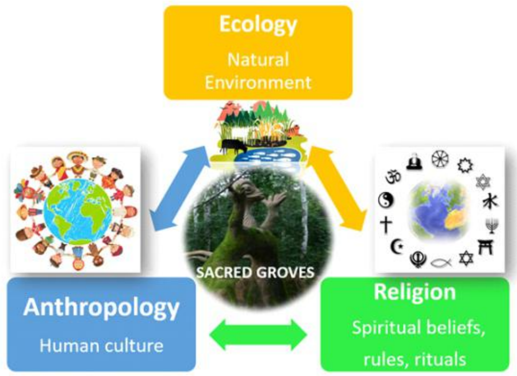
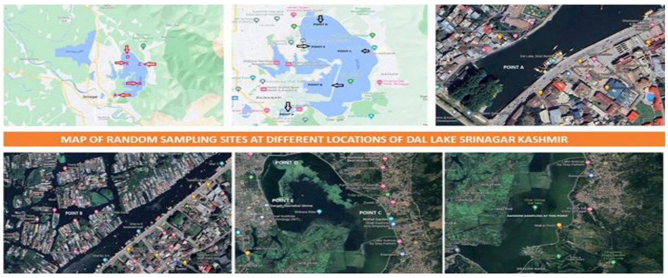
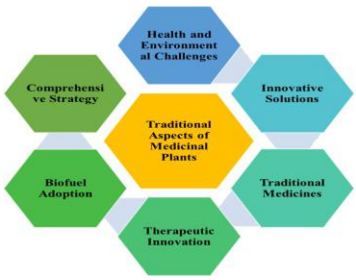
Volume 6, Issue 3 - July-September 2024

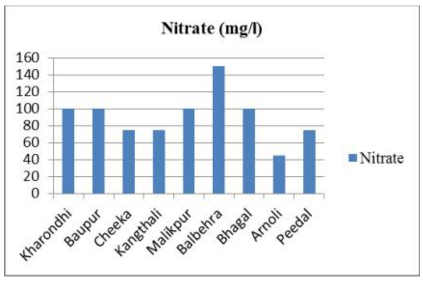
ISSN : 2582-5283
DOI: 10.47062
Indexed in International Scientific Indexing

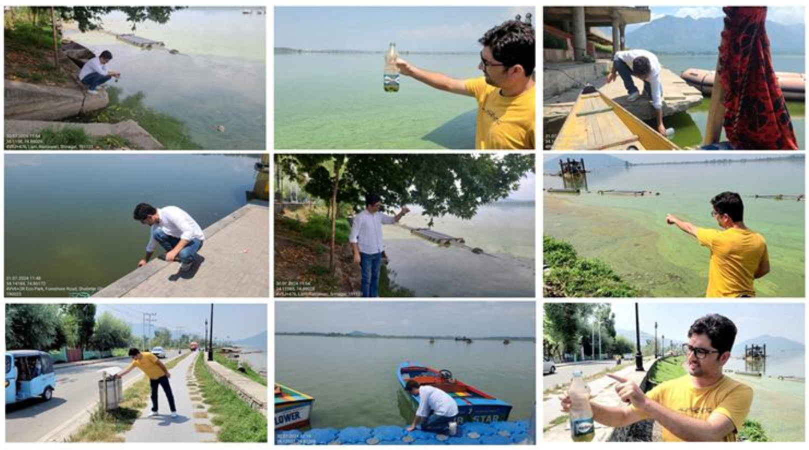
International Journal of Environment and Health Sciences











SAVE THE ENVIRONMENT (STE)
Editor-in-Chief: Dr. Maulin P. Shah
Phone: +91-9871372350 • E-mail: ijehseditor@gmail.com
Website: www.stenvironment.org

Volume 6, Issue 3 - July-September, 2024 ISSN: 2582-5283

A PEER REVIEWED & REFEREED JOURNAL

International Journal of Environment and Health Sciences

EDITORIAL OFFICE
INTERNATIONAL JOURNAL OF
ENVIRONMENT AND HEALTH SCIENCES

Address for correspondence: Flat No. 1107, Block 17, Heritage City, MG Road, Gurugram-122008, Haryana
Mobile: 9871 372 350 • E-mail: info@stenvironment.org

Head & Registered Office: 12, Diamond Harbour Road, Kolkata-700063
Mobile: 9871 372 350 • E-mail: info@stenvironment.org

INTERNATIONAL JOURNAL OF ENVIRONMENT AND HEALTH SCIENCES

Volume: 6 **Issue: 3** **July-September, 2024**

AIMS AND OBJECTIVES OF IJEHS:

The IJEHS is an official publication of Save The Environment (STE). It publishes peer reviewed quarterly, original articles (Research paper, Review articles, Short Communication, Case studies, etc.) related to all fields of Environment and Health Sciences. It disseminates the scientific research and recent innovations.

EDITORIAL BOARD

ADVISORY BOARD

INTERNATIONAL ADVISORS

ADVISORY BOARD

NATIONAL ADVISORS

Role	Name	Institution	E-mail
Advisor	**Dr. Arunabha Majumdar**	Professor Emeritus, School of Water Resources Engineering, Jadavpur University & Former Director, All India Institute of Hygiene and Public Health, Kolkata	arunabhamajumder@hotmail.com
Advisor	**Professor RK Sharma**	Coordinator, Green Chemistry Network Centre, University of Delhi, Delhi	rksharmagreenchem@hotmail.com
Advisor	**Dr. Anju Srivastava**	Principal, Hindu College, University of Delhi, Delhi	dr.anjusrivastava@gmail.com
Advisor	**Dr Shoma Paul Nandi**	Professor & Centre Head, Cellular & Molecular Bio-Technology, Amity University, Noida	spaul@amity.edu
Advisor	**Dr Susan Titus**	Former Scientist 'G' & Joint Director, NMRL, DRDO, Ambarnath	stitus@rediffmail.com
Advisor	**Prof. B. Rupini**	Professor, SOITS, IGNOU, New Delhi	brupini@ignou.ac.in
Advisor	**Dr Sushil K Singh**	Scientist 'F' & Additional Director, SSPL, DRDO, Delhi	singhksushil@gmail.com
Advisor	**Dr. Dinesh Rangappa**	Professor & Chairman, Department of Nanotechnology VTU, Belagavi, Karnataka	dineshrangappa@gmail.com
Advisor	**Dr Ajay Kumar Gupta**	Dept. of Applied Sciences, Himalayan Institute of Engg. & Technology, HP, Kala Amb, Dist. Sirmaur	profajayg@gmail.com
Advisor	**Professor Sanjeev Chaudhari**	Centre for Environmental Science and Engineering, IIT Bombay. Mumbai	sanjeev@iitb.ac.in
Advisor	**Prof. Shachi Shah**	Director(I/C) Center for Online Learning, Former Director, SOITS, IGNOU, New Delhi	sshah@ignou.ac.in
Advisor	**Dr. Manaswini Behera**	School of Infrastructure, IIT Bhubaneswar, Argul, Bhubaneswar	manaswini@iitbbs.ac.in
Advisor	**Prof. Suraj K. Tripathy**	Dean & Associate Professor, School of Biotechnology and Chemical Technology, KIIT University, Bhubaneswar	suraj.tripathy@kiitbiotech.ac.in
Advisor	**Dr. Gaurav Saxena**	Assistant Professor, Shoolini University, HP, Shoolini	Gaurav10saxena@gmail.com
Advisor	**Dr. Sankha Chakrabortty**	Assistant Professor, KIIT Schol of Biotechnology, Bhubaneswar	sankha.nit@gmail.com
Advisor	**Dr. R. Nithyatharani**	Assistant Professor PG & Research Department of Microbiology, Shrimati Indira Gandhi College, Trichy	nithyatharanir@gmail.com
Advisor	**Dr. Sudhir K Upadhyay**	Assistant Professor, Department of Environmental Science, VBS Purvanchal University, Jaunpur	sku.env.lko@gmail.com
Advisor	**Mrs. Anumita Mallick**	Faculty, Department of Nutrition Belda College, Belda, West Midnapore	anumita.mallick2013@gmail.com

International Journal of Environment and Health Sciences

From The Editor's Desk…

As we welcome the New Year 2024, the time has come to work together for creating a sustainable and environment-friendly earth around us by making the most of this recovery phase. New policies are being formulated for improving air, soil and water quality which will further improve the health status of public as well as the environment quotient. Undoing the economic losses and health crisis incurred in the past two years, by implementing more responsible actions will be the main pledge.

One important aspect of the 75th year of Indian independence under 'Azaadi ka Amrit Mahotsav' theme has been designated as repurposing natural compounds for therapeutic functions by harnessing the vast knowledge about traditional medical systems available in our ancient texts. Also, another major focus will be necessitating agricultural reforms in order to reduce gaps in crop production, while ensuring benefits of farmers, who are one of the most important pillars of nation-building.

In view of this, all of us have to act more responsibly by 'life management' such that we move a step closer towards achieving the goal of sustainability, as suggested by The United Nations.

Striving to achieve the aforesaid, The International Journal of Environment and Health Sciences (IJEHS) proposes to provide a reliable platform to discuss relevant technologies and strategies. IJEHS will be quintessential to academicians, industry professionals and researchers who are actively engaged in the areas of environmental issues and related health effects. We are pleased to inform that ISSN for IJEHS is available as 2582-5283. IJEHS is referenced in Crossref, the official Digital Object Identifier Agency (doi 10.47062). IJEHS is now also indexed in the International Scientific Indexing (ISI).

We invite original research articles, short communications and critical reviews directed towards an academic, clinical and industrial audience. The first section of the journal focuses on burning environmental issues like pollutants and their fate, waste management, resource conservation, remediation technologies, etc. The second section includes all topics relevant to physiological impact of environmental risk factors and application of alternative medicinal approaches as remedial measures. Detailed scope can be found in the home page of the journal (www.stenvironment.org/journals). Notes on development of any novel and validated strategy or tool to address environmental challenges are welcome. Discussion on proceedings of conferences conducted on environmental themes and related health aspects will also be considered.

All submissions will be meticulously scrutinized by pioneers in the field to ensure publication of only articles of high quality and relevance. Authors are requested to take special precautions to avert plagiarism and redundancy. It is high time that we realize the gravity of circumstances and take potent steps to undo the adversities already triggered. In this pursuit, IJEHS expects to be the ideal platform to discuss sustainable ideas and potential solutions.

We thank all authors who have contributed to the journal and have consistently been with us in the past years. With this, I wish all our readers a Very Happy New Year, 2024 and I hope our audience and patrons shall come together in this effort to promulgate their part in resurrecting our valuable environment.

Dr. Kshipra Misra
Executive Editor-In-Chief

International Journal of
Environment and Health Sciences

Volume: 6 Issue: 3 July-September, 2024

CONTENTS

Annual Subscription

Individual	Rs. 2000.00
Institutional	Rs. 5000.00

Other Countries

Individual	$ 500.00
Institutional	$ 650.00

A.
Environmental Science Section

International Journal of Environment and Health Sciences (IJEHS)
2024, VOL. 6, NO. 3, 1-7
https://doi.org/10.47062/

SACRED GROVES OF INDIA: BASTIONS OF BIODIVERSITY CONSERVATION IN A CHANGING WORLD

Ivan Aranha*

Department of Zoology, Ahmednagar College, Ahmednagar, Maharashtra-414001, India.

Received on: 20.05.2024 **Revised on:** 10.06.2024 **Accepted on:** 18.06.2024

Abstract
With 24% of its land area covered by forests, India ranks tenth in the world in terms of total forest area, making up 2% of the world's total. India, home to 1.428 billion people, faces the difficult task of maintaining its unique wilderness to safeguard biodiversity. The main causes of the decline in biodiversity are human activities associated with the utilization of forest resources. One of the seventeen countries with the highest level of biodiversity, India uses three different land management strategies to conserve its natural resources: biosphere reserves, which include protected areas, adjacent forest areas, and rivers, protected areas (like National Parks and Sanctuaries), and private lands (like agricultural lands and community conservation areas like sacred groves). Forest patches preserved for cultural and religious purposes are known as sacred groves. These forest fragments, numbering over 100,000, are revered as sacred spaces that serve as critical refuges for biodiversity. This article delves into the profound significance of sacred groves, highlighting their contribution to conservation, the escalating threats they face from modernization and resource demands, and the urgent need for robust management strategies to ensure their continued protection.

Keywords
Biodiversity; Conservation; Ecosystem services; Inda; Protected Areas; Sacred forests.

1. INTRODUCTION

The loss of productivity and ecological stability brought on by widespread species extinctions is causing an alarming decline in global biodiversity, which in turn is changing the processes within ecosystems. The loss of biodiversity causes ecosystems to become less productive, and increasing human pressure has changed the majority of natural environments worldwide. The most secure havens for animals and the cornerstones of biodiversity protection are believed to be protected areas (Bruner et al., 2001). A growing number of Indian anthropologists, botanists, traditional medicine experts, and environmental nongovernmental organizations (NGOs) have expressed a great deal of interest in the phenomenon known as "sacred groves," which are small forests or stands of trees whose produce is reserved for a deity's exclusive use (Kent, 2013). Often called sacred groves, sacred forests are places of cultural significance. Sacred forests, often called sacred groves, are places associated with religious and cultural beliefs. Indigenous cultures around the world have revered and inherited nature from their predecessors since the beginning of time. These areas of a forest were thought to be home to spiritual beings, and it was forbidden to carry out commonplace tasks like felling trees, gathering plants, wood, and leaves, fishing, hunting, grazing domestic animals, lowing, or harvesting crops, and constructing regular homes (Hughes and Swan, 1986). Dietrich Brandis, a German forester and the first General Inspector of Forests is credited with coining the term "sacred grove" to describe the phenomena of religiously motivated forest conservation in India (Brandis,1897).

Sacred groves have been documented in India from the Central Indian Plateau, the North-East Himalayan region, the Western and Eastern Ghats, the Coastal region, and the Western desert. For decades, Indian indigenous people have preserved small areas of forest near their towns as sacred groves. Grove tradition preserves a wide variety of ecosystems as well as its local and regional identities, which are reflected in the names, customs, and maintenance of groves. There are several regional names for The Scared Groves in every Indian state. Some of the names of these holy forests in the various Indian states are shown in Figure 1. India's sacred groves date back to pre-Vedic times. This ancient custom is still widely practiced today and is essential to resource conservation. In addition to their cultural and spiritual significance, they serve as repositories of the region's diversity, protecting its distinctive flora and animals. India's sacred woods are made up of a variety of ecosystems, such as the rainforests of Karnataka and Kerala's Western Ghats, the scrub forests of Rajasthan's Thar desert, and the rich biodiversity of the northeastern provinces and parts of the western Himalayas (Singh et al., 2017). With their close

CONTACT *Corresponding author: *ivanaranha@gmail.com*
Color versions of one or more of the figures in this article can be found online at www.stenvironment.org

and direct ties to the natural world, indigenous tribes find cultural and spiritual importance in sacred groves. People who live near or in woods typically use voluntary collaboration and group efforts to maintain and conserve biodiversity (Rath and Ormsby, 2020). Historically, sacred groves have been linked to culture-based conservation strategies as shared property resource systems.

Most nations in the world have made the creation of protected areas or nature reserves a key component of their biodiversity preservation strategies. Various classifications of protected places are acknowledged based on the intent and level of human exploitation. The most well-known community conservation zones, often known as sacred forests, have been essential in preserving biodiversity. Sacred groves are areas of a biodiversity-rich natural environment that the local people set aside for ceremonial purposes. They kept these areas pristine because they believed that the presence of strong spiritual forces would shield them from disease and natural disasters. However, these areas are currently in danger due to the waning of traditional beliefs and pressure for land (Parthasarathy et al., 2020). The Indian subcontinent is severely affected by human influences; for instance, 90% of the vegetation cover has been lost in the Indo-Burma region, 77% in the Western Ghats–Sri Lanka region, 75% in the Himalayan region, and an equivalent amount in the dry tropical forests of central India (Singh and Kushwaha, 2008). These effects significantly change the ecology and cause the extinction of species.

