | - | + | + | - | + | + | + | - | - | + | - |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. | B1 | +ve rods | + | + | - | + | - | ++ | + | + | + | - | - |  | + |
|  | B2 | +ve rods | + | + | - | + | - | ++ | + | + | + | + | - | + | + |
|  | B3 | +ve rods | + | + | - | + | + | ++ | + | + | + | - | - | + | + |
|  | B4 | +ve rods | + | + | - | + | + | ++ | - | + | + | + | - | + | - |
|  | B5 | +vecocci | + | + | - | + | - | - | + | + | - | - | - | + | - |
|  | B6 | +vecocci | + | + | - | + | - | - | + | + | - | - | - | + | - |
|  | B7 | -ve rod | + | + | - | + | - | - | + | + | - | - | - | + | - |
|  | B8 | -ve rod | + | + | + | + | - | - | + | + | - | + | - | + | - |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. | H1 | +ve rods | + | + | - | + | - | + | +/- | - | - |  | - | + | ++ |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | H2 | +ve rods | + | + | - | + | - | + | +/- | + | - | + | - | + | ++ |
| | H3 | +ve rods | + | + | - | + | - | + | +/- | - | - | + | - | + | ++ |
| | H4 | +ve rods | + | + | - | + | - | + | +/- | + | + | + | - | - | + |
| | H5 | +vecocci | + | + | + | + | - | + | - | - | - | + | - | + | ++ |
| | H6 | +vecocci | + | + | + | + | - | + | + | + | + | + | - | + | + |
| | H7 | +vecocci | + | + | - | + | - | + | - | - | - | + | - | + | ++ |
| | H8 | +vecocci | + | + | - | + | - | + | - | - | - | + | - | +/- | + |

Key:+ = positive,- = negative

### *Qualitative urease activity:*

The capability of isolates to hydrolyze urea by urease was tested onChristensen's Urea Agar medium. Fig.1 shows qualitative urease activity on plate after 24h of incubation. Positive urease activity appeared in plates which its color turned from yellow to pink in comparison with control negative (un-inoculated medium) which still yellow. Out of 28 isolates 16 showed positive results.

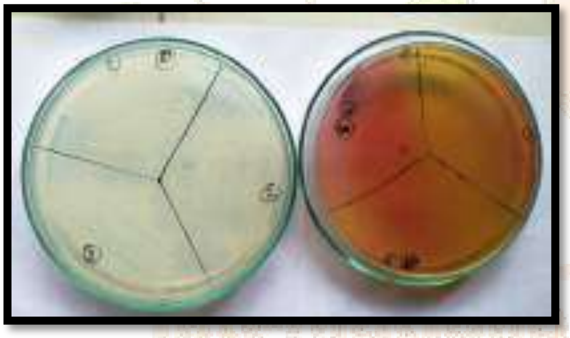


Fig 1: Urease positive test.

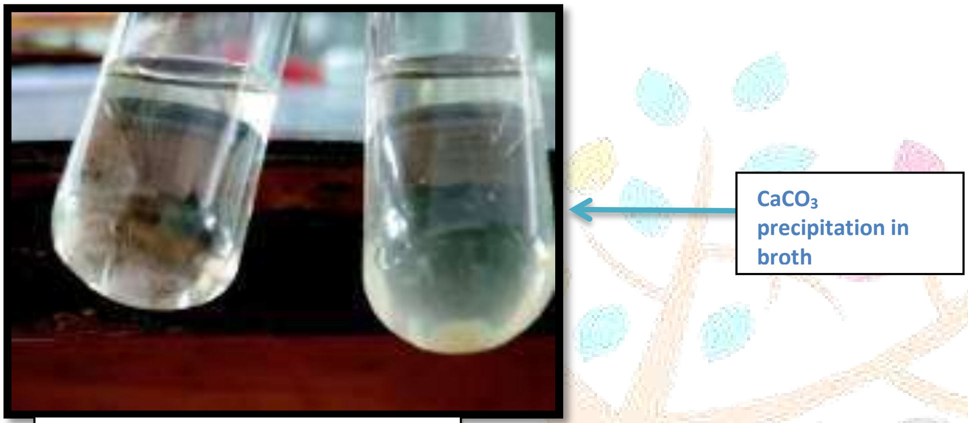
### *Quantitative urease assay by electric conductivity:*

Conductometery is considered to be accurate method for urease assay.After addition of culture into substrate, conductivity was recorded at zero time and at 1, 2, 3, 4, and 5 minutes. As showed in Table no. 2, the conductivity continuously increased with time in a positive proportional relation with urease activity. It shows stability and consistency in the rate of conductivity increase in the first 5 minutes of reaction (i.e. conductivity increase per minute). The rate of enzyme activity was in the range of 0.009-0.051.

Table No. 2 Electric conductivity (EC (mS/S) of urease assay mixture at different time intervals (min).

| Isolate | Electric conductivity (mS/min) | | Isolate | Electric conductivity (mS/min) | |
|---|---|---|---|---|---|
| | 0 min | 5 min | | 0 min | 5 min |
| A1 | 0. 023 | 0.029 | H1 | 0.010 | 0.018 |
| A2 | 0.032 | 0.043 | H2 | 0.012 | 0.016 |
| A3 | 0.029 | 0.030 | H3 | 0.010 | 0.011 |
| A4 | 0.028 | 0.040 | H4 | 0.031 | 0.039 |
| B1 | 0.036 | 0.041 | H5 | 0.033 | 0.034 |
| B2 | 0.042 | 0.047 | H6 | 0.010 | 0.012 |
| B3 | 0.047 | 0.051 | H7 | 0.014 | 0.017 |
| B4 | 0.028 | 0.030 | H8 | 0.007 | 0.009 |

***Calcium carbonate precipitation test:***B4 media was used for $CaCO_3$precipitation test.Calcium carbonate crystals formed in agar appeared as white precipitant within andaround the growth area. Fig.2 and Fig.3 shows the $CaCO_3$precipitation in broth and in plates respectively after 7 days of incubation.



$CaCO_3$ precipitation near colonies.

Fig 2: Calcium carbonate precipitation in broth.

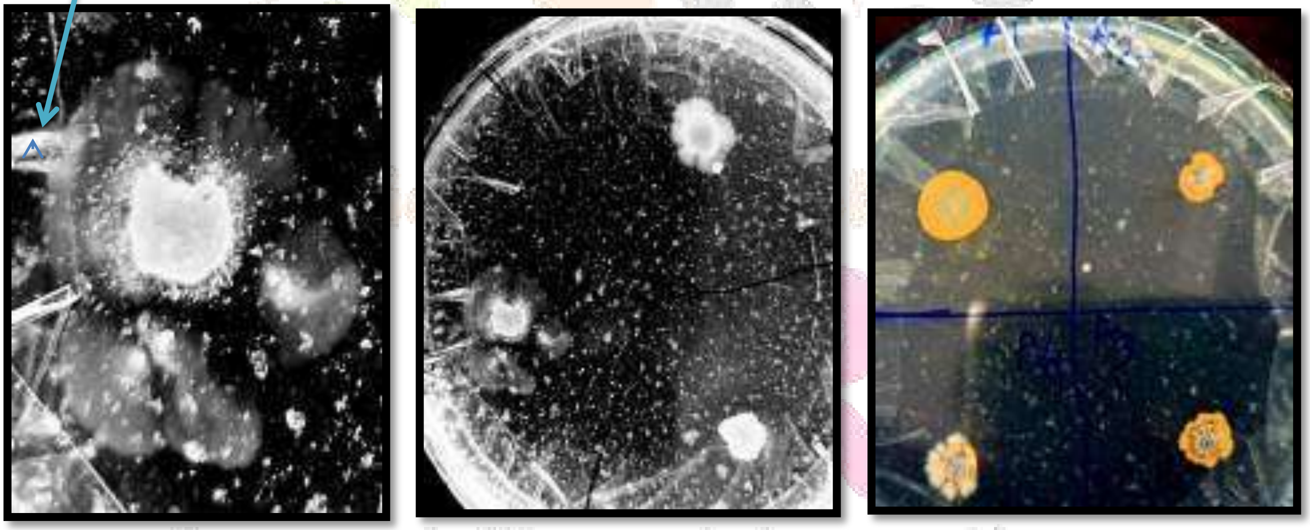


Fig 3: Calcium carbonate precipitation in agar medium within and around growth area.

