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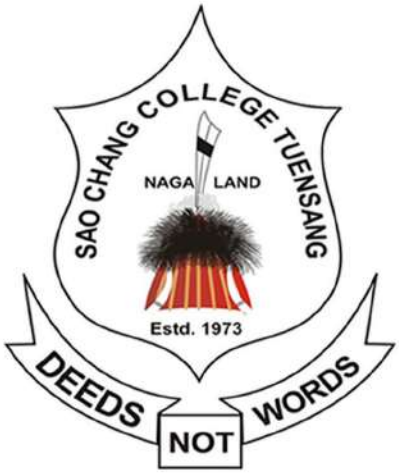

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Editorial

The editorial board is pleased to present this edition of Sao Chang College Journal volume 3, issue 1. The primary aim of the Journal is to offer a collaborative platform where academicians could share insights, foster innovative thinking and push the boundaries at the intersections of different disciplines. So the Journal is committed to advancing interdisciplinary research and facilitating the exchange of ideas among various fields of knowledge. The current issue covers nine articles exploring into educational policy, environmental issues, nature and its diversity, theories and scope of applied sciences, art, culture and literature.

We acknowledge the valuable contribution of all authors. We owe our indebtness to all the reviewers in and outside Nagaland, without their positive response and cooperation, this peer reviewed Journal would not have been materialized. We also express our gratitude to the Principal Dr.Lanurenla, and IQAC for their valuable guidance and support in all possible ways.

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Review Article
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Issues and Challenges of Research in Higher Education and NEP 2020: A Review

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Abstract

The advancement of any education system depends upon the knowledge generated through quality research. NEP 2020 has remarked that a robust research ecosystem is perhaps more critical than ever with the rapid changes occurring in the world today (NEP 2020). NEP 2020 has also remarked that although research is essential for advancing any education system, India currently spends only 0.69% of its GDP, much less than advanced nations. Although today's world is mainly dependent on science and technology and their application, we must also realize that some social issues and challenges can only be solved through social science and humanities research. The quality of any educational system depends upon the quality research undertaken in institutions such as NCERT, NIEPA, etc., as well as scholars engaged in research at the higher education level. Knowledge must also be constantly updated through research to keep pace with the ever-changing world. Higher education is where advanced research is conducted in the education sector, and knowledge generated at this stage through rigorous research can be used to advance and improve our education system. This paper attempts to discuss the importance of research in education, issues and challenges of research, and what NEP 2020 and its policy can do in light of these issues and challenges.

Keywords: *Research, higher education, issues, challenges, and NEP 2020.*

Introduction

Higher education in its modern form is an unintended gift of British rule in India. However, India was not a stranger to higher learning and instruction even before the British takeover. In ancient India, Takshashila and Nalanda occupied a prominent place of learning and were great seats for advanced Vedic and Buddhist studies, respectively.

Education can turn humans into human resources and inculcate essential abilities and skills that make a workforce productive. For a sustainable and prosperous nation, people with accumulated knowledge and skills that enhance their potential daily are necessary, which mainly depends upon the health and vitality of higher education. Higher education is an essential instrument for development and transformation. (Siddiqui and Sharma, p. 4).

Higher education can also be called tertiary or post-secondary education. All undergraduate colleges, post-graduate colleges, universities, and centers of advanced studies come under the scope of higher education.

Higher education occupies a significant place in the Indian system of education. It culminates in a name, a degree. Rigorous research is undertaken on this education, which helps advance Indian Education. The latest innovations and developments take place owing much to this stage of education.

National Education Policy 2020 is a comprehensive policy that deals with everything from pre-primary to higher education. Among all the essential recommendations, it has also touched upon the importance of research and envisions establishing a National Research Foundation to support and fund research in the country.

Brief history of modern education

The first modern college (Calcutta, Madras) was founded in 1781, followed by the Sanskrit Colleges of Banaras in 1792 and the Hindu College of Calcutta 1817)- all established by the English East India Company. Christian Missionaries also played their part by establishing colleges in India. The total number of colleges rose to 28 in 1855. The views about the medium of instruction in modern subjects varied; classical languages (Sanskrit and Persian), modern Indian languages, and English were advocated. Three universities – one each at Calcutta, Madras, and Bombay were established in 1854 on the pattern of London University, which was primarily an affiliating/examining body. Intermediate/Secondary classes were delinked from the university. More universities came up in the following years, so at the time of independence, the number stood at 19, with 496 colleges. Distance education was introduced in the 1970s. The first State Open University was opened in August 1982 at Hyderabad, followed by Indira Gandhi National Open Universities in 1985 (Hasan, M, p. 242).

Higher secondary and university/college education duration differed from state to state; however, the Indian Education Commission (1964-66) recommended a uniform pattern of 10+2+3. By and large, higher education is now handled by universities/deemed universities, autonomous colleges, and institutions of higher learning like IITs, IIMS, AIIMS, etc. National and regional laboratories conduct advanced research programmes in their respective fields. National Assessment and Accreditation Council NAAC accredits higher education institutions, and the National Council for Teacher Education NCTE oversees teacher education in India.

There are 54 central universities, 455 state universities, 126 deemed universities, 412 private universities, and 13,093 colleges in India (University Grants Commission).

Operational definition

Issues: Issue in this discussion refers to any situation that acts as problems to researchers.

Challenges: Some kind of problems that act as a barrier to researchers.

Research: Research in this discussion is referred to social sciences research.

Higher Education: Higher education in this discussion refers to stage of education offered after secondary education.

Importance of research in higher education

Research may be defined as the application of the scientific method in the study of various problems. Research is a planned activity to obtain answers to meaningful questions about phenomena or events through the application of a scientific approach. It is an objective, impartial, empirical, and logical analysis and recording of controlled observations that may lead to the development of generalization, principles, or theories, resulting to some extent in predicting and controlling events (Koul, 2009). Firstly, for us to undertake any research, a need is felt, and we can research to solve the issues and challenges being felt.

Any nation's progress and educational system depends on science, technology, and social sciences research quality. The findings of an academic study conducted in institutions have more significant implications for the health of our education system. The effectiveness of educational intervention or programme can be evaluated through research, and any dead leaves can be identified and removed from the system.

Our education system has many issues, problems, and challenges and requires immediate attention. No country can be expected to advance if these issues and challenges are left unattended. There are plenty of problems and difficulties, such as drop-out, retention, stagnation, low enrolment, poor mental health, low achievement, regional and rural divide, etc., in the Indian

education system. We must identify the causes of these issues, problems, and challenges and solve them through systematic research. Article 21 (A) of the Indian Constitution deals with the right to education in which the state shall provide free and compulsory education to all children under the age group of 6-14. We need to understand the word "all" in Article 21 A; it includes all children, including children with special needs, so we also need to do thorough research as to how we will include them in our education system and fulfill the dream of providing free and compulsory education to all children under the age group of 6-14 years which we failed to do so before. Therefore, if India wants to excel in this ever-competing world, she needs to empower her people and convert them into human resources who will carry the nation on their shoulders, which means education has to be provided to the citizens of this great nation. NEP 2020 has emphasized that addressing these issues and challenges will require rigorous research conducted in India as we cannot always rely on research findings from other countries. NEP 2020 has also emphasized the critical importance of the role of higher education in research.

Institutions funding research in India

Institutions that currently research works in India are the Department of Science and Technology DST, Department of Atomic Energy DAE, Department of Bio-Technology DBT, Indian Council of Agriculture Research ICAR, Indian Council of Medical Research, University Grants Commission UGC, Indian Council of Historical Research, Indian Council of Social Science Research ICSSR, National Council of Educational Research and Training, Indian Council of Philosophical Research, etc. The World Bank and UNESCO also play a role in funding research in India.

Issues and challenges of research in higher education

No society can be expected to progress without research, as a new body of knowledge is generated in our day-to-day lives, and this new body of knowledge is used to develop and advance our educational system. Through research, we can identify the dead leaves and eliminate them to improve our educational system. Without research, we cannot compete in this advanced technology-driven society, and we cannot even hope to compete with other countries that are very advanced in their educational system. India is the third largest system in higher education, just after the

USA and China, so we can say we are heading in the right direction. Still, we also need to emphasize the aspects of quantity and quality aspects of education.

Unfortunately, so many issues and challenges are creeping into the system, and many types of research that have taken place lack quality, and many of them remain in the paper. It is in this connection, Aggarwal (1988) has remarked that confused and confusing role research has played in the history of education; factors related methodology used; paucity of intellectual skill; lack of proper research environment. But we also need to know that all these issues and challenges do not lie only with the researchers but the whole system. Luthura and Shome (2013) have found that higher education's engineering and technology sector is performing as generators of new knowledge. We must wonder why research in social science and humanities is not progressing because the importance of research in social science and humanities cannot be neglected.

Studies suggest that research publications, presentations in the seminar, the number of books written, etc., determine the promotion of teaching faculty, so we question if this is the case: are teachers giving importance to their teaching? Even if there are many publications and a

number of books to their credit, their works remain mostly in papers. After India's independence, there was an increase in the number of higher education institutions. Currently, there are 1043 universities, and according to AISHE Report 2019-2020, around 38,986 Ph.D. degrees were awarded, and nearly 2.02 lakhs enrolled in the Ph.D. programme and 'their primary motivation of individuals undertaking research in any area is to obtain a doctorate or achieve career advancement. The scope, objectives, and coverage of such studies are, therefore, minimal…' (Varghese et al., 2017) and according to Yenkatesh (2003) if only students who have the right aptitude for research are permitted to register for Ph.D., there may be an improvement in the standard of research. Therefore, students' aptitude toward research also needs a thorough investigation.

There is a vast difference between the relevance and value of research undertaken in education and other disciplines. The most valuable research currently being conducted in India falls in technology and agriculture. Unfortunately, this is not so apparent in education. This is one question that needs some exploring. There are also issues of funding of research in our country, and even if a person has a high interest and aptitude for research, lack of funding can become a barrier for them, and 'given the resource crunch which higher education has always experienced, research on higher education has certainly become casualty' (Varghese et al., 2017).

In educational research, the population and sample are mostly the educational stakeholders, and when some essential academic research has to be conducted on pressing issues, some people may be reluctant to come forward due to the issue of privacy and lack of trust, which creates a severe problem. In research, especially in the field of science, many institutions lack laboratory facilities, which is another issue when conducting a meaningful study. They have to visit distant places to get their sample tested for their

study. Privacy is another concern in research, and in educational research, institutions do not want to disturb their schedule and are reluctant to provide data for research. One of the research issues is that some research works are not published, and 'as a consequence, unpublished research work often goes unnoticed' (Varghese et al., 2017).

National Policy on Education (NEP 2020)

The National Education Policy 2020 is a comprehensive policy with recommendations from the foundational to higher education levels. It has also been noted that less emphasis has been placed on research at most universities and colleges, and there is a lack of peer-reviewed research funding across disciplines.

Despite the critical importance of research, the research and innovation investment in India is at the current time only 0.69% of GDP where, as advanced countries spend 2.8% (USA), 4.3% (Israel), and 4.2% in South Korea (NEP 2020).

NEP 2020 aims to transform the quality and quantity of research in the country and to promote quality research in higher education institutions. It has also given the scope of including research and internship in the undergraduate curriculum and emphasizes regulatory changes to promote an environment of research and innovation.

NEP 2020 envisages a new conceptual understanding of higher education institutions, i.e., multidisciplinary higher education institutions offering undergraduate and postgraduate programmes, a Research-Intensive Universities focusing on both research and teaching, or Teaching-Intensive Universities placing more emphasis on teaching but conducting essential research. According to the policy, the university would be a multidisciplinary institution conducting high-quality research and teaching. The policy has also done away with M.Phil degree. The NEP 2020 proposes that India's higher

educational institutions should be flexible to offer 4 years bachelor's degree with research and a Master's degree needing only one year, so in this connection, Ph.D. entrants will require a Master's degree or 4-years bachelor's degree with research.

On realizing the critical importance of research for the advancement of our nation and its educational system, NEP 2020 envisions the establishment of the National Research Foundation NRF to fund research across disciplines, fund peer-reviewed research funding, develop a culture of research and recognize outstanding research and promote research capability in institutions where which are currently lacking in the field.

National Research Foundation NRF activities include:

1. Funding: - funding of research will consist of all disciplines.
2. Support: NRF will support emerging institutions to facilitate, seed, and grow research.
3. To make awareness of urgent research issues in India, NRF will act as a liaison between researchers, government, and industry.
4. NRF will recognize significant and outstanding research and progress (NEP 2020).

As it is evident that issues and challenges in the field of research are plenty, we need to address all these issues and challenges. The NEP 2020 has realized the importance of research for the progress of our nation and aims to create a conducive ecosystem to catalyze and energize research in higher education. Funding is also one of the major challenges in research in India and the NEP emphasizes on nurturing the culture of research by funding support in this area. If we as a nation has to achieve the growth and progress that it so aspires, we should strength the field of research as it is through systematic advanced research, new knowledge can be generated which can be used for the improvement and development of our educational system

which in turn will produce human resources who will carry the nation on their shoulders.

Conclusion

The foundation of a nation depends upon the country's education system. Education develops an individual intellectually, socially, emotionally, and physically; education is an overall development. New knowledge is generated every day through rigorous research undertaken by the people, so it becomes very crucial for a nation to strengthen its research in the field of education. New entrants into higher education should be trained and encouraged to research their area of interest; however, their aptitude and attitude should be assessed before doing so. The National Policy on Education NEP 2020, in the field of research, envisions establishing a National Research Foundation, which seems very promising; if it does not remain only on paper and gets implemented in the future, the field of research looks bright and hopeful. Research is the heart of higher education as it is this stage of education where important research works are conducted, and their findings have far-reaching implications for the advancement of our nation.

References

Agarwal, P. (2010). *Indian higher Education: Envisioning the future.* Sage Publication India Private Limited.

Aggarwal, Y.P. (1988). *Research in emerging fields of education: Concepts, trends and prospects.* Sterling Publishers Private Limited.

All India survey on higher education (AISHE). New Delhi: Ministry of Education, Government of India.

Chowdhary, N., & Hussain, S. (2021). *Handbook of research and publication ethics.* Bharat Publications.

https://www.ugc.ac.in/ list of universities.

Koul, L. (2009). *Methodology of education research.* Vikas Publishing House Pvt Ltd.

Kidwai, A.R. (2010). *Higher Education: Issues and challenges*. Viva Books Private Limited.

Kumar, R. & Kumar, N. (2013). *Higher education in India.* Atlantic Publisher & Distributors (P) Ltd.

National Policy on Education 2020, Ministry of Education Government of India.

National Council of Educational Research. Fifth Survey of Education Research 1988-1992, p.8.

Overcoming challenges common to doctoral researchers (n.d). Vitae.ac.uk. httpss://www.vitae.ac.uk/doing research/doing-a-doctorate/starting-a-doctorate/overcoming-challenges-common-to-doctoral-researchers

Problems encountered by researchers (n.d). Scribd.com. https://www.scribd.com/doc/15238122/Problems Encountered-by-researchers.

Varghese, N.V., Pachauri, A & Mandal, Satyantan. (2017). *Indian higher education report 2017: Teaching, learning and quality in Higher Education.* Sage Publication India Pvt. Ltd, New Delhi.

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Research Article
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Assessment of the Effects of Heavy Metals on the Milak River Affected by Coal Mining, Mokokchung, Nagaland

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Abstract

Coal mining is crucial for economic development worldwide, providing a significant energy source. However, unscientific coal mining practices lead to detrimental environmental effects, including the release of hazardous pollutants into the environment. This study investigates the impacts of coal mining on the Milak River in the North East region of India, focusing on heavy metal contamination. Water samples were collected from three sites along the river, and heavy metal concentrations were analyzed. The results indicate elevated levels of iron, copper, zinc, and aluminum at Site-1, exceeding WHO and BIS standards for drinking water quality. Manganese levels are slightly elevated at Site-1 but within safe limits. Arsenic, selenium, and chromium are either absent or at negligible levels at Sites 2 and 3. The findings emphasize the importance of monitoring and mitigating heavy metal contamination to protect public health and ensure access to safe drinking water. Implementing remediation efforts and sustainable land management practices are crucial for addressing environmental challenges associated with coal mining.

Keywords: *Abandoned coal mines, heavy metals, Milak River, Tuli, Nagaland.*

Introduction

Coal mining plays a significant role in the economic development of many regions in the world, providing a significant energy source. However, the extraction and processing of coal by unscientific coal mining is associated with detrimental effects on the environment with the direct release of a huge amount of hazardous pollutants and trace elements into the prevailing environment leading to the deterioration of forests, water, air, and soil (Ceto and Mahmud, 2000). The leachate of water or the acid mine discharge from the coalmine debris which occurs due to the oxidation of pyrite with coals increases the acidity, hardness, and dissolution rate of heavy metals in the water which seriously affects the water quality, disrupting the aquatic ecosystem, leading to a decline in marine life population and biodiversity, ecological imbalance and making it unhealthy and unsafe for drinking purposes (Kgari et al., 2016). Such leachates from the abandoned coal mine areas have led to the degradation of groundwater and surface water quality (Cooke, C.A et al., 2024). The environmental challenges brought by mining are mostly irreversible in nature and can persist for decades (Zeng Y et al., 2022; Shang H et al., 2022).

The North East region of India relies heavily on surface and open-cast mining for coal extraction. The coal found in this region belongs to the type called sub-bituminous tertiary coal, which has high levels of sulfur, volatile matter, and vitrinite content, along with low ash content. While mining this coal has contributed to economic growth by meeting energy demands, it also brings significant environmental challenges (Chabukdhara and Singh, 2016). The region is renowned for its abundant biodiversity, including dense forests, diverse flora and fauna, and valuable minerals. However, the unscientific mining practices employed here have led to severe water pollution, posing a major environmental threat (Garg, 2010). Certain

heavy metals like copper and zinc are required for growth and support in living organisms whereas, some of the metals like arsenic, lead, mercury, and cadmium are required by living organisms in trace amounts for various biochemical processes as they can mimic essential metals (Kocabas K et al., 2024). But exposure to excess concentration of such heavy metals may lead to health risk and in extreme conditions may even lead to death (Ouyang et al., 2002; Leung et al., 2006).

In recent years, the Milak River has become a focal point for understanding the detrimental effects of coal mining on freshwater systems. The unscientific mining in the region has gradually led to deforestation, degradation of soil quality, change in land use patterns, and change in water quality (Basu and Mishra, 2024; Orgiazzi et al., 2022; Atharinafi Z, and Wijaya N, 2021). Therefore, this paper aims to investigate and analyze the impacts of coal mining on the Milak River to develop strategies for sustainable resource management.

Methodology

Site selection and sampling: Three sites were selected in Tuli, under Mokokchung District, Nagaland. The first site is the core site located at Latitude 26°38′17′′ N and Longitude 94°38′44′′ E with an altitude of 185m above msl. This site was where the mining was abandoned for years as reported by villagers. The second site is the intersection point with a geographical coordinate of Latitude 26°38′10′′ N and Longitude 94°38′35′′ E with an altitude of 179m above msl. This site intersects the water flowing from the abandoned mine and Milak river. The third site or the main river is located at Latitude 26°38′14′′ N and Longitude 94°38′29′′ E with an altitude of 176m above msl. A total of 15 samples were collected from the sites during the post-monsoon season. The method of sampling applied for the research was grab sampling. Water samples were collected and packed in 500 ml

glassware and pre-washed plastic bottles with great precision and were labeled according to the sites from where it was collected. The water samples for heavy metal analysis were first treated with nitric acid (HNO_3) and the pH was lowered to 2 at the sampling time and stored at 4°C.

Heavy Metals

To estimate metal levels, the water samples underwent a digestion process to remove organic impurities, preventing interference during analysis. Initially, 100 mL of each acid-preserved water sample was combined in a beaker. Subsequently, 5 mL of concentrated HNO3 was added, and the mixture was gently evaporated on a hot plate within a fume-hood until the volume reduced to 10–20 mL, yielding a clear solution. The beaker's walls were rinsed with distilled water, and the volume was adjusted back to 100 mL using a volumetric flask. This prepared solution was then subjected to analysis using an Atomic Absorption Spectrophotometer (AAS). The heavy metals Cadmium (Cd), Lead (Pb), Iron (Fe), and Arsenic (As) were quantified in each water sample using Atomic Absorption Spectrometry, specifically with a Perkin Elmer AAnalyst 200 instrument utilizing an air-acetylene flame. Calibration for each metal was performed using certified AAS standards of 1000 mg/L (Merck, Germany). Calibration solutions for individual metal ions were prepared via serial dilution of the standard stock solution. Operational conditions were adjusted following the manufacturer's guidelines to ensure optimal determination. All chemicals employed were of analytical grade sourced from Merck, India.