Sacred groves are excellent indicators of the achievement of resource conservation and biodiversity. Many Indians who are worried about the consequences of deforestation have claimed the sacred groves of India as an ancient indigenous ecological heritage in response to the worsening global environmental catastrophe (Kent, 2013). Numerous sacred groves were losing their integrity due to mishandled care, lack of belief, and changes in social values. People began destroying these last remaining areas of native plants as soon as the taboo was lifted. There are different degrees of annihilation in different sacred woods. Sacred groves in India are often portrayed in the environmental discourse as a dying tradition, a remnant of ancient knowledge that is being lost as Indian civilization grows increasingly industrialized, educated, materialistic, and imbricated. This article discusses the current risks to sacred groves and highlights the importance of appropriate management measures for their preservation. It also covers the value of these small forest patches as sanctuaries for biodiversity restoration and conservation.

2. METHODOLOGY

This review is a comprehensive search of the literature conducted in the following databases; PubMed® (U.S. National Library of Medicine, USA), Web of Science® (Thomson Reuters, USA), MEDLINE, and Google Scholar, with the use of the following search terms; Biodiversity, Conservation, Ecosystem services, India, Protected areas, Sacred Groves.

Figure 1: Terminology variation of Sacred forests across Indian States.

3. Sacred Groves: An Overview

Indian culture responded to the need to protect forests by creating and maintaining sacred groves and woods. The forests have been the source of all South Asian religions and cultures not out of fear and ignorance, but rather because of ecological understanding (Shiva, 1991). Sacred groves can be divided into three categories: burial or cremation or memorial grounds (groves created around burial sites, cremation grounds, on agricultural land or near the grove of the village goddess), temple groves (groves created around a temple), and traditional sacred groves (places where the village deity resides and is represented by an elementary symbol) (Parthasarathy et al., 2020). Every holy grove has a different state-wide god and a local name (Figure 1). Apart from the fact that their preservation preserves pockets of rich and varied flora and fauna in otherwise deforested areas, sacred groves throughout different regions have little in common (Kent, 2013). Sacred groves are rich in biodiversity, hold cultural and spiritual value for the Indigenous tribes that look after them, and offer ecosystem benefits to the local populations that have defended them for generations all over the world (Figure 2). The green lung area of the sacred groves, in addition to offering a multitude of physical items, is the sole place that can mitigate the destructive effects of pollution and deforestation. It serves as a storehouse for oxygen, the life gas. Sacred groves are especially crucial for conserving water and soil. They increase the soil's stability.

Because of its great geographic and ethnocultural diversity, India has the biggest concentration of sacred groves in the world—an estimated 100,000—and these groves may be found across many different locations, each with its own unique set of cultural customs (Malhotra, 2007). For decades, Indian indigenous people have preserved small areas of forest near their towns as sacred groves. A network that maintains "a sizeable portion of the local biodiversity in areas where it would not be feasible to maintain large tracts of protected forests" is made possible by the quantity and spatial distribution of sacred groves (Gadgil and Vartak, 1975). In terms of physical characteristics, it is a small or large plot of forest with a temple inside, but in terms of culture, it is associated with taboos, myths, and ancestral spirits. These central customs appear to play a crucial conservation role in preserving biodiversity and have long maintained the integrity of sacred forests (Parthasarathy et al., 2020).

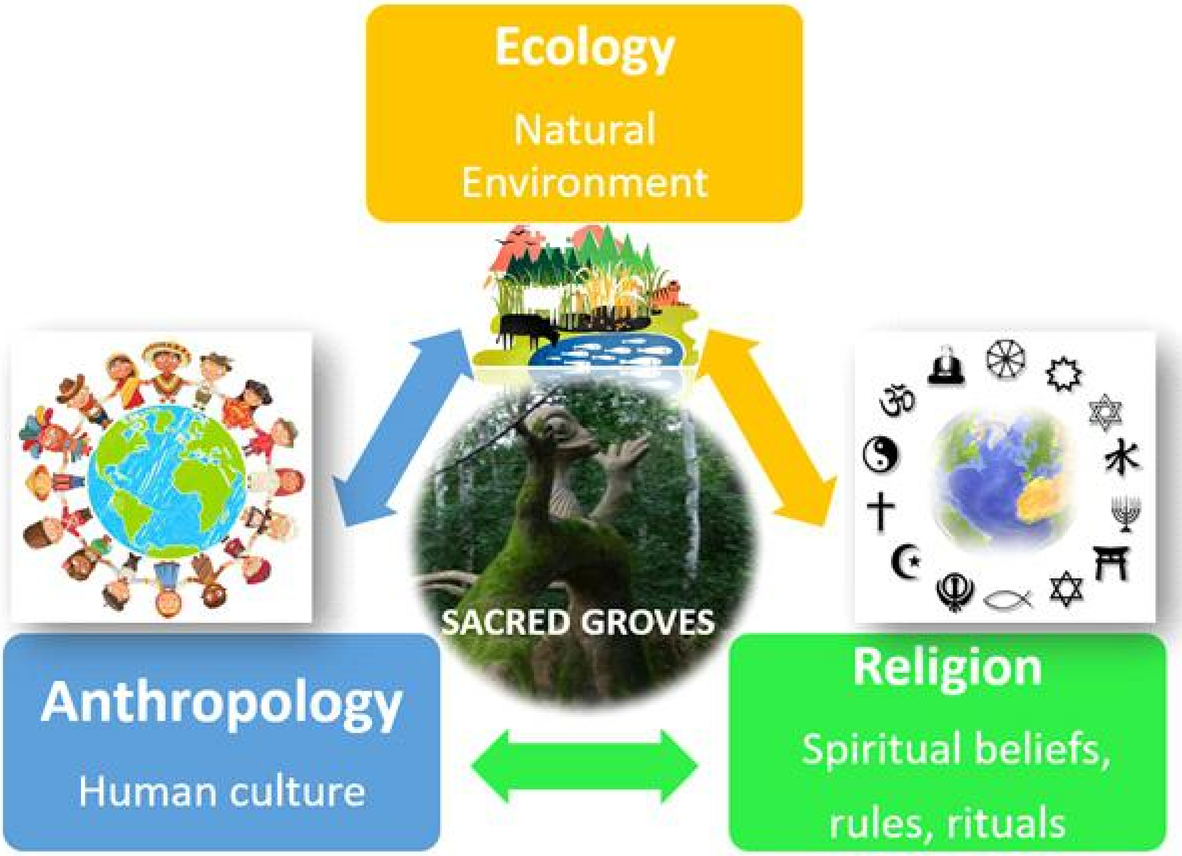


Figure 2: Illustration depicting the interconnected nature of sacred groves, highlighting their influence on diverse societal factors.

3.1 Origin and Distribution

In India, forested areas have long been set aside and preserved due to the religious convictions of the local communities. This practice dates back many centuries. Indian society is made up of several cultures, each of which has its customs for protecting the environment and the animals that live there. India is full of sacred trees, particularly in the areas inhabited by native populations. India's first Inspector General of Forests, Brandis, admitted that sacred forests existed (Brandis, 1897). The sacred groves have a historical connection to the pre-agricultural, hunting, and gathering stage of societies (hunter-gatherer people), before humans had settled down to cultivate land or raise cattle. This connection has been established by Gadgil and Vartak (1975). Thus, it is thought that the idea of the primordial forest dates back to the pre-Vedic era, which occurred between 3000- and 5000 years BC. Before the development of religion, tribes believed that gods lived in woods, animals, trees, and stones. This animism appears to be a way for people to honour and be grateful to nature for giving human civilization commodities and benefits (Parthasarathy et al., 2020). Sacred groves can be found practically everywhere in India, but the majority are said to be located in the Eastern Ghats, which include the Coromandel Coast, Northeast India, and the Western Ghats (Ray et al., 2014). Sacred groves are mainly located in areas that are home to native populations, especially in the states of Maharashtra, Kerala, Karnataka, and Tamil Nadu, which are situated along the Western Ghats. The states of Arunachal Pradesh, Meghalaya, and Manipur are considered to hold the majority of sacred groves in northeastern India. About 11669 sacred groves have been recorded to yet, even though there has not been a thorough study of all the sacred groves in the nation. According to expert estimates, the real figure may be far higher, between 100,000 and 150,000. There is a map that displays the locations of India's sacred woods along with an approximation of how many there are in each state (Husain et al., 2018).

3.2 ECOSYSTEM FUNCTION AND SERVICES

We directly rely on different plant types to meet our diverse demands. In the same way, we rely on different animal species and microbial species for varied purposes. Our need for a variety of foods, raw materials, fuel, etc. is met by biodiversity (Husain et al., 2018). Sacred groves are pure, biologically rich parts of the natural world that have been purposefully conserved by local communities for ceremonial purposes that meet a variety of demands (see Figure 3). The ecological functions that forest patches offer might have served as the driving force behind their preservation. These include preserving watersheds, conserving soil, and supplying forest products. Because it is believed that these groves are protected from disease and natural calamities by strong spiritual forces, they are revered. Their physical form consists of variously sized woodland areas with a central temple, but their cultural value comes from their connection to myths, rituals, prohibitions, and ancestor spirits. These ancient customs have been crucial in maintaining the integrity of holy groves and have been vital to biodiversity conservation and ecosystem management (Parthasarathy et al., 2020).

The holy grove is an essential element of the life of the local people and goes beyond being just a nature reserve. These groves can lessen interactions between people and wildlife and serve as corridors as well. In addition to their significant function in soil and water conservation, sacred woods are frequently the source of numerous water sources. It has often been shown that sacred woods have greater species variety than nearby places and, in many situations, even more than those in similar regions that are under official protection. There is also a great diversity of flora of medicinal significance in sacred forests. According to Boraiah et al., (2003), 60% of the regenerating species (136 out of 241 species) in five holy woods in Kodagu, Karnataka, India, have medicinal significance. In environments outside of protected zones, sacred woods provide protection for numerous species and a wide range of ecosystems. With an emphasis on plant species, numerous sacred forests in India have been investigated, mainly to determine their species richness. The results show that these woods are richer than the surrounding protected areas (Ormsby and Bhagwat, 2010). These pieces may be important biodiversity reservoirs and, in certain situations, the only surviving natural forests outside of protected areas (Parthasarathy et al., 2020).

Figure 3: Sacred Grove's potential for bioresources.

3.3 Community Perspectives

The sacred grove is more than just a natural reserve; it is an essential component of the lives of those who look after it, those who care for it, and other people in the neighbourhood (Sachs, 1993). To ensure that the sacred trees continue to be protected as both spiritual and subsistence resources, social science research projects have investigated the attitudes of the local populations toward them (Ormsby, 2013). Sacred woods provide havens for indigenous species and preserve ecosystems that are underrepresented in the current protected area network. Though many are now disturbed due to human activity, these have been described as relict forests and may be the only climax vegetation left in a region (Bhagwat and Rutte, 2006; Upadhaya et al., 2008). One important factor that makes the sacred groves so unusual is their distinct ownership and management. Sacred groves are owned and maintained by local communities most of the time, but occasionally by one or more families or clans (Ormsby, 2011). Some country homes would rather keep fast to the customs and traditions that have preserved the holy forests for hundreds of years. However, other stakeholders would prefer to use sacred trees for other purposes due to the influence of larger cultural, economic, and political pressures.

Ormsby conducted a social science study in the states of Meghalaya and Karnataka to find out how the locals felt about sacred groves, what kind of management the groves practiced, such as limiting the use of resources, and what kind of ceremonies were held there (Ormsby, 2013). According to the community response data from this survey, people who live in sacred groves desire to see the groves stay the same and unaltered for all time. By adding more plants and safeguarding the current grove, they hope to preserve and enhance what is already there. When asked if they thought the sacred woodland should be enlarged, most residents said they thought the sacred grove should (Ormsby, 2013). Additionally, they desire the restoration of the encroached sections of the sacred grove. As a commitment, some farmers still plant traditional trees in the grove, like *Ficus benghalensis*. There are still many sacred groves in both regions where communities maintain limits on the use of resources and perform rituals; however, in Karnataka, ceremonies related to sacred groves are held far more frequently than in Meghalaya (Ormsby, 2013).

3.4 Biodiversity, Bioresources, and Sustainable Utilization

It is commonly known that sacred groves are crucial for maintaining biological diversity. Numerous plant and animal species that are found in the sacred grove are essential to the preservation of biodiversity. A wide range of therapeutic plants, fruits, fodder, fuelwood, spices, and other items can be found in sacred groves. Some of the biological types that inhabit the sacred grove are unique to that area of the nation and cannot be found anywhere else. Because it can withstand any quantity of rain, the forest cover acts as a buffer and storage reservoir for recycled water. Sacred groves offer multiple ecosystem services, including lowering the erosive force of water, conserving soil, preserving the hydrological cycle, supplying desired-quality water, and naturally dispersing seeds of beneficial species. The sacred groves also contribute to the preservation of the ecosystem's desired health, lessen habitat destruction, protect viable populations of pollinators and predators, act as a potential source of propagules needed to colonize wastelands and fallow areas, preserve Indigenous flora and fauna, and uphold the moral and cultural norms that have been cultivated through generations of Indigenous knowledge (Khan et al., 2008). The species' significance in religion and culture plays a role in encouraging both their sustainable use and conservation (Sinha and Maikhuri, 1998).

One significant source of a variety of bioresources is sacred groves. Sacred groves continue to be valuable providers of bioresources, including fruits, fuelwood, medicinal plants, fodder, spices, and other items that are valued for their secular qualities by the local populations and help to encourage sustainable use. Sacred groves play an important role in the conservation of medicinal plants because of their species diversity and contribution to total individuals. Studies conducted not just in India but also in other parts of the world have highlighted the ecological and economic value of medicinal plants (Parthasarathy et al., 2020; Junsongduang et al., 2013). Sacred groves hold significance for conservation efforts in India; yet, the biodiversity found within them is significantly impacted by the surrounding terrain (Bhagwat et al., 2005). Crop production that is compatible with biodiversity has been crucial to the sustainable use of the bioresources around the holy woods. One of the key components of this procedure is the protection of native trees.

3.5 Current Status and Threats

India is one of the world's twelve mega biodiversity countries, home to 25 hotspots inside the world's richest and most endangered ecoregion (Myers *et al*., 2000). Forest management is still a difficult undertaking because of the growing population, forest degradation, and forest depletion. Sacred groves have withstood both the British-initiated heavy deforestation and the post-independence upsurge in deforestation. Sacred groves are losing ground to the fast-changing social structures, customs, beliefs, and practices that formerly characterized them. Population expansion, increased firewood use, increased access to electricity for irrigation, and the consequent capacity to cultivate more land are the current threats to them (Kent, 2013). Respecting and considering the values of the community is essential for the effective conservation of sacred woods. One example of a community-based approach to landscape-level conservation that is carried out and upheld locally is the practice of preserving holy forests. People who care for forest shrines find themselves more interwoven into larger social networks, and their perspectives on and actions in the groves are evolving as a result of exposure to new religious concepts. Even so, hundreds of areas of forest throughout India are shielded from development due to religious taboos (Kent, 2013). According to recent studies, there is a persistent need to utilize the natural resources found in sacred groves, including the land and soil there as well as the forest's trees for fuel or lumber (Ormsby, 2013). The conventional belief that groves are immutable, pristine forests is called into question by recent research (Ormsby and Ismail, 2015). Furthermore, the research shows that the locals appear to accept and even embrace the degradation and decline of the forested area.

The movement of spiritual emphasis from the forest to the temple has made it easier for commercial plantations to encroach on holy groves. Many locals accept the environmental benefits that the trees give, including what they regard as rainfall, despite the loss of some groves and encroachment on the ones that remain. Frequent communication between local temple committees and the Forest Department could enhance the management of the sacred groves. Furthermore, putting rare timber species under silvicultural management could complement efforts to conserve the environment and cultural traditions (Ormsby and Ismail, 2015). In many places in India, Sacred Groves have been destroyed due to a lack of awareness about their long-term benefits. Due to several reasons, these once-thriving regions of vegetation, rich in native species, have been reduced to small clusters of trees. One of the main reasons is the impact of various religious beliefs, which have attracted a lot of pilgrims and tourists and resulted in the axing of plants for financial benefit. In these groves, the native species are further endangered by grazing, lopping, the introduction of alien weeds, and biomass removal. A contributing factor in the Sacred Groves' loss has been human migration and immigration, as well as local communities and government agencies encroaching on their territory. These Sacred Groves are under serious threat now because of urbanization, modernization, and land mafia greed. The development of structures and the emphasis on monetary gain have led to the loss of ecological and cultural significance, especially for the younger residents who do not seem to understand the value of maintaining these holy places. Research indicates that there is still a strong cultural bond with the sacred groves, but from the standpoint of conservation, the temple committee's authority and responsibilities should be increased.