## CONCLUSION:

In this study, isolation of bacteria was done from different soil samples. All isolates were tested for the growth at high temperature, high pH and high salt concentration. For qualitative analysis of urease activity, Christensen’s Urea Agarwas used and for quantitative assay conductivity method was done.In solid and broth media effective $CaCO_3$ precipitation was tested. The study resulted in 5 efficient isolates capable of producing carbonate precipitates *in vitro* (A2, A4, B1, B2& B3).

Further studies on these isolates is to be carried out to exploit there use in the self-healing approach of concrete.

**ACKNOWLEDGEMENT:**

The authors acknowledge, Principal, MVP's, S.V.K.T College,Deolali Camp and Principal, K.T.H.M College, Nashik (Research Centre)for their support.

## REFERENCES:

1. Al-Thawadi, S. M. (2008) High Strength In-Situ Biocementation of Soil by Calcite Precipitating Locally Isolated Ureolytic Bacteria. Unpublished doctoral thesis, Murdoch University, Perth, Australia.
2. Bang SS, Galinat JK, Ramakrishnan V (2001) Calcite precipitation induced by polyurethane-immobilized Bacillus pasteurii. Enzyme MicrobTechnol 28:404–409
3. Boquet, E., Boronat, A., & Ramos Cormenzana, A. (1973). Production of calcite (calcium carbonate) crystals by syoil bacteria in a general phenomenon. Nature, 246, 527–529
4. Dhami, N. K., Reddy, M. S. and Mukherjee, A. (2013d) 'Biomineralization of calcium carbonate polymorphs by the bacterial strains isolated from calcareous sites', Journal of Microbiology and Biotechnology, 23(5), pp. 707-714.
5. Douglas, S. and Beveridge, T. J. (1998) 'Mineral formation by bacteria in natural microbial communities', FEMS Microbiology Ecology, 26(2), pp. 79-88.
6. Ferris, F. G., Phoenix, V., Fujita, Y. and Smith, R. W. (2004) 'Kinetics of calcite precipitation induced by ureolytic bacteria at 10 to 20°C in artificial groundwater', Geochimica et CosmochimicaActa, 68(8), pp. 1701-1710.
7. Hammes, F., Boon, N., de Villiers, J., Verstraete, W. and Siciliano, S. D. (2003b) 'Strain-specific ureolytic microbial calcium carbonate precipitation', Applied and Environmental Microbiology, 69(8), pp. 4901-4919.
8. Jonkers, H. M. (2007) 'Self healing concrete: a biological approach', in van der Zwaag, S. (ed.) Self Healing Materials: An alternative Approach to 20 Centuries of Materials Science. Netherlands: Springer, pp. 195–204.
9. Knorre, H. V. and Krumbein, W. E. (2000) 'Bacterial Calcification', in Riding, R.E. &Awramik, S.M. (eds.) Microbial Sediments. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 25-31.
10. Lowenstan, H.A. and S. Weiner, (1988). On Biomineralization. Oxford University Press, New York.
11. Massimiliano .M, Kimberley .G .L, Lilliam.C.M, William C. , Gloria .C. V&Visscher.P.T (2012) Importance of B4 Medium in Determining Organomineralization Potential of Bacterial Environmental Isolates, Geomicrobiology Journal, 29:10, 916-924
12. Mobley, H.L.T. and Hausinger, R.P.(2000) Microbial Ureases: significance, regulation and molecular characterization. Microbial Reviews; 53: 85- 108
13. Prescott M.L., John P.H. and Donald A.K. (2005) Textbook of Microbiology, 6th edition,. McGraw Hill, New York.

14. Stabnikov, V., Chu, J., Ivanov, V. and Li, Y. (2013) 'Halotolerant, alkaliphilicureaseproducing bacteria from different climate zones and their application for biocementation of sand', World Journal of Microbiology and Biotechnology, 29(8), pp. 1453-1460.
15. Whiffin, V. S. (2004) Microbial CaCO3 Precipitation for the production of Biocement. Unpublished doctoral thesis, Murdoch University, Perth, Australia.
16. Whiffin, V. S., van Paassen, L. A. and Harkes, M. P. (2007) 'Microbial Carbonate Precipitation as a Soil Improvement Technique', Geomicrobiology Journal, 24(5), pp. 417-423.

# रशिया–युक्रेन युद्ध : एक दृष्टिक्षेप

**प्रा. सतीश सुभाष कावळे,**
राज्यशास्त्र विभाग, एस. व्ही. के. टी. कला, विज्ञान व वाणिज्य महाविद्यालय,
देवळाली कॅम्प, नाशिक.

**प्रस्तावना :**

कित्येक दिवसांपासून चाललेल्या रशिया आणि युक्रेन यांच्यामधील तणावाची परिमिती अखेरीस युद्धात झाली. दोन्ही देशांमधील तणावाची परिस्थिती फार काळ टिकेल आणि त्यातून गंभीर परिस्थिती निर्माण होईल, असे जगातील कोणत्याही राष्ट्राला वाटले नव्हते. हा प्रश्न चर्चेने व शांततेच्या मार्गाने सुटेल अशी सर्वांना खात्री होती. परंतु एक–दोन दिवसात सुटणारा हा प्रश्न नाही हे सर्वांच्याच लक्षात आले. हा संघर्ष संपण्याऐवजी अधिकाधिक चिघळत व वाढतच गेला. यातून सर्व राष्ट्रांमध्ये भीतीचे वातावरण निर्माण होऊ लागले आहे. त्यात 'नाटो' सारख्या संघटनेने या युद्धात भाग घेतल्यामुळे रशिया आणि युक्रेन यांच्यामधील पेचप्रसंग सुटण्याऐवजी तो वाढतच राहिल्याचे दिसते. रशियाचे राष्ट्राध्यक्ष व्लादिमीर पुतीन यांनी वेळोवेळी आपण युक्रेनमधून सैन्य माघार घेणार नाही, असे जगाला वेळोवेळी ठणकावून सांगितले. परिणामी या संघर्षामध्ये युरोपियन देश आणि अमेरिकाविरुद्ध रशिया हा संघर्ष सुरू राहिलेला दिसतो. रशियाला अडचणीत आणण्याची एकही संधी अमेरिका कधीही सोडत नाही. हे जागतिक इतिहासावरून आपल्या लक्षात येतच असेल. अशा प्रसंगी अमेरिकेने रशियावर मोठ्या प्रमाणात आर्थिक निर्बंध जाहीर केले आहेत. रशियाला जागतिक राजकारणात एकटे कसे पाडता येईल आणि रशियाची आर्थिक कोंडी कशी करता येईल, अशा प्रकारचे कपटी राजकारण अमेरिका करताना दिसते. तर दुसरीकडे अमेरिका आणि रशियाच्या या संघर्षात युक्रेनसारखा देश पिळवटून निघत आहे. अशावेळी एक महत्वाची भूमिका घेऊन रशिया आणि युक्रेन यांनी चर्चेने हा प्रश्न सोडवणे आवश्यक आहे. कारण रशिया आणि युक्रेनचा हा संघर्ष सोडविण्याऐवजी त्याचा फायदा कसा घेता येईल यासाठीच बरीच राष्ट्रे प्रयत्नशील आहेत. म्हणून या दोन्ही देशांनी आपली आर्थिक आणि लष्करी हानी होण्यापेक्षा हा प्रश्न द्विपक्ष चर्चेने सोडविणे आवश्यक आहे.

**उद्दिष्टे :**

१. सद्यस्थितीच्या जागतिक राजकारणाचा अभ्यास करणे.
२. रशिया आणि युक्रेन यांच्यातील तणावाची कारणे समजून घेणे.
३. अमेरिकेच्या जागतिक धोरणाचे विश्लेषण करणे.
४. नाटो संघटनेचे कार्य आणि हेतू समजून घेणे.
५. रशिया आणि युक्रेन यांच्यातील सद्यस्थितीत असणारी आर्थिक, सामाजिक, लष्करीशक्तीची तुलना करणे.
६. रशिया–युक्रेन संघर्षामुळे बदलणाऱ्या जागतिक समीकरणांचा आढावा घेणे.
७. रशिया–युक्रेन संघर्ष आणि भारताची भूमिका समजून घेणे.