Results and Discussions

The table 1 presents concentrations of various heavy metals (Fe, Mn, Cu, Zn, As, Se, Al, Cr) measured at three different sampling sites (Site-1, Site-2, Site-3), along with the respective World Health Organization (WHO) and Bureau of Indian Standards (BIS) permissible limits for drinking water

quality. It is observed that several heavy metal concentrations exceed the permissible limits set by both WHO and BIS standards, indicating potential risks to human health from water consumption at these sites.

Table 1 *Values of heavy metal in Milak river along with WHO (2011) and BIS (2009) permissible standards.*

HEAVY METALS	**SITE-1 (Core) (mg/L)**	**SITE-2 (Intersection) (mg/L)**	**SITE-3 (Milak river) (mg/L)**	**WHO (2011) (mg/L)**	**BIS (2009) (mg/L)**
Fe	443.5	36.5	23.1	0.3	0.3
Mn	5.7	0.04	0.03	0.4	-
Cu	3.5	0.06	0.08	2	1.5
Zn	22.3	1.02	0.8	3	5.0
As	0.18	BDL	BDL	0.01	0.01
Se	2.3	BDL	BDL	0.04	0.01
Al	20.2	0.05	0.006	0.2	0.03
Cr	7.1	BDL	BDL	0.05	0.05

***BDL = Below Detection Level**

Iron (Fe): At Site-1, the concentration of iron (Fe) is significantly higher compared to the other sites, exceeding both WHO and BIS guidelines. This elevated level of Fe at Site-1 could potentially be attributed to the presence of iron-rich minerals or natural weathering processes and lack of remediation. Site-2 and Site-3 exhibit higher Fe concentrations than the recommended limits but to a lesser extent.

Manganese (Mn): Manganese concentrations are relatively low across all sites, with Site-1 showing a slightly elevated level compared to Sites 2 and 3, suggesting potential health concerns. The increase of Mn concentration in Site-1 can be due to natural weathering processes or accumulation over time. In abandoned mines there is no ongoing disturbance or management, manganese can continue to accumulate in water and

sediment, leading to higher concentrations. However, all measured values fall well below the recommended limits by WHO and BIS.

Copper (Cu): Site-1 demonstrates a notably higher concentration of copper (Cu) compared to the other sites, surpassing both WHO and BIS standards. This elevated Cu level could be indicative of a lack of vegetative cover in Site-1. Vegetation plays a crucial role in stabilizing soils and reducing erosion, without vegetation, soils are more prone to erosion, which can transport copper and other contaminants. Site-2 and Site-3 show Cu concentrations within acceptable limits.

Zinc (Zn): Similar to Cu, Site-1 exhibits a substantially higher concentration of zinc (Zn) compared to Sites 2 and 3, exceeding WHO and BIS guidelines. The elevated Zn levels at Site-1 may suggest environmental contamination or weathering of rocks. Site-2 and Site-3 show Zn concentrations within permissible limits.

Arsenic (As) and Selenium (Se): Arsenic and selenium concentrations are not detectable (BDL) at Sites 2 and 3, suggesting either minimal presence or absence of these metals in the water samples. At Site-1, there is a slight elevation of arsenic and selenium, likely influenced by natural geological conditions, oxidation processes, or insufficient remediation efforts. However, these elevated levels remain well below the recommended limits set by the WHO and BIS.

Aluminum (Al): Aluminum concentrations are noticeably higher at Site-1 compared to Sites 2 and 3, albeit still within permissible limits outlined by WHO and BIS. The elevated Al levels at Site-1 may be attributed to natural geological sources or anthropogenic activities.

Chromium (Cr): Chromium concentrations are below detection limits (BDL) at Sites 2 and 3, indicating negligible presence. Site-1 exhibits a

slightly elevated level of Cr which can be attributed to rainwater runoff as this can transport dissolved chromium into water bodies.

Conclusion

The analysis of heavy metal levels in water samples from three sites indicates significant concerns for water quality and potential health risks. Elevated levels of iron (Fe), copper (Cu), zinc (Zn), and aluminum (Al) at Site-1 exceed both WHO and BIS standards for drinking water quality, suggesting environmental contamination possibly due to natural processes, insufficient remediation, or human activities. Specifically, iron, copper, and zinc levels at Site-1 pose hazards for water consumption, while aluminum levels raise environmental concerns. Although manganese levels are slightly elevated at Site-1, they remain within safe limits. The absence of arsenic and selenium at Sites 2 and 3 suggests satisfactory water quality, but slight elevations at Site-1 require further investigation. Chromium is undetectable at Sites 2 and 3, with a slight elevation at Site-1 possibly from rainwater runoff. The findings underscore the importance of monitoring and mitigating heavy metal contamination in water sources to safeguard public health. Implementing remediation efforts and sustainable land management practices are necessary to mitigate environmental contamination and ensure access to safe drinking water for communities residing near these sites. Additionally, continued monitoring and research are essential to assess the effectiveness of remediation measures and address emerging environmental challenges.

References

Atharinafi Z, Wijaya N. (2021). Land Use Change and Its Impacts on Surface Runoff in Rural Areas of the Upper Citarum Watershed (Case Study: Cirasea Sub-watershed). *Journal of Regional and City Planning*. 32(1):36-55, DOI:10.5614/jpwk.2021.32.1.3.

Basu, D and Mishra, S. (2024). Mine reclamation practices and effects of stakeholder perception - a case study of Saoner mines, Maharashtra, India. *Journal of Engineering and Applied Science*. 71:62 https://doi.org/10.1186/s44147-024-00393-y.

Ceto, N., Mahmud, S., (2000). Abandoned mine site characterization and cleanup handbook. United States Environmental Protection Agency, Washington, DC, p 129.

Chabukdhara, M., Singh O.P, (2016). Coal mining in northeast India: an overview of environmental issues and treatment approaches. *Int J Coal Sci Technol*. 3(2):87-96 DOI 10.1007/s40789-016-0126-1.

Cooke, C.A., Emmerton, C.A., Drevnick, P.E. (2024). Legacy coal mining impacts downstream ecosystems for decades in the Canadian Rockies. *Environ Pollut*. 344:123328. doi: 10.1016/j.envpol.2024.123328. Epub 2024 Jan 7. PMID: 38195024.

Garg, S.K., (2010). Water supply engineering. *Khanna publishers.* ISBN:978-81-7409-120-8.

Kgari, T., Wyk, Y.V., Coetzee H., Dippenaar M. (2016). Mine water approach using tracers in South African abandoned coal mines. *In*: Mining meets water-conficts and solutions, pp 410–416.

Kutluyer Kocabas, F., Basaran, E., & Kocabas, M. (2024). Seasonal Monitoring of Heavy Metal Pollution in Water and Zebra Mussels *Dreissena polymorpha* as a Potential Bioindicator Species from Lake Habitat. *Bull Environ Contam Toxicol*. 112(43). https://doi.org/10.1007/s00128-024-03869-y.

Leung, C. M., Jiao, J. J. (2006). Heavy metal and trace element distributions in groundwater in natural slopes and highly urbanized spaces in Mid-Levels area, Hong Kong. *Water Res.* 40, 753–767.

Orgiazzi, A., Panagos, P., Fernandez-Ugalde, O., Wojda, P., Labouyrie, M., Ballabio, C., Franco, A., Pistocchi, A., Montanarella, L., & Jones, A. (2022). LUCAS Soil Biodiversity and LUCAS Soil Pesticides, new tools for research and policy development. *European Journal of Soil Science*, 73(5), e13299. https://doi. org/10.1111/ejss.13299.

Ouyang, Y., Higman, J., Thompson, J., Toole, O.T., Campbell, D. (2002). Characterization and spatial distribution of heavy metals in sediment from Cedar and Ortega Rivers sub-basin. *J Contam Hydrol.* 54:19–35.

Shang, H., Zhan, H.Z., Ni, W.K., Liu, Y., Gan, Z.H., Liu, S.H. (2022). Surface Environmental Evolution Monitoring in Coal Mining Subsidence Area Based on Multi-Source Remote Sensing Data. *Front. Earth Sci. 10*, 790737.

Zeng, Y., Pang, Z., Wu, Q., Hua, Z., Lv, Y., Wang, L., Zhang, Y., Du, X., Liu, S. (2022). Study of Water-Controlled and Environmentally Friendly Coal Mining Models in an Ecologically Fragile Area of Northwest China. *Mine Water Environ. 41*, 802–816.

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Opinion
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The Illusion of Time in the fabric of the Universe

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Abstract

The exploration of the concept of the illusion of time, delves into our perception of time as subjective and is influenced by factors such as relativity. The idea of time may be more fluid and interconnected than our linear understanding suggests. Scientific insights challenge the conventional notion of past, present and future, inviting contemplation on the nature of time as a complex and elusive phenomenon.

Key words: *Time, four-dimensional space, Future light cone, Past Light Cone, Special Theory of Relativity.*

Opinion

The concept of time encompasses various facets that puzzled scholars throughout history. One aspect of time is its role as a coordinate assigning labels to moments in our existence while another aspect involves its function as a measure, quantifying the duration between events. The most perceptible aspect is the continuous flow of time, seemingly moving from the past into the future.

Three coordinates are always needed to specify a point in space and are called the spatial coordinate. An event is something that happens at a particular point in space at a particular time. For instance, an event, say an appointment with someone requires a particular location and a specific time.

These four coordinates of an event i.e. the three coordinates of space and one coordinate of time forms the four dimensional space called the Minkowski's space. Time and space are interwoven into a single continuum known as spacetime.(Sorli & Celan, 2022)

As Stephen Hawking explains in his book A brief History Of Time From the Big Bang to Back Holes 'When a pulse of light goes on it will spread out as a sphere of light like a ripple that spread out on the surface of a pond when a stone is thrown in. The ripple spread out as circle that gets bigger as time goes on. If we take snapshots of the expanding circle of ripples and think of the snapshots as one dimension of time and of the two-dimensional surface of the pond to a three-dimensional model, then the expanding circles will mark out a cone whose tip is at the place and time at which the stone hits the water. Similarly, the light spreading out from an event forms a three-dimensional cone in the four-dimensional space-time. This cone is called the future light cone of the event. Inside the future light cone of the event is the set of all the events that can possibly be affected by what happens at the event. In the same way a past light cone can also be drawn which is a set of events from which a pulse of light is able to reach the given event.'(Holyoke & Hawkings, 1989)

If the sun is to explode right now, we would know about it only after eight minutes, the time it takes for the light to reach earth from the sun. When we look at the star Alfa Centauri, we see it as four years ago. We might wonder what it is like, now. We can only see Alfa Centauri by the light that has come from our past up to four years from ago, but we do not know what it is doing right now. It will take four years before what it is doing now can affect us. In a sense we can say that the past state of Alfa Centauri is our present observation while its present state, represents our future observation as we perceive the light emitted from the star. In the same way, we do not

know what is happening at the moment further away in the universe: the light that we see from distant galaxies left them millions of years ago. Thus, when we look at the universe now, we are seeing it as it was in the past. Again, if an observer is moving, he/she could not agree with us, because he/she would put his/her axis at an angle and his/her now would be a different time because of the fact that simultaneity is not a unique thing according to the special theory of relativity.(Feynman et al., 1965) With this bold concept Einstein shattered one of the basic concept of how we experience time. The distinction between past, present and future he once said is only an illusion, however persistent.(Brain Greene, 2004).

Conclusion

Our everyday experience of time may exert a powerful influence. But current reasoning and recent breakthrough in science, made possible by new technologies has compelled us to think beyond our common-sense notion of time. The motion through space affects motion in time. The time it takes from the stars or galaxies to reach us, makes observations of its past state in our present. Thus, in a way time at the deepest sense maybe just an illusion.

References

Brain Greene (2004). The fabric of the cosmos: space, time, and the texture of reality. Choice Reviews Online, 41(11). https://doi.org/10.5860/choice.41-6506

Feynman, R. P., Leighton, R. B., Sands, M., & Hafner, E. M. (1965). The Feynman Lectures on Physics; Vol. I. American Journal of Physics, 33(9). https://doi.org/10.1119/1.1972241

Holyoke, T. C., & Hawkings, S. (1989). A Brief History of Time: From the Big Bang to Black Holes. The Antioch Review, 47(3). https://doi.org/10.2307/4612083

Sorli, A., & Celan, S. (2022). Time, observer, and consciousness. Physics Essays, 35(2). https://doi.org/10.4006/0836-1398-35.2.123

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Research Article
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Socio-Economic Study on Handicraft and Handloom Practices of Yimkhiung Tribe in Kuthur Village of Shamator District, Nagaland.

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Abstract

Handicrafts and handloom could be a means of income as well as protecting and preserving the cultures, but due to the loss of importance that failed the rural people to notice huge advantages which could be extracted from this profession. In present days the practice or learning of handicrafts has been reduced. Young people have less or no interest in handicraft activities due to various aspects like more importance given to government jobs, lack of motivation, less practice of cultural activities, etc. Many people fail to see handicraft practice as an important rural aspect that was once a means of earning for many. Thus, huge unused human resources and other material resources are been wasted, which might give employment opportunities to many as well as preserve the rich culture of the community at the same time. The majority of the younger generation lacks interest in pursuing handicrafts as a profession, because of this; less importance is given to handicrafts which automatically lead to the vanishing culture of the community. Hence the present study aims to study the artisan and young peoples' view on handicraft and handloom and also to analyze the potentiality of this sector as a source of utilizing human resources.

***Key words**: Yimkhiung, Profession, Culture.*

Introduction

Handicraft is a skilled activity in which something is made traditionally with the hands rather than being produced by machines in a factory, or an object made by such activity Handlooms are manually operated looms or weaving devices operated by hands.

Various handicrafts like handlooms, ornaments, wood carving, furniture making, knitting, jewelry, basket making, etc. signify cultural identity. Most of the people still use handmade tools, especially for kitchen and agricultural purposes. Moreover, It is a must for Yimkhiung people to use traditional '*Rungtsun*' (wrapper or mekhala), *Khim* (traditional shawls), and ornaments on various festivals or occasions at the same time '*Hah*' and '*Khi*' (baskets for carrying firewood and grain) that signifies their tribal identity.

About the tribe

Yimkhiung tribe is one of the major tribes in the state of Nagaland, India. It lies in the Eastern part of Nagaland. The word Yimkhiung means "the ones who have reached their place of choice". Strong ties to cultural identity in the form of their love and passion for agriculture are reflected in the hymns and beats of songs devoted to the craft. The musical instruments of the Yimkhiung tribe include simple log drums, trumpets, and flutes. The traditional dress of the Yimkhiungs includes colorful cane-made headgear decorated with hair and bird feathers. Medumnyo and Tsungkamnyo are the two main festivals of the Yimkhiung tribe.

Increased tourism to the region has brought new life to many in Nagaland. Tourism has been supported and encouraged by the locals in the form of shows and demonstrations of the life and customs of the Yimkhiungrü. The Government of Nagaland has been instrumental in providing the proper tools and venues for the Yimkhiungrü to properly share

their traditions, culture, and craft with tourists. Over the last decade, an explosion of tourism in the region has catapulted attempts at preserving the culture of the relevant tribes. The Yimkhiungrü have been at the forefront of preserving culture in the region due to their dedicated festivals aided in part by the Naga State. The Yimkhiung tribe is one among many Naga tribes that contribute to the Hornbill Festival in the Nagaland State of India; the Hornbill Festival showcases the culture and customs of the different tribes of the Naga region. Highlights of the festival include: tribal dances across the many groups of the Naga region, spin top demonstrations by the Yimkhiungrü, and folk songs.

About the village

Kuthur is one of the villages of the Yimkhiung tribe under the Shamator district of Nagaland. It has a total population of 5915 people with 3415 males and 2502 females. The village has 591 households, 6 schools (1 private and 5 government), and 1 Primary Health Centre according to the 2001 census.

Tuensang town of Tuensang district is the nearest town for all trades and communication 10km approximately. The primary sector is the main source of income in the village.

Figure 1. *Kuthur village, Shamator District, Nagaland (Credit: Google Map)*

The study is descriptive as such the methodological approach is both Qualitative and Quantitative. This study has used both primary and secondary sources for data collection. Secondary data were taken from books, journals, and internet sources. Primary data was collected by interview using Interview Schedule and field notes. Two sets of interview schedules were prepared for artisans (producers) and non-producers.

Purposive sampling and convenient sampling are used for the study. Convenient sampling is used on youth and throw ball sampling is used for artisans. The study is conducted on 35 citizens of Kuthur village, who are further categorized based on artisans (producers) i.e. 15 respondents that are engaged in handicrafts, and youth (Non-Producer) i.e. 20 respondents under the age of 30.

Significance

Handicrafts could be a means of income as well as protecting and preserving the cultures, but due to the loss of importance that fails the rural people notice huge advantages which could be extracted from this profession.

However, majority of the younger generation lacks the interest to pursue handicrafts as a profession because of this, less importance is given to handicraft which automatically lead to the vanishing culture of the community. Most of the young people view handicraft as a non-profitable profession and the income from this profession is too low which does not meet their daily expenses. Thus, young people are not willing to accept this profession, and nowadays-day young people want to pursue other professions and in this way handicraft practice is gradually vanishing from their social structure.

Hence the paper aims to study the artisans and non-artisans with the objectives of understanding the changing patterns in products, examining the

present cultural and economic aspects of handicrafts and handlooms, analysing the problems faced by artisans, and, understanding the perception of youth on traditional handicraft.

Changes in the patterns of Handicraft and Handlooms products

Handicrafts and handlooms have undergone immense changes in their patterns as well as the meaning attached to them. As in rural areas, most of the products are somehow been influenced by the culture and practices of the community around them. Jahangir Ahmad Bhat and Pushpender Yadav (2016), in their article, *The Sector of Handicrafts and its Share in Indian Economy. Arabian J Bus Manage Review* suggests that: The sector of handicrafts not only provides employment for the development of the economy but is also a means of expressing views on artisans. Handicrafts also express the representation of the culture, tradition, and heritage of a country Aligning with this view, it can be stated/said that almost every item has some meaning or significance attached to it. In addition to the changing trends as well as the influence of Western culture, traditional items, and designs are modified with the likes of the people.

The study shows there are changes in the type of tools used by the artisans where with the growth of technology, much modern equipment has developed and is used which actually helps in reducing the labour force, and time and improves the quality of the product as well. New colours and designs are made where the combination of modern outlooks and traditional handicraft designs actually meet the needs of consumers but at the same time, the importance and significance attached to it are gradually diminishing.

The study shows that people want the traditional design on their clothes and other modern products but are not in favour of the typical traditional form of these products. Handicraft and handloom products today

are re-designed and beautified with the help of machines and modern techniques based on modern needs.

In the past, materials and resources for preparing handicraft products and handlooms were confined to traditional sources like forest products, self-production, etc. But in contemporary times, resources for producing these items are easily available in the market making it easier for the artisans. The process of producing these items or products has become easier and as a result, the cost of these handicraft products and handlooms has become relatively cheaper. Changes can also be seen in the type of market where people can sell and buy products through online marketing.

Figure 2. *Cane fruit basket*

Figure 3. *A customer using the fusion-cultural headwear*

Figure 4.
An artisan showcasing some of its finished craft

Figure 5.
A middle-aged woman active in weaving

Figure 6.
A woman making traditional attires

Figure 7.
An artisan engaged in ironwork

Figure 8.
Wood carving using indigenous methods
***Photo Credit:** Ruktsula Jangrii 2024*

To examine the present cultural and economic aspect of Handicraft and Handlooms

The study reveals that Handicraft and Handloom products or items are been widely used and are still an important part of village rituals. Though the majority view that the practice of handicrafts and handlooms is fading away due to the introduction of modern companies manufacturing goods and Western wear, people have less interest in the old traditional styles moreover even if the local producer tried to bring out the best it becomes difficult to compete with the company price. Apart from that with the wide importance given to modern occupations and less advertisement in these sectors, the

younger generation hesitate to learn or give less or no importance. However, handicrafts and handloom products are still used on an everyday basis though company-produced goods are equally used.

The study also reveals that the majority of the artisans who are engaged in this profession depend on it for their monthly income; they either sell it for money or at times barter their goods. Moreover, income or profit of production is mostly more good profit out of their work than the expense. Hence it depicts the possibility of employment for others who might gain interest in this sector.

Analyses on the problems faced by artisans

Artisans can make multiple products that are been sold within the locality as well as outside the locality by money or barter system. Most of the artisans relatively get good profit out of their work.