3.6 Management and Conservation

In India, the preservation of forests and biodiversity is linked to various religions, each with its customs, beliefs, and rituals. It is a classic Hindu concept that the five essential elements—Earth (Prithvi), Fire (Agni), Water (Jal), Air (Vayu), and Space (Akash)—are revered by nature. Every one of the five elements is revered and regarded as the body of God (Pal and Mukhopadhyay, 2011). A sustainable ecosystem and the preservation of biodiversity have resulted from this conscience through a variety of mechanisms, such as the idea of sacred groves. One of the best methods for protecting natural resources is the idea and belief that sacred trees and forest groves are important.

The locals have long guarded sacred trees because of taboos and cultural and religious beliefs that the deities dwell there and shield the community from various disasters. But over time, a lot has changed—including how big the sacred groves are, how their vegetation is organized, how people view them, and what taboos and religious beliefs they hold. In several regions, such as the Chamoli district of Uttarakhand state, India, people still hold the traditional belief that the married pair must plant a tree seedling in the bride's home after marrying a rural country girl. In this area, planting tree seedlings is a customary and cultural practice that gained popularity in the late 1980s and succeeded in raising a lot of awareness among the populace (Kandari, 2014). Taboos are the unwritten, oral traditions that have been passed down through society that dictate acceptable behavior. Many floras and animals in India's rural areas have religious importance; they represent cultural values that are deeply rooted in the lives of tribal tribes. These holy convictions are essential to preserving the existence of threatened forest animals (Pandey, 2003). Due to the enormous variance in various land rights systems inside sacred groves, no one method works for all sacred grove management situations worldwide. For instance, forest ownership differs between and within the states of India (Parthasarathy et al., 2020). Seeking the people's involvement is vital to guarantee the Sacred Groves' vital conservation and maintenance. Maintaining the integrity of these trees and strengthening their inherent uniqueness requires educating and advising the nearby village communities. Together, we can protect these priceless natural regions for future generations.

4. CONCLUSION

Sacred groves are pristine forest regions with significant ecological value that are recognized for supporting a wide variety of species, particularly uncommon, threatened, and endangered ones. Regrettably, encroachments and changes in land use have increased risks to these groves and their fragmentation. Since sacred groves represent harmony and a deep connection with nature, a complete conservation approach that integrates traditional, scientific, and cultural methodologies is recommended, given the unique ecological and biological value of each grove. There will always be natural habitats in India mixed in with human-dominated landscapes, and to maintain the diversity of our biodiversity, we must resolve conflicts on the edges and guarantee strong protection of the central regions. The loss of biodiversity is mostly caused by human activity, which also modifies species composition, richness, diversity, and abundance. A comprehensive comprehension of human influences is essential for efficiently managing protected areas. While there are still some protected places that are entirely unaltered, reducing human intervention within them is crucial to their continued existence.

FUNDING

No financial support for the research and publication of this article.

CONFLICTS OF INTEREST

The author declares no conflicts of interest.

ETHICS APPROVAL STATEMENT

Ethical review and approval were not required for the present review.

REFERENCES

1. **Bhagwat SA, Kushalappa CG, Williams PH, Brown ND.** A landscape approach to biodiversity conservation of sacred groves in the Western Ghats of India. *Conservation Biology*. 2005 Dec;19(6):1853-62.
2. **Bhagwat SA, Rutte C.** Sacred groves: potential for biodiversity management. Frontiers in Ecology and the Environment. 2006 Dec;4(10):519-24.

3. **Boraiah KT, Vasudeva R, Bhagwat SA, Kushalappa CG.** Do informally managed sacred groves have higher richness and regeneration of medicinal plants than state-managed reserve forests? *Current science*. 2003 Mar 25:804-8.
4. **Brandis D.** Indian forestry. Oriental University Institute; 1897.
5. **Bruner AG, Gullison RE, Rice RE, Da Fonseca GA.** Effectiveness of parks in protecting tropical biodiversity. *Science*. 2001 Jan 5;291(5501):125-8.
6. **Gadgil M, Vartak VD**. Sacred groves of India-a plea for continued conservation. *Journal of the Bombay Natural History Society*. 1975;72(2):314-20.
7. **Hughes JD, Swan J.** How much of the earth is sacred space? *Environmental Review*. 1986 Dec 1;10(4):247-60.
8. **Husain M, Vishwakarma DK, Rathore JP, Rasool A, Parrey AA, Mahendar K.** Local people strategies in biodiversity conservation and sustainable development. *The Pharma Innovation Journal*. 2018;7(1):444-50.
9. **Junsongduang A, Balslev H, Inta A, Jampeetong A, Wangpakapattanawong P.** Medicinal plants from swidden fallows and sacred forest of the Karen and the Lawa in Thailand. *Journal of ethnobiology and ethnomedicine*. 2013 Dec; 9:1-10.
10. **Kandari LS, Bisht VK, Bhardwaj M, Thakur AK**. Conservation and management of sacred groves, myths and beliefs of tribal communities: a case study from north-India. *Environmental Systems Research*. 2014 Dec; 3:1-10.
11. **Kent EF**. Sacred groves and local gods: religion and environmentalism in South India. Oxford University Press; 2013 Jun 20.
12. **Khan ML, Khumbongmayum AD, Tripathi RS.** The sacred groves and their significance in conserving biodiversity: an overview. *International Journal of Ecology and Environmental Sciences*. 2008 Sep;34(3):277-91.
13. **Malhotra KC**. Sacred groves in India: An overview. Indira Gandhi Rashtriya Manav Sangrahalaya; 2007.
14. **Myers N, Mittermeier RA, Mittermeier CG, Da Fonseca GA, Kent J.** Biodiversity hotspots for conservation priorities. *Nature*. 2000 Feb; 403 (6772): 853-8.
15. **Ormsby A.** Analysis of local attitudes toward the sacred groves of Meghalaya and Karnataka, India. *Conservation and Society*. 2013 Apr 1;11(2):187-97.
16. **Ormsby AA, Bhagwat SA.** Sacred forests of India: a strong tradition of community-based natural resource management. *Environmental Conservation*. 2010 Sep;37(3):320-6.
17. **Ormsby AA, Ismail SA.** Cultural and ecological insights into sacred groves: managing timber resources for improved grove conservation. *Forests, Trees and Livelihoods*. 2015 Oct 2; 24(4): 244-58.
18. **Ormsby AA**. The impacts of global and national policy on the management and conservation of sacred groves of India. *Human Ecology*. 2011 Dec;39(6):783-93.
19. **Pal T, Mukhopadhyay M.** Change in Socio-cultural dimensions and its impact on exiting Sacred grove. Int J Human Soc Sci. 2011;1(10):242-50.
20. **Pandey DN**. Sacred Forest: the case of Rajasthan. India in Forest Service, India. 2003:1-6.
21. **Parthasarathy N, Naveen Babu K.** Sacred groves: potential for biodiversity and bioresource management. InLife on Land 2020 Nov 25 (pp. 865-880). Cham: Springer International Publishing.
22. **Rath S, Ormsby AA.** Conservation through traditional knowledge: a review of research on the sacred groves of Odisha, India. Human Ecology. 2020 Aug;48(4):455-63.
23. **Ray R, Chandran MD, Ramachandra TV**. Biodiversity and ecological assessments of Indian sacred groves. Journal of forestry research. 2014 Mar; 25:21-8.
24. **Sachs W**, editor. Global ecology: A new arena of political conflict. Zed Books; 1993.
25. **Shiva V.** Ecology and the politics of survival: Conflicts over natural resources in India. (No Title). 1991 Dec 2.
26. **Singh JS, Kushwaha SP.** Forest biodiversity and its conservation in India. International Forestry Review. 2008 Jun 1;10(2):292-304.
27. **Singh S, Youssouf M, Malik ZA, Bussmann RW**. Sacred groves: myths, beliefs, and biodiversity conservation—a case study from Western Himalaya, India. *International journal of ecology*. 2017; 2017(1):3828609.
28. **Sinha B, Maikhuri RK.** Conservation through sociocultural-religious practice in Garhwal Himalaya: A case study of Hariyali sacred site. Conserving the sacred for biodiversity management. 1998; 299:289.
29. **Upadhaya K, Barik SK, Pandey HN, Tripathi OP.** Response of woody species to anthropogenic disturbances in sacred forests of northeast India. *International Journal of Ecology and Environmental Sciences*. 2008;34(1):01-.07.

International Journal of Environment and Health Sciences (IJEHS)
2024, VOL. 6, NO. 3, 8-22
https://doi.org/10.47062/1190.0601.02

A RECENT STUDY OF WATER QUALITY OF DAL LAKE IN SRINAGAR J&K

Ruhail Maqbool Sheikh[1] **and Sushmitha Baskar**[2]

[1]Water quality analyst, Department of Jal Shakti J&K, India
[2]Associate Professor, Environmental Studies, School of Interdisciplinary and Trans-disciplinary Studies, IGNOU, New Delhi 110068

Received on: 28.06.2024 **Revised on:** 10.07.2024 **Accepted on:** 22.07.2024

Abstract
The issues of sewage disposal and contamination of surface waters in lakes are rapidly rising due to urbanisation, technological advances, and growing populations. Over the past few decades, the water quality of Dal Lake has experienced significant degradation, rendering it unsuitable for domestic consumption and diminishing its visual appeal. This report aims to provide an overview of the current state of water quality in Dal Lake. Water quality can be evaluated using various physio-chemical and biological indicators such as turbidity, pH, taste, odour, iron, fluoride, total dissolved solids (TDS), conductivity, nitrate, phosphorus, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and coliform bacteria. Water samples were randomly sampled from several locations in Dal Lake, spanning from Dal-gate to Hazratbal. Based on the test findings and data, we observed that majority of the lake's surface is covered by weeds. This is caused by a high concentration of nitrate and phosphorus, which leads to the siltation of the lake water. Bacteriological contamination was found along the entire span of Dal Lake. The primary factor contributing to the diminished water quality of the lake is the introduction of untreated sewage, detergents, and runoff from floating gardens and houseboats. Focus group discussions were held with participants and some awareness programmes were also held to educate the people on the lakes degradation and suggestions for improving the same.

Keywords: Dal Lake, Water quality assessment, Focus group discussions.

1. INTRODUCTION

The Dal Lake in Kashmir, is known as the "*Liquid heart*" of Srinagar, the capital city of the Union Territory of Jammu and Kashmir. The lake is plagued by numerous ailments primarily caused by human encroachments both around its edges and within its waters. The lake is currently experiencing significant environmental issues, such as the large influx of untreated residential sewage, continual accumulation of sediment, leading to unpleasant algal blooms and excessive weed growth, deterioration of water quality, and decline in biodiversity. Dal is a body of water located in Srinagar, which serves as the summer capital of Jammu and Kashmir. The urban lake, known as the "*Jewel in the crown of Kashmir*" or "Srinagar's Jewel," plays a crucial role in tourism and relaxation in the region of Kashmir. The lake serves as a vital resource for economic activities such as fishing and water plant harvesting.

Water testing is essential for monitoring the operations of water supply, assuring the safety of drinking water, detecting disease outbreaks, validating procedures, and implementing preventive measures. To assess the safety of drinking water, it is necessary to employ water quality testing methods either at the point of origin, inside a piped distribution system, or at the final consumer's location. Water quality surveillance and drinking water quality monitoring are distinct yet interrelated endeavours. The Dal Lake, spanning approximately 15.5 kilometres, is surrounded by a boulevard adorned with Mughal era gardens, parks, houseboats, and hotels. It serves as the primary water source for a significant part of Srinagar city.

The shore side Mughal gardens, including Shalimar Bagh and Nishat Bagh, constructed during the rule of Mughal Emperor Jahangir, offer picturesque vistas of the lake. Additionally,

CONTACT *Corresponding author: *sheikhruhail@gmail.com; sushmithab@ignou.ac.in*
Color versions of one or more of the figures in this article can be found online at www.stenvironment.org

the lake can be admired from houseboats sailing in vibrant shikaras. In the winter season, the temperature occasionally drops to as low as −10 °C, causing the lake to freeze. The floating gardens, referred to as "Raad" in the Kashmiri language, flourish with lotus blooms in the months of June, July, and August. The wetland is partitioned by causeways into four basins: Gagribal, Lokut Dal, Bod Dal, and Nagin (although Nagin is also regarded as a distinct lake). Lokut-dal and Bod-dal both possess a central island, referred to as Rup Lank (or Char Chinari) and Sona Lank respectively. Dal Lake is intimately linked to houseboats, which serve as lodging options for tourists in Srinagar. The Hanjis, who have inhabited the Dal for millennia, have developed such a comprehensive infrastructure within the lake that they hardly need to venture onto land (Fazal & Amin, 2012) Dal Lake is important due to its strategic location and unique physical characteristics. A number of tourist attractions have been constructed around its border, including as the Mughal gardens, Nishat gardens, Shalimar gardens, Cheshma Shahi, Naseem Bagh, Pari Mahal, Botanical Garden, and several religious temples like Hazratbal and Shankaracharya temple.

Dal Lake, being a lake located in an urban area, has experienced changes in its surface water content due to the discharge of waste from municipalities and households. This has resulted in an increase in eutrophication of the reservoir (Hutchinson, 1999). In addition, high rates of the formation of sediments caused by widespread soil erosion resulting from degradation and intrusion by the neighbouring populace, have significantly decreased the volume of the lake (Chakrapani, 2002). The lake functions as a vital source of potable water and for griculture, fishing, recreational activities, and ecotourism. The biodiversity of lakeshore ecosystems is presently endangered by several human disturbances, with the most significant ones being elevated nutrient load, contamination, pH imbalances, and the introduction of non-native species (Bronmark and Hansson, 2002). The ecological strain on the ecosystem is evidenced by the decline in water quality and the heightened levels of biological productivity. Urbanisation generates significant amounts of pollutants and diminishes the ability of water to infiltrate the ground, resulting in increased surface runoff. Pollutants originating from urban land uses are more susceptible to being carried by runoff from the surface compared to pollution from other types of land applications. In their study, Kanakiya et al. (2014) examined the Water Quality Index of Dal Lake for all four basins during summer, winter, and monsoon seasons. They concluded that the water was unsuitable for consumption. Ahamad et al. (2023) performed a comparative evaluation of the water quality in Dal and Nigeen Lakes in Jammu and Kashmir, India. Their study emphasises the need for efficient water management techniques and conservation initiatives to safeguard the water quality of these lakes.

The Dal Lake is contaminated by sewage systems originating from nearby hotels, houseboats, and various small- and large-scale operations due to its passage through multiple locations within the city. This study was conducted on the Dal Lake, and five sampling locations were selected randomly, starting from Dal Gate and extending up to Dargah Hazratbal. An awareness program was also conducted for the residents living around Dal Lake and houseboat owners, focusing on the importance of cleaning and maintaining the water quality of Dal Lake. The program aimed to educate and involve the local community in preserving the lake's ecosystem, which is vital for both the environment and the livelihood of those dependent on the lake.

2. OBJECTIVES

The objectives of the present study were to:

- analyze the water quality at various points of Dal Lake, Srinagar.
- identify the reasons for the difference in the analyzed parameters.
- understand the public opinion through focus group discussions.

Based on the study results recommendations for improvement in the water quality can be suggested.

Study Area and Sampling

The Dal lake's shoreline, spans approximately 15.5 kilometres.

Water Sampling Spots from Dal Gate to Dargah Hazratbal

Water sampling along the stretch from Dal Gate to Dargah Hazratbal is critical for monitoring the quality and health of Dal Lake. This route covers diverse areas of the lake, each with distinct characteristics and varying degrees of human impact.