**गृहीतके :**

१. रशिया आणि युक्रेन यांच्यातील आर्थिक, राजकीय व लष्करी स्थिती भिन्न स्वरूपाची आहे.
२. रशियाचे जागतिक लष्करी सामर्थ्य.
३. युक्रेनचा नाटोकडे झुकता कल.
४. नाटोच्या माध्यमातून अमेरिकेचे स्वार्थी राजकारण.
५. रशियाचे साम्राज्यवादी व विस्तारवादी धोरण.
६. युक्रेनच्या नैसर्गिक आणि भौगोलिक बाबींचे रशियाच्या दृष्टिकोनातून महत्त्व.
७. 'नाटोची' आंतरराष्ट्रीय राजकारणातील भूमिका.

**संशोधन पद्धती :** प्रस्तुत शोधनिबंधासाठी

ऐतिहासिक वर्णनात्मक व विश्लेषणात्मक पद्धतीचा अवलंब केला आहे. तसेच वर्तमानपत्रे, मासिके, न्यूज चॅनेल, इंटरनेट या दुय्यम साधनांचा उपयोग केला आहे.

### युक्रेन–रशिया संघर्षाची कारणे :

#### १. 'नाटो' चा युक्रेनवर वाढता प्रभाव :

ज्या प्रकारे भारत आणि पाकिस्तान ही दोन राष्ट्रे एकाच दिवशी अस्तित्वात आलीत, त्याच प्रकारे रशिया आणि युक्रेन ही राष्ट्रे एकाच दिवशी जन्माला आली. अमेरिका आणि सोव्हिएत संघ यांच्यातील संघर्ष किंवा शीतयुद्ध रशियाच्या विघटनामुळे संपुष्टात आले. २५ डिसेंबर १९९१ रोजी सोव्हिएत संघाचे विघटन झाले आणि नव्या १५ देशांची निर्मिती झाली. या १५ देशांमधूनच बाहेर पडलेला एक देश म्हणजे युक्रेन होय. सोव्हिएत संघ प्रथमपासूनच कम्युनिस्ट गटाचे नेतृत्व करीत होता, तर अमेरिकेसारखा देश भांडवलशाही देशांचे नेतृत्व करीत होता. या संघर्षात अमेरिकेला यश मिळाले. १९९१ नंतर एक महासत्ता म्हणून अमेरिकेने वर्चस्व जगातील सर्वच राष्ट्रांवर राहिले. अमेरिकेला शह देऊ शकेल किंवा अमेरिकेला विरोध करू शकेल, असे एकही राष्ट्र सोव्हिएत संघाच्या विघटनानंतर अस्तित्वात राहिले नाही. परिणामी अमेरिका ही एकमेव महासत्ता म्हणून जगावर वर्चस्व गाजवताना दिसते. अमेरिकेने शीतयुद्धाच्या काळातच पश्चिमी राष्ट्रांना सोबत घेऊन एक लष्करी गट म्हणजेच 'नाटो संघटना' तयार केली. युक्रेन हा देश सोव्हिएत युनियनमधून वेगळा झाल्यापासून रशिया आणि युक्रेन यांच्यात अंतर्गत संघर्ष पाहायला मिळत होता. युक्रेन हा रशियाचाच भाग असून त्याचं स्वतंत्र अस्तित्व मान्य करायला रशिया तयार नाही. अशा वेळी युक्रेन आणि 'नाटो' या देशांची जवळीकता हा रशियासाठी चिंतेचा विषय बनला आहे. युक्रेनला नाटोचे सदस्यत्व मिळण्यास रशियाचा तीव्र विरोध आहे. तसं झालं तर आशियातील रशियाचे महत्त्व कमी होणार, अशी भीती रशियाला आहे. 'नाटो म्हणजे 'नॉर्थ अटलांटिक ट्रीटी ऑर्गनायझेशन' ही जगातील २९ देशांचा सहभाग असलेली अमेरिकाप्रणीत एक लष्करी संघटना आहे. 'नाटोची' स्थापना ०४ एप्रिल १९४९ रोजी १२ राष्ट्रांनी केली. दुसऱ्या महायुद्धानंतर नाटोची स्थापना करण्यात आली. उत्तर अटलांटिक प्रदेशातील राष्ट्रांमध्ये राजकीय स्वातंत्र्य, समान संस्कृती व आर्थिक स्थैर्य निर्माण करून देणे व सभासद राष्ट्रांना संरक्षण देणे या गोष्टी सर्व सभासद राष्ट्रांना बंधनकारक आहेत. नाटोच्या माध्यमातून युरोपियन राष्ट्रे विशेषत: अमेरिकेसारखे राष्ट्र रशियाच्या उंबरठ्यापर्यंत येऊन पोहोचतील, अशी भीती व्लादिमीर पुतीन यांना आहे. युरोपियन राष्ट्रे आणि युक्रेन यांची जवळीकता संपुष्टात यावी आणि युक्रेन नेहमी रशियन विचाराने भारलेला असावा, असा विचार पुतीन करताना दिसतात. नाटोच्या आणि युक्रेनच्या या जवळीकतेतूनच सद्यपरिस्थिती उद्भवलेली आपणास दिसते.

#### २. युक्रेनमधील नैसर्गिक साधन संपत्ती :

युक्रेन येथील भूभाग हा अतिशय सुपीक आहे. त्यामुळे येथे गव्हाचे उत्पादन मोठ्या प्रमाणात घेता येते. युक्रेनच्या शेजारी असणारे पूर्व युरोप ही एक मोठी बाजारपेठ मिळालेली दिसते. याशिवाय युक्रेनमधील 'लुहान्स्क' व 'डोनेत्स्क' हे दोन्ही भाग 'दोनबास' नदीच्या खोऱ्यात येताना दिसतात. नदी खोऱ्यातला हा भाग रशियाचा भूभाग असल्याचे रशिया नेहमी सांगत आले आहे. यातील 'डोनेत्स्क' या ठिकाणी कोळसा खाणी मोठ्या प्रमाणात उपलब्ध आहेत. जवळजवळ युक्रेनमधील कोळसा खाणीचे ते एक महत्त्वाचे केंद्र आहे. सोव्हिएत संघाच्या काळातच या ठिकाणी स्टील उद्योगही मोठ्या प्रमाणात वाढला गेला. १९९१ नंतरच्या सोव्हिएत संघ फुटीनंतर हे दोन्ही प्रांत स्वतंत्र युक्रेनचा भाग झालेत, परंतु प्रत्यक्ष राष्ट्राध्यक्ष व्लादिमीर पुतीन हे युक्रेन हा रशियाचाच भाग असल्याचे मानतात. सध्या हे दोन्ही प्रांत अधिकृतरीत्या युक्रेनचा हिस्सा असले, तरी यातील 'डोनेत्स्क' भागातल्या सुमारे साडेसात लाख नागरिकांकडे रशियन पासपोर्ट आहे आणि हे लोक रशियाच्या निवडणुकीत मतदान करतात. याशिवाय युक्रेनकडे मोठा सुपीक भूप्रदेश, औद्योगिक कारखाने तसेच तेल व नैसर्गिक वायूचे स्रोत आहेत. याशिवाय महत्त्वाचे म्हणजे 'ब्लॅक सी' हे त्यांचे भूसामरिक सामर्थ्य आहे. या सर्वांचा विचार करता रशियाला हा भूभाग आपल्या प्रदेशास जोडल्यास मोठा लाभ मिळू शकेल, असे वाटते. यातूनच १९९१ पासूनच रशिया आणि युक्रेन यांच्यात संघर्ष सुरू होता. या संघर्षात खरी ठिणगी ही २०१२-१३ पासून पडलेली दिसते. या कालखंडापासून हा संघर्ष दिवसेंदिवस वाढत गेला आणि अखेरीस रशिया-युक्रेन युद्धाला तोंड फुटले.

रशियाने सुरू केलेल्या या युद्धाला जगातील अनेक देशांनी विरोध दर्शवला. अमेरिकेसारख्या महासत्तेने आणि

युरोपियन युनियन यांनी रशियावर अनेक निर्बंध लागू केले. त्यानुसार रशियन अर्थव्यवस्था कशी कोलमडेल त्यासाठी व्यक्ती आणि संस्थांशी संबंधित निर्बंध, बँकिंग आणि वित्तीय सेवा, निर्यात आणि आयात सेवा, तंत्रज्ञान, ऊर्जा, तेल, वायू, कोळसा, पोलाद, खाणकाम आणि शेती यासारख्या क्षेत्रांवर बंधने लादण्यात आली. रशियानेही आपल्यावरील आर्थिक झळ कमी व्हावी यासाठी अनेक पावले उचललीत. यात भांडवली नियंत्रणे, लोकांना चलन हस्तांतरण बंदी करणे. काही वस्तू, कच्चामाल आणि उपकरणे यांच्या निर्यातीवर बंधने घातली. इंधन रुबलमध्ये खरेदी करणे, अशा अनेक उपायांद्वारे रशिया आपली आर्थिक बाजू सांभाळताना दिसत आहे.