In the process of the work, respondents express the problems that they encounter which include the problem of the market for getting raw materials as well as for selling the finished products due to lack of agents, market, transportation communication, etc. Morof Redzuan and Fariborz Aref (2010), *Constraints and potential of handicraft industry in understanding region of Malaysia. African Journal of Business Management* points out that various constraints faced in the handicraft sector can be grouped into two: the demand constraints and the supply constraints which are seen in various markets for handicraft goods i.e. the local and national Market; the tourist market; and the export market. As such, the current artisans also face the problem of the unavailability of raw materials which affects the quality of goods. The financial aspect is another main problem that they face, as they are from a rural area. Respondents have less or no opportunity to enlighten themselves or have not been enlightened by others about various financial schemes. Moreover, due to their illiteracy and

ignorance most of the producers have no idea about such schemes they cannot avail the benefits as it becomes unapproachable for certain reasons. Adding to that, with the introduction of modern companies manufacturing goods and western products, people have less interest in the old traditional styles moreover even if the local producer tries to bring out the best, it becomes difficult to compete with the company price as the cost of production is higher compare to the value of the product that is available in the market.

A good number of artisans use modern techniques for their work but the majority of the artisans still use or carry out traditional methods thus make harder for them to compete with the company goods and prices in the market. One of the major problems that most of the artisans express is the problem they face during their sickness or health problems as during this period, almost all their works get affected and create a huge financial crisis. Respondents also express that, in present days, the wants and needs of the consumers are very complex and flexible and it becomes hard to reach all their requirements. Changes can also be seen in the type of market where people can sell and buy products through online marketing, which is not easy and convenient for the artisans to benefit from these services as most of them lack the knowledge of availing these services and there are no proper agents to assist them.

Understanding the perception of youth on traditional handicraft

The study reveals that youth still consider handicrafts and handloom products or designs as fashionable but at the same time express that the tradition of handicrafts is fading away. Most of the youth feel that new designs and advanced technological goods are better than traditional ones, thus, prefer relatively the company products as it much cheaper and easily accessible. It is also observed that the majority of the youth respondents that

were taken for study are not interested in any handicraft or handloom practice, as they do not look up to this sector as a source of income or a profitable profession to earn their livelihood.

The study also shows cast that most of the youth who are not artisans are not aware of any schemes as they have not attended or have not encountered any workshops related to this sector, though the responsibility might also lie in the negligence of the respondent, which might be due to lack of interest or lack of motivations of respondents. Hence, the majority of the respondents have no idea or knowledge regarding the government Schemes.

Suggestions.

1. Schemes should be provided directly to the people i.e., the public rather than to some head, and a monitoring officer should be appointed from within the village

   to check the proper distribution of funds or tools, as transparency is required in all government-sponsored schemes and the craftsmen have to be made to understand the benefits that accrue to them.
2. Upgrading the infrastructure of the handicraft clusters by building proper workshops, showrooms, and roads and by providing facilities like power transportation, and marketing places. This would make the clusters into active hubs for sales and for taking orders, and lengthen their outreach, especially for clients from cities and abroad
3. Proper agents are employed by the government to help the artisans in sailing their goods in the market as well as in E- the market.
4. Handicraft and handloom schools should be open in every district with placement opportunities.
5. In other to preserve the culture, elders who are artisans should be appointed.

6. Giving awareness programs or training in schools to enlighten the students at a young age along with the handicraft and handlooms instructor including the existing instructor.
7. Upgrade and try to develop modern strategies for cost minimization and profit maximization by giving Training provide training and awareness about the latest technology and market trends to developing new and existing skilled, semi-skilled, and unskilled manpower, so to uplift them for flexible business environment.

Conclusion

The paper shows that the handicraft and handloom practices used in making cultural attires, indigenous tools, and decors which are also a cultural identity of the Yimkhiung tribe can be a source of income for many people. It can also be a means of utilizing the available human resources which will contribute to the economic growth of the people as well as the society. The government has also taken many steps in uplifting this sector to help the people, but only a few benefits of it especially in the rural areas due to the ignorance of the people, the appointed government officials, and the civil societies. A good number of the population has great capacity and potential to be a contributor to the overall economic development of any nation. Hence, programs and policies need to be customized to not just encourage artisans and youth but also implement strategies that can help support handicraft culture among the masses in general and rural people in particular. The research is open-ended and further study can be carried out in the area of Shamator District.

References

AJ Bhat, P. Y. (2016). The Sector of Handicrafts and its Share in Indian Economy. Arabian J Bus Manage Review.

Dar Ahmad Mansoor, P. H. (n.d.). The socio-Economic potential of handicraft industry in Jummu and Kashmir: opportunities and challenges. International monthly refereed journal of research in management and technology.

Export promotion council for Handicrafts. (n.d.). Retrieved 06 23, 2018. https://www.epch.in.

Haita Kapur, S. M. (2014). Design Intervention &Craft Revival . International Journal of Science Publication.

Jahav, S. (n.d.). IOSR Journal of Business and Management. PP 07-13; www.iosrjournals.org.

Jena, P.K. (2010). Indian handicrafts in globalization times: an analysis of global-local dynamics.

Maureen Liebil, R.T. (2003). Handmade in India: Preliminary Analysis of Crafts Producers and Crafts Production. Economic an Political Weekly, Vol.38, 5366-5376.

Morof Redzuan, F.A. (2010). Constraints and potential of handicraft industry in understanding region of Malaysia. African Journal of Business Management.

Ram, M.K. (2014). Present Scenario of Handloom and Handicrafts Industries of the ADIS. Journal of Global Economy, research centre for Social Science, Mumbai, India, 191-203.

Solanki, S.S. (1998). Sustainability of Rural Artisans. Economic and Political Weekly, Vol.43,no. 19.

YTC. A brief account of Yimkhiung tribe. Retrieved www.yimkhiungrutruk.com.

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Research Article
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Study of Interstellar Extinction by Aggregate Model

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Abstract

Transition Matrix approach's framework, the relevant optical properties of interstellar dust grains, modeled as composite, irregular shaped particles are calculated. Ballistic Particle-Cluster Aggregation (BPCA) and Ballistic Cluster-Cluster Aggregation (BCCA) are the two aggregation mechanisms used for producing clusters with different structure and degree of fluffiness. In the present work, a scientific study on the interstellar extinction is done. The results show about the extinction efficiencies that bring out the effect of grain sizes.

Key words: *dust, extinction*

Introduction

Microscopic grains of matter that occur in space play an important role in the origin of planetary systems and possibly even that of life itself. The composition, size, and other properties of dust particles vary from one location to another.Maximum dust in interstellar space coming from stars have moved off the main sequence and entered the red giant phase of their evolution. These stars have extended atmospheres rich in silicon, oxygen, and carbon – elements that were manufactured in the stellar core but that have been dredged to the surface by convection currents. Through a variety

of chemical "sticking" processes, other substances may then be added to the mantle ices, including small molecules such as carbon monoxide (CO) and hydrogen sulfide (H_2S). Bombardment by ultraviolet radiation from local hot stars, or more remote stars, triggers reactions between the different chemical species on a grain's surface and leads to the formation of simple organic substances interstellar chemistry. Even though there is some portion of direct knowledge of the true nature of interstellar dust grains, two pieces of evidence point toward the possibility that interstellar grains are composites of many small grains of silicates and amorphous carbon (Mathis & Whiffen, 1989). First, dust grains are thought to grow through coagulation, rather than by gas accretion onto their surfaces (Draine, 1985). At that time smaller grains collide and come together to form larger grains, with cavities and voids incorporated into the conglomerate. Second, studies of interplanetary and cometary dust indicate that cosmic grains are likely to be porous and fluffy (Krueger & Kissel, 1989). These grains are termed as units (monomers) sizing in micrometer scale. They can aggregate into fluffy particles with sizes 0.1–10 μm (Wolff et al., 1994).

The Interstellar dust particles strongly absorb, scatter, and polarize visible light at the wavelengths comparable to their sizes and they reemit the light in the far-infrared region of the spectrum. The amount of visual interstellar extinction is wavelength-dependent and leads to both a dimmingand a reddening of starlight, as blue wavelengths tend to be scattered the most (Hagen & Greenberg, 1990).

A model for interstellar grains was proposed by Mathis in the year 1996 where it was mentioned that the bulk of the infrared, visual and ultraviolet extinction arises from composite grains containing voids. These fluffy or porous aggregates can produce more extinction per unit mass than

their combined individual constituent dust grains. The validity of mixing techniques, the Bruggeman rule (Bohren & Huffman, 1983) requires that the size of the whole particle to be comparable to the wavelength, while in the homogeneities should be much smaller than latter. It is now well accepted that the interstellar grains are non spherical in shape. The collected interplanetary particles are non spherical and highly porous and composites of very small grains glued together. Moreover, the interstellar polarization that accompanies extinction requires that the interstellar grains must be aligned and non spherical. Now a day's several numerical techniques are practiced for obtaining scattering and absorption cross sections for non-spherical particles (Mishchenko et al., 2000). T-matrix technique plays a crucial role in aggregation models by enabling researchers to investigate how electromagnetic waves interact with complex structures formed by the aggregation of particles. It transforms the expansion coefficients of the incident field into those of the scattered field and can be used to compare any scattering characteristic of a non-spherical particles (Mishchenko et al., 2002). With the application of this approach, the relevant optical properties of cosmic dust grains of amorphous carbon and silicates were calculated by Iati and his team in the year 2004 (Iati et al., 2004). Two mechanisms of aggregation were considered, producing clusters with different degrees of fluffiness i.e. ballistic particle cluster aggregation and ballistic cluster cluster aggregates. Vaidya evaluated the extinction curve and compared with average observed interstellar extinction curve using DDA method (Vaidya et al., 2006).

We are using the Superposition T-matrix theory to study the extinction properties for porous and composite interstellar particles. The T-Matrix code on the other hand runs much faster than DDA and the results

obtained can be tuned easily because in a short interval of time the input parameters to the code can be adjusted and run again (Asano et. al., 1976).

The web site *http://www.giss.nasa.gov/crmim* provides several FORTRAN T-Matrix codes and these codes compute the whole set of scattering characteristics, the optical cross sections, and expansion coefficients, and the scattering matrix for the particles which randomly oriented and aligned.

Aggregate dust model

In our computations, we build our aggregates using ballistic aggregation procedure (Meakin, 1984). Two different models of cluster growth are adopted: first via single-particle aggregation and then through cluster–cluster aggregation (Meakin, 1983). These aggregations are made by random hitting and sticking particles together. Ballistic Particle-Cluster Aggregate (BPCA) aggregation allows only single particles to join the cluster of particles whereas Ballistic Cluster–Cluster Aggregate (BCCA) aggregation allows clusters of particles to stick together (Bhattacharjee et al., 2011).

The scattering calculations are performed by the Superposion T-Matrix Method, which gives rigorous solutions for ensembles of spheres (Mackowski & Mishchenko, 1996). The wavelength- dependant extinction of starlight i.e, the extinction curve remains the principal source of information about interstellar dust (Draine, 2009). At shorter wavelength, Interstellar extinction increases and as a result interstellar reddening takes place. The extinction curve contains the spectral feature that constrains the composition of the dust. The strongest feature is a broad bump peaking near $2175A^0$. The strength of this feature requires that it be produced by a substance composed of high abundance elements, such as C, Mg, Si, or Fe (Draine 1989). Modelling of the wavelength dependencies of interstellar

extinction, and linear polarization allows one to obtain information about properties like, grain size, composition, shape etc. Interstellar polarization also gives the information about the structure of magnetic fields because it arises due to dichoric extinction of non-spherical grains aligned in large scale Galactic magnetic fields. Very often interstellar extinction and interstellar polarization are modelled separately. The modelling of these phenomena usually includes consideration of normalized extinction and normalized polarization (Chakraborty et al., 2011). Interstellar extinction grows with a radiation wavelength decrease while interstellar linear polarization has a maximum at the visual part of the spectrum and declines at shorter and longer wavelengths (Weingartner & Draine 2001).The following inferences can be drawn from the modelling of the partially aligned spheroid grains.

i. The particle's composition and size determine the wavelength dependence of $P(\lambda)/A(\lambda)$.
ii. Values of $P(\lambda)/A(\lambda)$ is measured by the particle shape, degree and the direction of the alignment.
iii. The modeling of the wavelength dependence of polarizing efficiency does not allow one to determine all parameters dust ensemble. Therefore, interpretation of observation must include consideration of extinction.

Extinction properties of interstellar Grains

One of the main objectives of the paper is to study the extinction efficiencies of the silicate and graphite grains, using the T-Matrix calculations and to see the effects of shape of the varioussizes which are typical to interstellar grain sizes i.e. 0.001 to about 0.500μ. These materials (i.e. silicate and graphite) have been the ingredients for most of the grain models (Mathis et. al. 1977) We present the results for the

extinction efficiencies Qext as a function of wavelength in the spectral range (3.4 to 0.1 μ*m*). We have evaluated the interstellar extinction curves for grain size distribution with the smaller size limit starting at a=0.001 μm and the larger size limit up to a=0.10 μm for silicates and 0.06 μm for graphites (Draine & Lee, 1984).

Extinction curves for Silicate grains

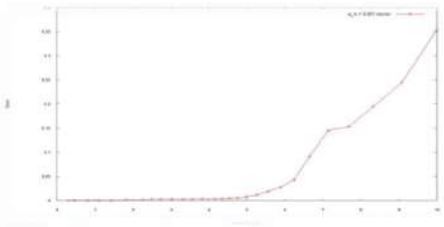

Figure1(a)

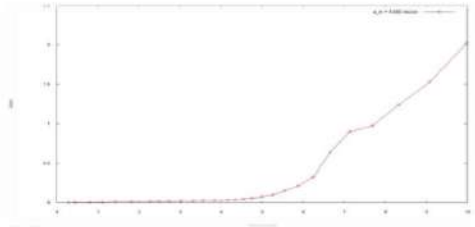

Figure 1(b)

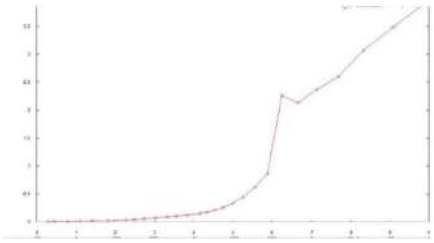

Figure 1(c)

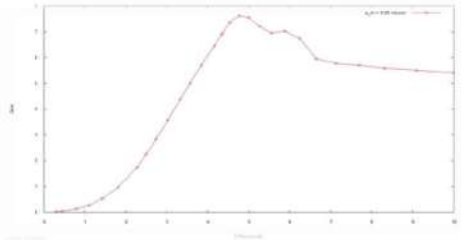

Figure 1(d)

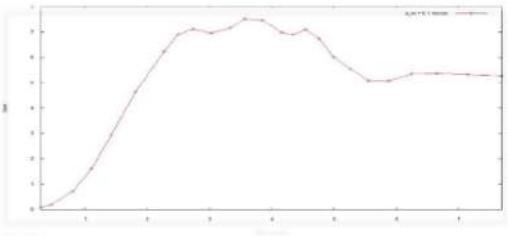

Figure 1(e)

Figure 1 *shows the extinction efficiencies (Q_{ext}) versus wavelength for randomly oriented silicate grains for five different grain sizes i.e. 0.001, 0.005, 0.01, 0.05 and 0.1 μm with step size in entire wavelength range (3.4 - 0.1 μm) and how the extinction efficiencies bring out the effect of grain sizes. It is seen from this figure that there is a UV bump in the extinction curve within the wavelength range from 0.160-0.130 μm, the grains (0.001-0.050 μm) display similar extinction properties.*

Extinction curves for Graphites:

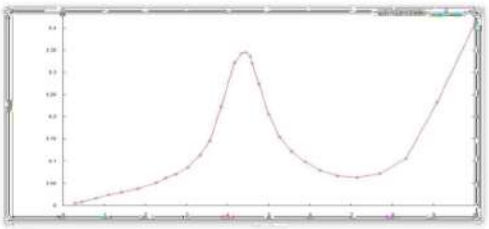

Figure 2(a)

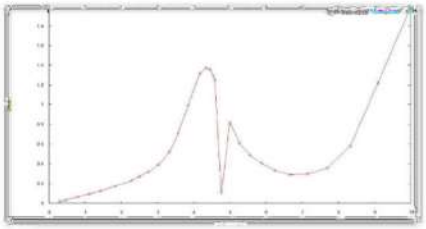

Figure 2(b)

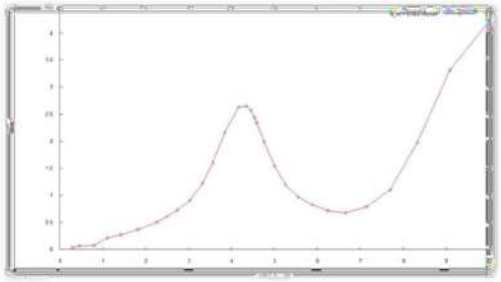

Figure 2(c)

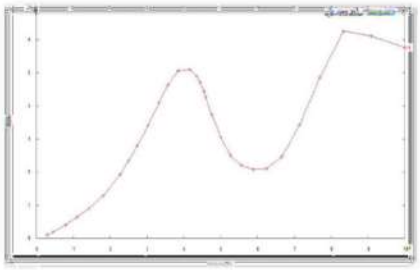

Figure 2(d)

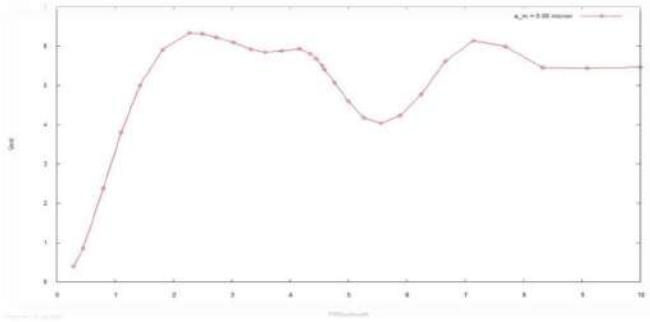

Figure 2(e)

Figure 2. *Shows extinction efficiencies (Q_{ext}) versus wavelength (ranges from 3.4 to 0.1 μm) forrandomly oriented graphite grains for five different grain sizes i.e, 0.001, 0.004, 0.008, 0.02 & 0.04μm.*

For small graphite grains (a=0.01 μm) the 2175Å extinction feature is displayed by all the spheroidal grain models (Gupta et al, 2005), but the peak is shifted for various axial ratios. In order to emphasize this aspect we show in Figure 2(c), 2(d) the extinction efficiency Qext for the graphite grains for a=0.008 and 0.020 μm in the wavelength range 0.30 - 0.20 μ*m*. These curves clearly show the shift in the peak moves left with the increase in grain size. These results on the spheroidal grains indicate that the shape of the grains plays an important role in studying extinction properties and needs to be studied in more details. It has also found the variation in the 2175Å feature with the shape of the grain (Voshchinnikov, 1990). It is to be noted from Figure 2(c) & 2(d) that for graphite grains with grain size, there is no appreciable variation in the extinction. The Figure 2(c) shows the best fit model curve. The top panel shows the curve in the wavelengthregion 3.4 to 0.1 μ*m* i.e. far UV to NIR. The bottom panel highlights the UV bump region. The best model curve thus consists of a size distribution a=0.005-0.225 μm in steps of 0.005 μm (Vaidya et. al., 2001).

Summary and Conclusions

By applying T-matrix calculations, the extension efficiencies of interstellar dust grains made of silicate and graphite across a wavelength range of 3.4 to 0.3 micrometer are found. Using aggregate models for interstellar extinction provides a more comprehensive framework for understanding how dust impacts straight. The Qext computations were used to model the interstellar extinction and then compared with the observed curve. The real interstellar grains might be more complex. The T-matrix method is a useful approach for studying the optical properties of silicate and graphite grains. It allows for flexibility in adjusting the grain shape, size, and

composition to fit the observational data more accurately. This approach enhances our knowledge of the composition and properties of interstellar dust, aiding in the interpretation of astronomical observations and improving our understanding of the interstellar medium.

References

Asano, S., and Yamamoto, G. (1976). Light scattering by a spheroidal particle: errata. *Appl. Opt. 15*, 2028-2028.
https://opg.optica.org/ao/abstract.cfm?URI=ao-15-9-2028

Asano,S., and Yamamoto, G. (1975). Light Scattering by a Spheroidal Particle. *Appl. Opt*, *14*, 29-49.
https://opg.optica.org/ao/abstract.cfm?URI=ao-14-1-29

Bhattacharjee, C., Das, H.S., Sen, A.K. (2011). Study of interstellar extinction by aggregate dust model, *ASI Conference Series*, *3,*112.