- **Dal Gate:** This is one of the primary outlets of Dal Lake, where water is regulated and flows out towards the Jhelum River. Due to its proximity to urban areas, Dal Gate often experiences higher levels of pollution from sewage and waste discharge. Regular sampling here is essential to assess the impact of urban runoff on the lake's water quality.
- **Nehru Park:** A popular tourist spot, Nehru Park is surrounded by houseboats and shikaras (traditional wooden boats). Water sampling in this area helps in evaluating the impact of tourism and houseboat activities on the lake's ecosystem.
- **Char Chinar:** This small island, with its iconic Chinar trees, is located towards the center of Dal Lake. Sampling here provides insights into the central part of the lake, where water quality may be influenced by a mix of natural processes and human activities from surrounding areas.
- **Nigeen Lake:** Connected to Dal Lake, Nigeen Lake is often considered a separate water body due to its relatively cleaner water (Mukhtar et al. 2014). Sampling in this area is important for comparing the water quality between the two interconnected lakes and understanding how activities in Dal Lake might affect Nigeen.

- o **Hazratbal:** Near the northern end of Dal Lake, Hazratbal is a significant religious and cultural site. The area sees a mix of pilgrimage-related activities and local residential influence. Water sampling near Dargah Hazratbal is crucial for assessing the combined impact of religious activities and local habitation on the lake's water quality.

Mineralogy and Rock Types in the Area

The Dal Lake area, including the region extending from Dal Gate to Dargah Hazratbal, is geologically part of the Kashmir Valley, which is characterized by a complex assemblage of rock types and mineral deposits. The surrounding hills and mountains are primarily composed of:

- o **Limestone:** The dominant rock type in the area is limestone, particularly in the Zabarwan Range that overlooks Dal Lake. This sedimentary rock is rich in calcium carbonate and contributes to the slightly alkaline nature of the lake's water. The weathering of limestone influences the mineral content of the water, particularly in terms of calcium and magnesium ions.
- o **Shale:** Shale layers are also present in the region, particularly in the valley surrounding the lake. These fine-grained sedimentary rocks are rich in clay minerals and can contribute to the sediment load in the lake, especially during the rainy season when runoff increases.
- o **Sandstone:** Sandstone deposits are found in some parts of the Kashmir Valley, including areas near Dal Lake. The sandstone here is generally composed of quartz and feldspar minerals, which are resistant to weathering and contribute to the coarser sediment fraction in the lake's deposits.
- o **Glacial Deposits:** The Kashmir Valley has been shaped by glacial activity, leaving behind moraines and glacial till. These deposits, composed of a mix of rock types, contribute to the varied mineralogy of the sediments found in Dal Lake.

The interaction between these geological formations and the water of Dal Lake plays a significant role in determining the mineral content and overall chemistry of the lake's water. This, in turn, affects the aquatic life and the health of the lake's ecosystem.

The present study was carried out for the water quality assessment of Dal Lake. The study is based on primary and secondary sources of data. The primary information was collected from random sampling and testing in the laboratory. The present study is an attempt to examine the water quality in Dal Lake. The present research work is based on intensive fieldwork. The data and information were gathered from various sources. Inferences were drawn based on personal field survey and other field works and observations. Based on the random sampling method, the locations were classified based on the quality of water i.e., from every corner of the lake area, including the central part (Figure 1). The primary data thus gathered was processed, classified and quantified using MS-excel graphs. . Regarding water quality of the Dal Lake from different sources, the recent data was collected from the department of Jal Shakti Kashmir, Department of Lakes and water ways development authority (LAWDA), Srinagar municipal corporation (SMC), Srinagar development authority (SDA). Also data was obtained through discussions with the awareness among locals living around Dal Lake and among hanjis regarding degradation of the lake.

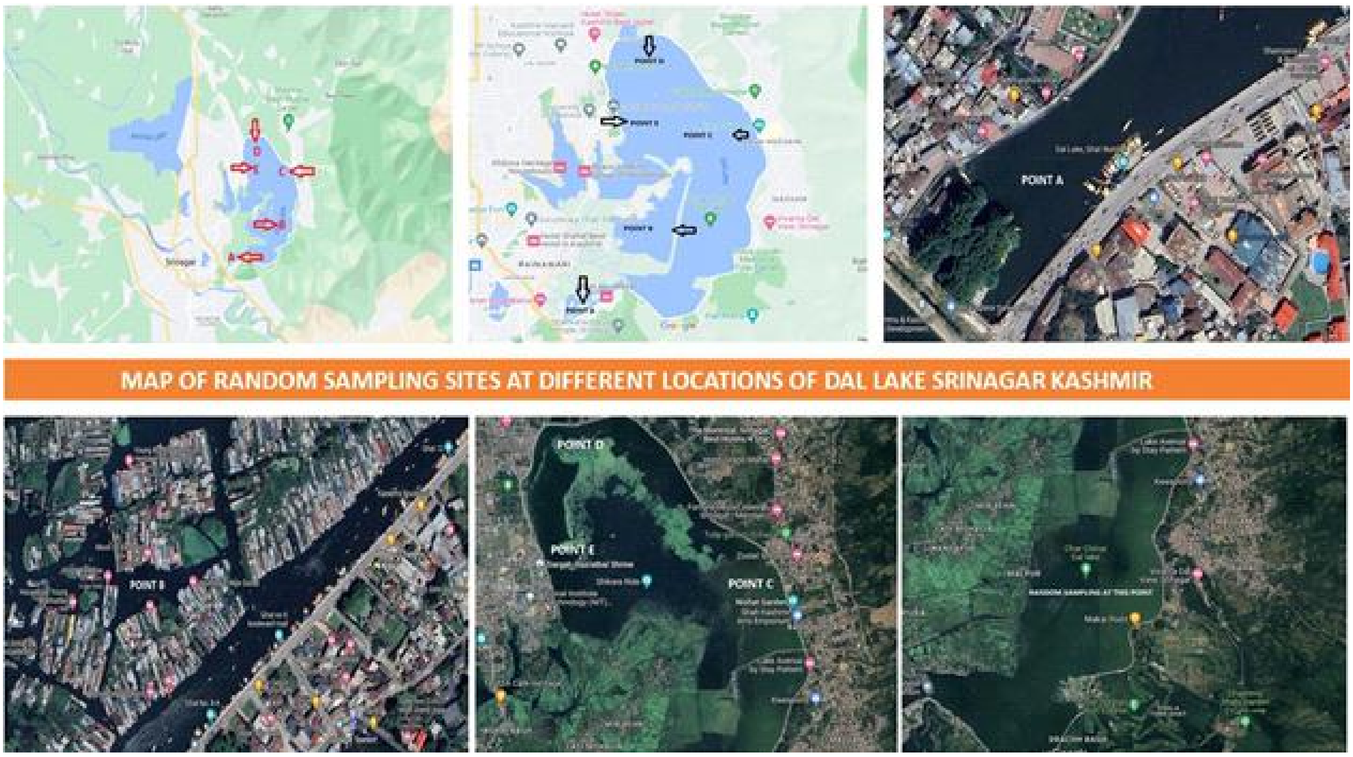


Figure 1: Map of sampling sites at different locations of Dal Lake, Srinagar, Kashmir

3. Methodology

3.1 Sample collection

Water samples were taken from Dal Lake at various locations detailed in Table 1. We chose these points for sampling because some points have occupied large areas with several houseboats resulting in more pollution where some areas are less affected, few other sites are heavily populated and have a greater impact on the water quality. Some points have become contaminated because of increased drainage systems that flow directly or indirectly into the dal lake. Field test kits were used to analyze samples on the spot from all the sites. The samples were collected using the grab sampling method. All samples were collected in 1.5 litre sterile bottles, transported to the lab, and processed within 1- 2 days.

Table 1: Location of sampling sites.

S. No	Name of Location and sampling points	Location Code	Latitude	Longitude
1.	Dalgate	A	34.0985	74.8761
2	Nehrupark	B	34.1251	74.8782
3	Charchinar	C	34.1032	74.8667
4	Nigeen	D	34.1182	74.8317
5	Hazratbal	E	34.1289	74.8425

3.2 Physicochemical and Biological analysis

The samples were collected from April 2024 to July 2024. Standard methods were used to investigate the physicochemical and biological parameters. pH (Digital pH meter Eutech), Turbidity, Total dissolved solid (TDS) was determined by (Digital meter Eutech), Electrical conductivity (EC) (Digital EC meter Eutech). Fluoride, Iron, Nitrate, Sulphate, Chloride, photo spectrometer E. coli by H_2S Vials. Total Alkalinity (TA) as HCO^{3-} , Calcium (Ca^{2+}), Magnesium (Mg^{2+}) Total hardness (TH), chloride (Cl), was estimated by standard titrimetry. Sulphate (SO_4^{2-}) by turbidometry, Nitrate (NO_3^{2-}) by UV-VIS spectrophotometer. Standard methods such as APHA (2017) and BIS were used in the analysis (2012). Field Test Kits were utilized for on-the-spot examination, and additional methods included photo spectrometric methods, turbidity and pH were measured using electrometric methods. As a result, the results were obtained using either digital meters or the colour comparison approach. Figure 2, 3 and Table 2 shows the sample collection, various water quality parameters analysed and the methods employed.

Figure 2: Instruments used, and methods employed.

Table 2: Water quality parameters analysed and methods employed.

Parameters	Methods Adopted	Equipment used
pH	Electrometric method	pH meter
Turbidity	Nephelometric method	Turbidity meter
Odour	Threshold water test	Burette
Taste	Flavour Rating Assessment	Beaker
TDS	Electrometric method	TDS/Conductivity meter
Electrical Conductivity	Electrometric method	TDS/Conductivity meter
Fluoride (as F)	(SPADNS) method	UV-Visible Spectrophotometer
Nitrate (as NO_3)	Chromotropic acid method	UV-Visible Spectrophotometer
Iron (As Fe)	UV-Visible Spectrophotometer	UV-Visible Spectrophotometer
Chloride (as Cl)	Argentometric method	Burette
Sulphate (as SO_4)	Turbidimetric method	UV-Visible Spectrophotometer
E. coli	H_2S vial test	Bacteriological Incubator

Figure 3: Sample collection at various points.

3.3 Focused Group Discussion (FGD)

This aimed to gather insights, opinions, and suggestions from various stakeholders involved in or affected by the condition of Dal Lake. The discussion focussed on understanding the current state of the lake, identifying challenges, and exploring effective measures for cleaning and maintaining water quality. A questionnaire was framed for the discussion and participants were asked about the general perception and other specific questions regarding the deterioration of the lake. The questionnaire is given below.

Questionnaire:

1. **General Perception:**
   - What is your overall perception of the current state of Dal Lake?
   - How do you believe Dal Lake has changed over the past few years?
2. **Personal and Community Involvement:**
   - What steps are you personally taking to help clean and maintain the quality of Dal Lake water?
   - How is your community or organization involved in preserving Dal Lake?
   - What motivates you or your community to participate in these efforts?
3. **Awareness and Education:**
   - How informed do you feel about the environmental issues affecting Dal Lake?
   - What educational resources or programs have you participated in regarding Dal

Lake conservation?
- How do you think awareness can be increased among the general public?

4. **Challenges and Grievances:**
    - What challenges do you face in your efforts to clean and maintain the lake?
    - Are there any grievances or concerns you have regarding the current conservation efforts?
5. **Government and Organizational Support:**
    - How do you perceive the role of government and NGOs in the conservation of Dal Lake?
    - What support have you received from government agencies or NGOs?
    - What additional support do you believe is necessary from these entities?
6. **Impact of Tourism:**
    - How do you think tourism affects the water quality and overall health of Dal Lake?
    - What measures can be taken to balance tourism with conservation efforts?
7. **Houseboat Owners and Residents:**
    - What practices are houseboat owners and lakeside residents adopting to minimize pollution?
    - How do you manage waste disposal from houseboats and lakeside homes?
    - What support do you need to improve waste management practices?
8. **Suggestions for Improvement:**
    - What new initiatives or strategies would you suggest to further improve the quality of Dal Lake?
    - How can the local community be more effectively involved in the conservation process?
    - What role can schools, religious institutions, and local businesses play in this effort?
9. **Future Outlook:**
    - What do you envision for the future of Dal Lake if current conservation efforts continue?
    - How can we ensure the long-term sustainability of Dal Lake?

Random Questions:

1. How do you feel when you see pollution in Dal Lake?
2. What do you think are the main sources of pollution in Dal Lake?
3. How can we involve more youth in the conservation of Dal Lake?
4. What do you think about the current regulations on waste disposal near the lake?
5. How do seasonal changes affect the lake, and what can be done to mitigate these effects?
6. Do you think the current awareness programs are effective? Why or why not?
7. How do religious practices and rituals impact Dal Lake, and how can we manage this respectfully?
8. What role do you think traditional knowledge and practices play in the conservation of Dal Lake?

General Perception:

1. What is your overall perception of the current state of Dal Lake?
2. How do you believe Dal Lake has changed over the past few years?

Personal and Community Involvement:

1. What steps are you personally taking to help clean and maintain the quality of Dal Lake water?
2. How is your community or organization involved in preserving Dal Lake?
3. What motivates you or your community to participate in these efforts?

Awareness and Education:

1. How informed do you feel about the environmental issues affecting Dal Lake?
2. What educational resources or programs have you participated in regarding Dal Lake conservation?
3. How do you think awareness can be increased among the general public?

Challenges and Grievances:

1. What challenges do you face in your efforts to clean and maintain the lake?
2. Are there any grievances or concerns you have regarding the current conservation efforts?

Government and Organizational Support:

1. How do you perceive the role of government and NGOs in the conservation of Dal Lake?
2. What support have you received from government agencies or NGOs?
3. What additional support do you believe is necessary from these entities?

Impact of Tourism:

1. How do you think tourism affects the water quality and overall health of Dal Lake?
2. What measures can be taken to balance tourism with conservation efforts?

Houseboat Owners and Residents:

1. What practices are houseboat owners and lakeside residents adopting to minimize pollution?
2. How do you manage waste disposal from houseboats and lakeside homes?
3. What support do you need to improve waste management practices?

Suggestions for Improvement:

1. What new initiatives or strategies would you suggest to further improve the quality of Dal Lake?
2. How can the local community be more effectively involved in the conservation process?
3. What role can schools, religious institutions, and local businesses play in this effort?

Future Outlook:

1. What do you envision for the future of Dal Lake if current conservation efforts continue?
2. How can we ensure the long-term sustainability of Dal Lake?

4. RESULTS AND DISCUSSION

Water is a crucial resource that is necessary for the survival of humans, as well as for the production of goods. The foundation and continuity of social and economic advancement rely on this vital resource (Taiwo et al. 2012). Uninterrupted and convenient availability of clean and high-standard water is an essential entitlement of every individual (Corcoran et al. 2010). The United Nations General

Assembly (UNGA) has identified the provision of clean water and sanitation for all as one of the key objectives to be accomplished by 2030 for sustainable development (UN, 2018). The quality of water is determined by its physical, chemical, biological, and visual characteristics. These factors are used to assess its suitability for various purposes, such as safeguarding people's health and maintaining the health of the aquatic environment. The qualities of water are primarily affected by substances that are either dissolved or suspended in it. Water quality can be altered by both natural processes and human intervention (DWA, 2010; Hubert and Wolkersdorfer, 2015).

The samples for the present study were analysed and were compared to the permissible limit given by the IS: 2296 and the Central Pollution Control Board (CPCB). A wide range of physico-chemical and biological characteristics were studied at these places, along with the comprehensive findings. Significant amounts of rubbish are indiscriminately discarded in various locations by visitors, houseboats, and through drainage systems. This poses a significant issue for the residents living in proximity to these sites and houseboats. The lake is contaminated by different types of waste materials, such as weeds and organic trash originating from nearby locations and marketplaces. These waste materials accumulate and create rubbish mounds at various locations, leading to pollution. Thirteen parameters were checked for Dal Lake in the water testing laboratory as well as on spot. The results obtained are given below in table 3.

Table 3: Water Testing Report of Dal Lake.