रशिया-युक्रेन युद्धाचा विचार करता दोन्ही राष्ट्रे शस्त्रसंपन्न असली तरी याबाबत दोघांची तुलना होणे अवघड आहे. शस्त्राचा विचार करता रशिया अण्वस्त्र संपन्न असलेले राष्ट्र आहे. त्यामुळे या युद्धात युक्रेनचा किती टिकाव लागेल हा एक महत्त्वाचा प्रश्न आहे. पुढील उपलब्ध साधनांद्वारे आपल्याला दोन्ही राष्ट्रांमधील तफावत जाणून घेता येईल.

| Sr. No. | Available Materials | Russia | Ukraine |
|---|---|---|---|
| १. | Population | 146,047,248 | 43,192,122 |
| २. | Nominal GDP | 1.71 Trillion | 203.93 Billion |
| ३. | Active Person | 1,014,000 | 2,45,000 |
| ४. | Combat Tank | 20,800 | 6,500 |
| ५. | Armoured Vehicles | 36000 | 7,000 |
| ६. | Rocket Projectors | 4,000 | 550 |
| ७. | Total Artillery | 11,200 | 3,100 |
| ८. | Total Helicopters | 1,570 | 140 |
| ९. | Navy-Submarine | 70 | 00 |
| १०. | Corvettes | 85 | 01 |
| ११. | Fleet Strength | ५९८ | ३८ |
| १२. | Nuclear Weapons | ५,५८० | ०० |

वरील तक्त्यावरून असे लक्षात येते की, रशिया हा युक्रेनपेक्षा अधिक पटीने सक्षम आहे.

### भारत आणि रशिया-युक्रेन युद्ध :

भारताचा विचार करता भारत आणि रशिया यांची मैत्री जगप्रसिद्ध आहे. जेव्हा-जेव्हा भारताला गरज पडली तेव्हा-तेव्हा रशिया खंबीरपणे भारताच्या पाठीमागे उभा राहिला. रशिया आणि युक्रेन यांच्या युद्धात भारताने ही तटस्थता दाखवण्याचा प्रयत्न केला. संयुक्त राष्ट्राने मांडलेल्या रशियाच्या विरोधातील निंदाजनक प्रस्तावाच्या विरोधात भारताने कोणाच्याही बाजूने मतदान न करता तटस्थतेची भूमिका घेतली. या वेळी भारताचे परराष्ट्र मंत्री जयशंकर यांनी केवळ दोन्ही देशांना शांततेच्या मार्गाने चर्चा करण्याचे आवाहन केले. भारताच्या या तटस्थतेमुळे अमेरिकेने भारतावर दबाव टाकण्याचा बराचसा प्रयत्न केला. परंतु अशा दबावाला बळी न पडता भारताने आपली जागतिक भूमिका स्पष्ट केली. एवढेच नाही, तर अमेरिकेने रशियावर आर्थिक निर्बंध लागू केले. अशा वेळी रशियाकडून उत्पादित होणारे कच्चे तेल घेण्यास कोणताही देश तयार नसताना भारताने मात्र रशियाकडून मोठ्या प्रमाणात कच्चे तेल आयात केले. यावर अमेरिका आणि युरोपियन देशांनी भारतावर रशियाकडून तेल न खरेदी करण्यासाठी दबाव तंत्राचा अवलंब करण्यास सुरुवात केली. अशाही परिस्थितीत भारत न डगमगता रशियाकडून तेल खरेदी करू लागला. एक प्रकारे आर्थिक निर्बंधाच्या काळात रशियाला आर्थिक मदत देण्याचे धोरण भारताचे दिसून येते. त्यामुळे रशिया-युक्रेन युद्धप्रसंगी जगासमोर भारताचे एक नवीन चित्र उभे राहिले. भारत कोणाही समोर न झुकता आपले परराष्ट्र धोरण बनवतो, असा संदेश जगातील सर्व राष्ट्रांना गेला. नुकतेच युक्रेनचे पंतप्रधान झेलेंस्की यांनी भारताला रशिया आणि युक्रेनचे युद्ध थांबवावे यासाठी प्रयत्न करावे, अशा प्रकारचे आवाहन भारताला केले. एक प्रकारे भारताचे जागतिक महत्त्व आणि भारताची जागतिक राजकारणातील भूमिका यातून स्पष्ट होताना दिसत आहे. याचा निश्चितच भारताला येणाऱ्या काळात मोठा फायदा होणार आहे.

### निष्कर्ष :

जागतिक राजकारणात 'नाटो' सारखी संघटना आपले विस्तारवादी धोरण राबवताना दिसते. या संघटनेत जास्तीत जास्त देश कसे सहभागी होऊ शकतील असा प्रयत्न ही संघटना, विशेषता अमेरिका करताना दिसते. या

संघटनेवर अमेरिकेचे संपूर्ण नियंत्रण प्रस्थापित झाल्याचे बघायला मिळते. या संघटनेत सहभागी होणाऱ्या राष्ट्रांवरही अमेरिकेसारख्या महासत्ता असणाऱ्या राष्ट्रांचा प्रभाव निर्माण झाल्याचे दिसते. एक प्रकारे रशियाला घेरण्याचा व कोंडीत पकडण्याचा प्रयत्न नाटोच्या माध्यमातून अमेरिकेसारख्या राष्ट्रांनी केलेला दिसतो. परंतु रशियाने युक्रेन बरोबर युद्ध सुरू करून एक प्रकारे नाटोसारख्या संघटनेला आव्हान दिले आहे. 'या युद्धात युक्रेन हा एकटा लढतोय' या झेलेन्स्की यांच्या विधानावरून असे लक्षात येते की, नाटोसारखी संघटनादेखील रशियाच्या आक्रमक धोरणापुढे शिथिल झाल्याचे या नमते घेत असल्याचे दिसते. यातून भविष्यात निश्चितच नाटोसारख्या संघटनेवरील विश्वास कमी वा इतर देशांवरचा प्रभाव कमी होऊ शकेल. पर्यायाने अमेरिकेसारख्या महाशक्तिशाली राष्ट्रांची दादागिरी व मनमानी कारभारावर निश्चितच नियंत्रण प्रस्थापित होईल यात शंका नाही.

**संदर्भ :**

१. https://www.youtube.com/watch?v=eg5d6dvmGZU
२. https://sanatanprabhat.org
३. https://www.bbc.com
४. https://maharashtratimes.com

**नवोदीत संशोधकांसाठी**

**कॉम्रेड प्राचार्य डॉ. विठ्ठल मोरे पारितोषिक**

राज्यशास्त्र व लोकप्रशासन विषयाचे पदव्युत्तर विद्यार्थी/पीएच.डी. संशोधक विद्यार्थी / सहाय्यक प्राध्यापक फक्त यांचेसाठी महाराष्ट्र राज्यशास्त्र व लोकप्रशासन परिषदेच्या वार्षिक अधिवेशनात प्रत्यक्ष उपस्थित राहून पेपर सादर करणाऱ्यांकरीता कॉम्रेड प्राचार्य डॉ. विठ्ठल मोरे पारितोषिक.

**उत्कृष्ट संशोधन पेपर सादरीकरण**

**प्रथम पारितोषिक:**-२१०० रुपये रोख सन्मानचिन्ह व प्रमाणपत्र
**द्वितीय पारितोषिक** -१००१ रुपये रोख सन्मानचिन्ह व प्रमाणपत्र
**तृतीय पारितोषिक**- ७०१ रुपये रोख सन्मानचिन्ह व प्रमाणपत्र
इतर तीन प्रोत्साहन पर प्रमाणपत्र
(टीप पेपर सादरीकरणासाठी विषय बंधन नाही.)