Bohren, C.F., and Huffman, D.R. (1983). Absorption and Scattering of Light by Small Particles,*John Wiley*, New York.

Borghese, F., Denti, P., Saija, R (2003) Scattering from Model Nonspherical Particles:Theory and Applications to Environmental Physics'. *Springer*, p.224.

Chakraborty, A., Debroy, P., Das, H.S. (2011). Modeling interstellar extinction using a mixture of compact and aggregate particles, *ASI Conference Series*, *3,*111.

Draine B.T. (1985). Tabulated optical properties of graphite and silicate grains. *The Astrophysical Journal Supplement Series*, *57*,587-594.

Draine B.T. (1989). On the Interpretation of the λ 2175 Å feature. *Interstellar Dust*, *135,313*-327

Draine, B.T., and Lee, H.M. (1984), Optical properties of interstellar graphite and silicate grains. *The Astrophysical Journal*, *285*, 89-108.

Gupta, R., Mukai, T., Vaidya, D.B., Sen, A., Okada Y. (2005), Interstellar

extinction by spheroidal dust grains, *A & A*, *441*(2), 555-561, DOI: 10.1051/0004-6361:20052707

Iatì, M.A., Saija, R., Borghese, F., Denti, P., Cecchi-Pestellini, C., Williams, D.A. (2008). Stratified dust grains in the interstellar medium-I: An accurate computational method for calculating their optical properties. *Monthly Notices of the Royal Astronomical Society*, *384*(2), *591-598.*

Iati, M.A, Cecchi-Pestellini C., Williams D.A., Borghese F, Denti, P. (2001). Porous interstellar grains. *MNRAS, 322,*749-756.

Krueger, F. R., and Kissel, J. (1989). Origins Life Evol. *Biosphere*, *19*, 87-93

Mackowski D.W., and Mishchenko M.I. (1996) Calculation of the *T* matrix and the scattering matrix for ensembles of spheres. *JOSAA*, *13* (11);2266-2278.

Mathis J.S., and Whiffen G. (1989). Composite interstellar grains. *Astrophysical Journal, 341*, 808-822.

Mathis, J.S. (1996). Dust Models with Tight Abundance Constraints. *Astrophysical Journal, 472,*643-655.

Mathis, J.S., Rumpl, W., Nordsieck, K.H. (1977). The Size Distribution of Interstellar Grains. Astrophysical Journal, *217,* 425-433. https://doi.org/10.1086/155591.

Meakin, P. (1983). The Vold-Sutherland and Eden Models of Cluster Formation. *Journal of Colloid and Interface Science*, *96*(2);415-426.

Michael, P., Zoltan, R. (1984). Active zone of growing clusters: Diffusion-limited aggregation and the Eden model. *Physical Review Letters*, *53* (5);415-418.

Mishchenko M.I, Travis L.D. and Lacis A.A. (2002). Scattering, Absorption, and Emission ofLight by Small Particles'. CUP, Cambridge UK.

Mishchenko, M.I., Hovenier, J.W., Travis L.D., Eds. (2000). Light Scattering by Nonspherical Particles: Theory, Measurements, and Applications.

Academic Press, San Diego.

Vaidya, D.B. & Gupta, R. (1997). Extinction by porous silicate and graphite grains. *Astronomy and Astrophysics*, *328*, 634-640.

Vaidya, D.B. & Gupta, R. (1999). Interstellar extinction by porous grains. *Astronomy and Astrophysics*, *348*, 594-599.

Voshchinnikov, N.V. (1990). Interstellar Lambda 2200 Band and Aspherical Graphite Grains.Soviet Astronomy Letters, *16*, (3), 215-222.

Waterman, P.C. (1971). Symmetry, Unitarity, and Geometry in Electromagnetic Scattering. *Physical Review D*, *3*, 825-839. http://dx.doi.org/10.1103/PhysRevD.3.825.

Waterman. P.C. (1965). Matrix formulation of electromagnetic scattering. *Proceedings of the IEEE*. *53*(8);805-812. https://doi.org/10.1109/PROC.1965.4058.

Wolff, M.J., Clayton, G.C., Martin, P.G., Schulte-Ladbeck, R.E. (1994). Modeling composite and fluffy grains: The effects of porosity. *The Astrophysical Journal*, *423* (1), 412-425.

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Research Article
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Extract of Botanical Trip to Yaongyimchen, Longleng Nagaland

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Abstract

This paper gives preliminary report on flowering plants from Yaongyimchen, Alayung and Sanglu village under Longleng district, Nagaland, India. The specimen collected gives an account of total 124 taxa belonging to 63 angiosperm families, including some with medicinal and ornamental values.

Key words: *Community, Biodiversity, Angiosperms, Conservation, Nagaland.*

Introduction

Yaongyimchen Community Biodiversity Conservation Area under 3 villages (Yaongyimchen, Alayung and Sanglu) has been in news recently, associated with Green Oscar Award (Whitley Fund for Nature) to one of its proponents ([3]YNP). The community conservation initiatives have also been recognized in several platform including the National Biodiversity Award for

conservation of wild species (2015), Governor's Gold Medal Award (2021), United Nations Recognition (2016) for efforts to conserve *Falco amurensis*.

Geographically the area is located along the 26.512474° North Latitude and 94.730825° East Longitude. Stretching about 17 Sq.Kms, a Biodiversity Conservation Area was declared by the Citizens of Yaongyimchen, Alayung and Sanglu villages, covering a population of about 1800 comprising 320 families.

Educational trip including Botanical survey in this part of the region is very limited and there are no reports of flora and faunal exploration. The remoteness, difficult hilly terrain, poor connectivity, makes the region least accessible and inhospitable for botanical exploration (Moaakum *et al*, 2016). A conspectus of families of different groups indicating number of genera, species, subspecies and varieties in the checklist of flora of Nagaland have been published by Mao *et al* (2017). They have reported a total of 2363 floral species belonging to 189 families.

Vegetation Types of the Study Area

The present study was conducted in tropical forest type. Tropical forests are found in area receiving an annual rainfall of about 200 cm and with a varying range of elevation up to 900m. The top canopy trees are *Erythrina stricta*, *Emblica officinalis*, *Kydia calycina*, *Schima wallichii*, *Albizzia stipulata*, *Bischofia javanica*, *Bombax ceiba*, *Gmelina arborea*, *Litsea monopetala*, *Stereospermum colais*, *Firmiana colorata*, etc.

The second storey is composed of *Archidendron clypearia*, *Bauhinia variegata*, *Callicarpa arborea*, *Litsea glutinosa*, *Syzygium syzygioides*, *Garcinia paniculata*, *Sambucus javanica*, *Elaeocarpus floribundus*, *Grewia abutilifolia*, *G. serrulata*, *Macaranga denticulata*, *Micromelum integerrimum*, *Breynia retusa* etc. Common shrubs include *Ficus hirta*, *F.*

hispida, *F. semicordata*, *F. gasparrianiana*, *F. subincisa*, *Clerodendron viscosum*, *C. serratum*, *Saurauia napaulensis*, *Maesa chisia*, *M. indica*, *Melastoma nepalensis*, *Osbeckia* spp., *Phogacanthus tubiforus*, *P. curviflorus*, *Lantana camara*, *Costuss peciosus*, *Desmodium sequax*, *D. multiflorum*, *D. gyroides*, *Leea guineensis*, *L. macrophylla*, *L. compactiflora*, etc.

Lianas are fewer but scandent shrubs like *Bridelia scandens*, *Combretum acuminatum*, *Entada rheedei*, *M. glabra*, *Butea parviflora*, *Ampelocissus divaricata*, *Cayratia japonica*, *Cissus adnata*, *C. repens* etc. are commonly found.

The ground flora is represented by the species of *Crotalaria ferruginea*, *Desmodium heterocarpon*, *D. heterophyllum*, *D. triflorum*, *Phlogacanthus curviflorus*, *P. tubiflorus*, etc. However, due to intensive Jhum cultivation this type of forest are highly degraded which results in growth of common invasive taxa like *Eupatorium* spp., *Lantana camara*, *Macaranga peltata*, *Artemisia nilagirica*, *Justicia* spp., *Torenia* spp., *Mikania micrantha etc*. Bamboo species likes *Dendrocalamus hamiltonii*, *Bambusa tulda*, *B. pallida*, etc. are also found everywhere in these forests as successional vegetation.

On the other hand, herbaceous vegetation comprises of *Impatiens* spp., *Sonerila* spp., *Oxalis corniculata*, *O.corymbosa*, *Torenia* spp., *Justicia* spp., *Begonia* spp., *Salomonia cantoniensis* etc. are also common in this area.

Materials and Methods

The Botanical field trip was carried out aiming to document floristic diversity. The field guide and community elders assisted in obtaining valuable information about the field floral diversity. The plant specimens were collected and preserved based on standard procedure (Jain and Rao, 1977) and identified following valid scientific keys through available

regional and national flora literatures (Clarke, 1887; Kanjilal *et al*, 1934;1936;1938;1940; Joseph, 1982; Balakrishnan, 1981–1983; Haridasan and Rao, 1985–1987; Hynniewta *et al*, 2000).

Results

During the present Botanical trip, 124 taxa belonging to 63 families were recorded reflecting that the study area harbors a diverse flora. Out of them 30 species were found to have medicinal values and several others with ornamental and traditional significance. A large number of faunal species and physico-chemical composition of soil and water (unpublished data) also shows richness of natural process in the area.

The following table presents list of flora documented during the study:

Sl. No.	Scientific name	Family
1.	*Abelmoschus moschatus* Medik.	Malvaceae
2.	*Abroma augusta* (L.) L.f.	Malvaceae
3.	*Abrus precatorius* L.	Fabaceae
4.	*Achyranthes aspera* L.	Amaranthaceae
5.	*Actinodaphne obovata* (Ness) Blume	Lauraceae
6.	*Aeschyranthus micranthus* C.B. Clarke	Gesneriaceae
7.	*Aeschynanthus parviflorus* (D.Don) Spreng.	Gesneriaceae
8.	*Ageratum conyzoides* (L.) L.	Asteraceae
9.	*Alangium chinensis* (Lour.) Harms	Cornaceae
10.	*Alpinia nigra* (Gaertn.) Burtt	Zingiberaceae
11.	*Amischotolype hookeri* (Hassk.) H.Hara	Commelinaceae
12.	*Aporosa octandra* (Buch. -Hamilton. ex D.Don) Vickery	Euphorbiaceae
13.	*Argyreia capitiformis* (Poir.) Ooststr	Convolvulaceae

15.	*Baccurea ramiflora* Lour.	Phyllanthaceae
16.	*Bauhinia acuminata* L.	Fabaceae
17.	*Begonia roxburghii* Miquel	Begoniaceae
18.	*Bischofia javanica* Blume	Phyllanthaceae
19.	*Buddleja asiatica* Lour.	Scrophulariaceae
20.	*Callicarpa arborea* Roxb.	Lamiaceae
21.	*Canscora andrographioides* Griff. ex C.B.Clarke	Gentianaceae
22.	*Carallia brachiata* (Lour.) Merr.	Rhizophoraceae
23.	*Casearia vareca* Roxb.	Salicaceae
24.	*Centella asiatica* (L.) Urb.	Apiaceae
25.	*Chonemorpha fragrans* (Moon) Alston	Apocynaceae
26.	*Clerodendrum bracteatum* Wall. ex Walp.	Lamiaceae
27.	*Clerodendrum sp.* Lindl.	Lamiaceae
28.	*Coelogyne imbricata* (Hook.) Rchb.f.	Orchidaceae
29.	*Colona floribunda* (Kurz) Craib	Malvaceae
30.	*Combretum acuminatum* Roxb.	Combretaceae
31.	*Croton persimilis* Müll.Arg.	Euphorbiaceae
32.	*Croton caudatus* Geiseler	Euphorbiaceae
33.	*Dalbergia millettii* var. *mimosoides* (Franch.) Thoth.	Fabaceae
34.	*Daubanga grandiflora* (Roxb. ex DC.) Walp.	Lythraceae
35.	*Decalobanthus mammosus* (Lour.) A.R.Simões & Staples	Convolvulaceae
36.	*Derris taiwaniana* (Hayata) Z.Q Song	Fabaceae

37.	*Dianella ensifolia* (L.) Redoute	Asphodelaceae
38.	*Dienia ophrydis* (J.Koenig) Seidenf.	Orchidaceae
39.	*Dimetia scandens* (Roxb.) R.J.Wang	Rubiaceae
40.	*Dioscorea pentaphylla* L.	Dioscoreaceae
41.	*Dioscorea glabra* Roxb.	Dioscoreaceae
42.	*Dioscorea* sp.	Dioscoreaceae
43.	*Dischidia bengalensis* Colebr.	Apocynaceae
44.	*Elaeocarpus* sp.	Elaeocarpaceae
45.	*Embelia ribes* Burm.f.	Primulaceae
46.	*Engelhardtia spicata* Lechen ex Blume	Juglandaceae
47.	*Entada rheedii* Spreng.	Fabaceae
48.	*Eryngium foetidum* L.	Apiaceae
49.	*Erythrina stricta* Roxb.	Fabaceae
50.	*Etlingera linguiformis* (Roxb.) R.M.Sm.	Zingiberaceae
51.	*Eurya acuminata* DC.	Pentaphylacaceae
52.	*Ficus hispida* L.f.	Moraceae
53.	*Ficus simplicissima* Lour.	Moraceae
54.	*Ficus auriculate* Lour.	Moraceae
55.	*Ficus semicordata* Buch. -Ham. ex Sm.	Moraceae
56.	*Ficus squamosa* Roxb.	Moraceae
57.	*Ficus subincisa* Buch.-Ham. ex Sm.	Moraceae
58.	*Firmiana colorata* (Roxb.) R.Br	Malvaceae
59.	*Firmiana sp.*	Malvaceae
60.	*Floscopa scandens* Lour.	Commelinaceae
61.	*Garcinia sopsopia* (Buch.-Ham.) Mabb.	Clusiaceae
62.	*Geranium nepalense* Sweet	Geraniaceae

63.	*Gmelina arborea* Roxb. ex Sm.	Lamiaceae
64.	*Grewia abutilifolia* Vent. ex Juss.	Malvaceae
65.	*Grona heterocarpos* (L.) H.Ohashi & K.Ohashi	Fabaceae
66.	*Heptapleurum venulosum* (Wight & Arn.) Seem.	Araliaceae
67.	*Hibiscus macrophyllus* Roxb. ex Hornem.	Malvaceae
68.	*Hodgsonia marcocarpa* (Blume) Cogn.	Cucurbitaceae
69.	*Houttuynia cordata* Thunb.	Saururaceae
70.	*Impatiens arguta* Hook.f. & Thomson	Balsaminaceae
71.	*Ipomoea pileata* Roxb.	Convolvulaceae
72.	*Itea macrophylla* Wall.	Iteaceae
73.	*Kydia calycina* Roxb.	Malvaceae
74.	*Leea asiatica* (L.) Ridsdale	Vitaceae
75.	*Litsea monopetala* (Roxb.) Pers.	Lauraceae
76.	*Litsea cubeba* (Lour.) Pers.	Lauraceae
77.	*Macaranga denticulata* (Blume) Müll.Arg.	Euphorbiaceae
78.	*Macrosolen cochinchinensis* (Lour.) Tiegh.	Loranthaceae
79.	*Magnolia hodgsonii* (Hook.f. & Thomson) H.Keng	Magnoliaceae
80.	*Mallotus tetracoccus* (Roxb.) Kurz	Euphorbiaceae
81.	*Mastersia assamica* Benth.	Fabaceae
82.	*Meistera koenigii* (J.F.Gmel.) Škorničk. & M.F.Newman	Zingiberaceae
83.	*Mikania scandens* (L.) Willd.	Asteraceae

84.	*Mimosa pudica* L.	Fabaceae
85.	*Mischocarpus pentapetalus* (Roxb.) Radlk.	Sapindaceae
86.	*Morinda angustifolia* Roxb.	Rubiaceae
87.	*Musa cheesmanii* N.W.Simmonds	Musaceae
88.	*Musa flaviflora* N.W.Simmonds	Musaceae
89.	*Musa itinerans* Cheesman	Musaceae
90.	*Myrica esculenta* Buch. -Ham.ex D.Don	Myricaceae
91.	*Oroxylum indicum* (L.) Kurz	Bignoniaceae
92.	*Osbeckia nepalensis* Hook.	Melastomataceae
93.	*Oxalis corniculata* L.	Oxalidaceae
94.	*Paederia foetida* L.	Rubiaceae
95.	*Parkia timoriana* (DC.) Merr.	Fabaceae
96.	*Phlogacanthus curviflorus* (Nees) Nees	Acanthaceae
97.	*Plantago asiatica* subsp. *erosa* (Wall.) Z.Yu Li	Plantaginaceae
98.	*Pterospermum acerifolium* (L.) Willd.	Malvaceae
99.	*Raphidophora dicursiva* (Roxb.) Schott	Araceae
100.	*Rhus chinensis* Mill.	Anacardiaceae
101.	*Rhynchoglossum obliquum* Blume	Gesneriaceae
102.	*Salomonia cantoniensis* Lour.	Polygalaceae
103.	*Sapium eugeniifolium* Buch. -Ham. ex Hook.f.	Euphorbiaceae
104.	*Saurauia punduana* Wall.	Actinidiaceae
105.	*Schima wallichii* (DC.) Korth.	Theaceae
106.	*Scutellaria sp.*	Lamiaceae
107.	*Smilax perfoliata* Lour.	Smilacaceae

108.	*Stachytarpheta jamaicensis* (L.) Vahl	Verbenaceae
109.	*Stemona tuberose* Lour.	Stemonaceae
110.	*Stereospermum colais* (Buch. -Ham. ex Dillwyn) Mabb.	Bignoniaceae
111.	*Stixis suaveolens* (Roxb.) Baill.	Resedaceae
112.	*Styrax serrulatum* Roxb.	Styracaceae
113.	*Syzygium* sp.	Myrtaceae
114.	*Tadehagi triquetrum* (L.) H.Ohashi	Fabaceae
115.	*Tephrosia candida* DC.	Fabaceae
116.	*Thunbergia grandiflora* Roxb.	Acanthaceae
117.	*Tolypanthus involucratus* (Roxb.) Tiegh.	Loranthaceae
118.	*Torenia violacea* (Azaola) Pennell	Linderniaceae
119.	*Trema orientale* (L.) Blume	Cannabaceae
120.	*Triumfetta rhomboidea* Jacq.	Malvaceae
121.	*Triumfetta pilosa* Roth	Malvaceae
122.	*Uraria* sp.	Fabaceae
123.	*Urena lobata* L.	Malvaceae
124.	*Wallichia oblongifolia* Griff.	Arecaceae

Conclusion

Biological diversity is visibly manifested in certain regions where there is no external interference on the ecological processes. Forests dependent communities are encouraged to adopt the biodiversity conservation initiatives emphasizing that efforts to conserve the rich flora and fauna must start from grassroot level communities. However, campaign for deforestation alone will have little impact since the question of their sustenance remains unaddressed in most intervention measures. Relevant research is required to obtain detailed information with valid scientific

documentation on practices that influence biodiversity. Educating the forest dependent communities towards improved understanding of conservation and management, involving them in the implementation process, inculcate a sense of ownership are some pressing need. When these pertinent issues are addressed, more communities can come forward to participate in conservation of forest, wildlife and the natural resources. Involvement of grassroot level communities can have far reaching impact in providing nature-based remedies, ensuring a local effort for global cause.