Sr. No	Parameter	Unit Site A	Sample Site B	Sample Site C	Sample Site D	Sample Site E	Sample	MEAN
1.	pH	-	7.8	7.7	8.3	8.2	8.5	8.38
2.	Turbidity	NTU	25.95	20.00	27.59	33.62	29.20	32.672
3.	Odour	mg/l	O	O	O	O	O	Objectionable
4.	Taste	mg/l	O	O	O	O	O	
5.	TDS	mg/l	105.4	110.1	119.5	97.4	160.5	118.58
6.	Conductivity	μs/cm	219.3	260.2	199.3	187.4	178.5	208.94
7.	Fluoride (as F)	mg/l	0.00	0.01	0.00	0.01	0.00	0.004
8.	Nitrate (as NO_3)	mg/l	10	05	10	10	05	8.00
9.	Iron (As Fe)	mg/l	0.00	0.01	0.00	0.01	0.00	0.004
10.	Chloride (as Cl)	mg/l	10	05	15	10	20	12.00
11.	Sulphate (as SO_4)	mg/l	0.10	0.50	0.80	0.30	0.10	0.36
12.	Hardness	mg/l	200	180	210	250	160	200
13.	Alkalinity	mg/l	150	110	140	130	120	130
14.	E. coli	MPN	Positive	Positive	Positive	Positive	Positive	-
15.	Residual Chlorine	mg/l	Raw	Raw	Raw	Raw	Raw	-

4.1. pH

According to water quality standards, the pH limits should be 6.5 - 8.5. The pH values for all the samples were above 7.0 at all points (Figure 4). The pH of all the samples was found to be within the BIS range of 6.5 to 8.5. Samples were mostly neutral. The pH from A to E points were normal. The pH limit for drinking water is 6.5 to 8.5. Majority of the samples most of the time showed more than a pH of 8 (Table 1). Similar results were reported by other researchers on the dal lake. Therefore, the pH fluctuated from 7.8 to 8.5. In lakes the occurrence and abundance of components of carbonate system and the pH are determined primarily by current and chemical nature of the substrate. The pH greatly affects the biogeochemistry in aquatic ecosystems, such as growth of fishes and aquatic plants. Because most of their metabolic activities are pH dependant, pH has an impact on aquatic species.

Figure 4: pH of the samples analysed.

4.2. Turbidity

The samples were tested for their turbidity, and it was observed to be high and exceeds the permissible limits at almost all points (Figure 5). At point A it was 25.95 NTU and it was above 25 NTU at points C, D, and E but remains above 20 NTU at all points up to point E. At point A the turbidity was noted as (25.95), B (20.0), C (27.59), D (33.62), E (29.20) NTU. Hence, turbidity was above permissible limit at all points (Table 2). The normal range of turbidity as per BIS is that it should not exceed 5NTU.The higher turbidity values indicate pollution and contamination of the waters.

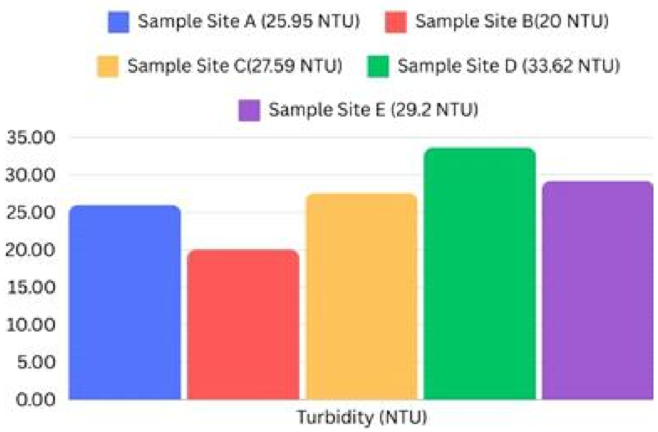


Figure 5: Turbidity of the samples analysed.

4.3 TDS:

High concentrations of total dissolved solids (TDS) was observed at site E with 160.5 mg/L. This may be due to saprophytic substances due to the decomposition of aquatic plants and animals. The lowest value of TDS was 97.4 mg/L at site D (Figure 6). The rainwaters may have a role in this decrease of TDS concentration during monsoon.

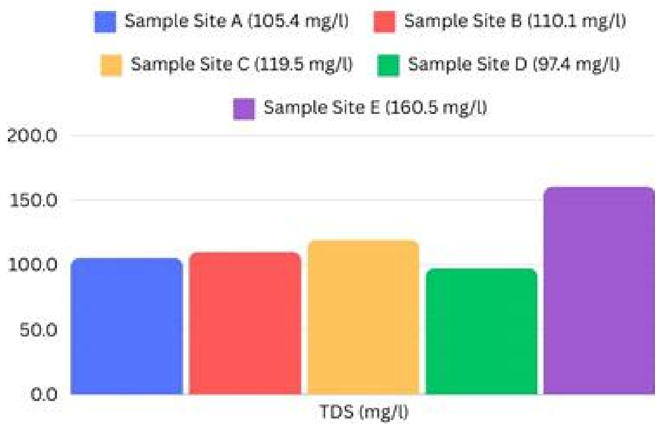


Figure 6: TDS of the samples analysed.

4.4 Conductivity:

This served to assess the purity of water and the conductivity was not more than 260 and not less than 170 thus, average conductivity was around 208.9 us/cm (Figure 7). A high level of conductivity may indicates the pollution status of the lake as well as trophic levels.

Figure 7: Conductivity of the samples analysed.

4.5. Fluoride:

Fluoride was also determined spectrophotometrically. Fluorides in the water samples were present within permissible limits (Figure 8). It did not go above 0.5 at all points (Table 2). The permissible limit for fluoride is 0.5-1.5 mg/l as per BIS and WHO. Very low levels of fluorides can lead to deficiency and health effects such as dental caries and higher levels can lead to bone deformities and mottling of the teeth.

Figure 8: Fluoride content of the samples analysed.

4.6. Nitrate:

Nitrate was estimated using a UV-Visible Spectrophotometer. Nitrogen and phosphorus are important factors in an aquatic ecosystem and play a key role in the productivity of an aquatic habitat. Nitrates were present within the permissible limits at all points throughout the period of study. The maximum permissible limit of Nitrate is 40 mg/l.

Almost all the samples had nitrate levels of nearly 05-10 mg/l (Figure 9).

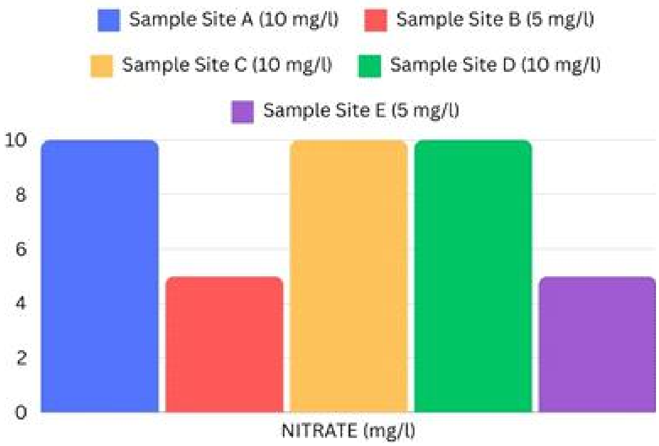


Figure 9: Nitrate content of the samples analysed.

4.7. Iron:

Iron was also determined spectrophotometrically. Iron in the water samples was zero at all points (Table 2). Hence the water was free from iron content at all points of the study area. The permissible limit for iron is up to 1 mg/l as per BIS and WHO.

4.8. Chloride:

Highest concentrations of chloride of 20 mg/L was reported at site E (Figure 10). The high chloride concentrations indicate the presence of organic matter. The lowest value of chloride was 05 mg/L at site B. It may be possible that during the rains dilution of lake can occur. Similar values between 15 -28 mg/L were reported in Dal lake by Samie and Khan, 2022).

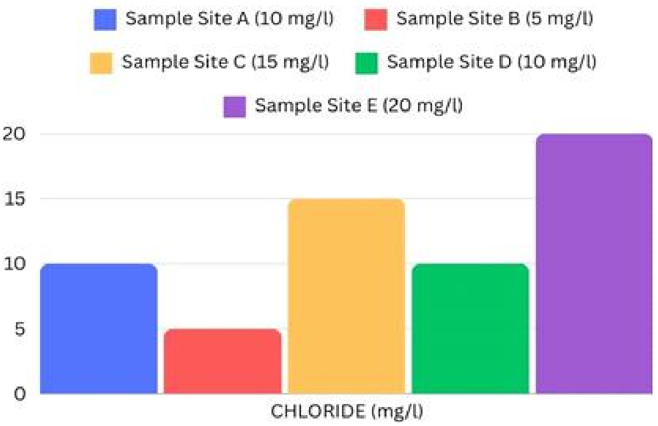


Figure 10: Chloride content of the samples analysed.

4.9. Sulphate

Sulphate concentration was analysed through spectrophotometer as well as on spot using Field Test Kit Sulphate was found within the permissible limits at all sampling points (Figure 11). At point A, sulphate was observed as 0.10 mg/l. The points at B,C,D and E recorded almost similar values of sulphate concentrations from 0.1 and 0.8 mg/l (Table 2, Figure 4). The higher values may be due to municipal waste effluents and agricultural run-off.

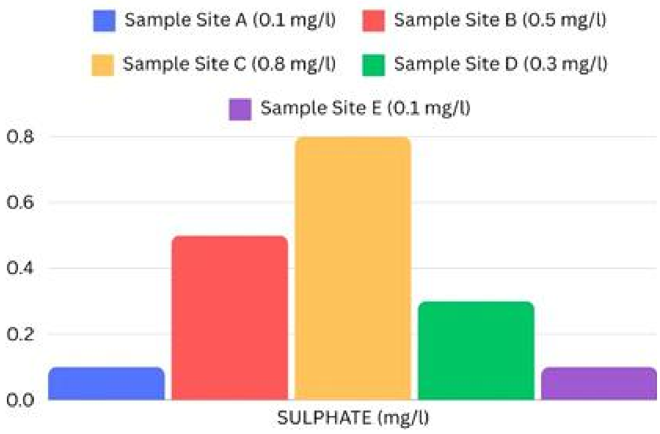


Figure 11: Sulphate content of the samples analysed.

4.10. Hardness.

Total hardness of all the samples was found to be within permissible limit. Average total hardness of most of the samples in the study area was found to be higher than 150mg/l indicating that the water is hardwater. Total hardness in most cases is always higher than 200mg/l which is the permissible limit by BIS as well as WHO standards. At point A Hardness was found (200). B (180), C (210), D (250), E (160) mg/l (Figure 12).

Figure 12: Hardness of the samples analysed.

4.11. Alkalinity is the capacity of water to neutralize acid. It is a measure of bicarbonates, carbonates and hydroxides present in water. Alkalinity was found to be within permissible limit. Total alkalinity of all the samples was not found to be higher than permissible value (200mg/l & 600mg/l) suggested by BIS as well as WHO. At point A Alkalinity was found (150). B (110), C(140),D(130),E(120) mg/l (Figure 13).

Figure 13: Alkalinity of the samples analysed.

4.12. Residual chlorine the value of residual chlorine at all points was 0mg/l.

4.13. Taste & Odour Taste and Odour was Objectionable at all points.

4.14. Total coliforms

Bacteriological contamination was found at all points (Table 2). The reason for the bacteriological contamination may be that at most of the places all the waste products, animal debris, drainage waste, were thrown to the Dal Lake which has resulted in the biological contamination of all samples. Bacteriological parameters were analysed using H_2S Vial.

The results suggest that the lake is polluted with respect to the biological wastes which affect the overall water quality and dissolved oxygen in the lake.

Several reports have studied the lake on different aspects. Samie and Khan (2022) observed higher values of concentration of major elements in the Dal lake nearer to the sewer drains, restaurants and other commercial activity areas. Similar observations of the lake degradation was reported by Kumar et al. (2022). Heavy metal contamination causing toxicity in the Dal Lake has been reported by several researchers (Mukhtar and Chisti, 2018; Shah et al. 2021). Discharges and releases of untreated water from houseboats and motorboats have contaminated the lake with hydrocarbons and heavy metals (Kumar et al. 2022).

4.13 Findings of the Awareness Program:

Dal Lake is not only a popular tourist attraction but also a critical source of water and livelihood for many residents. The program highlighted the ecological significance of the lake and its role in supporting biodiversity. Discussions were held on the various factors contributing to the pollution of Dal Lake, such as sewage discharge, waste disposal, and the use of non-biodegradable materials. The participants were made aware of how these practices negatively impact the water quality and the lake's overall health.

4.14 Role of Houseboat Owners and Local Residents:

The program emphasized the responsibilities of houseboat owners and local residents in maintaining the cleanliness of the lake. Participants were encouraged to adopt eco-friendly practices, such as proper waste management and minimizing the use of harmful chemicals (Figure 14).

Figure 14: Various dustbins & hoardings installed at various points around the lake.

Community Involvement in Conservation Efforts: The importance of community participation in conservation efforts was underscored. Residents were encouraged to form local groups to monitor and maintain the cleanliness of their surroundings, and to report any activities that might harm the lake's ecosystem.

Government Initiatives and Support: Information was provided on the various government initiatives aimed at preserving Dal Lake, including financial assistance for adopting eco-friendly practices and the implementation of stricter regulations on waste disposal. The program also highlighted the role of government agencies in supporting the community's efforts.

Interactive Sessions and Feedback: The program included interactive sessions where participants could voice their concerns and suggestions. This feedback was crucial for understanding the challenges faced by the community and for developing more effective conservation strategies.

Outcome: The program successfully raised awareness among the participants about the critical need to preserve Dal Lake. The active involvement of the community and the commitment shown by the houseboat owners were promising steps towards ensuring the lake's long-term sustainability. Follow-up initiatives are planned to maintain momentum and ensure continuous community engagement in the conservation of Dal Lake. This awareness programme marks a significant effort in the mission to protect and maintain the pristine condition of one of Kashmir's most treasured natural resources.

Overall perception of the current state of Dal Lake: Participants generally expressed concern about the deteriorating state of Dal Lake. Many noted that the water quality has significantly declined due to pollution, encroachments, and unchecked tourist activities. However, some participants were optimistic about recent conservation efforts, though they emphasized that much more needs to be done. Most participants observed a noticeable decline in the lake's health over the past few years. They pointed to increased algae blooms, reduced water clarity, and the shrinking size of the lake as evidence of ongoing environmental degradation. Some noted that the lake has lost much of its former beauty and ecological balance (Figure 15, 16).

Figure 15: Sampling sites where aquatic weeds, silt & untreated sewage was found.

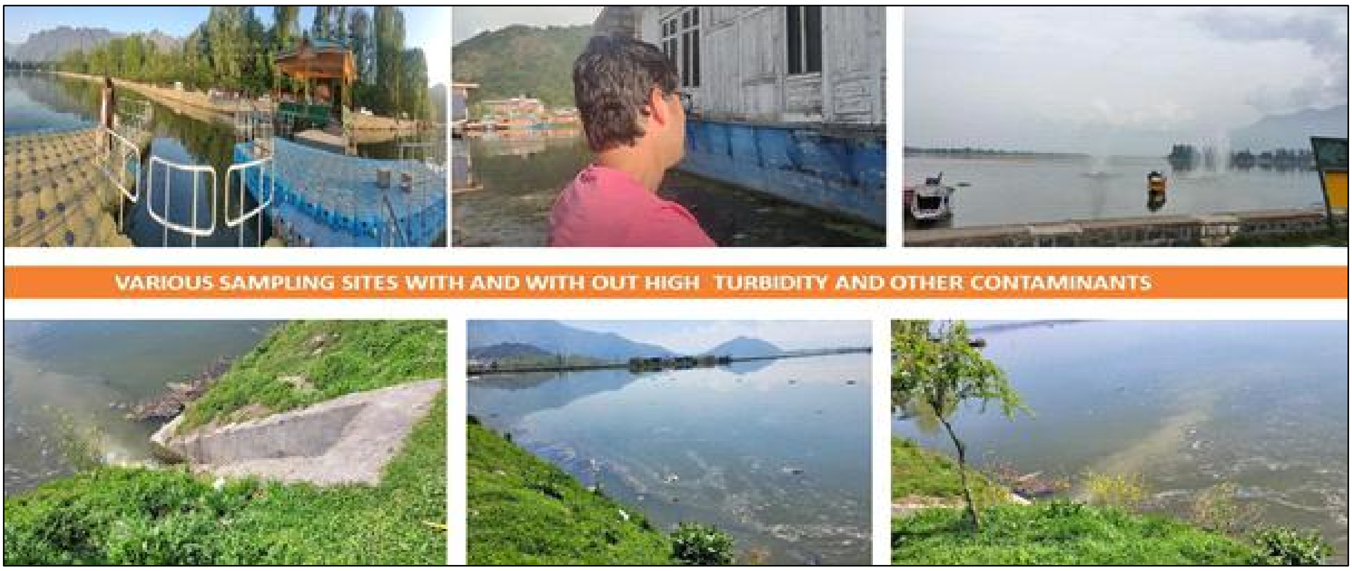


Figure 16: Sampling sites with high turbidity and other contaminant.