VOLUME - XI, ISSUE - II - FEBRUARY - JULY - 2023 CC-06
GENIUS - ISSN 2279 - 0489 - IMPACT FACTOR - 7.508 (www.sjifactor.com)

# ८. राष्ट्रीय शैक्षणिक धोरण आणि डिजिटल साधने

**प्रा. सतिश सुभाष कावळे**
राज्यशास्त्र विभाग, एस. व्ही. के. टी. महाविद्यालय, देवळाली कॅम्प, नाशिक.

## प्रस्तावना

देशाला स्वातंत्र्य मिळाल्या बरोबर भारतीय राज्यकर्त्यांनी शिक्षण व्यवस्थेला आपल्या धोरणात महत्वाचे प्राधान्य दिले.
तत्कालीन परिस्थितीचा विचार करून राज्य सरकार आणि केंद्रांनी मिळून अनुरूप धोरण आखावे असा सल्ला देण्यात आला.स्वातंत्र्या
नंतर सर्वात मोठी समस्या होती ती म्हणजे शिक्षणाचा ग्रामीण भागातील प्रत्येक घटकांन पर्यंत शिक्षण पोहचवणे, तसेच निरक्षरता, स्त्री
शिक्षण, मागासलेले, अल्पसंख्यांकाना या प्रवाहात आणणे. याशिवाय शिक्षणा संबंधीच्या पायाभूत सुविधा उपलब्ध करून देणे.या
सर्व समस्या सोडविण्यासाठी केंद्र सरकारने प्रथम १९४८ मध्ये डॉ. राधाकृष्णन यांच्या अध्यक्षतेखाली विश्वविद्यालय शिक्षा समिति
गठीत केली.त्यांतर १९५२ मध्ये डॉ.लक्ष्मण मुदलियार यांच्या अध्यक्षते खाली माध्यमिक शिक्षा आयोग तर १९६४ मध्ये विविध
शैक्षणिक समस्यांच्या अभ्यासाकरिता व त्याच्या नीराकरणा करीता डॉ. दौलत सिह कोठारी यांच्या अध्यक्षतेखाली 'शिक्षा आयोग'
गठीत करण्यात आला.या शिवाय शैक्षणिक धोरणाचा विचार करता १९६८ मध्ये पहिले शैक्षणिक धोरण, १९८६ मध्ये दुसरे शैक्षणिक
धोरण, १९९२ मध्ये तिसरे शैक्षणिक धोरण बदलण्यात आले होते. २९ जुलै २०२० रोजी झालेल्या केंद्रीय मंत्रिमंडळाच्या बैठकीत
नवीन शैक्षणिक पद्धतीला मंजुरी दिली. जवळ जवळ ३४ ते ३५ वर्षानंतर देशाच्या शिक्षण पद्धतीमध्ये मोठे मोठे बदल या दृष्टिकोनातून
करण्यात आले, मनुष्यबळ विकास मंत्री डॉ. कस्तुरी रंगन यांच्या अध्यक्षतेखाली नवीन शैक्षणिक धोरणाचा मसुदा तयार करण्यात
आला आहे. भारताचे आतापर्यंत तिसरे शैक्षणिक धोरण असून हे धोरण बनवताना सरकारने अनेक लोकांकडून सल्ले मागवली होते.
त्यानुसार आता यात मोठे बदल करण्यात आले त्यानुसार शालेय शिक्षणाचे स्वरूप १०+२ ऐवजी ५+३+३+४ असे करण्यात आले
आहे.उच्च शिक्षणामध्ये ही मोठ्या प्रमाणात बदल या ठिकाणी केलेले आहे. अनेक नवीन बाबींचा समावेश यात केला आहे. उच्च
शिक्षणातील समता आणि समावेशकता उच्च शिक्षणाच्या संस्थांमध्ये प्रभावी व्यवस्थापन आणि नेतृत्व, व्यावसायिक शिक्षण
प्रौढशिक्षण व निरंतर शिक्षण,शैक्षणिक संस्था व महविद्यालयाना स्वायत्ततेचे धोरण, भारतीय भाषा आणि संस्कृतीला प्रोत्साहन,
तंत्रज्ञानाचा वापर व एकात्मिकरण ऑनलाईन आणि डिजिटल शिक्षण, तंत्रज्ञानाचा वापर सुनिश्चित करणे. यासारख्या महत्त्वपूर्ण
बाबींचा समावेश या ठिकाणी केलेला दिसतो.आधुनिकता आणि तंत्रज्ञान यांचा विचार करता आजच्या काळामध्ये ऑनलाईन आणि
डिजिटल शिक्षण ही एक महत्त्वपूर्ण गरज बनली आहे. ऑनलाइन शिक्षणाचा अनुभव आपण बऱ्याच अंशी कोविड-१९ च्या काळात
घेतला आहे. विद्यार्थी या तंत्रज्ञानाचा वापर करण्यासाठी सक्षम व्हावा तसेच त्याला या तंत्रज्ञानाची माहिती आणि हाताळणी योग्य

पद्धतीने व्हावी यासाठी अनेक नवीन ऑनलाईन आणि डिजिटल बाबींचा विचार या शैक्षणिक धोरणामध्ये केलेला त्याची सविस्तर माहिती आपल्याला पुढील प्रमाणे बघता येईल.

**विषय विवेचन**

नवीन राष्ट्रीय शैक्षणिक धोरण-२०२०नुसार शालेय शिक्षण उच्च शिक्षण यात महत्वपूर्ण बदल करण्यात आले आहे. एकविसाव्या शतकातीलहे पहिले शैक्षणिक धोरण आहे. आणि या धोरणाचे ध्येय आपल्या देशातील वाढत्या विकासात्मक आवश्यकतांवर उपाययोजना करणे हे आहे. या धोरणामध्ये २१च्या शतकातील शिक्षणाच्या महत्वकांक्षी उद्दिष्टांशी सुसंगत अशी नवीन प्रणाली तयार करण्यासाठी भारताच्या परंपरा आणि मूल्य यावर भर देऊन शैक्षणिक रचनेचे नियमन आणि व्यवस्थापन या रचनेच्या सर्व पैलुन मध्ये बदल आणि सुधारणा अपेक्षित आहे. हे धोरण विशेषतः प्रत्येक व्यक्तीच्या सृजनक्षमतेच्या विकासावर जास्त भर देते. शिक्षणाने केवळ आकलन क्षमता विकसित केल्या पाहिजे असे नाही तर साक्षरता आणि संख्याज्ञान या मूलभूत क्षमता आणि उच्च दर्जाच्या तार्किक आणि समस्या निराकरण क्षमताच नव्हे तर सामाजिक नैतिक आणि भावनिक क्षमतांचा विकास सुद्धा केला पाहिजे. त्यानुसार हे नवीन धोरण तयार केलेले आहे. या अगोदरच्या शैक्षणिक धोरणामध्ये मुख्यतः प्रवेश आणि समानतेवर भर दिला होता. परंतु आधीच्या धोरणातील पूर्ण न झालेले काम या धोरणाद्वारे पूर्ण करण्याचा पुरेपूर प्रयत्न करण्यात आला आहे. १९८६/९२च्या मागील धोरणामधीलएक महत्वाचा निर्णय म्हणजे 'निशुल्क' आणि अन्य 'वर्गीय शिक्षण' याद्वारे सार्वजनिक प्राथमिक शिक्षण हे कायदेशीर दृष्टिकोनातून उपलब्ध करून देण्यात आले.याशिवाय प्रारंभीच्या शैक्षणिक धोरणानुसार १०+२ असा फॉर्मुला होता त्यानुसार पहिली ते दहावीचे १० वर्ष आणि अकरावी व बारावी मिळवून २ वर्ष असे १०+२ असा फॉर्म्युला होता पण आता यात बदल करून ५ +३ +३ +४ नवीन फॉर्मुला अमलात आणला जाईल, यामध्ये ५ म्हणजे प्री स्कूल ची ३ वर्ष आणि पहिली व दुसरीचे २ वर्ष , तिसरी व चौथी आणि पाचवी चे एकूण ३ वर्ष, सहावी सातवी आणि आठवीचे एकूण ३ वर्ष आणि नववी, दहावी, अकरावी आणि बारावीचे ४ वर्षे अशाप्रकारे हा नवीन फार्मूला लागू करण्यात आला आहे. यानुसार लहान मुलं आता तीन वर्षापासून शाळेत जाऊ शकणार आहे. सध्या ६ वर्षांची लहान मुलं पहिलीत जातात नव्या धोरणात सुद्धा सहाव्या वर्षीच लहान मुल पहिलीत असतील परंतु त्याच्या आधी ३ वर्षांचे शिक्षण आता औपचारिक पद्धतीने गणले जाईल प्ले स्कूलची म्हणजेच के.जी, नर्सरीची तीन वर्षे शालेय शिक्षणाचा आता भाग असणार आहे. महाविद्यालयीन शिक्षणात कला वाणिज्य आणि विज्ञान अशा तीन शाखा प्रवेश प्रक्रियेत आहेत पण नवीन मसुद्यानुसार कला आणि वाणिज्य या शाखांमध्ये काही विषय निवडून विद्यार्थ्यांनी पदवी शिक्षण घेत येणार आहे यामध्ये मानवी शिक्षण विज्ञान कला स्पोर्ट्स वोकेशनल कोर्स असे पर्यायअसतील याशिवायपदवी मिळवण्यासाठी आता विद्यार्थ्यांना ४ वर्षे शिक्षण घ्यावे लागेल त्यानुसार पहिल्या वर्षी विद्यार्थ्याला केवळ 'सर्टिफिकेट' दिले जाईल दुसऱ्या वर्षी 'ॲडव्हान्स सर्टिफिकेट' दिले जाईल तिसऱ्या वर्षी 'पदवी' आणि चार वर्षे पूर्ण केल्यास 'पदवीच प्रमाणपत्र' दिले जाईल तर पदवीत्तर शिक्षणासाठी विद्यार्थ्यांना तीन प्रकारचे पर्याय दिले जातील दोन वर्षांचा पदव्युत्तर अभ्यासक्रम अशा विद्यार्थ्यांकरता असेल ज्यांनी तीन वर्षांचा डिग्री अर्थात पदवी अभ्यासक्रम पूर्ण केला आहे. आणि दुसरा पर्याय म्हणजे एका वर्षाच्या पदव्युत्तर अभ्यासक्रमाचा असेल हा चार वर्षांचा पदवी