Abelmoschus moschatus
Local Name: Aakphempa

Abroma augusta
Local Name: Aijenasu

Abrus precatorius
Local name: Suji Leplang

Aeschyranthus micranthus
Local name: Ousukokem

Aeschynanthus parviflorus
Local Name: Annalü

Alangium chinense
Local Name: Cha sung

Alpinia nigra
Local Name:Saa

Amischotolype hookeri
Local Name: Cheplujang

Aporosa octandra
Local Name: Dük

Argyreia capitiformis
Local Name: Anjhelü

Artocarpus lacucha
Local name: Düngdulüshi

Baccurea ramiflora
Local name: Jangshi

Bauhinia acuminata
Local Name: Nokphaelang

Begonia roxburghii
Local Name: Kojenaleve

Bischofia javanica
Local Name: Julü

Buddleja asiatica
Local Name: Meji

Callicarpa arborea
Local Name: Bhajet

Canscora andrographioides
Local Name: Jioknalo

Carallia brachiata
Local Name: Salongselong

Casearia vareca
Local Name: Dhüngling

Chonemorpha fragrans
Local Name: Chetonalo

Clerodendrum bracteatum
Local Name: Kainemdelave

Clerodendrum sp.
Local Name: Kainem

Colona floribunda
Local Name: Melangnem

Combretum acuminatum
Family: Combretaceae

Croton persimilis
Local Name: Kokalü

Grona heterocarpos
Local Name: Longnyangasu

Tadehagi triquetrum
Local Name: Navükla

Dianella ensifolia
Local Name: Jükteve

Dioscorea pentaphylla
Local Name: Chujaang

Dienia ophrydis
Local Name: Chingenamh

Embelia ribes
Local Name: Lennaklü

Engelhardtia spicata
Local Name: Jinglütembe

Eryngium foetidum
Local Name: Menem

Erythrina stricta
Local Name:
Lojeth

Etlingera linguiformis
Local Name: Kumlü

Eurya acuminata
Local Name: Mükdu

Ficus simplicissima
Local Name: Phangsem

Ficus hispida
Local Name:Phangsem delave

Ficus auriculata
Local Name: Mumu

Ficus sp.
Local Name: Khulü

Ficus subincisa
Local Name: Mumu delave

Firmiana colorata
Local Name: Metangpen

Floscopa scandens
Local Name: Mongoasu

Garcinia sopsopia
Local Name: Outaü

Geranium nepalense
Local Name: Naongmaji

Gmelina arborea
Local Name: Nyekhung

Grewia abutilifolia
Local Name: Aakjumen

Dimetia scandens
Local Name: Chingkunalo

Hibiscus macrophyllus
Local Name: Achasüng

Hodgsonia marcocarpa
Local Name: Asuh

Houttuynia cordata
Local Name: Münyü nalo

Impatiens arguta
Local Name: Oksau

Ipomoea pileate
Local Name: Mehelaasu

Itea macrophylla
Local Name: Mejinyidok

Kydia calycina
Local Name: Ajilendung

Leea asiatica
Local Name: Chongnyang

Litsea monopetala
Local Name: Lenh

Macaranga denticulata
Local Name: Khavo

Macrosolen cochinchinensis
Local Name: Angumalet

Magnolia hodgsonii
Local Name: Kemjük

Mallotus tetracoccus
Local Name: Pongnyeü

Mastersia assamica
Local Name: Nemnalü

Decalobanthus mammosus
Local Name: Shilulü

Derris taiwanniana
Local Name: Phaesunalo

Mimosa pudica
Local Name: Ayaknalo

Mischocarpus pentapetalus
Local Name: Mondüngjang

Morinda angustifolia
Local Name:
Ayungchinglang

Musa cheesmanii
Local Name: Lanyak

Musa flaviflora
Local Name: Nyalang

Musa itinerans
Local Name: Changche

Litsea cubeba
Local Name: Angüt

Myrica esculenta
Local Name: Sensalashi

Oroxylum indicum
Local Name: Dhoklo

Osbeckia nepalensis
Local Name: Nyüksem

Oxalis corniculata
Local Name:Akhumaji

Paederia foetida
Local Name: Mesüngasu

Phlogacanthus curviflorus
Local Name: Akungnalo

Pterospermum acerifolium
Local Name: Mokhok

Rhus chinensis
Local Name: Thangmu

Rhynchoglossum obliquum
Local Name: Dühnalo

Salomonia cantoniensis
Local Name: Anyingsu

Saurauia punduana
Local Name: Uotaü

Schima wallichii
Local Name: Mangsüng

Smilax perfoliata
Local Name: Düngdulüshi

Stemona tuberose
Local Name: Khulilü

Stereospermum colais
Local Name: Süngnalo

Stixis suaveolens
Local Name: Selajang

Styrax serrulatum
Local Name: Tenemsüng

Tephrosia candida
Local Name: Ashiliyangleong

Thunbergia grandiflora
Local Name: Düthetnalo

Tolypanthus involucratus
Local Name: Nalüpung

Torenia violacea
Local Name: Shikumalü

Trema orientale
Local Name: Dohea

Urena lobata
Local Name: Khuüevei

Wallichia oblongifolia
Local Name: Pungh

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Conflict of interest

The authors declare that there is no conflict of interest.

References

Balakrishnan, N.P. 1981–1983. *Flora of Jowai and vicinity, Meghalaya.* Vol. 1–2. Botanical Survey of India, Howrah.

Clarke, C.B. 1887. On the plants of Kohima and Munneypore. *J. Linn. Soc. London*. 25: 1-107.

Haridasan, K. & Rao, R. R. 1985–1987. *Forest Flora of Meghalaya.* Vol. 1–2. Bishen Singh Mahendra Pal Singh, Dehradun.

Hynniewta, T. M., Kataki, S.K. & Wadhwa, B.M. 2000. *Orchids of Nagaland* [P.K. Hajra& U. Chatterjee (eds.)]. Botanical Survey of India, Calcutta.

Jain, S. K. and Rao, R. R. (1977). Handbook of field and Herbarium Methods. Today and Tomorrow Publishers, New Delhi.

Joseph, J. 1982. *Flora of Nongpoh and its vicinity*. Vol. 1–3. Botanical Survey of India, Howrah.

Kanjilal, U.N, Kanjilal, P.C, Das, A. & Purkayastha, C. 1934. *Flora of Assam*. Vol. 1. Government of Assam, Shillong.

Kanjilal, U.N., Kanjilal, P.C. & Das, A. 1936. *Flora of Assam*. Vol. 2. Government of Assam, Shillong.

Kanjilal, U.N., Kanjilal, P.C., Das, A. & De, R.N. 1938. *Flora of Assam*. Vol. 3. Government of Assam,Shillong.

Kanjilal, U.N., Kanjilal, P.C., De, R.N. & Das, A.1940. *Flora of Assam*, Vol. 4. Government of Assam, Shillong.

Mao A. A, Odyuo N, Verma D, Singh P (2017). Checklist of Flora of Nagaland. Botanical Survey of India. ISBN: 978:81-8177-069-1.

Moaakum, Dey S, Achumi A (2016). A note on botanical trip to Fakim wild life sanctuary, Nagaland, India. *RÜSIE: A Journal of Contemporary Scientific, Academic and Social Issues*. 3; 33-43.

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A review on Nanoferrites: Synthesis, Characterization and Applications

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Abstract

The nanoferrites attract worldwide attention due to their wide range of applications in many areas as they exhibit versatile magnetic and physicochemical properties. Physical, electrical and magnetic properties of Nanoferrites and their applications in various fields are studied by this review article. It also presents a description of what are ferrites, its types and the preparation methods of ferrites. There are different methods for synthesising nanoferrites. As Co-precipitation being easy and comfortable, it is the preferred method for synthesis of nanoferrites by varying the precipitation temperatures. The samples are characterised by the systematic study of X-Ray Diffractometer (XRD), impedance, ac conductivity, dielectric studies and Vibrating Sample Magnetometer (VSM). X-Ray Diffractometer is a non-destructive technique that provides the detailed information about the crystallography structure, chemical composition and physical properties of the material. Impedance analysis reveals metallic and semiconducting behaviour at room temperature. A semiconducting to metallic transition accompanied by the grain boundary effect gradually replaced by grain contribution has been found from the impedance analysis. Confirmation of phase transition is also obtained from ac conductivity and dielectric analysis. Magnetic properties of the sample are measured with the help of Vibrating sample magnetometer. If researchers and engineers who are concerned with ferrites take a deeper look at the future aspects of ferrites and devote themselves to the subjects of great value, it will play an important role for the advancement of science and technology.

Keywords: *Nanoferrites, X-Ray Diffractometer, Impedance, AC conductivity, Vibrating Sample Magnetometer*

Introduction:

Nanoferrites are a fascinating class of materials that have garnered significant attention in various scientific and technological fields due to their unique properties and potential applications. These materials are a subtype of ferrites, which are compounds consisting of iron oxides and other metal ions, such as nickel, cobalt, zinc or manganese in a crystalline structure (Yang et al., 2006). The distinguishing feature of nanoferrites lies in their nanoscale dimensions, typically ranging from one to hundred nanometers in size. This nanostructuring imparts them with exceptional physical, chemical, magnetic, and electrical properties that are distinct from their bulk counterparts. One of the most notable properties of nanoferrites is their high magnetization, which makes them valuable in various magnetic applications such as data storage, magnetic resonance imaging (MRI), magnetic sensors, and magnetic hyperthermia for cancer treatment (Laokul et al., 2011). Additionally, nanoferrites exhibit excellent chemical stability, thermal conductivity, and tunable magnetic properties, making them suitable for diverse applications in electronics, telecommunications, catalysis, and environmental remediation.

The synthesis of nanoferrites involves various methods including sol-gel, hydrothermal, co-precipitation, and mechanical milling, which enable precise control over particle size, shape, composition, and magnetic properties (Singhal et al., 2005). Furthermore, surface modifications and functionalization techniques can tailor the surface chemistry of nanoferrites, enhancing their compatibility and performance in specific applications. Nanoferrites represent a promising class of nanomaterials with wide-ranging applications spanning multiple disciplines, and ongoing research continues to explore and exploit their unique properties for novel technological advancements (Calero- Ddel C & Rinaldi, 2007).

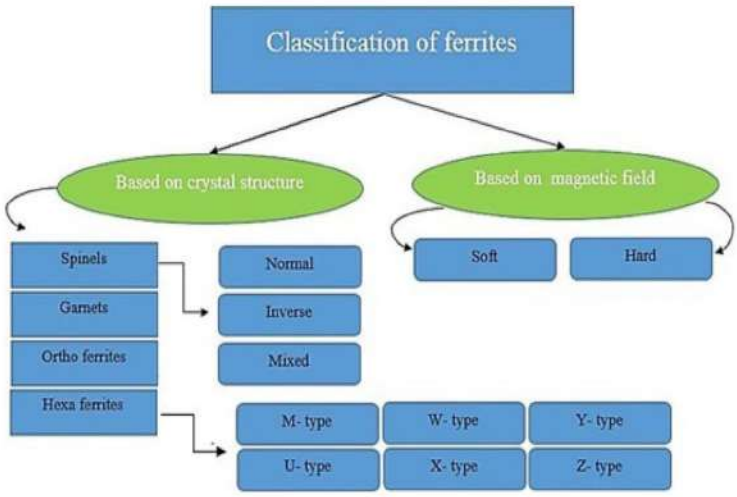
Purpose of the review

Study of synthesis, properties, morphology and characterization method of Nanoferrites is the main focus of this review paper. Various methods such as sol-gel method, co-precipitation method, conventional ceramic technique, hydrothermal method, citrate precursor method, solid state reaction method, Auto-combustion method and micro emulsion method for the synthesis of Nanoferrites are discussed. This review paper critically analyzes all the above mentioned methods in details and gives the idea of selecting best method for the synthesis of Nanoferrites in a given application.

Classification and Types of ferrite

Depending upon the crystal structure, ferrites are of following types.

(1). Spinel ferrite (2). Garnet (3). Ortho- ferrite (4). Hexagonal ferrites



Spinel ferrites

Spinel ferrites are a class of magnetic materials with a general formula of (AB_2O_4) where (A) ia a divalent metal cation (Such as Fe, Zn, Mn, Ni, or Co) and (B) is a trivalent metal cation (usually Fe). The crystal structure of spinel ferrite possesses two interstitial sites namely tetrahedral and octahedral. They

have a crystal structure based on the spinel mineral, which features a cubic close-packed array of oxides ions where one-eighth of the tetrahedral holes are occupied by (A) cations and half of the octahedral holes are occupied by (B) cations (Pullar & Robert, 2012).

Spinel ferrites are of following types

1. Normal Spinel Ferrites
2. Inverse Spinel Ferrites
3. Mixed Spinel Ferrites

Normal Spinel: Spinels with only divalent ions in tetrahedral sites are called normal or regular spines. $(A)[B_2]O_4$ => A-Tetrahedral (2+ - divalent); B-Octahedral (3+ - trivalent) All divalent are in A site. Example: $ZnFe_2O_4$

Mixed Spinel: Spinels with only trivalent ions in tetrahedral sites are called Inverse spines. $(A_{1-x}B_x)[A_xB_{2-x}]O_4$ => Divalent and trivalent occupies both A and B site. Example: $MnFe_2O_4$

Inverse spinel: Spinels with divalent and trivalent ions both in tetrahedral and octahedral sites are called Mixed spines. $(B)[AB_2]O_4$ = > B site shared by both divalent and trivalent where A site completely filled with trivalent ions. Example: $CoFe_2O_4$

Garnet

The chemical formula for ferrimagnetic garnet is $Me_3Fe_5O_{12}$ where, Me is the trivalent ion. Unit cell is cubic and contains eight molecules of $Me_3Fe_5O_{12}$ i.e. (160 atoms). The metal ions are distributed over three types of sites (Sangmanee & Maensiri, 2009). The Me ions occupy the dodecahedral sites (called c sites), where they are surrounded by eight oxygen ions, the Fe3+ ions being distributed over the tetrahedral and octahedral sites in the ratio 3:2. Thus, the cation distribution $Me_3Fe_5O_{12}$ can be written as $Me_3Fe_2Fe_3O_{12}$.

Ortho-ferrites

Me Fe O $_3$ is the general formula of Ortho-ferrites where, Me is a large trivalent metal ion, such as rare-earth ion or Y. They crystallize in a distorted pervoskite structure with an orthorhombic unit cell. These ortho-ferrites show a weak ferromagnetism, which has been attributed to the small canting in the alignment of two anti-ferromagnetically coupled lattices. The canting angle is of the order of 10^{-2} radian but is sufficient to introduce a small net ferromagnetic moment perpendicular to the anti ferromagnetic axis (Wang et al., 2015). The direction of spin orientation of the Fe ion in $HOFeO_3$ and $ErFeO_3$ has been experimentally determined at room temperature and found to be parallel to the axis on reducing the temperature the spin axis rotates, and at 1.25K the direction is (001) for $HOFeO_3$ and (110) for $ErFeO_3$. The spin moment on the rare earth ion gets ordered at a much lower Neel temperature [6.5 K for HO Fe O_3 and 4.3 K for $ErFeO_3$].

Hexagonal ferrites

There are a number of ferrites that crystallize in hexagonal structure, and some of them have gained considerable technological importance in recent years (Koseoglu et al., 2012).. These ferrites are further sub-classified into M, W, Y, Z and U compounds. All these have different, though related, crystal structures. The M compounds have the simplest structure. Barium ferrite, the well known hard ferrites, belongs to this class. These compounds have the general formula MeFe $_{12}O_{19}$ where Me is a divalent ion of a large ionic radius, such as Ba^{2+}, Sr^{2+}, or Pb^{2+}. Some compounds with trivalent Me (e.g. La^{3+}, Al, Ga, Cr, Fe) are also known. In these, one iron per formula unit is present as Fe^{2+} to allow for the charge compensation (Brabers, 1969). Concerning the magnetic properties of ferrites, they are classified as-

(1). Soft Ferrites (2). Hard Ferrites (3). Semi- Hard Ferrites

Soft Ferrites

Soft ferrites are magnetic materials made from iron oxide mixed with other metals like manganese, zinc, or nickel. They have low coercivity, which means they can easily be magnetized and demagnetized. Soft ferrites have high magnetic permeability and high electrical resistivity (Sun et al., 2009).

Hard Ferrites

Hard ferrites, also known as permanent ferrites, are a type of magnetic material with high coercivity, meaning they retain their magnetic properties even when an external magnetic field is removed. They are made from a mixture of iron oxides, such as barium, strontium, or cobalt (Salunkhe et al., 2012).

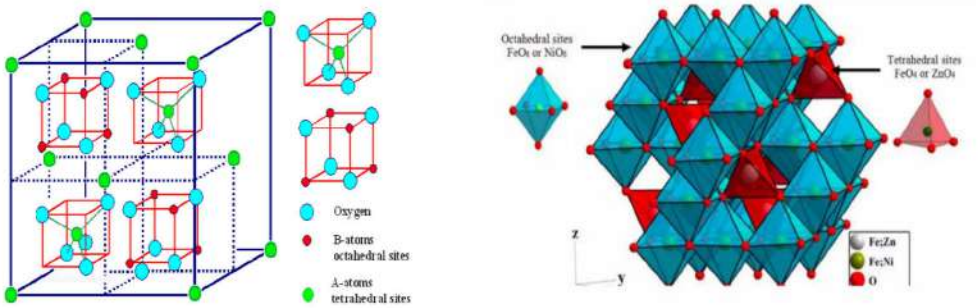
Semi-hard Ferrites

Cobalt ferrite, which has the chemical formula $CoFe_2O_4$ ($CoOFe_2O_3$), is a semi-hard material that falls between soft and hard magnetic materials. Because of its high saturation magnetostriction (at 200 ppm), it is mostly employed in magnetostrictive applications such as actuators and sensors (Pillai & Shah, 1996).

Morphology of Nanoferrites

Nanoferrites, with their robust spinel structure, display a fascinating arrangement of metals cations distributed across two distinct lattice sites within a cubic framework of oxygen ions: the A and B sites. The A sites, which are tetrahedral, are coordinated by four oxygen atoms and are typically occupied by divalent metal cations (such as Mg^{2+} or Zn^{2+}) in normal spinels (Sugimoto, 1999). In inverse spinels, these tetrahedral A sites are occupied by trivalent cations (like Fe^{3+}), comprising half of the trivalent ions present in the structure. The B sites, which are octahedral, on the other hand, are coordinated by six oxygen ions (Nikumbh et al., 2014). In normal spinels, these sites are exclusively occupied by trivalent cations (eg Fe^{3+}, Al^{3+}),

whereas in inverse spinels, the B sites accommodate the remaining trivalent cations along divalent cations (such as Fe^{2+}).

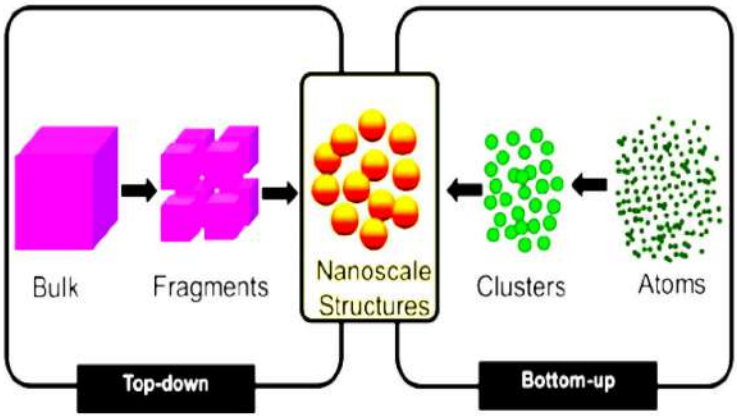


The distinct ionic arrangement in A and B sites significantly impacts the magnetic characteristics of nanoferrites, influencing properties such as saturation magnetization, coercivity, and magnetic anisotropy. These properties are vital for applications across magnetic storage catalysis, and medical imaging.

Additionally, the morphology of these nanoparticles- potentially spherical, cubic, or rod-like- is largely governed by their synthesis conditions, including temperature, pH, and the presence of surfactants. Such morphological characteristics further influence the surface-to-volume ratio, enhancing the reactivity and specific applications of nanoferrites. Thus the morphology of these nanoparticles is highly dependent on the synthesis method, affecting the material's physical and chemical characteristics. Understanding and manipulating the occupancy of the A and B sites, alongside controlled morphological synthesis, are key to tailoring nanoferrites for specialized technological applications (Gonzalez et al., 2004).

Synthesis methods to prepare Nanoferrites

Nanoferrites can be synthesized using Bottom up or top-down approaches, each catering to different aspects of particles control and ease production.