4.15 Personal and Community Involvement: Participants shared various personal efforts, including reducing plastic use, participating in clean-up drives, and educating others about the importance of preserving the lake. Houseboat owners mentioned efforts to improve waste management, while local residents discussed using organic methods in their nearby gardens to reduce runoff. Many participants described their community's involvement in initiatives such as regular clean-ups, awareness campaigns, and advocacy for stricter environmental regulations. Some communities have formed local groups dedicated to monitoring and reporting pollution sources, while others collaborate with NGOs to implement sustainable practices. Participants expressed a strong emotional and cultural connection to Dal Lake as their primary motivation. The desire to preserve the lake for future generations and the recognition of its importance to their livelihood, culture, and environment were also frequently mentioned.

4.16 Awareness and Environmental Education: Most participants felt moderately informed about the issues. They acknowledged that while they are aware of the general problems, there is a need for more detailed and accessible information, especially regarding effective conservation methods.

Some participants had attended workshops and training sessions organized by local NGOs and government agencies. However, many noted that such programs are not widespread, and access to educational resources is often limited. Suggestions included launching more targeted awareness campaigns, using social media platforms, involving schools in environmental education, and organizing community event focused on lake conservation (Figure 17). Participants also emphasized the importance of continuous education rather than one-time events.

Figure 17: Awareness Programmes Conducted.

4.17 Challenges and Grievances: Participants identified several challenges, including a lack of resources, and the difficulty of changing long-established practices among the local residents. The influx of tourists and the resulting waste were also significant concerns. Many participants voiced concerns about the lack of enforcement of existing regulations.

4.18 Government and Organizational Support: While participants acknowledged the efforts of both government and NGOs. There was a call for more proactive and transparent actions from the government, as well as greater collaboration between NGOs and local communities. Some participants reported receiving technical support, training, and resources from NGOs, while others mentioned government schemes aimed at improving waste management. Participants highlighted the need for more financial assistance, better infrastructure for waste management, and stronger enforcement of environmental laws. There was also a call for more inclusive planning processes that involve local communities in decision-making. Further extraction of the weeds and using them as biofertilizers is also being in the lake (Figure 18).

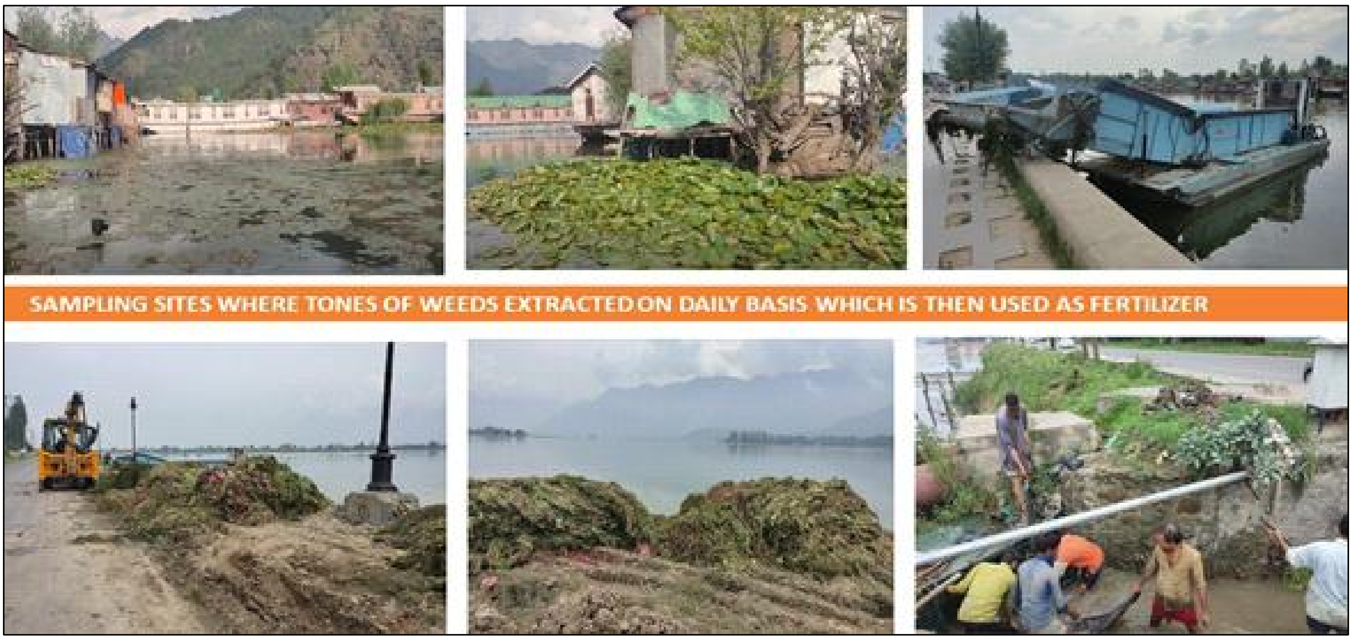


Figure 18: Sampling sites where tones of weeds, silt are extracted and used as biofertilizers.

4.19 Impact of Tourism: Participants generally agreed that tourism significantly impacts the lake's health, particularly through waste generation and increased boat traffic. The seasonal influx of tourists often leads to higher levels of pollution, which are difficult to manage with the current infrastructure. Suggestions included implementing stricter regulations on waste disposal, promoting eco-friendly tourism, and educating tourists about the importance of preserving Dal Lake. Participants also suggested creating designated areas for tourist activities to minimize their impact on the rest of the lake.

4.20 Houseboat Owners and Residents: Houseboat owners mentioned efforts to improve waste disposal practices, such as using bio-digesters and reducing the use of harmful chemicals. Some residents discussed community-driven initiatives to clean the lake and reduce household waste. Participants mentioned the use of both traditional and modern waste management practices. However, many noted that the infrastructure is still inadequate, leading to some waste inevitably ending up in the lake. There was a strong desire for more effective waste management solutions. Houseboat owners and residents expressed a need for better access to waste disposal facilities, more frequent waste collection services, and financial assistance to adopt eco-friendly technologies. There was also a call for more educational programs to help residents understand the best practices for waste management.

4.21 Suggestions for Improvement: Participants suggested a range of initiatives, including introducing stricter environmental regulations, launching large-scale clean-up operations, and developing better waste management infrastructure. They also emphasized the importance of continuous monitoring and research to track the lake's health. Participants recommended establishing community-led conservation groups, increasing the frequency of community meetings, and involving local leaders in decision-making processes. They also suggested that more resources be allocated to community education and empowerment.

Participants saw schools as crucial in educating the next generation about the importance of Dal Lake. Religious institutions were seen as potential leaders in promoting eco-friendly practices during rituals, while local businesses could support conservation efforts through funding and sustainable practices.

4.22 Future Outlook: Opinions were mixed, with some participants expressing optimism that the lake could recover if efforts are intensified and sustained. Others were more pessimistic, fearing that without significant changes, Dal Lake could continue to degrade. Participants emphasized the need for a multi-faceted approach, combining strong regulations, community involvement, and continuous monitoring. They also highlighted the importance of integrating traditional knowledge with modern conservation techniques to ensure the lake's long-term sustainability. Based on feedback from locals living around Dal Lake, the following species contribute to water pollution in different ways:

1. **Mangola:** This plant species tends to grow rapidly in the lake, forming dense mats that block sunlight and reduce oxygen levels, leading to poor water quality and harming aquatic life.
2. **Kandil:** Similar to mangola, kandil's dense growth blocks sunlight, which disrupts the natural ecosystem of the lake. It also decays in the water, releasing nutrients that lead to further algae blooms and deoxygenation.
3. **Shallot:** Shallot species, when overgrown, can contribute to nutrient overload in the lake. The decaying matter from these plants adds to the organic load in the water, worsening the water quality.
4. **Khor:** Khor contributes to the sedimentation of the lake, making the water murky. It also interferes with the natural flow of the water, trapping pollutants and contributing to the overall degradation of water quality.
5. **Oov:** This species tends to accumulate organic matter, which decays and depletes oxygen in the water. The resulting eutrophication leads to the growth of harmful algae and a decline in water quality.
6. **Goor:** Goor species are known to form thick mats on the water surface, which block sunlight and reduce the oxygen levels in the water. This leads to the death of fish and other aquatic organisms, further polluting the lake.
7. **Zud:** Zud contributes to nutrient overload in the lake, especially when it decomposes. This leads to algal blooms and the depletion of oxygen, which can cause dead zones in the lake.
8. **Bumb:** Bumb species, by growing excessively, block sunlight and reduce oxygen levels in the water. Their decay further adds to the organic load, worsening the overall water quality.
9. **Nadhil:** Nadhil species trap sediment and organic matter, which decay and contribute to the eutrophication of the lake. This results in the growth of harmful algae and a decrease in water quality.
10. **Batikhor:** Batikhor also contributes to sedimentation and nutrient overload, leading to water pollution. Its dense growth blocks sunlight and disrupts the natural ecosystem of the lake.
11. **Pumbich:** Pumbich species can quickly cover large areas of the lake, blocking sunlight and reducing oxygen levels. Their decay adds to the organic load in the water, leading to poor water quality.
12. **Lotus:** While lotus is aesthetically pleasing, its large leaves can block sunlight, affecting underwater plant growth. The decay of lotus plants adds organic matter to the lake, contributing to eutrophication and pollution.
13. **Azola:** Azola is an invasive species that grows rapidly, covering the water surface and blocking sunlight. This leads to reduced oxygen levels in the water and the death of aquatic organisms, further degrading the water quality.
14. **Weed:** Various weed species contribute to the nutrient load and organic matter in the lake, leading to eutrophication. Their overgrowth can also block sunlight and reduce oxygen levels, harming aquatic life.

On the other hand, Khel is considered beneficial as it removes weeds from the lake, helping to maintain the water quality. Additionally, the STP sump (containing drainage and trench water) is a significant source of pollution in Dal Lake. It introduces untreated or poorly treated wastewater into the lake, which carries organic pollutants, chemicals, and pathogens. This further deteriorates the water quality, harming aquatic life and making the water unsuitable for human use.

5. CONCLUSION

The current analysis demonstrates that the parameters examined fall within the acceptable thresholds along the Dal Lake. There is evidence of biological contamination at all locations. The Government should consistently take measures to ensure the impeccable quality of the Dal. During the focused group talks, it was noted that most individuals exhibited a significant level of awareness and were also highly motivated to contribute to the preservation of clean water. For maintaining the cleanliness of Dal Lake, it is necessary to have contributions and assistance from both the organised and unorganised sectors, in addition to the efforts made by our governments.

ACKNOWLEDGEMENT

Ruhail Maqbool Sheikh would like to thank the Department of Jal Shakti, Jammu and Kashmir for providing testing kits and experimental support.

REFERENCES

1. **Ahamad, F., Sharma, A. K., & Tyagi, S. K.** (2023). A Study on Comparative Assessment of Water Quality of Dal and Nigeen Lakes of Jammu and Kashmir, India. *Agro Environmental Sustainability*, 1(1), 48–56. https://doi.org/10.59983/s2023010107.
2. **Brönmark C, Hansson LA.** (2002). Environmental issues in lakes and ponds: current state and perspectives. Environmental Conservation.
3. **Chakrapani GJ.** (2002). Water and sediment geochemistry of major Kumaun Himalayan lakes, India. *Environ Geol*. 43, 99–107.
4. **Corcoran, E.,** et al. (2010). Sick water? The central role of wastewater management in sustainable development: A rapid response assessment. United Nations Enviromental Programme UN-HABITAT, GRID-Arendal. https://wedocs.unep.org/20.500.11822/9156.
5. Drinking Water Standards of *BIS* (IS: 10500: 1991)
6. **Fazal S. and Amin, A.** (2012). Hanjis Activities and its Impact on Dal Lake and its Environs (A Case study of Srinagar City, India*). Research Journal of Environmental and Earth Sciences. Vol. 4. Issue 5.* pp 511-524.
7. **Hubert, E. and Wolkersdorfer, C.** (2015). Establishing a conversion factor between electrical conductivity and total dissolved solids in South African mine waters. Water S.A. 41, 490–500.
8. **Hutchinson G. E.** (1967). A Treatise on Limnology, Vol. II, Introduction to Lake Biology and the Limnoplankton, John Wiley and Sons, Inc. New York.
9. ICMR Manual of standards of quality for drinking water supplies. ICMR, New Delhi (1975).
10. **Kanakiya RS, Singh SK, Sharma JN.** (2014). Determining the Water Quality Index of an Urban Water Body Dal Lake, Kashmir, India. IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 8, Issue 12 Ver. III (Dec. 2014), PP 64-71.
11. **Kanakiya, R.S., Singh S.K., Sharma J.N.** (2014).” Determining the Water Quality Index of an Urban Water Body Dal Lake Kashmir, India” *IOSR Journal of Environmental Science, Toxicology and Food Technology* Volume 8 (12), pp 64-71.
12. **Kumar R, Parvaze S, Huda MB and Allaie SP.** (2022). The changing water quality of lakes—a case study of Dal Lake, Kashmir Valley. Environ. Monit. Assess., 194 (3), 228.
13. **Mukhtar F and Chisti H.** (2018). The study of heavy metals in sediments sampled from Dal Lake. *Journal of Environmental Treatment Techniques*, 6 (2), 33-35.
14. **Mukhtar, F., Bhat, M.A., Basher, R., Chisti. H.** (2014). “Assessment of surface water quality by evaluating the physic-chemical parameters and by checking the water quality index of Nigeen basin and Brari Nambal lagoon of Dal Lake, Kashmir” *Master. Environ.sci*. ISSN: 2028-2508,Volume 5 (4) pp 1178-1187.
15. **Samie, S and Khan A.** (2022). Assessment of water quality of dal lake Srinagar. *International journal of advances in engineering and management*, 1 (4), 912 – 917.
16. **Shah RA, Achyuthan H, Krishnan H,** *et al.* (2021). Heavy metal concentration and ecological risk assessment in surface sediments of Dal Lake, Kashmir Valley, Western Himalaya. Arabian J. Geosci., 14 (2021),187, 10.1007/s12517-021-06504-w
17. **Taiwo, A.M., Olujimi, O.O., Bamgbose, O. & Arowolo, T.A.** (2012). Surface water quality monitoring in Nigeria: Situational analysis and future management strategy. In Water Quality Monitoring and Assessment (ed. Voudouris, K) 301–320 (IntechOpen).
18. **United Nations** (2018). The 2030 Agenda and the Sustainable Development Goals: An opportunity for Latin America and the Caribbean (LC/G.2681-P/Rev.3), Santiago.