अभ्यासक्रम पूर्ण करणाऱ्या विद्यार्थ्यांसाठी हा पर्याय असेल आणि तिसरा पर्याय म्हणजे पाच वर्षांचा 'इंटिग्रेटेड प्रोग्रॅम' असेल यामध्ये 'ग्रॅज्युएशन' आणि 'पोस्ट ग्रॅज्युएशन' दोन्ही एकत्रित पूर्ण करता येईल याशिवाय 'पी.एचडी' करणाऱ्या विद्यार्थ्यांसाठी आता ती पाच ऐवजी चार वर्षांत पूर्ण करता येईल. नव्या संरचनेनुसार एम.फिल.हाअभ्यासक्रम बंद करण्याची तरतूद केली आहे. आता एमफिलची डिग्री न घेता ही पीएचडी करता येणार आहे.

**उद्दिष्टे**

१. नवीन राष्ट्रीय शैक्षणिक धोरण समजून घेणे.
२. नवीन राष्ट्रीय शैक्षणिक धोरणातील महत्त्वपूर्ण बाबींचा अभ्यास करणे.
३. जुने राष्ट्रीय शैक्षणिक धोरण आणि नवीन राष्ट्रीय शैक्षणिक धोरण यांच्यातील फरक जाणून घेणे.
४. नवीन राष्ट्रीय शैक्षणिक धोरणातीलउच्च शैक्षणिक धोरणे समजून घेणे.
५. नवीन राष्ट्रीय शैक्षणिक धोरणाचा सामाजिक सांस्कृतिक आणि राजकीय दृष्टिकोनातून विचार करणे.
६. नवीन राष्ट्रीय शैक्षणिक धोरणातील ऑनलाईनडिजिटल शिक्षणातील संधींचा अभ्यास करणे
७. नवीन राष्ट्रीय शैक्षणिक धोरणे आणि आव्हाने समजून घेणे.

**गृहीतके**

१. नवीन राष्ट्रीय शैक्षणिक धोरणाद्वारे आधुनिक शिक्षण कडे वाटचाल.
२. ऑनलाईन व डिजिटल शिक्षण ही काळाची गरज
३. शिक्षणाबरोबरच कला साहित्य संस्कृती या विषयांवर भर.
४. शिक्षणासाठी जागतिक दर्जाच्या डिजिटल पायाभूत सुविधा शैक्षणिक डिजिटल सामग्री आणि क्षमता निर्माण करणारे युनिट तयार करण्यावर भर.
५. शालेय शिक्षण ते उच्च शिक्षण पर्यंत सर्व पातळीवरील शिक्षणाच्या अभ्यासक्रमात सुसूत्रता शिकण्यासाठी सातत्यपूर्ण मूल्यांकनावर भर बहुशाखीय समग्र शिक्षणाचा विकास.
६. अध्यापन आणि अध्ययनात तंत्रज्ञानाचा पुरेपूर वापर.

**संशोधन पद्धती**

प्रस्तुत शोध निबंधासाठी ऐतिहासिक वर्णनात्मक व विश्लेषणात्मक पद्धतीचा अवलंब केला आहे. तसेच वर्तमानपत्रे, मासिके, न्यूज चैनल, इंटरनेट या दुय्यम साधनांचा उपयोग केला.

**नवीन राष्ट्रीय शैक्षणिक धोरण आणि ऑनलाईन आणि डिजिटल शिक्षण**

आधुनिक काळानुसार शैक्षणिक साधनांमध्ये देखील मोठ्या प्रमाणात बदल झालेला दिसतो केवळ 'फळा खडू' आणि 'अभ्यासक्रम पुस्तके' या चौकटीतून बाहेर पडत नवनवीन साधनांचा उपयोग या शैक्षणिक धोरणानुसार स्वीकारण्यात आला आहे.

वास्तविक २०१९ नंतर जगभर covid-19 या महामारीने जगभर थैमान घातले असताना आणि सर्वच राष्ट्रांचे सामाजिक, राजकीय, धार्मिक प्रकारचे जीवन बंदिस्त झाले लॉकडाऊन हा शब्द खऱ्या अर्थाने या काळात रूढ झाला. या वाढत असलेले साथीचे रोग आणि महामारीची परिस्थिती लक्षात घेता जेव्हा कधी आणि जिथे कुठे पारंपारिक आणि प्रत्यक्ष शिकवण्याच्या माध्यमांचा वापर शक्य नसेल तेव्हा दर्जेदार शिक्षणाची पर्यायी माध्यमे उपलब्ध असणे आवश्यक आहे. यानुसारच या सर्व बाबींचा विचार करता तंत्रज्ञानामुळे मिळणाऱ्या फायद्यांचा लाभ घेण्याचे महत्त्व 'राष्ट्रीय शिक्षण धोरण 2020' ने मान्य केले आहे एकविसाव्या शतकात ऑनलाईन शिक्षणाचे महत्त्व ओळखून भारतातल्या सर्व खेड्यापाड्यांपर्यंत ही सुविधा उपलब्ध करून देणे त्याचे महत्त्व पटवून देणे शासनाला आवश्यक वाटते. परंतु या ऑनलाइन शिक्षणातील तोटे दूर करून किंवा त्यांचे निराकरण करून ऑनलाईन शिक्षणाचे फायदे कसे मिळवता येतील यासाठी या नवीन राष्ट्रीय शैक्षणिक धोरणात या बाबींचा विचार केला आहे.जागतिक स्पर्धेचा विचार करता दर्जेदार शिक्षण उपलब्ध करून देण्यासाठी वर्तमान आणि भविष्यातील आव्हानांचा सामना करण्याकरता आयसीटी आधारित शैक्षणिक उपक्रमांचा दर्जा वाढवावा लागेल याची जाणीव निश्चितच शासनाला आहे. त्यातूनच उच्च शिक्षणासाठी आजही अनेक डिजिटल साधने उपलब्ध असलेली आपल्याला दिसतात. तिचा योग्य वापर केल्यास निश्चितच शैक्षणिक गुणवत्ता वाढीस मदत मिळू शकेल आज अशी अनेक डिजिटल साधने उपलब्ध आहे. या साधनांचा योग्य वापर करून आधुनिकशैक्षणिक गुणवत्ता वाढीवर भर देणे आवश्यक आहे. या साधनांपैकीच काही डिजिटल साधनांचा वापर कसा करता येईल या विषयीची माहिती पुढील प्रमाणे बघू शकतो-