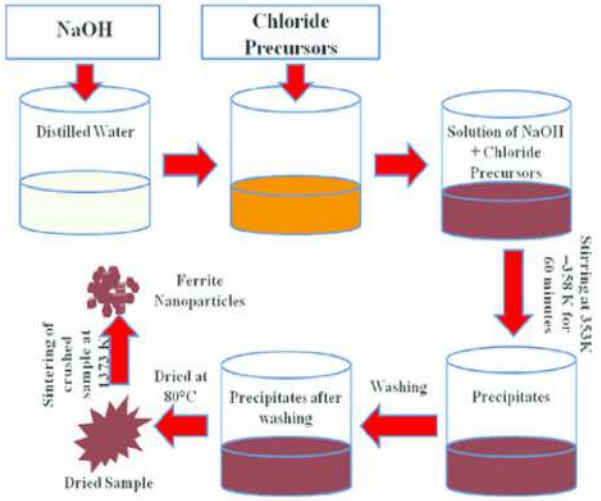
Bottom –up synthesis involves building materials from atomic or molecular-scale components. These methods are often preferred for their ability to produce nanoparticles with uniform sizes and well-defined components (Silva et al., 2004). Some common synthesis methods under this approach are Co-precipitation method, Sol-gel method, hydrothermal method, Thermal decomposition method, Microwave-assisted method etc. Top-down synthesis involves mechanically breaking down bulk materials into smaller pieces. This technique is generally less controlled but can be more straightforward and cost effective for bulk production. Mechanochemical synthesis, laser ablation, ball milling, etc, methods are the some common synthesis methods under this approach. Thus, various synthesis techniques are used to prepare nanoparticles. Each method has its advantages and is chosen based on the desired properties of the nanoferrites, such as particle size, shape, crystallinity, and magnetic properties as well as scalability and environmental considerations. Bottom–up approach is the

most favourable method for synthesising nanoparticles because the products in this method are homogeneous, highly pure and have narrow size distribution. The final choice often depends on the specific application of the nanoferrites being produced (Shokrollahi, 2008).

Co-precipitation Method

Since the early 1960s, this method has been utilized to produce desirable ferrites that include the chemical co-precipitation of salts and bases. A wet chemical technique was developed in order to improve uniformity. In the synthesis procedure, an aqueous solution of metal salts was precipitated using a powerful base (Zhang and Lan, 2008). The formed hydroxide was subsequently oxidized by bubbling air through the suspended product to produce a fine ferrite product. More recently, a solution with non-stoichiometric amounts of iron and barium salts was co-precipitated with sodium hydroxide while maintaining a pH of 14. To maintain the pH at 7, the resulting hydroxides are subsequently oxidized with hydrogen peroxide. The final product in the form of dried hydroxide is then heated at around 600°C to get pure BaM (M-type hexaferrite). The advantage of the co-precipitation method is being cost-effective method and simple. In this method, particle size can be controlled effectively and there is a requirement for lower temperatures and homogeneous particle size is obtained (Khedr et al., 2006).

Flow chart for preparing ferrite by co-precipitation



Hydrothermal method

This approach involves placing an aqueous medium in a stainless steel autoclave and applying autogenous pressure while keeping a consistent temperature. The process of oxidation, hydrolysis, or neutralization of mixed metal hydroxides is used to create ferrite (Jiang & Ai, 2010). The temperature of the reaction, the reaction duration, the ratio of solvent and precursors, and the reactant concentration can all be altered to regulate the particle size in this situation. The simplicity of creating such crystalline phases, which are proven to be unstable at higher temperatures, is a benefit of this technology. Materials with high vapor pressure can be grown and this method also helps in producing large-size as well as better-quality crystals. A simple flow of steps involved in the hydrothermal method is given below (Zhao et al., 2007).

Sol-gel method

The needed amount of citric acid is added to nitrate solutions using this approach, and a pH of 7 is subsequently maintained by adding ammonia solution to the mixture. This solution is now heated until it transforms into a gel, auto combustion occurs, and a dry ash product is formed. The final ferrite product is produced by heating the ash product to temperatures between 1000

and 1500°C after a preheating step of about 500°C. The procedure of using sol-gel is straightforward, economical, and energy-efficient. Additionally, the finished product is homogeneous. The creation of nanoparticles can be done without the need for significantly greater temperatures (Baldi et al., 2007). The main drawback to this approach is that the raw materials needed occasionally could be more expensive.

Solid state reaction method

The oxide and barium carbonate powder are combined in the traditional ceramic way and heated to produce the appropriate phase formation. The finished ceramic product is next crushed and powdered to produce a finer product, which is subsequently subjected to a sintering process to increase its density. Obtaining grains with an average size of 1–10μm for ferrites, the phase formation often necessitates higher temperatures and longer heating durations, but the resulting particles are not small enough. There are many other synthesis methods for the preparation of hexaferrite, however, most of them involve precursor formation at a certain point (Kwon et al., 2002). Here in this method, more quantity of final product can be obtained. But there is a higher temperature requirement for phase formation and also another disadvantage is that it is not used for the formation of nanomaterial along with an emphasis on better grinding.

Ball Milling method

A ball mill is a primary piece for crushing/milling and it is extensively utilized for products like cement, silicate, ceramics, etc. In the ball milling process, wet or dry processes can be used depending on the requirement (Baldi et al., 2007). The surface area of the solid material can be increased appreciatively using ball milling; even the desired size of grain can be obtained using this method. The advantages of the ball milling technology include the ability to produce extremely small particle sizes and operate

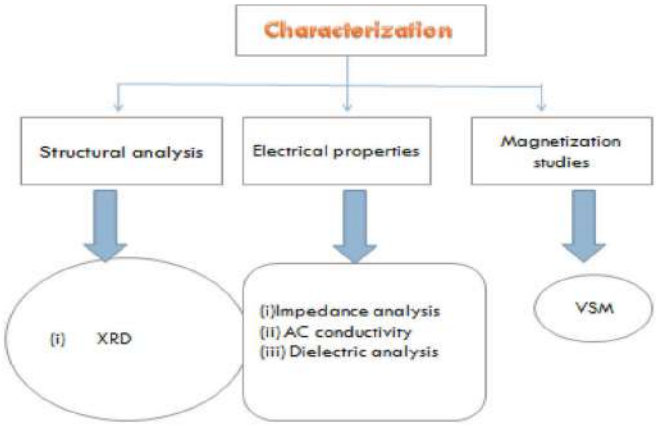
continuously. However, there are significant drawbacks including high machine noise levels, the potential for contamination brought on by the system's used balls wearing out over time, and occasionally lengthy grinding times.

Spray drying method

The size of the particles can be varied by changing the wheel speed and the liquid feed system works at very low pressures. It is a low-cost synthesis process; however, it may face pollution control issues (Shafi et al., 1998). For comparing all the synthesis method, I found that Co-precipitation Method is being cost-effective method and simple. In this method, particle size can be controlled effectively and there is a requirement for lower temperatures and homogeneous particle size is obtained.

Characterization

The characterization of the prepared ferrite nanoparticles was conducted by using following three methods for verifying particle size and distribution (1) Structural analysis (2) Electrical Properties (3) Magnetization Studies.



Structural analysis

The structure of the Ferrites nanoparticles is characterized by the X-Ray Diffraction (XRD) technique. XRD is one of the most extensively used

techniques for the characterisation of nanoparticles. XRD measures the size, shape, internal stress of small crystalline regions and average spacing between the layers or rows of atoms (Chen et al., 2009). It determines the orientation of a single Crystal or grain and helps to find the crystal structure of an unknown material. The XRD studies confirm the spinel cubic and single-phase formation.

Electrical properties

Electrical properties of ferrites generally depend upon the composition and preparative parameters of the synthesized materials (Sui et al., 2003). The electrical properties of the nanoferrites are characterized by the following methods –

(1). Impedance analysis (2). AC conductivity (3). Dielectric analysis

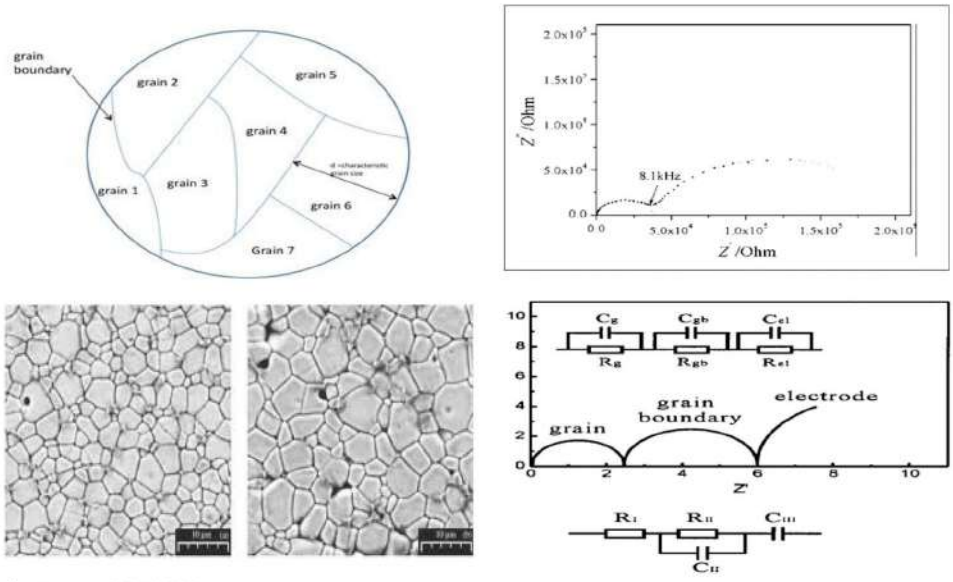
Impedance analysis

Existence of single semicircle is due to grain boundary volume, suggesting that the main contribution for conductivity comes from grain boundaries because the grain boundary volume is very large due to smaller particle size. Existences of two semicircle is explained by means of an equivalent circuit (i.e) two parallel R (resistance) and C (Capacitance) circuits connected in series. The low frequency arc corresponds to the grain boundary relaxation mechanism, while the high frequency arc to the grain relaxation in polycrystalline ceramics (Gul et al., 2008).

AC conductivity

In nanoferrites, electrical conduction primarily occurs due to electronic hopping between the ion pairs such as between different oxidation states of metal ions. The number of such ion pairs depends upon the sintering conditions and extent of reduction of Fe3+ to Fe2+ at elevated temperature. Fe2+/Fe3+ ratio on the B-sites controls the overall resistivity in ferrites materials. It helps to understand the conduction mechanism and type of

polarons responsible for the conduction (Fan et al., 2009). The switch over from the frequency independent conductivity region to frequency dependent region is the signature of the conductivity relaxation, which shifts towards higher frequencies as the temperature increases.



Sugimoto, M. (1999)

Dielectric analysis

The dielectric behaviour of spinel ferrites is significantly influenced by interfacial polarization due to the surface effects. At low frequencies, dipolar and interfacial polarization can both contribute to the overall dielectric constant of a material but at higher frequency, only the electronic polarization becomes significant (Lotgering et al., 1980). At low frequency, the electron exchange between Fe2+ and Fe3+ ions is capable to follow the alternating field but the frequency of electron exchange between two ions cannot follow the high alternating field. As a result, polarization decreases and lags conduction beyond the particular frequency of external applied field. Therefore, the value of dielectric constant is lower at high frequencies than at low frequencies. Furthermore, the dielectric properties of ferrites depend on many factors which include method of preparation, sintering temperature,

sintering atmosphere, etc. Since, ferrite powdered samples are sintered under slightly reducing conditions, the divalent iron Fe2+ is expected to be formed in the body of the ferrite material leading to high conductivity grains. When such a material is cooled in an atmosphere of oxygen, it is possible to form layers of very low conductivity over its constituent grains. Almost all the ferrites in the polycrystalline form have more such conductivity grains separated by low conductivity layers so that they behave as heterogeneous dielectric materials (Schoenberg, 1958). Due to the heterogeneous dielectric behaviour, dielectric constant as high as 10^3–10^5 is observed in the case of ferrites at low frequencies.

Magnetization Studies

Magnetic measurement is a powerful method to characterize properties of materials. Among numbers of magnetic measurement equipment, Vibrating Sample Magnetometer (VSM) is known as a very effective way to determine magnetization (Roy et al., 2005). By analyzing the results, useful informations of materials can be extracted. Magnetization studies independently confirm the migration of cations between A and B sites due to the size effect apart from electrical properties.

Applications

a. Ferrites are a class of materials known for their magnetic properties, which make them crucial in engineering and technology applications. Like iron, cobalt, and nickel, ferrites are also ferromagnetic below their curie temperature possessing spontaneous magnetic moment.
b. The Ferrites are not suited for high-field and high-powered applications due to their limited permeability and flux density but they are valuable in low field and low power applications due to

their high resistivity, frequency stability, and noise suppression capabilities.

c. When an alternating magnetic field is applied to a ferrite rod, the magnetostrictive property of ferrites causes the rod to vibrate. This vibration creates ultrasonic waves, which can be used in various applications such as cleaning and medical imaging.
d. Some ferrites possess high rectangular hysteresis loop and therefore useful in the construction of computer memory system for rapid storage and retrieval of digital information (Giannakopoulou et al., 2002).
e. Ferrites possess good permeability/dielectric properties even at high frequencies and hence ferrites could be utilized as microwave absorbers.
f. Ferrites are used as cores in coils for microwave frequency devices and computer memory core elements because they have very low eddy currents.
g. Ferrites are used as Energy storage.
h. They are used as catalyst.
i. In electromagnetic interference shielding, ferrites are also used.
j. Ferrites are used as magnetic carrier.
k. Ferrites are attracting worldwide attention in drug delivery applications due to their magnetic and physicochemical properties. Their magnetic properties allow them to be directed to specific location in the body using external magnetic field, enabling targeted drug delivery. This reduces side effect and increases treatment effectively. Additionally, their physicochemical properties allow them to carry and release drugs in a controlled manner, responding to specific stimuli such as

changes in PH or temperature. This makes them useful for delivering drugs precisely where they are needed, such as in cancer treatment (Mendelson, 1969).

l. Nanoferrites offer multiple platforms for detoxification applications in biological fluids, with potential benefits in environmental remediation, medical treatments and biotechnology. High surface area to volume ratio properties of Nanoferrites make them effective in binding and removing toxic metals like lead, mercury or arsenic. Magnetic nanoferrites can be functionalized with specific coatings to selectively bind and remove drugs or toxins from biological fluids. They can serve as support matrices for immobilizing enzymes involved in detoxification processes (Gharagozlou, 2009).

Discussion and Suggestions

There are different methods for preparing Nanoferrites but in this work, I tried to explain why co-precipitation method is the most preferable one. For characterization of the samples, X-ray diffraction, AC analysis, Impedance analysis, dielectric analysis and vibration sample magnetometer are also suggested to use as theses analysis will provide more accurate intended data. While discussing the uses of Nanoferites, it was explained as to why Nanoferrites do not affect the healthy cells in the human body while treating the cancerous cell. Through targeted delivery, they can bind to receptors on cancer cells or accumulate in tumor areas. Magnetic nanoferrites can generate heat when exposed to an alternating magnetic field. By attaching these nanoferrites to cancer cells or injecting them into tumor tissues, localized hyperthermia can be induced, which damages or kills cancer cells while spraying surrounding healthy tissue. These mechanisms can improve the efficacy of cancer therapy while minimizing side effects on healthy

tissues. However, research is needed in the use of nanoferrites in cancer treatment to further understand their potential and safety. Scientist must explore how to optimise targeted delivery to cancer cells, improve methods such as magnetic hyperthermia, and minimize any possible side effects on healthy cells. Ferrites possess good permeability/dielectric properties even at high frequencies and hence ferrites could be utilized as microwave absorbers. While significant progress has been made in understanding and utilizing nanoferrites, there is still a need for more research in several areas.

Conclusion

The nanoferrites are magnetic materials made of iron oxides and other metal oxides at the nanoscale. They have unique magnetic properties and are used in applications like data storage, sensors, and targeted drug delivery. They also play a role in environment cleanup, helping in removal of pollutants from water. All the different types of ferrites described in this paper play crucial roles in engineering and technology. The different synthesis methods used for the preparation of ferrites have been explained along with their merits and demerits. As described at the beginning, no one doubts that the production of quantity ferrite will continue to increase each year, even in the future, as will the advancement of electronic technologies. Their versatility and potential for future innovation make them important across various fields. If researchers and engineers who are concerned with ferrites take a deeper look at the future aspects of ferrites and devote themselves to the subjects of great value, the nanoferrites will show a steady and more advanced prosperity in science and technology, and their industries will be continued to grow in the future. Despite their promising properties and applications, challenges such as achieving uniform particle size distribution, controlling particle aggregation and stability, ensuring

biocompatibility for biomedical applications, and addressing toxicity concerns remain areas of ongoing research.

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Conflict of interest

The authors declare that there is no conflict of interest.

References

Baldi, G., Bonacchi, D., Innocenti, C., Lorenzi, G., & Sangregorio, C. (2007). Cobalt ferrite nanoparticles: the control of the particle size and surface state and their effects on magnetic properties. *Journal of Magnetism and Magnetic Materials*, *311*(1), 10–16.

Brabers, V. A. M. (1969). Infrared spectra of cubic and tetragonal manganese ferrites. *Physica Status Solidi*, *33*(2), 563–572.

Calero-Ddel C, V.L. & Rinaldi, C. (2007). Synthesis and magnetic characterization of cobalt-substituted ferrite (CoxFe3−xO4) nanoparticles. *Journal of Magnetism and Magnetic Materials*, *314* (1), 60–67.

Chen, L., Shen, Y., & Bai, J. (2009). Large-scale synthesis of uniform spinel ferrite nanoparticles from hydrothermal decomposition of trinuclear heterometallic oxo-centered acetate clusters. *Materials Letters*, *63* (12) ,1099–1101. doi; 10.1016/j.pmatsci.2012.04.001.

Fan, H.M., Yi, J.B., Yang, Y. et al. (2009). Single-crystalline MFe2O4 nanotubes/nanorings synthesized by thermal transformation process for biological applications. *ACS Nano, 3*(9), 2798–2808.

Gharagozlou, M. (2009). Synthesis, characterization and influence of calcination temperature on magnetic properties of nanocrystalline spinel Co-

ferrite prepared by polymeric precursor method. *Journal of Alloys and Compounds*, *486* (1-2), 660–665.

Giannakopoulou, T., Kompotiatis, L., Kontogeorgako, A., & Kordas, G., (2002). Microwave behavior of ferrites prepared via sol-gel method. *Journal of Magnetism and Magnetic Materials*, *246* (3), 360–365.

Gonzalez-Sandoval, M.P., Beesley, A.M., Miki-Yoshida, M., Fuentes-Cobas, L., & Matutes-Aquino, J.A. (2004). Comparative study of the microstructural and magnetic properties of spinel ferrites obtained by coprecipitation. *Journal of Alloys and Compounds*, *369* (1-2), 190–194.

Gul, I.H., & Maqsood, A. (2008). Structural, magnetic and electrical properties of cobalt ferrites prepared by the sol-gel route. *Journal of Alloys and Compounds*, *465* (1-2), 227–231.

Jiang, J & Ai, L.H. (2010). Synthesis and characterization of Fe-Co binary ferrospinel nanospheres via one-step nonaqueous solution pathway. *Materials Letters*, *64* (8), 945–947.

Khedr, M.H., Omar, A.A., & Abdel-Moaty, S.A. (2006). Magnetic nanocomposites: Preparation and characterization of Co-ferrite nanoparticles. *Colloids and Surfaces A*, *281*(1–3), 8–14.

Koseoglu, Y., Alan, F., Tan, M., Yilgin,R., & Ozturk,M. (2012). Low temperature hydrothermal synthesis and characterization of Mn doped cobalt ferrite nanoparticles. *Ceram.Int,* doi:10.1016/j.ceramint.2012.01.001.

Kwon,Y.J., Kim,K.H., Lim, C.S., & Shim, K.B. (2002). Characterization of ZnO nanopowders synthesized by the polymerized complex method via an organochemical route. *Journal of Ceramic Processing Research*, *3*(3), 146–149.

Laokul, P., Amornkitbamrung, V., Seraphin,S., & Maensiri, S. (2011). Characterization and magnetic properties of nanocrystalline CuFe2O4,

NiFe2O4, ZnFe2O4 powders prepared by the Aloe vera extract solution. *Current Applied Physics*, *11*(1), 101–108.

Lotgering, F. K., Vromans, P. H. G. M., & Huyberts, M. A. H. (1980). Permanent-magnet material obtained by sintering the hexagonal ferriteW=BaFe18O27. *Journal of Applied Physics*, *51* (11),5913–5918. bibcode:1980jap.51.5913l. doi:10.1063/1.327493.

Mendelson, M.I. (1969). Average grain size in polycrystalline ceramics. *Journal of American Ceramic Society, 52* (8), 443–446.

Nikumbh, A.K., Pawar, R.A., Nighot, D.V., Gugale, G.S., Sangale, M.D., Khanvilkar, M.B., Nagawade, A.V. (2014). Structural, electrical, magnetic and dielectric properties of rare-earth substituted cobalt ferrites nanoparticles synthesized by the co-precipitation method. *J.Magu.Magn.Mater*, doi: 10.1016/j.jmmm.2016.08.02.