International Journal of Environment and Health Sciences (IJEHS)
2024, VOL. 6, NO. 3, 23-27
https://doi.org/10.47062/1190.0601.02

ASSESSMENT OF GROUNDWATER QUALITY FOR DRINKING PURPOSE IN GUHLA BLOCK OF KAITHAL DISTRICT, HARYANA

Anup Kumar[1]*, Baru Ram[2] and Naresh Kumar[2]

[1,3]Haryana Space Applications Centre (HARSAC), Hisar
[2]Deptt. of Geology, Kurukshetra University, Kurukshetra

Received on: 30.06.2024 **Revised on:** 16.07.2024 **Accepted on:** 28.07.2024

Abstract
Good quality water is important for living beings to avoid many health problems. But in the present time availability of good quality water especially groundwater is very scarce. The present study area Guhla block is located in Kaithal district of Haryana state. The geo-coordinates of the study area are latitudes 29.94^0 N to 30.19^0 N and longitudes 76.19^0 E to 76.47^{0}E. The study area covers 372.48 sq. km area. Geologically alluvium and geomorphologically alluvial plain are present in the study area. The main objective was to assess groundwater quality for drinking purpose in the study area. In the study area nine groundwater samples were collected in 250 ml double capped plastic bottles. Geo-coordinates of sample locations were noted with the help of mobile GPS. Chemical analysis of nine groundwater samples were done using Tamilnadu Water Supply and Drainage (TWAD) Board, Chennai prepared Field Water Testing kit for twelve chemical parameters viz. pH, alkalinity, hardness, chloride, total dissolved solids, fluoride, iron, nitrite, nitrate, ammonia, phosphate and residual chlorine. Results of groundwater samples analysis were compared with BIS drinking water standards (IS 10500:2012) to know groundwater quality for drinking purpose. In the study area pH ranges 7.5 to 9, alkalinity 270 mg/l to 570 mg/l, hardness 130 mg/l to 420 mg/l, chloride 20 mg/l to 110 mg/l, TDS 672 mg/l to 1200 mg/l, fluoride nil to 2 mg/l, iron nil to 2 mg/l, ammonia nil to 1 mg/l, nitrite 0.2 mg/l to 0.5 mg/l, nitrate 45 mg/l to 150 mg/l, phosphate nil in all the nine groundwater samples and residual chlorine nil to 0.2 mg/l. The study is highly useful for planning and monitoring of groundwater quality for drinking purpose in the study area.

Keywords: Groundwater, quality, drinking, Guhla, Kaithal, Haryana.

1. INTRODUCTION

Water is important for living beings mainly for drinking, irrigation and industrial purposes. Good quality water is necessary for health to avoid many diseases. In the present time availability of good quality water is become very scarce due to anthropogenic pollution. Bunkar and Kumar (2019); Kaur et al. (2017), Khan and Jhariya (2017), Madhav et al. (2018), Nelly and Mutua (2016), Singh and Kumar (2014), Spanos et al. (2014), Vijaya Lalitha et al. (2016) had done work on groundwater quality assessment for drinking purpose in different areas.

2. STUDY AREA

Guhla block is located in Kaithal district of Haryana state (Fig.1). The geo-coordinates of the study area are latitudes 29.94^0 N to 30.19^0 N and longitudes 76.19^0 E to 76.47^0 E. The study area covers 372.48 sq. km area. Geologically alluvium and geomorphologically alluvial plain are present in the study area.

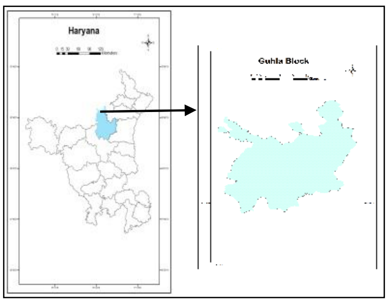


Figure1: Location map of the study area

CONTACT *Corresponding author: *anup0106@yahoo.com*
Color versions of one or more of the figures in this article can be found online at www.stenvironment.org

3. OBJECTIVE

The main objective of the study was to assess groundwater quality for drinking purpose in the study area.

4. MATERIALS AND METHODOLOGY

In the study area nine groundwater samples were collected in 250 ml double capped plastic bottles from tube wells (TW). Geo-coordinates of sample locations were noted with the help of mobile GPS. Chemical analysis of nine groundwater samples were done using Tamilnadu Water Supply and Drainage (TWAD) Board, Chennai prepared Field Water Testing kit for twelve chemical parameters viz. pH, alkalinity, hardness, chloride, total dissolved solids (TDS), fluoride, iron, nitrite, nitrate, ammonia, phosphate and residual chlorine (Table 1). Results of chemical analysis of groundwater samples were entered in excel software and prepared bar graphs for each chemical parameter. Results of groundwater samples analysis were compared with BIS (IS 10500:2012) drinking water standards (Table 2) to know groundwater quality for drinking purpose.

Table 1: Results of groundwater samples analysis in the study area.

S. No.	Sample Location	Latitude	Longitude	Source	pH	Alkalinity	Hardness (mg/l)	Chloride (mg/l)	TDS (mg/l)	Fluoride (mg/l)	Iron (mg/l)	Ammonia (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Residual Chlorine (mg/l)(mg/l)
1	Kharondhi	30.01	76.29	TW	7.5	400	270	110	936	2	2	0.5	0.2	100	0	0.2
2	Baupur	30.11	76.38	TW	8	370	130	110	732	2	0.3	1	0.5	100	0	0.2
3	Cheeka	30.03	76.34	TW	8	330	200	30	672	2	0	0.5	0.5	75	0	0
4	Kangthali	29.97	76.35	TW	8	550	220	20	948	2	0	1	0.5	75	0	0
5	Malikpur	30.13	76.23	TW	7.5	450	420	50	1104	0	0	0.5	0.5	100	0	0
6	Balbehra	30.03	76.39	TW	8.5	570	400	30	1200	1	0	0.5	0.5	150	0	0
7	Bhagal	30.06	76.42	TW	7.5	270	280	50	720	1.5	0	0.5	0.5	100	0	0
8	Arnoli	30.17	76.40	TW	8	390	270	70	876	1.5	0	1	0.2	45	0	0
9	Peedal	29.99	76.36	TW	9	430	270	80	936	1.5	0	0	0.5	75	0	0

Table 2: BIS (10500:2012) Drinking Water Standards.

S. No.	Characteristics	Potable		
		Desirable	Permissible	Non-Potable
1.	pH	6.5-8.5	-	<6.5 and >8.5
2.	Alkalinity (mg/l)	200	200-600	>600
3.	Hardness (mg/l)	200	200-600	>600
4.	Chloride (mg/l)	250	250-1000	>1000
5.	Total Dissolved Solids (mg/l)	500	500-2000	>2000
6.	Fluoride (mg/l)	<1.0	1.0-1.5	>1.5
7.	Iron (mg/l)	<0.3	-	>0.3
8.	Ammonia (mg/l)	<0.5	-	>0.5
9.	Nitrite (mg/l)	<0.1	-	>1.0
10.	Nitrate (mg/l)	<45	-	>45
11.	Phosphate (mg/l)	<1.0	-	>1.0
12.	Residual Chlorine (mg/l)	<0.2	0.2-1.0	>1.0

5. RESULTS AND DISCUSSION

5.1. pH

In the study area pH ranges 7.5 to 9 (Table 1, Fig.2). As per BIS drinking water standards pH is desirable between 6.5 to 8.5 and non-potable if less than 6.5 and more 8.5 (Table 2). pH is desirable in eight groundwater samples (Kharondhi, Baupur, Cheeka, Kangthali, Malikpur, Balbehra, Bhagal, Arnoli) and non-potable in one groundwater sample (Peedal (9)).

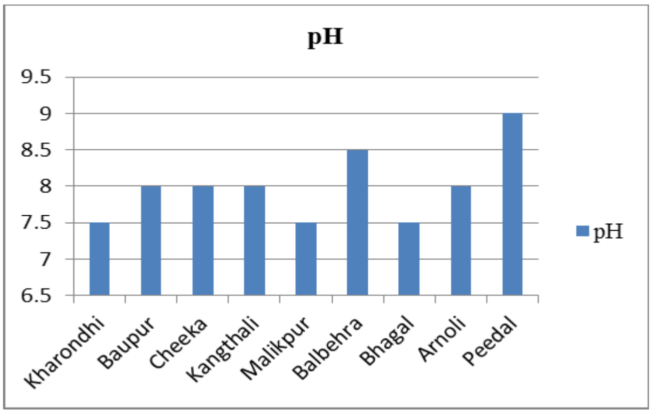


Figure 2: pH in groundwater samples.

5.2. Alkalinity

In the study area alkalinity ranges 270 mg/l to 570 mg/l (Table 1, Fig.3). As per BIS drinking water standards alkalinity is desirable if less than 200 mg/l, permissible between 200mg/l-600 mg/l and non-potable if more than 600 mg/l (Table 2). Alkalinity is permissible in all nine groundwater samples (Kharondhi, Baupur, Cheeka, Kangthali, Malikpur, Balbehra, Bhagal, Arnoli, Peedal).

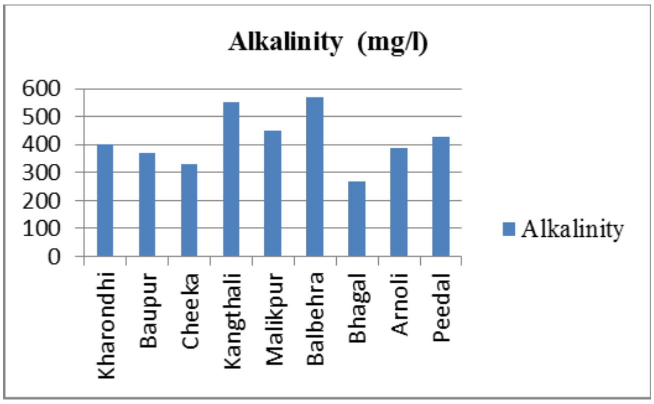


Figure 3: Alkalinity in groundwater samples.

5.3. Hardness

In the study area hardness ranges 130 mg/l to 420 mg/l (Table 1, Fig.4). As per BIS drinking water standards hardness is desirable if less than 200 mg/l, permissible between 200mg/l-600 mg/l and non-potable if more than 600 mg/l (Table 2). Hardness is desirable in one groundwater sample (Baupur) and permissible in eight groundwater samples (Kharondhi, Cheeka, Kangthali, Malikpur, Balbehra, Bhagal, Arnoli, Peedal).

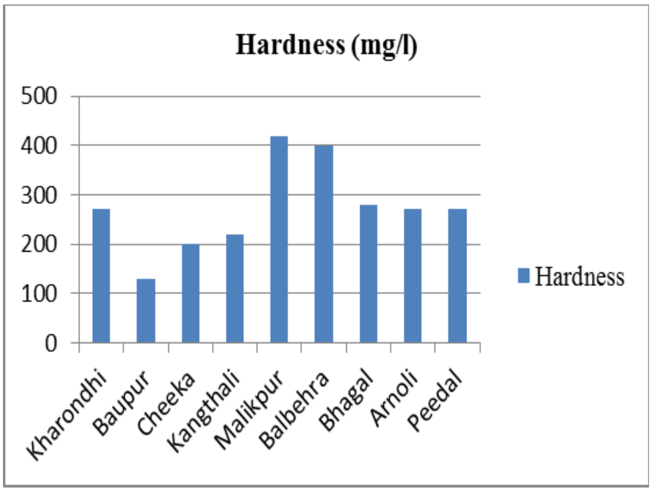


Figure 4: Hardness in groundwater samples.

5.4. Chloride

In the study area chloride ranges 20 mg/l to 110 mg/l (Table 1, Fig.5). As per BIS drinking water standards chloride is desirable if less than 250 mg/l, permissible between 250mg/l-1000 mg/l and non-potable if more than 1000 mg/l (Table 2). Chloride is desirable in all nine groundwater samples (Kharondhi, Baupur, Cheeka, Kangthali, Malikpur, Balbehra, Bhagal, Arnoli, Peedal).

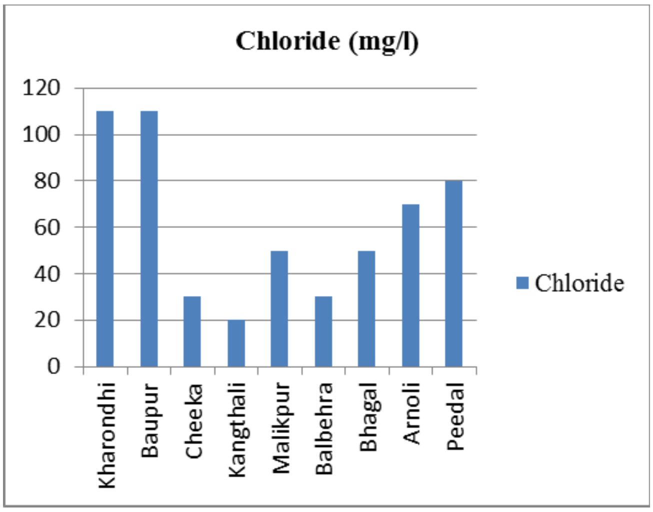


Figure 5: Chloride in groundwater samples.

5.5. Total Dissolved Solids (TDS)

In the study area TDS ranges 672 mg/l to 1200 mg/l (Table 1, Fig.6). As per BIS drinking water standards TDS is desirable if less than 500 mg/l, permissible between 500 mg/l-2000 mg/l and non-potable if more than 2000 mg/l (Table 2). TDS is permissible in all nine groundwater samples (Kharondhi, Baupur, Cheeka, Kangthali, Malikpur, Balbehra, Bhagal, Arnoli, Peedal).

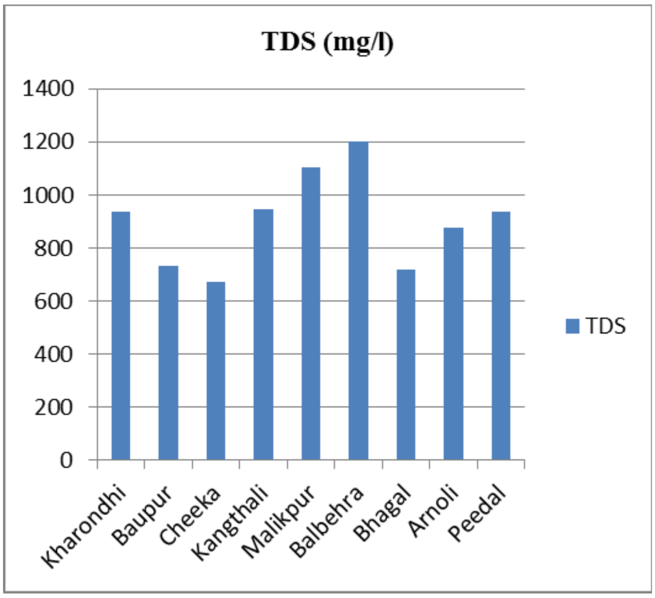


Figure 6: TDS in groundwater samples .

5.6. Fluoride

In the study area fluoride ranges nil to 2 mg/l (Table 1, Fig.7). As per BIS drinking water standards fluoride is desirable if less than 1.0 mg/l, permissible between 1.0 mg/l-1.5 mg/l and non-potable if more than 1.5 mg/l (Table 2). Fluoride is desirable in one groundwater sample (Malikpur), permissible in four groundwater samples (Balbehra, Bhagal, Arnoli, Peedal) and non-potable in four groundwater samples (Kharondhi (2 mg/l), Baupur (2 mg/l), Cheeka (2 mg/l), Kangthali (2 mg/l)).

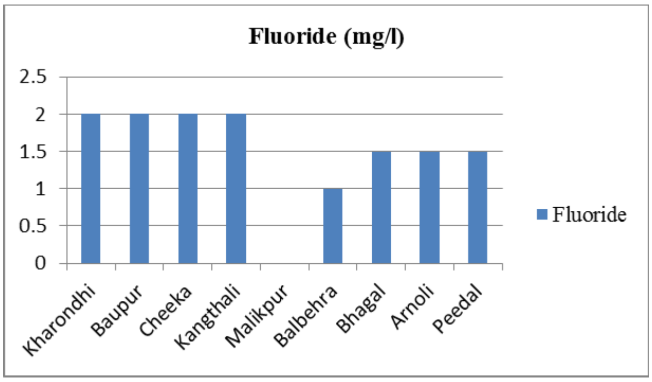


Figure 7: Fluoride in groundwater samples.