### १. Swayam

उच्च शैक्षणिक संस्थांमध्ये नावनोंदणी वाढवण्यासाठी सरकारने अनेक उपाय योजले आहेत, ज्यात इतर गोष्टींबरोबरच अधिक केंद्रीय अर्थसहाय्यित संस्था उघडणे, राष्ट्रीय उच्च शिक्षा अभियान (RUSA) योजनेद्वारे राज्य सरकारांकडून संस्था उघडण्यास प्रोत्साहन देणे, खर्चाला पूरक शिष्यवृत्ती कार्यक्रम यांचा समावेश आहे.शिक्षण, लोकांपर्यंत पोहोचण्यासाठी आणि त्यांना चांगल्या दर्जाचे शिक्षण मिळवून देण्यासाठी आयसीटी तंत्रज्ञान-स्वयं पोर्टलचा वापर करणे. शासनाने केलेल्या प्रयत्नांचा परिणाम म्हणून, गेल्या काही वर्षांत सकल नोंदणी प्रमाण २७.१ %पर्यंत वाढले आहे.Swayam या पोर्टलद्वारे अनेक प्रकारचे अभ्यासक्रम उपलब्धत करून दिले जाते.इयत्ता ९ वी ते पोस्ट ग्रॅज्युएशन पर्यंत वर्गात शिकवले जाणारे सर्व अभ्यासक्रम या ठिकाणी उपलबद्ध करून दिले आहे. कोणालाही, कधीही, कुठेही या अभ्यासक्रमांसाठी प्रवेश घेता येऊ शकतो. यातील सर्व अभ्यासक्रम परस्परसंवादी आहेत, देशातील सर्वोत्कृष्ट शिक्षकांनी हे अभ्यासक्रम तयार केले आहेत आणि कोणत्याही विद्यार्थ्यांसाठी विनामूल्य उपलब्ध आहेत. या अभ्यासक्रमांच्या तयारीसाठी देशभरातील १००० हून अधिक विशेष निवडक प्राध्यापक आणि शिक्षक सहभागी झाले आहेत.SWAYAMवर आयोजित केलेले अभ्यासक्रम ४ विभागात विभागले आहेत. व्हिडिओ लेक्चर, उत्कृष्ट रितीने तयार केलेले वाचन साहित्य जे डाउनलोड/मुद्रित केले जाऊ शकते तसेच चाचण्या आणि प्रश्नमंजुषाद्वारे स्वयं-मूल्यांकन चाचण्या आणिक्लिअरिंगसाठी ऑनलाइन चर्चा मंच थोडक्यात SWAYAM द्वारे ऑडिओ-व्हिडिओ आणि मल्टी-मीडिया आणि अत्याधुनिक अध्यापनशास्त्र/तंत्रज्ञान वापरून शिकण्याचा अनुभव समृद्ध करण्यासाठी पावले उचलली गेली आहेत.

**२. Google for Education**

ही Google ची अत्यंत महत्वपूर्ण सेवा आहे. Google च्या अनेक सेवांचा लाभ आपण या आगोदर पासून घेत आहोत. यात Gmail, Hangouts, Meet, Google Calendar, Drive, Docs, Sheets, Slides,Google Groups, News, Play Sites आणि Vault इत्यादी महत्वाचेशैक्षणिक साधने google कडे उपलब्ध आहे.कोविड-१९ च्या काळात या सर्वच साधनांचा वापर मोठ्या प्रमाणात करण्यात आला. यातील googleMeet, googleClassroom,Google Groups, या साधनांचा सर्वाधिक वापर करण्यात आला. या साधनांद्वारे विद्यार्थ्यांशी संवाद साधने, प्रोजेक्ट देणे, स्वाध्याय देणे, जमा करणे, परीक्षा घेणे. या सारख्या अनेक गोष्टींसाठी google च्या या साधनांचा मोठ्या प्रमाणात वापर झाला.

**३. YouTube Edu**

हे एक शैक्षणिक YouTube चॅनेल आहे जे भौतिकशास्त्र आणि रसायनशास्त्रापासून, चित्रपट निर्मिती आणि सार्वजनिक भाषणापर्यंत विविध विषयांवर विस्तृत प्लेलिस्ट प्रदान करते. याद्वारे अनेकशैक्षणिक व्हिडिओ या वाहिनीद्वारे प्रक्षेपित केली जातात. हे एक दृकश्राव्य असल्याने विद्यार्थी चांगल्याप्रकारे विषयाचे आकलन करू शकतो.

**४. Teacher Tube**

हे शिक्षकांसाठी एक विनामूल्य संसाधन आहे जिथे ते शिकवण्यासाठी चित्रफित आणि साहित्य सामायिक करू शकतात. तुम्ही तुमचे चित्रफित व स्वाध्याय या वरती अपलोड करू शकता आणि तुमच्या चित्रफित मध्ये शिकण्याच्या क्रियाकलाप, मूल्यांकन आणि पाठाच्या नोट्स संलग्न करू शकता. तुम्ही इतर शिक्षकांची सामग्री देखील संग्रहित करू शकता आणि समान रूची असलेल्या शिक्षकांशी संपर्क करू शकता.

**५. Project Gutenberg**

गुटेनबर्ग हे ६०,०००हून अधिक विनामूल्य ई-पुस्तके असलेली डिजिटल ग्रंथालय आहे. या ग्रंथालयाचा वापर विद्यार्थी, शिक्षक अथवा कोणती ही अभ्यासू व्यक्ती करू शकतो. याद्वारे तुम्ही ऑनलाइन कोणतेही पुस्तक अथवा आपणास आवश्यक लेख संकलित करू शकता अथवा वाचू शकता. या साईटवर तुम्हाला जगातील उत्कृष्ट साहित्य मिळू शकेल.

**६. Chartsbin**

'चार्ट्सबिन' हे एक डेटा व्हिज्युअलायझेशन ॲप आहे जे शिक्षकांद्वारे 'इन्फोग्राफिक्ससह' विविध विषयांची ओळख करून देण्यासाठी वापरले जाते. तुम्ही तुमच्या विद्यार्थ्यांना या विषयावरील त्यांचे प्रभुत्व दाखवण्यासाठी शिकलेल्या साहित्यातून इन्फोग्राफिक्स तयार करण्याबाबत मार्गदर्शन करण्यासाठी या साधनाचा फायदा घेऊ शकता.

**७. Goboard**

'गोबोर्ड' हे एक ऑनलाइन सहयोगी साधन आहे जे व्हिडिओ कॉन्फरन्सिंगला परस्परसंवादसह एकत्र जोडते. विद्यार्थ्यांना अक्षरशः कोणत्याही विषयावर एकमेकांशी सहकार्य करण्यात मदत करण्यासाठी हे डिझाइन केले आहे. गोबोर्डमध्ये एक डिजिटल व्हाईटबोर्ड आहे, ज्यामुळे वापरकर्ते त्यांच्या नोट्स, चित्रे आणि गणना एकमेकाना शेअर करू शकतात.

**८. Teacheroo**

हे एकमेव जागतिक 'सामाजिक नेटवर्क' आहे जे विशेषत: शिक्षकांसाठी डिझाइन केलेले आहे. तुम्ही तुमची संसाधने,आणि शैक्षणिक टिपा पोस्ट करू शकता, टिप्पणी करू शकता, लाइक करु शकता, इतर शिक्षकांचे साहित्य पुन्हा पोस्ट करू शकता आणि व्यावसायिक कनेक्शन तयार करू शकता.

**९. Bloomz**

हे एक परस्परसंवादी ॲप आहे जे शिक्षक आणि शाळांना वर्गातील अपडेट, कार्यक्रम आणि फोटो पालकांसोबत सुरक्षितपणे शेअर करण्यास सक्षम करते. तुम्ही एका क्लिकवर ई-मेल आणि स्मार्टफोनवर पालक-शिक्षक बैठकीची सूचना पाठवू शकता.अथवा त्या संदर्भातील कल्पना देऊ शकता.

**१०. Teach Learn Lead**

हा एक समुदाय आहे जो नवीन शिक्षकांना पाठबळ देण्यासाठी, प्रोत्साहन देण्यासाठी आणि एकमेकांच्या संपर्कात रहाण्यासाठी तयार केले आहे. कारण बर्याच वेळा बहुतेक शिक्षक त्यांच्या सुरवातीच्या काळात असंदिग्ध मानसिकतेत असतात. सुरुवात कुठून, कशी, केव्हा करावी अशा द्विधा मानसिकतेतून जात असतात अशा वेळी या साईटच्या माध्यमातून आत्मविश्वास वाढविण्याचे काम केले जाते. शिवाय या मध्ये जागतिक शिक्षण लायब्ररींचा समावेश आहे.

**११. Flipgrid**

'फ्लिपग्रीड' ही एक ऑनलाइन सेवा आहे जी पीएचडी शिक्षक, शिकणारे आणि कुटुंबांसाठी एक साधा, विनामूल्य आणि प्रवेश करण्यायोग्य व्हिडिओ चर्चा अनुभव प्रदान करते. तुम्ही चर्चेचा विषय तयार करू शकता आणि तो तुमच्या शिकणाऱ्या समुदायासह शेअर करू शकता. प्रतिसादात, शिकणारे त्यांचे व्हिडिओ रेकॉर्ड करतील आणि तुम्हाला आणि तुमच्या टीम सोबत शेअर करतील.