Pillai, V., & Shah, D.O. (1996). Synthesis of high-coercivity cobalt ferrite particles using water-in-oil microemulsions. *Journal of Magnetism and Magnetic Materials*, *163* (1-2), 243–248.

Pullar & Robert C. (2012). Hexagonal ferrites: A review of the synthesis, properties and applications of hexaferrite ceramics. *Progress in Materials Science*, *57* (7), 1191–1334.

Roy, M.K., Haldar, B., & Verma, H.C. (2005). Characteristic length scales of nanosize zinc ferrite. *Nanotechnology, 17* (1), 232–237.

Salunkhe, A.B., Khot, V.M., Phadatare, M.R., & Pawar, S.H. (2012). Combustion synthesis of cobalt ferrite nanoparticles – Influence of fuel to oxidizer ratio. *J.Alloys comp*, doi: 10.1016/j.jallcom.2011.10.094.

Sangmanee, M., & Maensiri, S. (2009). Nanostructures and magnetic properties of cobalt ferrite (CoFe2O4) fabricated by electrospinning. *Applied Physics A*, *97* (1), 167–177.

Schoenberg, A., & Ernst (1958). Ferrites. *Journal of the American Ceramic Society*. *41* (11), 484–489. doi:10.1111/j.1151-2916.1958.tb12901.x. issn 0002-7820.

Shafi, K. V. P. M., Gedanken, A., Prozorov, R., & Balogh, J. (1998), "Sonochemical preparation and size-dependent properties of nanostructured CoFe2O4 particles," *Chemistry of Materials,* 10(11), 3445–3450.

Shokrollahi, H. (2008). Magnetic properties and densification of Manganese – Zinc Soft ferrites (Mn1-xZnxFe2O4) doped with low melting point oxides. *Journal of Magnetism and Magnetic Materials, 320* (3-4), 463-474.

Silva, J.B., De Brito,W., & Mohallem, N. D. S. (2004). Influence of heat treatment on cobalt ferrite ceramic powders. *Materials Science and Engineering B*, *112* (2-3), 182–187.

Singhal, S., Singh, J., Barthwal, S.K., & Chandra, K. (2005). Preparation and characterization of nanosize nickel substituted cobalt ferrites (Co1−xNixFe2O4). *Journal of Solid State Chemistry*, *178*(10), 3183–3189.

Sugimoto, M. (1999). The past, present, and future of ferrites. *Journal of the American Ceramic Society*, *82*(2), 269–280.

Sui, Y., Huang, X., Ma, Z. et al (2003). The effect of thermal annealing on crystallization in a-Si:H/SiO2 multilayers by using layer by layer plasma oxidation. *Journal of Physics Condensed Matter, 15* (34) ,5793–5800.

Sun, Z. Zi, Y., Zhu, X., Yang, Z., Dai,J., & Song, W. (2009). Synthesis and magnetic properties of CoFe2O4 ferrite nanoparticles. *Journal of Magnetism and Magnetic Materials*, *321*(9), 1251–1255.

Wang, Jiquan, Gao, Xuexu, Yuan, Chao, Li, Jiheng, Bao, Xiaoqian. (2015). Magnetostriction properties of oriented polycrystalline $CoFe_2O_4$". *Journal of Magnetism and Magnetic Materials*, *401*, 662–666. doi:10.1016/j.jmmm. 2015.10.073.

Yang, H., Yang, N., Fan, Y., Zhu, H., & Zou, G. (2006). The effect of reaction temperature on the particle size, structure and magnetic properties of coprecipitated CoFe2O4 nanoparticles. *Materials Letters*, *60* (29-30) ,3548–3552.

Zhang, J., & Lan, C.Q., (2008). Laser-generated Ni and Co nanoparticles in organic media. *Materials Letters*, *62*(10-11), 1521–1524.

Zhao, D., Wu, X., Guan, H., & Han, E. (2007). Study on supercritical hydrothermal synthesis of CoFe2O4 nanoparticles. *Journal of Supercritical Fluids*, 42 (2), 226–233.

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Examining *Gitanjali* from a Religious Aspect

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Abstract

Indian literature by and large has grown massively through the contribution of great writers like Rabindranath Tagore. India is also a land of diverse religious background. However, in Tagore's Gitanjali the God he mentions has no abode. He is omnipresent. At times he can in the cottage door and at times in the sky and riverside. In this paper I would like to discuss how the poet as an individual has no religion. Though born into a Hindu family, his faith remained solitary paving a way to a universal citizenship. The readers can rarely find Tagore mentioning any medieval or ancient texts except for an allusion of the Vedas and the English Romantic Poetry. The question of how a person referred as a nationalist poet turns into a religious poet not confined by established religious institutions will be discussed.

***Key words**: Universal Religion, Human Flaw, Social Critic.*

Introduction

"There is only one religion, though there are a hundred versions of it."

George Bernard Shaw 1856-1950 (Shaw vii)

In this paper, how the poet as an individual has no religion will be discussed. He is not in favor of a particular religion or belief. He respects and at the same time acts as a social commentator through the eye of religion. The *Oxford Advanced English Learner's Dictionary* defines religion as:

a. The belief in the existence of a god or gods, and the activities that are connected with the worship of them.

b. One of the systems of faith that are based on the belief in the existence of a particular god or gods.

c. A singular interest or influence that is very important in your life. (p.1287)

Though born into a Hindu family, his faith remained solitary. The God that Tagore mentions in the poems has no abode. He is omnipresent. At times he can be in the cottage doors and at times in the sky and riverside. The reader can rarely find Tagore mentioning any medieval or ancient texts except for the few verses from the *Vedas*, *Upanishads* and from English Romantic Poetry.

Gitanjali is a collection of 103 poems in English. In England, a splendor volume was published in 1912 with an introduction by W. B. Yeats. It was with this work that he achieved international fame and recognition, and became the first non- European to win the Nobel Prize in Literature in 1913. Basically, *Gitanjali* is a song of offering to the motherland India and the deity that reigns upon the land. However, at times it seems that the poet has personalized the divinity in the form of a person: at other times he refers to the divinity in the abstract. Though the poetry is beautiful and evocative of nature, it is at times disjointed. The common thread that binds the poems is the relationship between the singer and the object of his adoration. Like many other poems, these songs are also a melancholy yearning as the poet seeks to come out with his dream i.e. to see India as a free nation. The songs are more clearly depicted like the mosaic. The key to understand these songs is the poet has interwoven number of unrelated themes together.

Numerous studies have been conducted on Tagore and his writings. For the purpose of this paper, only a select few of these works have been chosen to guide the discussion. In *Rabindranth Tagore* (1962) Krishna Kripalani gives a biography and quotes freely from Tagore's writings. He

describes Tagore as someone deeply devoted to humanity, with a love that extended to all people. He also points out that in India, Tagore critically addressed social institutions and religious customs that endorsed superstitions, inequality, and tolerated injustice during that era.

In his 1986 book *Rabindranath Tagore*, Sirikumar Ghosh provides a brief overview of Tagore's life and contributions. The book enriches readers with insights into Tagore's viewpoints as well as those of the author himself. Ghosh describes Tagore's life as one filled with challenges, constant tension, and surprises, yet he remained creatively active until the end. Ghosh notably states, "Tagore's faith is Tagore's faith, the lengthened shadow of his personality," (84) highlighting how Tagore's beliefs were deeply intertwined with his own character.

In the *Selected Essays, Rabindranath Tagore* (2012) Mohit K. Ray lays down thirty-seven essays of Tagore. The ideas that Tagore expressed about the unity of man, patriotism, humanism and religion are vividly revealed. The book suggests that Tagore believed in the essential unity and the universality of the mind.

The texts provide an insight to the life and works of Tagore which help the paper in analyzing the poetry and draw its relevance in today's context. It aims to elicit a deeper knowledge and implement them for religious unity and harmony. Analytical and close reading method has been applied to analyze and reinterpret the existing ideas.

Findings

True religion is not to be found in external forces but from within. It is determined by the connection that one builds with God. It is not confined to a set of people but even to the lowest and the poorest. Tagore considers religion to be free and autonomous. It is up to us humans to find the true religion. He sees his union with the infinite through the use of nature. His

religion is not confined to a set of places or people, and has no boundary. Debnath Sujit in his article "Relevance of Tagore's Religious Philosophy in the Modern Age" adds "Tagore in his thinking of religion throws its gate wide open to every individual" (Sujit 105). This can also be a sign of his universal faith.

Tagore and religion

To Tagore, true religion is free and spontaneous in each individual which correlates to the third definition of the dictionary. It is the realization of one's kinship with everything that is around us. For him what matters more is one's faith. His religion is not confined to anything particular but is universal. He gave importance to moral distinction for his universal faith. The central theme of *Gitanjali* is devotional. It expresses the yearning of a devotee to be united with the divine. The opening poem, "Thou has Made Me Endless" says,

> Thou hast made me endless, such is thy
> Pleasure. This frail vessel thou emptiest again
> And again, and fullest it ever with fresh life.
> This little flute of a reed thou hast carried over
> Hills and dales, and hast breathed through it
> Melodies eternally new, (1-6)

It is an acknowledgement to the supreme that without Him, he is nothing. It is the presence of the unknown which makes him complete or whole.

In Poem No XI, "Leave This Chanting", we are made known of Tagore's view of religion. He writes:

> Leave this chanting and singing and telling
>
> of beads! Whom dost thou worship in this
> lonely dark corner of a temple with doors all

shut? Open thine eyes and see thy God is
not before thee! (1-5)

He wants the religious heads not to confine themselves to chanting and telling of beats in a closed room. He does not want people praying endlessly without action. In a way Tagore is a man who is faithful to his religion and also puts himself into action. We can see this through his effort to establish Patha Bhavana, the school of his ideas in Shantinikitan which was an abode of peace. He asks them to remove their holy mantle and search for God outside the dark temple, as it is the ritualistic form to which he is against. To him, true religion must not be confused with what is called "institutional religion". Tagore's view asking the religious leaders to step out is to let them be aware of reality where the poor whom come across everyday are suffering and on the other, they place flowers and incense in the temple to please God. He asks,

Deliverance? Where is this deliverance to be
found? Our master himself has joyfully taken
upon him the bonds of creation; he is bound
with us all forever, (12-15)

The poem is a call to religious institutions by presenting the truth that God is manifested even in the tiller who is tilling the hard ground and where the path maker is breaking stones. He is of the view that it will not harm them if their clothes become tattered or stained. In a way, he is encouraging them to venture beyond the set rules and be more humanitarian towards mankind. However, it does not mean that one should do only charitable work and not be religious. The act of helping is known to us from the great religious personalities. According to Y. Masih in his book *Introduction of Religious Philosophy* states, "A Jesus or a Buddha would not only pray in solitariness or meditate, but also would come out into public life preaching to the poor,

healing the sick, comforting the widows and so on." (p.11). The statement can perhaps be aligned to Tagore's view on what a true religious person must do. He wants both the physical and spiritual elements to merge and attain union with the infinite. He focused on the relationship between the known and the unknown. Studies on Tagore's poetry indicate that the poet has personified the divinity in the form of a person; at other times, he refers to the divinity in the abstract. According to Kripalani, Tagore in India served as a critic of social institutions and religious practices which at that particular time had a belief on superstitions, inequality and tolerated injustice. (p.72)

Tagore differentiates between religion and religious institutions in the poems. We see that, for him, true religion is free from rituals and bondage. Religious institution binds one with rules and regulations. Thus, we see how the religious heads are seen chanting and counting beads. This in a way can be seen as a critic of the society. This is echoed in William Blake's poem, "The Chimney Sweeper" from *Songs of Experience*, where the church turns blind to the suffering of the poor children who are forced to work, (2008, p.10). The condition of the poor Indians was no better than them. Caste system which was rigid during that time played a major role in discriminating the poor especially the untouchables. They were treated like animals and lived under the mercy of the higher castes. For Tagore, a true religion of an individual will be that which continues to grow in a humane way and expand its universal outlook.

Tagore's finest achievement in English verse can be a devotion of God, Poem No XV "I am Here to Sing Thee Song". He sees himself send to the world for a purpose. He portrays music as an instrument which will link him with God. He wants to be acknowledged and be honoured by God. He sees God as an unbroken perfection. The quest for religion can be seen as a quest for truth which is also a value for artistic sensibility according to

Tagore. This can be found in poem no XXXV, "Where the Mind is Without Fear" where he says, he wants words to come out from the depth of truth and strive towards perfection.

God is introduced in human qualities. The God of Tagore comes to us daily in different forms at different moments and time of our life. It is only when our hearts are empty that God will come and fill it with love. Tagore says, "strike, strike at the root of penury in my heart" in the poem "This is my Prayer to Thee" (p. 37). He wishes for strength to lead an earthly life by sacrificing all material attractions and surrender himself to God. God is not only the creator but he is present in every piece of his creation. It only takes for us humans to observe. It is through that one can achieve transcendental union of soul with the divine. He says worship does not only consist of religious rituals but also an extension of helping hand. Thus, he pleads:

> Give me the strength to rise my
> mind high above daily trifles;
> And give me the strength to surrender my
> strength to do thy will with love, (10-14)

A lucid illustration is portrayed in poem no L, "I Had Gone A- Begging" where the poet places himself in the position of a beggar wherein, he goes begging from door to door in the village path. On his way, he sees the Supreme's chariot in the distance "like a gorgeous dream". He "wondered on who was this king of all kings". His hope rose high thinking his bad times will soon be over waiting for the alms to be given "unasked and for the wealth/ scattered on all sides in the dust". To his surprise instead of giving him alms, the chariot stopped and the supreme which the poet addresses as "thou" hold out his right hand and asked the poet of what he has to offer him. The "kingly jest" opened his palm to a beggar. The beggar like many human

beings searched for his wallet and took out the least little grain of corn and gave it to him. He says:

> But how great my surprise when at the day's
> end I emptied my bag on the floor to find a
> least little gram go gold among the poor heap.
> I bitterly wept and wished that I had had the
> heart to give thee my all. (21-25)

He realized his flaw, wept bitterly in regret but all in vain. Through this poem Tagore conveys to the readers to have a heart to give and in that way will receive full in return. Had he been generous, he would have fulfilled his wish to be free from poverty. This also indicates how human beings want to acquire more wealth without wanting to spare a little. This can be implied to people who are waiting for the chariot to be prepared in their hearts as the majesty, which they wait will turn up in any form at an unexpected time.

In poem no X, "Here is Thy Footstool" Tagore describes God as being too humble living with the poorest and the lowliest, and the lost. The poet himself tried to bow to him but his obedience cannot reach his depth. This shows how humble one should be to reach God. It is the pride in man that prevents him to mingle with the poor in whom God is also found. Pride cannot approach where God is present. Tagore himself finds that he cannot humble himself like God. This shows human nature where pride is present. He places God in the highest position that he, as a mortal being is not fit to reach even his feet. In most of the poems in *Gitanjali* the poet compares himself humbly to a beggar to convey how low he feels in front of the divine.

Poem no XXVI "He Came and Sat by my Side" depicts the shortcomings of an individual. He places himself to a situation where he missed the time to meet Him. This also explains how many a times, humans fail to feel the presence of God who come and sit by our side. This is a

miserable time for man. He regrets, "what a cursed sleep it was, O miserable/ me!" (1-2), this can be a relation of how man forgets to remember God when he gets lost in this materialistic world. This is indicated when he says his dreams became resonant with its melodies. The poem is an allusion of how we forget to give praises in times of our happiness.

Tagore throughout his poems is seen yearning and longing in melancholic but at the same time he accepts his position as a mortal being that is not free from the thoughts of the world. Poem no LIV, "I Asked Nothing from Thee" makes the readers wake up from their comfortable zone when through the speaker he asks "Indeed, what had I/ done for thee to keep me in remembrance?" He raises the question to the readers of what have they done for God from whom they always expect good things. He continues to say that the least he had done is "I could give water to/thee to allay thy thirst will cling to my heart/and enfold it in sweetness". All he had done in the poem is pour water from his jar on his joined palms. He contemplates on what exactly he has done for others. This reminds him of what kind of mark is left behind for others to remember one with whether it is a mark of good deeds or of ignorance which draws one back.

The poet also presents a picture of how humans are busy building walls around them in poem no XXIX, "He Whom I Enclose". A wall which not only divides a neighbour from another but as it goes up, a man loses sight of a true being in a dark shadow. He says:

> I am ever busy building this
> Wall all around; and as this wall goes up into
> the sky day by day I lose sight of my true
> being in its dark shadow, (2-5)

A disconnection from the world occurs and the poet laments "for all the care I lose my true being". This indicates the struggle to build the wall go in vain.

Indeed, the wall is alienating us from the true being. A similar situation is discussed by Robert Frost 1875-1963, in his poem "Mending Wall", where he talks about man's isolation and the barriers that he creates for himself or for others. He discusses how a force of something does not want him and his neighbor to have a wall, but human tend to build wall for themselves alienating from one another. Walls are sometimes good to maintain one's privacy but turns out to be opposite when its blocks increase which detach a person from others.

Tagore also talks of how his life was made endless because of God's endless time. God's time cannot be counted but for humans, there is a time limit. This reminds us that time is not ours. He goes on to say in poem no LXXXII, "Time is Endless in Thy Hands",

Time is endless in thy hands, my lord. There
is none to count thy minutes.
Days and nights pass and ages bloom and fate
Like flowers. Thou knowest how to wait, (1-4)

Human come and go but God does not change. Humanity knows time only in part while God knows in its entirety. Nothing in this world is entirely for man and woman to have, but it is God's. And in God's time we are too poor to be late. Everything has to be completed till we are in this world. Human beings can repent as long as they live. Tagore continues in poem no LXXXVI "Death Thy Servant, is at My Door", about time and death when he refers to himself as standing in front of death. Death is personified as a person. Tagore is ready and asks us to be prepared to face it as it is from God. He expresses "death thy servant, is at my door". He adds, "I will worship him with folded hands, and with tears" (91). He knows his fate yet worship death by placing at the feet the treasures of his heart. The simplest way is to worship him with folded hands, and with tears. This shows that simplicity and true prayer will

also result in tears which mean purification. He expresses that death is the last fulfillment of life. It is through the channel of death that he can get connected with the supreme forever. He says in poem no XCI "O thou the Last Fulfilment of Life"

…Death, my
death , come and whisper to me!
Day after day have I kept watch for thee;
for thee have I borne the joys and pangs of
life, (1-5)

Since Tagore prefers to call true religion as poetic religion, we can see the free thinking of imagination in the poems. Parallel to the third definition of the dictionary which is mentioned in the beginning of this chapter, Tagore's religion as a poetic religion also fits as he is faithful to his principle where he lays down his yearning for divine connection through his poetic ways. There is no setting in the poems. His imagination gives free reign to his spirit. The God he mentions is not confined in a particular place. He is omnipresent, at times found in the cottage, riverside, in dust and in the temple. God is said to be the embodiment of Beauty, Truth and Goodness. This is an influence from the English Romantic poetry while I have mentioned earlier in the introduction about some of his influences. This term of beauty and truth is the repetition of the famous statement of John Keats: "Beauty is Truth, truth beauty–that is all" from the poem "Ode on a Grecian Urn" Keats, (p. 258). Tagore's art in the form of poetry which dominates beauty can also be considered as a religion. The poet seems to yearn for the love and freedom with the infinite.

According to Tagore, true religion and religious institutions are different. True religion does not bind but preaches freedom, whereas religious organizations make religion a slave of their institutions. He is not

against the worship of God but the misinterpretation by some religious heads. In one of his poems in *Gitanjali*, he speaks against the established religious institutions but the fact remains that he acknowledges rites and rituals in worshipping. This can be seen in poem no LXXXVIII," Diety of the Ruined Temple" where he mentioned "strings of *Vina* sing no more your praise" (p. 93). This makes the readers understands that music as a form is important in worshipping God. He also does not ignore the view that religion becomes attractive and popular to the masses when combined with art, and art becomes sanctified. However, art is not restricted to religion alone. The constant yearning and praying of the poet is seen taking a higher level where he gives a gist of the union with the person whom he addresses as "thou" throughout his poetry. He compares it to the love which is similar to that of the lovers. In poem no LVI, "Thus it is that joy in me is so full" he says:

> Thus it is that thou hast come down to me.
> O thou lord of all heavens, where would be
> Thy love if I were not?
> Thou hast taken me as thy partner of all this
> wealth. In my life thy will is ever taking
> shape, (2-7)

We can see his union with the infinite when he asserts that his love losses itself in the love of his lover. And that He is seen in the perfect union of the two. This can mean the acceptance and acknowledgement of the poet to the union of love with the infinite. True religion is not to be found in external forces but from within. It is determined by the connection that one builds with God. It is not set of people but even to the lowest and the poorest. It is up to humans to find the true religion. He sees his union with the infinite using nature.