**१२. Vocaroo**

हे एक ऑनलाइन साधन आहे जे तुमच्या 'व्हॉइस नोट्स रेकॉर्ड करण्यास, पाठवण्यास आणि संकलित करण्यात मदत करते. तुम्ही ते ब्रॉडकास्टिंग, डिजिटल स्टोरीटेलिंग किंवा फीडबॅक देण्यासाठी वापरू शकता.

### १३. Free Cam

व्यावसायिक 'व्हिडिओ धडे' आणि e-Learning सादरीकरणे तयार करण्यासाठी वैशिष्ट्यांचा संपूर्ण संच प्रदान करतो. तुम्ही स्क्रीनकास्ट सहजपणे रेकॉर्ड करू शकता, रेकॉर्ड केलेले व्हिडिओ संपादित करू शकता आणि YouTube वर अपलोड करू शकता किंवा ते तुमच्या विद्यार्थ्यांना ई-मेल करू शकता.

### १४. Ezvid Wikimaker

आवाज संश्लेषणाद्वारे समर्थित एक विनामूल्य व्हिडिओ निर्मता आहे. हे सुरुवातीला संशोधक आणि पत्रकारांना मजकूर चित्रित बदलण्याची परवानगी देण्यासाठी तयार  करण्यात आले होते. परंतु या द्वारे आपण प्रतिमा आणि व्हिडिओ क्लिपसह व्हिडिओ ट्यूटोरियल तयार करू शकता. यात तुम्हाला आवाज संकलित करण्याचीही गरज पडत नाही.या साधनाचा वापर करताना तुम्ही मजकूर जोडता तेव्हा तो आपोआप कथनात रूपांतरित होत असतो.

### १५. Tableau Public

या साईटद्वारे विद्यार्थी अभ्यासासाठी बहुआयमी उपयोग करू शकता जे तुम्हाला काही मिनिटांत परस्पर आलेख, आकर्षक नकाशे आणि थेट डॅशबोर्ड तयार करण्यास सक्षम करते. तुम्ही याचा वापर वर्गातील व्यायाम आणि गृहपाठ, स्वाध्याय, व्यवस्थापित करण्यासाठी केला जातो. या शिवाय अनेक लोकांशी तुम्ही संपर्क साधू शकता.

### १६. Pic-Lits

ही एक e-Learning साक्षरता वेबसाइट आहे जी सर्जनशील लेखनाला प्रेरणा देण्यासाठी आणि स्फूर्ती देण्यासाठी करण्यात आली आहे. या साईटद्वारे लेखन आणि छायाचित्रण यांचा वापर करता येतो विद्यार्थ्यांना मधील लेखन गुणाना प्रोत्साहन देऊन, नवीन लेखक निर्माण करणे या उद्देशातून या साईटचा मोठा उपयोग होतो.

### १७. Google Books

ही Google ची एक महत्वपूर्ण सेवा आहे. यात Google ने स्कॅन केलेली, मजकूरात रूपांतरित केलेली आणि त्याच्या डिजिटल डेटाबेसमध्ये संग्रहित केलेली अमर्यादित पुस्तके आणि मासिकांचा समावेश यात आहे. या साईट वरून विद्यार्थी, शिक्षक याचा मोठ्या प्रमाणात वापर करू शकता. शिक्षकाना वर्गात शिकवू इच्छित असलेल्या संकल्पनांशी संबंधित पुस्तके संकलित करू शकता किंवाबुकमार्क करू शकता.

### १८. Story bird

कथाकथनाद्वारे विद्यार्थ्यांमधील लेखन आणि वाचन कौशल्यांना चालना देण्याच्या उद्देशाने हे साधन विकसित केले आहे. या साधनाद्वारे शिक्षक साध्या आणि वापरण्यास सोप्या भाषेत परस्परसंवादी आणि कलात्मक पुस्तके ऑनलाइन तयार करू शकतात. तयार केलेल्या कथा ब्लॉगमध्ये समाविष्ट केल्या जाऊ शकतातअथवाई-मेलद्वारे पाठवल्या जाऊ शकतात. या शिवाय त्या  मुद्रित

केल्या जाऊ शकतात. स्टोरीबोर्डमध्ये, शिक्षक विद्यार्थ्यांसह प्रकल्प तयार करू शकतात, सतत अभिप्राय देऊ शकतात आणि वर्ग आणि टेस्ट आयोजित करू शकतात.

**१९. Projeqt**

प्रोजेक्ट हे एक महत्वाचेशैक्षणिक साधन आहे जे तुम्हाला डायनॅमिक स्लाइड्ससह मल्टीमीडिया सादरीकरणे तयार करण्यास अनुमती देते. ज्यामध्ये तुम्ही इतर पर्यायांसह परस्पर नकाशे, लिंक्स, ऑनलाइन क्विझ, Twitter टाइमलाइन आणि व्हिडिओ एम्बेड करू शकता. वर्गाच्या सत्रादरम्यान, शिक्षक विद्यार्थ्यांसह शैक्षणिक सादरीकरणे सामायिक करू शकतात जे दृश्यमानपणे भिन्न उपकरणांमध्ये जुळवून घेतात.

**२०. N-LIST**

E-SodhSindhu Consortium, INFLIBNET सेंटर आणि INDEST-AICTE, IIT दिल्ली यांच्या संयुक्त विद्यमाने राबविण्यात येत असलेल्या "नॅशनल लायब्ररी अँड इन्फॉर्मेशन सर्व्हिसेस इन्फ्रास्ट्रक्चर फॉर स्कॉलरली कंटेंट (N-LIST)" नावाचा प्रकल्प राबविण्यात येतो. N-LIST द्वारे महाविद्यालये आणि इतर लाभार्थी संस्थांमधील विद्यार्थी, संशोधक आणि प्राध्यापकांना ई-संसाधनांमध्ये प्रवेश प्रदान करतो. INFLIBNET केंद्रावर तैनात केलेल्या सर्व्हरद्वारे अधिकृत वापरकर्ते म्हणून अधिकृत वापरकर्ते म्हणून प्रमाणीकरण झाल्यानंतर महाविद्यालयातील अधिकृत वापरकर्ते आता ई-संसाधनांमध्ये प्रवेश करू शकतात आणि त्यांना आवश्यक असलेले लेख थेट प्रकाशकाच्या वेबसाइटवरून डाउनलोड करू शकतात.

## निष्कर्ष

नवीन राष्ट्रीय शैक्षणिक धोरण आणि त्या द्वारे स्वीकारलेली नवीन धोरणे याचा विचार करता आधुनिक शिक्षणाकडे वाटचाल करण्यासाठी आणि खऱ्या अर्थाने विद्यार्थ्यांना आधुनिक साधनांचा वापर आपल्या शैक्षणिक जीवनात करता यावा यासाठी ही धोरणे महत्वपूर्ण ठरतात. यात अनेक नवीन धोरणांचा समावेश केलेला असला तरी या धोरणामध्ये प्रामुख्याने डिजिटल साधनांना ही महत्वाचे प्राधान्य देण्यात आले आहे. अनेक शैक्षणिक संस्था आणि विद्यार्थ्यांनी ही कोविड च्या काळात या सर्व साधनांचा वापर मोठ्या प्रमाणात केला आहे. या नवीन शैक्षणिक धोरणानुसार जरी या साधनांचा वापर करावयाचा असला तरी तो समाजातील शेवटच्या घटकांपर्यंत या साधनांचा वापर होणे कितपत शक्य होऊ शकेल हा एक महत्वाचा प्रश्न आहे कारण भारत हा खेड्यांचा देश आहे आणि देशातील अतिशय दुर्गम भागामध्ये देखील आजही 'कॉम्प्युटर' अथवा 'नेट' सारखी सुविधा उपलब्ध नाही. एवढंच काय तर विजेसारखी उपलब्धता देखील नसल्याने अशा साधनांचा वापर शैक्षणिक बाबींकरता किती होऊ शकेल हा एक मोठा प्रश्न निर्माण होऊ शकतो. तरी देखील शासनाच्या या धोरणाची आवश्यकता ही काळाला धरून असल्याची दिसते यावर निश्चितच शासन मार्ग काढून योग्य पद्धतीने याची अंमलबजावणी करेल अशी आशा वाटते.