Conclusion

Religion according to Tagore is free and does not confine to a particular system. It is not that he absolutely rejects the notion of religion but he is against established institutions. His devotion to God can be seen in his poems where he puts himself in the position of a temple singer waiting for God for acknowledgement. His sense of religion is higher than what ordinary people describes. For him, God is not only an image who is above as ordinary believers think but is manifested in every of his creation. His belief again can be linked to the social where God will be present as it is in social that people come together. Through his poems, he also urges the readers not to detach themselves from common activities, as it is also the acknowledgement of simple things that connects the thread to the infinite. This can also be an echoing of the common saying "Service to mankind is service to God." To stand on the dust and perspire in the service of others is thus to be in service of God. To him, to worship God is the truest sense of service. He disdains the high-class people who live their life without a time to observe the common things like nature, plough man, tiller, etc.

The paper also mentioned that the religion of Tagore is a poetic one. The statement is supported from his poems where his devotion is in the form of a lyric. It is through his poetry that his ideas are clearly presented. It is through constant prayers that he aims at being connected with the divine. He compares himself to a piece of creation in God's hand to perform his duty.

References

Oxford Advanced Learner's Dictionary. (2010). Religion (8th ed.). Oxford University Press.

Augustus, C. (2001). *Major religions of India*. ISPCK.

Blake, W. (2008). *Songs of innocence and songs of experience*. Retrieved April 27, 2008, from http://www.gutenberg.org

Blunden, E. (Ed.). (2000). *Selected poems: John Keats*. Rupa.

Debnath, S. (2014). Relevance of Tagore's religious philosophy in the modern age. *International Journal of Interdisciplinary and Multidisciplinary Studies*, 1(3), 105-106.

Blunden, E. (Ed.). (2000). *Selected poems: John Keats*. Rupa.

Frost, R. (2015). Mending wall. In *NBSE: Alternative English*. Pearson.

Ghosh, S. (1986). *Rabindranath Tagore*. Sahitya Akademi.

Kripalani, K. (1962). *Rabindranath Tagore*. Oxford University Press.

Masih, Y. (1971, reprinted 2012). *Introduction to religious philosophy*. Banarsidass.

Nair, N. V. R. (2015). Mysticism in Tagore's Gitanjali. *Scholedge International Journal of Multidisciplinary & Allied Studies*, 2(2), 6-12.

Ray, K. M. (2012). *Selected essays: Rabindranath Tagore*. Atlantic.

Shaw, B. (1898). *Pleasant and unpleasant* (Vol. 2). G. Richards. Retrieved from https://archive.org/details/playspleasantunp02shawrich/page/n9/mode/2up

Tagore, R. (1912). *Gitanjali* (W. B. Yeats, Intro.). Maple Press. (Original work published 1912).

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Preferential adsorption of phenolic compounds onto activated biocarbon: Theoretical investigation using DFT method

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Abstract

Density functional theory (DFT) based quantum chemical descriptors were used to delve into the preferential adsorption of phenolic compounds onto activated biocarbon. The molecular reactivity of phenolic compounds, i.e., phenol, 4-nitrophenol, and 2,4-dinitrophenol, were studied through key descriptors such as electrophilicity index (ω), nucleophilicity index (N), hardness (η), chemical potential (μ), and electronegativity (χ). These descriptors, established through the Gaussian 09 W suite of programs, aid in understanding the selectivity and reactivity of different phenolic compounds and their affinity for adsorption on activated biocarbon surfaces. The study revealed that 2,4-dinitrophenol exhibited higher reactivity and electrophilic nature than phenol and 4-nitrophenol.

Key words: DFT, Phenols, Activated Carbon

Introduction

Quantum-based chemical reactivity descriptors are widely used to understand the structural reactivity of chemical species(Deuri & Phukan, 2012). Reactivity descriptors such as electrophilicity index(ω), nucleophilicity index(N), hardness(η), chemical potential(μ), and electronegativity(χ), which are defined with the help of Density Functional Theory (DFT) have been gaining much importance in comprehending the quantitative structure-activity relationship. These DFT-based descriptors have widely been used to study the site selectivity of nitrogen nucleophiles(Deuri & Phukan, 2012), the antioxidant activity of flavonoids(Sarkar et al., 2012), corrosion inhibitors(Rotaru et al., 2014), and the reactivity of various organic reactions(Domingo et al., 2016)(Vektariene et al., 2009)(Benallou et al., 2014). It has also been found essential to understand the reactivity of various pollutants with activated carbon. De Souza et al. have used the DFT-based reactivity descriptors to study the reactivity of basic dyes with activated carbon(de Souza et al., 2018a), while cationic dyes' reactivity with activated carbon has been reported by Regti et al. (Regti et al., 2016). The use of DFT-based chemical reactivity descriptors in adsorption studies would thus facilitate our understanding towards the selectivity and reactivity involved in the removal of different pollutants by using bioactivated carbon.

In the present study, the reactivity of phenol, 4-nitrophenol, and 2,4-dinitrophenol were studied using DFT. DFT-based quantum molecular descriptors such as HOMO-LUMO energy gap (H), Ionisation potential(I), electron affinity(A), hardness (η), chemical potential (μ), electrophilicity index (ω), electronegativity (χ), electron acceptor power (ω^+) and electron-donating power (ω^-) were calculated using HOMO(E_{HOMO}) and

LUMO(E_{LUMO}) frontier orbitals to determine the reactivity of the phenolic compounds.

Experimental

DFT-based molecular descriptors

The reactivity of different phenolic compounds was studied by DFT-based quantum chemical reactivity descriptors. Gauss View 05 was used to design the 3D structures of all the phenolic compounds, and the necessary computations relating to structural optimization and energy calculations were performed on Gaussian 09 W suite of programs using Density Functional Theory (DFT) employing the B3LYP hybrid functional together with the 6-31g basis set in a dielectric medium of $\varepsilon = 80$ (corresponding to water). A frequency calculation was carried out after the structural optimization so as to confirm the stability of the optimized structures. It was observed that all the optimized structures possessed a positive frequency, indicating a stable conformation. DFT-based quantum molecular descriptors such as HOMO-LUMO energy gap (H), Ionisation potential(I), electron affinity(A), hardness (η), chemical potential (μ), electrophilicity index (ω), electronegativity (χ), electron acceptor power (ω^+) and electron-donating power (ω^-) were calculated using HOMO(E_{HOMO}) and LUMO(E_{LUMO}) frontier orbitals.

HOMO-LUMO energy gap

The study of the HOMO-LUMO energy difference of any molecule helps comprehend its kinetic stability and, thereby, its chemical reactivity. A large HOMO-LUMO energy gap of a molecule implies its lower chemical reactivity and higher stability and vice-versa. This is because it would be energetically unfavorable to add electrons to a high-lying LUMO and to extract electrons from a low-lying HOMO(Karmaker et al., 2018). In the present study, the MO diagrams of the optimized structures have been

produced using the "CubeGen" formalism implemented within the Gaussian software. The HOMO-LUMO energy gap is given by the equation.

$$H = E_{HOMO} - E_{LUMO} \quad (1)$$

Chemical Hardness (η)

Chemical hardness is one of the most important electronic molecular descriptors in describing the stability and reactivity of a molecule. The stability of a molecule increases with hardness, which decreases its reactivity. The electron densities of hard molecules cannot be easily altered owing to their large excitation energies, thereby contributing to their high stability and low reactivity(de Souza et al., 2018b). The global hardness is measured by using the formula

$$\eta = \frac{E_{LUMO} - E_{HOMO}}{2} \quad (2)$$

Chemical softness (S)

Another important parameter in determining the reactivity of a molecule is the chemical softness. A soft molecule will possess a low hardness. The global softness is calculated by the following equation(Bendjeddou et al., 2016),

$$S = \frac{1}{2\eta} \quad (3)$$

Chemical potential (μ)

Another important requisite for determining the reactivity of a molecule is the chemical potential of the molecule(Cárdenas, 2011). The chemical potential generally represents the escaping tendency of electrons in a molecule. A high chemical potential value often indicates the more reactive nature of the molecule. The chemical potential(μ) is calculated by the following equation

$$\mu = \frac{E_{HOMO} + E_{LUMO}}{2} \quad (4)$$

Electrophilicity index (ω)

The electrophilicity index helps in understanding the electrophilic nature of the molecule. The larger a molecule's electrophilicity power, the higher its reactivity as an electrophile (Cortés-Arriagada et al., 2013).

The electrophilicity index of a molecule is measured by the equation:

$$\omega = \frac{\mu^2}{2\eta} \qquad (5)$$

Where μ is the chemical potential and η corresponds to the chemical hardness of the molecule.

Electron donating and electron accepting power

The electron-accepting power and electron-donating power of a molecule are given by equations 6 and 7, respectively (Gázquez et al., 2007).

$$\omega^+ = \frac{(I + 3A)^2}{16(I - A)} \qquad (6)$$

$$\omega^- = \frac{(3I + A)^2}{16(I - A)} \qquad (7)$$

Where ω^+ represents the propensity of a given molecule to accept charge and, ω^- is the measure of the propensity to donate charge, 'A' represents the electron affinity, and 'I' is the Ionisation potential. 'A' is given by negative of LUMO, and 'I' is given by negative of HOMO. A larger electron accepting power value of a molecule indicates its larger capability to accept charge, whereas a smaller electron donating power value indicates its larger capability to donate charge.

Nucleophilicity Index

The nucleophilic nature of a molecule is known by its nucleophilicity index (N), which is given by the inverse of the electron-donating power(Pratihar & Roy, 2010),

$$N = \frac{1}{\omega^-} \, x \, 10 \qquad (8)$$

Results and discussion

Theoretical calculations of reactivity

DFT-based chemical molecular descriptors widen our understanding of the reactivity of phenolic compounds at their atomic level. The higher reactivity of the molecule would indicate its greater ability to react/bind with adsorbents such as activated carbon. Table 1 represents the molecular parameters of phenol, 4-nitrophenol, and 2,4-dinitrophenol, while Figure 2 represents the HOMO-LUMO distribution of all three phenolic compounds.

Table 1. Molecular chemical descriptor of phenolic compounds calculated using B3LYP/6-31g level of theory

	E_{HOMO} (eV)	E_{LUMO} (eV)	η (eV)	S (eV)	μ (eV)	ω (eV)	H (eV)	χ (eV)	N (eV)	ω^+ (eV)	ω^- (eV)
P	-6.416	-0.562	2.926	0.170	-3.489	2.080	5.853	3.489	2.843	0.701	4.190
4-NP	-7.106	-2.963	2.071	0.241	-5.034	6.118	4.143	5.034	1.640	3.859	8.894
2,4-NP	-7.647	-3.540	2.053	0.243	-5.594	7.620	4.106	5.594	1.404	5.079	10.674

The rationalization of the chemical reactivity of a molecule at the electronic level can be made by its electrophilicity and nucleophilicity. The electrophilicity index(ω) allows to classify molecules as strong electrophiles (ω > 1.5 eV), moderate electrophiles (0.8 eV < ω < 1.5 eV) and marginal electrophiles (ω < 0.8 eV) (Domingo & Pérez, 2011). The electrophilicity index of all three phenolic compounds decreases in the order 2,4-NP > 4-NP > P. The highest electrophilicity index for 2,4-dinitrophenol (7.620 eV) and 4-nitrophenol (ω= 6.118eV) show their highest reactivity as an electrophile while the lowest value for phenol (ω=2.080eV) indicates its least reactive nature. The Nucleophilicity index also classifies molecules as vital (N > 3 eV), moderate (2 eV< N < 3 eV), and marginal (N< 2 eV) nucleophiles (Jaramillo et al., 2008). The nucleophilic index of 2.843 eV for phenol

indicates that they can also act as a moderate nucleophile. However, the nucleophilicity index of 4-nitro phenol and 2,4-nitrophenol were found to be marginal; this shows that these molecules can better act as an electrophile than as a nucleophiles. The decrease in nucleophilicity (P > 4-NP > 2,4-NP) may be due to the presence of electron-withdrawing substituent in 2,4-dinitrophenol and 4-nitrophenol which decreases the electron density on the aromatic ring. The electrophilic and nucleophilic characteristics are also supported by the electron-donating power and electron-accepting power. 2,4-dinitrophenol possessed the strongest electron-accepting power with the highest value of 1.526 eV and conversely showed the weakest electron-donating ability. This proves its stronger reactivity as an electrophile rather than as a nucleophile. The electron-accepting ability of the molecule decreases in the order 2,4-dinitrophenol > 4-nitrophenol > phenol, while the electron-donating ability decreases in the order phenol > 4-nitrophenol > 2,4-dinitrophenol. A large HOMO-LUMO energy gap generally represents a molecule with low reactivity and high stability and vice-versa. The larger HUMO-LUMO energy difference of phenol (5.853 eV) reflects its lesser reactivity and higher stability as compared to other phenols, while the smallest HOMO-LUMO energy gap of 2,4-dinitrophenol (4.106eV) indicates its more reactive and polarized nature. The HOMO-LUMO orbital gap decreases in the order of 2,4-nitrophenol > 4-nitrophenol > phenol. The reactivity of a molecule increases with a decrease in chemical hardness. Among all the molecules, 2,4-dinitrophenol was found to be more reactive as the molecule shows a lower value for chemical hardness at 2.053eV, as compared to 4-nitrophenol and phenol whose values for global hardness were 2.071eV and 2.926eV respectively. Also, 2,4-dinitrophenol possesses a higher electronegativity value (5.594eV) than 4-nitrophenol (5.034eV) and phenol (3.489eV). This shows that 2,4-dinitrophenol can act as a better

electron acceptor than the other two molecules. Another important parameter in determining the reactivity of a molecule is the chemical softness. Soft molecules tend to react more than hard molecules. The chemical softness value for 2,4-dinitrophenol was found to be the highest, which again proves its higher reactivity as the softest molecule compared to 4-nitrophenol and phenol. According to the DFT-based molecular descriptors, the reactivity of the phenolic compounds decreases in the order 2,4-dinitrophenol > 4-nitrophenol > phenol, and their stability increases in the order 2,4-dinitrophenol< 4-nitrophenol < phenol.

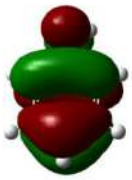
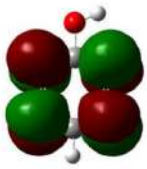
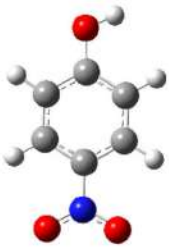
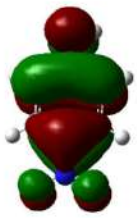
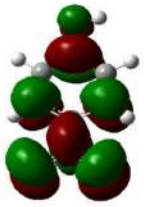
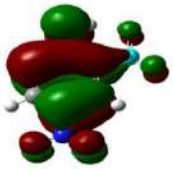
Molecule	Optimized geometry	HOMO	LUMO
Phenol			
4-nitrophenol			
2,4-dinitrophenol			

Figure 2. HOMO and LUMO orbitals of phenolic compounds

Conclusion

According to DFT-based chemical reactivity descriptors, the electrophilicity index(ω), chemical potential(μ), softness(S), electron accepting power(ω^+), and electronegativity (χ) of phenols decreased in the order: 2,4-nitrophenol > 4-nitrophenol > phenol. The theoretical findings suggest that phenolic compounds with higher reactivity and ability to accept electrons would adsorb more strongly onto the activated biocarbon. The study provides insights for developing effective strategies in the pollutant removal process.

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Conflict of interest

The authors declare that they have no conflict of interest.

References

Benallou, A., Garmes, H., Knouzi, N., Alaoui, H. El, & Abdallaoui, E. (2014). Quantitative study by the Electrophilic and Nucleophilic indexes of chemical reactivity for the intramolecular Diels-Alder reaction of the Triene-Amide Molecule. DFT investigation. *Morrocan Journal of Chemistry*, *2*(2), 110–124. https://doi.org/10.48317/IMIST.PRSM/morjchem-v2i2.1912

Bendjeddou, A., Abbaz, T., Gouasmia, A. K., & Villemin, D. (2016). Molecular Structure , HOMO-LUMO , MEP and Fukui Function Analysis of Some TTF-donor Substituted Molecules Using DFT (B3LYP) Calculations. *International Research Journal of Pure and Applied Chemistry, 12*(1), 1–9. https://doi.org/10.9734/IRJPAC/2016/27066

Cárdenas, C. (2011). The Fukui potential is a measure of the chemical hardness. *Chemical Physics Letters*, *513*(1–3), 127–129. https://doi.org/10.1016/j.cplett.2011.07.059

Cortés-Arriagada, D., Sanhueza, L., & Santander-Nelli, M. (2013). Modeling the physisorption of bisphenol A on graphene and graphene oxide. *Journal*

of Molecular Modeling, *19*(9), 3569–3580. https://doi.org/10.1007/s00894-013-1872-2

de Souza, T. N. V., de Carvalho, S. M. L., Vieira, M. G. A., da Silva, M. G. C., & Brasil, D. do S. B. (2018a). Adsorption of basic dyes onto activated carbon: Experimental and theoretical investigation of chemical reactivity of basic dyes using DFT-based descriptors. *Applied Surface Science*, *448*, 662–670. https://doi.org/10.1016/j.apsusc.2018.04.087

Deuri, S., & Phukan, P. (2012). A DFT study on nucleophilicity and site selectivity of nitrogen nucleophiles. *Computational and Theoretical Chemistry*, *980*, 49–55. https://doi.org/10.1016/j.comptc.2011.11.017

Domingo, L. R., & Pérez, P. (2011). The nucleophilicity N index in organic chemistry. *Organic and Biomolecular Chemistry*, *9*(20), 7168–7175. https://doi.org/10.1039/c1ob05856h

Domingo, L. R., Ríos-Gutiérrez, M., & Pérez, P. (2016). Applications of the conceptual density functional theory indices to organic chemistry reactivity. *Molecules*, *21*(6). https://doi.org/10.3390/molecules21060748

Gázquez, J. L., Cedillo, A., & Vela, A. (2007). Electrodonating and electroaccepting powers. *Journal of Physical Chemistry A*, *111*(10), 1966–1970. https://doi.org/10.1021/jp065459f

Jaramillo, P., Domingo, L. R., Chamorro, E., & Pérez, P. (2008). A further exploration of a nucleophilicity index based on the gas-phase ionization potentials. *Journal of Molecular Structure: THEOCHEM*, *865*(1–3), 68–72. https://doi.org/10.1016/j.theochem.2008.06.022

Karmaker, R., Kuotsu, N. B., Ganguly, A., Guchhait, N., & Sinha, U. B. (2018). A theoretical and experimental study on the effect of cationic moiety of quaternary ammonium tribromides in bromination reactions. *Chemical Physics Letters*, *711*, 118–126. https://doi.org/10.1016/j.cplett.2018.09.022

Pratihar, S., & Roy, S. (2010). Nucleophilicity and site selectivity of commonly used arenes and heteroarenes. *Journal of Organic Chemistry*, *75*(15), 4957–4963. https://doi.org/10.1021/jo100425a

Regti, A., Ayouchia, H. B. El, Laamari, M. R., Stiriba, S. E., Anane, H., & Haddad, M. El. (2016). Experimental and theoretical study using DFT method for the competitive adsorption of two cationic dyes from wastewaters. *Applied Surface Science*, *390*, 311–319. https://doi.org/10.1016/j.apsusc.2016.08.059

Rotaru, I., Varvara, S., Gaina, L., & Muresan, L. M. (2014). Antibacterial drugs as corrosion inhibitors for bronze surfaces in acidic solutions. *Applied Surface Science*, *321*, 188–196. https://doi.org/10.1016/j.apsusc.2014.09.201

Sarkar, A., Middya, T. R., & Jana, A. D. (2012). A QSAR study of radical scavenging antioxidant activity of a series of flavonoids using DFT based quantum chemical descriptors - The importance of group frontier electron density. *Journal of Molecular Modeling*, *18*(6), 2621–2631. https://doi.org/10.1007/s00894-011-1274-2

Vektariene, A., Vektaris, G., & Svoboda, J. (2009). A theoretical approach to the nucleophilic behavior of benzofused thieno[3,2-b]furans using DFT and HF based reactivity descriptors. *Arkivoc*, *2009*(7), 311–329. https://doi.org/10.3998/ark.5550190.0010.730

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