In the study area iron ranges nil to 2 mg/l (Table 1, Fig.8). As per BIS drinking water standards iron is desirable if less than 0.3 mg/l and non-potable if more than 0.3 mg/l (Table 2). Iron is desirable in eight groundwater samples (Baupur, Cheeka, Kangthali, Malikpur, Balbehra, Bhagal, Arnoli,Peedal) and non-potable in one groundwater sample (Kharondhi (2 mg/l)).

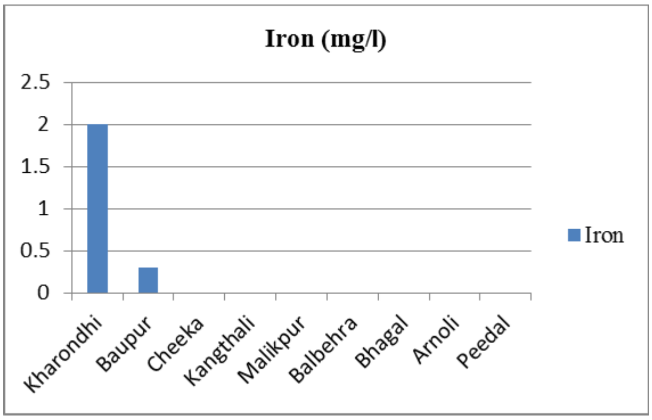


Figure 8: Iron in groundwater samples.

5.7. Ammonia

In the study area ammonia ranges nil to 1 mg/l (Table 1, Fig.9). As per BIS drinking water standards ammonia is desirable if less than 0.5 mg/l and non-potable if more than 0.5 mg/l (Table 2).Ammonia is desirable in six groundwater samples (Kharondhi, Cheeka, Malikpur, Balbehra, Bhagal, Peedal) and non-potable in three groundwater samples (Baupur (1 mg/l), Kangthali (1mg/l), Arnoli (1 mg/l)).

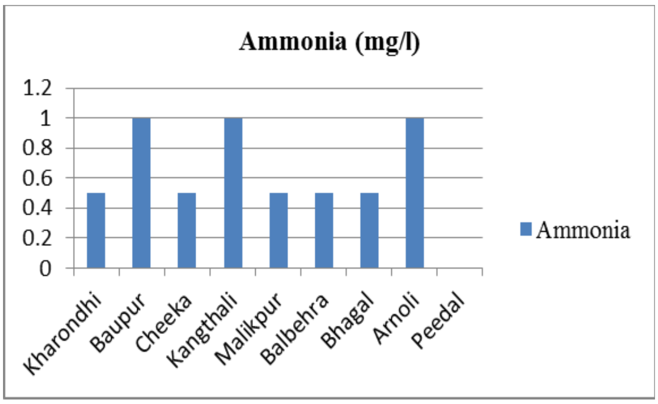


Figure 9: Ammonia in groundwater samples.

5.8. Nitrite

In the study area nitrite ranges 0.2 mg/l to 0.5 mg/l (Table 1, Fig.10). As per BIS drinking water standards nitrite is desirable if less than 1.0 mg/l and non-potable if more than 1.0 mg/l (Table 2). Nitrite is desirable in all nine groundwater samples (Kharondhi, Baupur, Cheeka, Kangthali, Malikpur, Balbehra, Bhagal, Arnoli, Peedal).

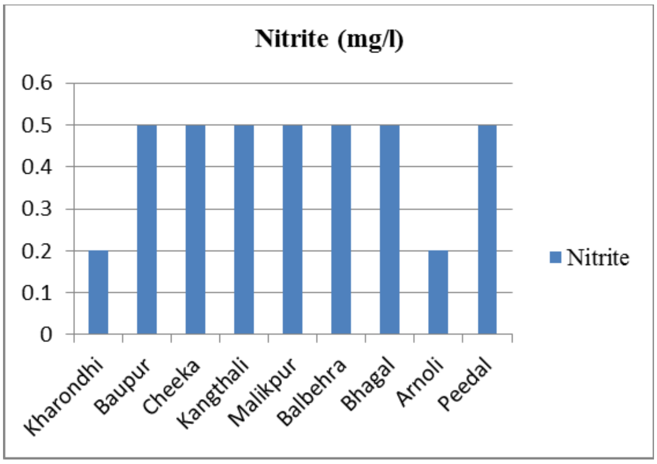


Figure 10: Nitrite in groundwater samples.

5.9. Nitrate

In the study area nitrate ranges 45 mg/l to 150 mg/l (Table 1, Fig.11). As per BIS drinking water standards nitrate is desirable if less than 45 mg/l and non-potable if more than 45 mg/l (Table 2). Nitrate is desirable in one groundwater sample (Arnoli) and non-potable in eight groundwater samples (Kharondhi (100 mg/l), Baupur (100 mg/l), Cheeka (100 mg/l), Kangthali (100 mg/l), Malikpur (100 mg/l), Balbehra (150 mg/l), Bhagal (100 mg/l), Peedal (100 mg/l)).

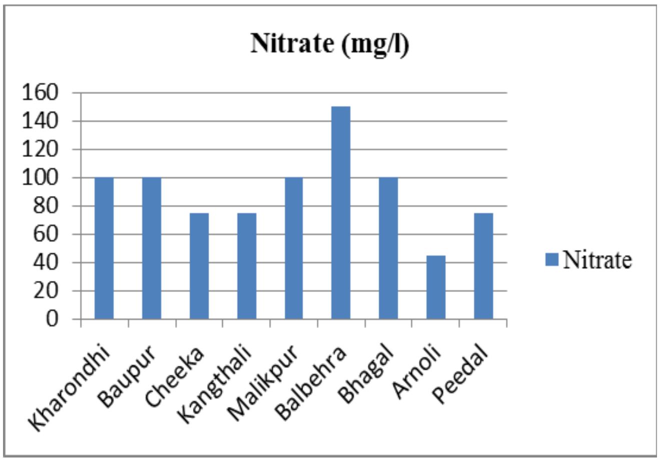


Figure 11: Nitrate in groundwater samples.

5.10. Phosphate

In the study area phosphate is nil in all the nine groundwater samples (Table 1, Fig.12). As per BIS drinking water standards phosphate is desirable if less than 1.0 mg/l and non-potable if more than 1.0 mg/l (Table 2). Phosphate is desirable in all nine groundwater samples (Kharondhi, Baupur, Cheeka, Kangthali, Malikpur, Balbehra, Bhagal, Peedal).

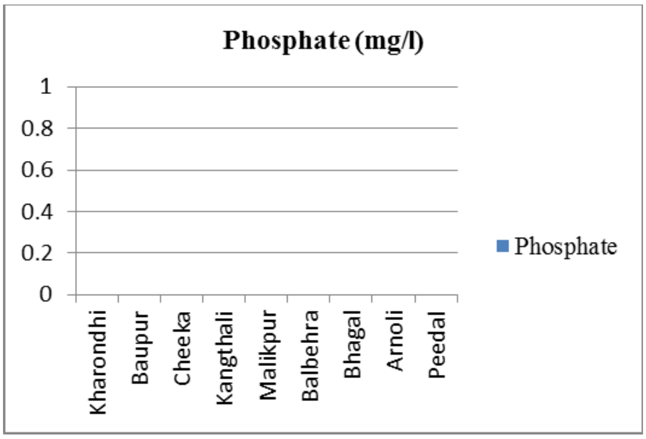


Figure 12: Phosphate in groundwater samples.

5.11. Residual Chlorine

In the study area residual chlorine ranges nil to 0.2 mg/l (Table 1, Fig.13). As per BIS drinking water standards residual chlorine is desirable if less than 0.2 mg/l, permissible between 0.2 mg/l-1.0 mg/l and non-potable if more than 1.0 mg/l (Table 2). Residual Chlorine is desirable in seven groundwater samples (Cheeka, Kangthali, Malikpur, Balbehra, Bhagal, Arnoli, Peedal) and permissible in two groundwater samples (Kharondhi, Baupur).

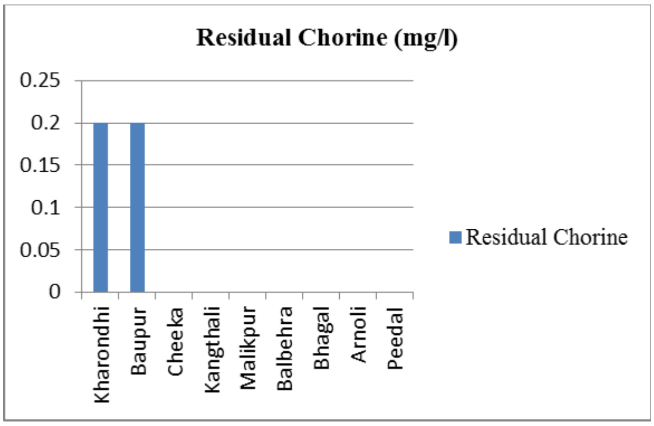


Figure 13: Residual Chlorine in groundwater samples

6. CONCLUSIONS

In the study area pH is desirable in eight groundwater samples and non-potable in one groundwater sample. Alkalinity and TDS are permissible in all nine groundwater samples. Hardness is desirable in one groundwater sample and permissible in eight groundwater samples. Chloride is desirable in all nine groundwater samples. Fluoride is desirable in one groundwater sample, permissible in four groundwater samples and non-potable in four groundwater samples. Iron is desirable in eight groundwater samples and non-potable in one groundwater sample. Ammonia is desirable in six groundwater samples and non-potable in three groundwater samples. Nitrite is desirable in all nine groundwater samples. Nitrate is desirable in one groundwater sample and non-potable in eight groundwater samples. Phosphate is desirable in all nine groundwater samples. Residual Chlorine is desirable in seven groundwater samples and permissible in two groundwater samples. The study is highly useful for planning and monitoring of groundwater quality for drinking purpose in the study area.

REFERENCES

1. **Bunkar, Neelam and Kumar, Vinod** (2019): Water quality index for assessment of groundwater quality parameters in Udham Singh Nagar District of Uttrakhand, International Journal of Current Microbiology and Applied Sciences, **8**:68-72.
2. **Kaur, Tajinder, Bhardwaj, Renu, Arora, Saroj** (2017): Assessment of groundwater quality for drinking and irrigation purposes using hydrochemical studies in Malwa region, southwestern part of Punjab, India, Applied Water Science, **7**:3301-3316.
3. **Khan, Rubia and Jhariya, D. C.** (2017): Groundwater quality assessment for drinking purpose in Raipur City, Chhattisgarh using water quality index and geographic information system, Journal Geological Society of India, **90**:69-76.
4. **Madhav, Sughosh, Ahamad, Arif, Kumar, Ashutosh, Kushawaha, Jyoti, Singh, Pardeep and Mishra, P. K.** (2018): Geochemical assessment of groundwater quality for its suitability for drinking and irrigation purpose in rural areas of Sant Ravidas Nagar (Bhadohi), Uttar Pradesh, Geology, Ecology, and Landscapes, **2** **(**2):127-136.
5. **Nelly, Kiplangat, C. and Mutua, Felix** (2016): Groundwater quality assessment using GIS and remote sensing- a case study of Juja location, Kenya, American Journal of Geographic Information System, **5** (1):12-23.
6. **Singh, S. K. and Kumar, L.** (2014): Characterization of rural drinking water sources in Bhiwani district, Haryana (2014), International Journal of Interdisciplinary Research and Innovations, **2** (4): 27-37.
7. **Spanos, Thomas, Ene, Antoaneta, Xatzixristou, Christina, Papaioannou, Agelos** (2014): Assessment of groundwater quality and hydrogeological profile of Kavala area, Northern Greece, Environmental Physics, **60** (7-8):1139-1150.
8. **Vijaya Lalitha, B., Surya Teja, V., Rajesh, V.** (2016): A study on assessment of groundwater quality and its suitability for drinking in Shivajipalem area, Visakhapatnam, A.P., International Journal of Engineering Development and Research, **4** (2):1618-1621.

B.
Health Sciences Section

International Journal of Environment and Health Sciences (IJEHS)
2024, VOL. 6, NO. 3, 31-40
https://doi.org/10.47062/

ECO-FRIENDLY APPROACHES IN PHARMACEUTICAL WASTE MANAGEMENT: PAVING THE WAY FOR SUSTAINABILITY

Aakash Kumar Jaiswal*[1], Abhishek Gautam[2] and Pradeep Kumar[2]

[1]Assistant Professor, School of Pharmaceutical Sciences, IIMT University, Meerut, 250001
[2] Dayashwati Laboratory and Training Centre (DLTC), Dhaulana, District Hapur-245301, Uttar Pradesh, India

Received on: 05.07.2024 **Revised on:** 20.07.2024 **Accepted on:** 30.07.2024

Abstract
Pharmaceutical waste management stands as a critical issue in contemporary society due to its environmental impact and public health risks. Addressing this challenge requires a shift toward eco-friendly approaches that prioritize sustainability. It delves into the imperative need for sustainable solutions in pharmaceutical waste management and highlights key strategies to pave the way for a greener and healthier future. Pharmaceutical waste poses a multifaceted challenge due to its complex composition and potential for environmental contamination. Traditional disposal methods, often involving landfill or incineration, contribute significantly to environmental degradation and chemical exposure. Consequently, there is a growing urgency to adopt eco-friendly practices that mitigate these adverse effects. It explores innovative approaches to pharmaceutical waste management that embrace sustainability. It will delve into the concept of green chemistry, emphasizing the development of eco-friendly drugs with reduced environmental impact throughout their lifecycle—from production to disposal. Additionally, the discussion will encompass strategies for optimizing drug formulation to minimize waste generation without compromising efficacy. Furthermore, this will highlight the importance of proper disposal and recycling methods. It will shed light on emerging technologies and processes for the safe disposal of unused or expired medications, ensuring minimal ecological footprint and reducing the risk of water contamination. Collaboration among pharmaceutical companies, healthcare facilities, regulatory bodies, and the public is crucial in implementing effective waste management strategies. It will explore successful case studies and initiatives that exemplify the positive outcomes achievable through collaborative efforts. In conclusion, this aims to emphasize the urgency of transitioning toward eco-friendly approaches in pharmaceutical waste management for a sustainable future. By advocating for the adoption of green practices, leveraging innovative technologies, and fostering collaborative partnerships, we can pave the way for a more environmentally conscious and responsible pharmaceutical industry.

Keywords
Pharmaceutical waste, Eco-friendly approaches, Sustainability, Waste reduction, Stakeholder collaboration.

1. INTRODUCTION

In the relentless pursuit of medical advancements, the pharmaceutical industry has historically forged groundbreaking innovations in healthcare. However, the laudable progress in pharmaceutical development has been accompanied by an escalating concern – the environmental impact of pharmaceutical waste. The conventional modes of pharmaceutical waste disposal, including incineration and landfilling, have come under scrutiny for their sustainability and potential adverse effects on the environment. In response to these challenges, there is a growing imperative to explore and implement eco-friendly approaches in pharmaceutical waste management, setting the stage for a more sustainable future –(Birania et al., 2022; James and Yadav, 2021; Monga et al., 2022; September et al., 2023).

CONTACT *Corresponding author: *akj03241994@gmail.com*

The pharmaceutical industry, by virtue of its commitment to developing life-saving drugs, is deeply entwined with a complex web of environmental consequences. The life cycle of pharmaceutical products encompasses various stages, from raw material extraction and synthesis to manufacturing, distribution, usage, and eventual disposal. At each juncture, the industry leaves an indelible environmental footprint, prompting a critical examination of the ecological sustainability of its practices. A significant contributor to this environmental burden is pharmaceutical waste, manifesting in diverse forms such as unused medications and manufacturing by-products. The traditional methods of pharmaceutical waste disposal, while effective in some respects, have inherent drawbacks that necessitate a reevaluation of their long-term viability. Incineration, a common practice, raises concerns about the release of harmful pollutants into the atmosphere, contributing to air quality deterioration. Landfilling, another prevalent method, poses risks of leaching pharmaceutical compounds into soil and water, potentially compromising ecosystems'– (Budny and Benscoter, 2016; Crane et al., 2021; Perry et al., 2013; Vallejos et al., 2020).

Moreover, the nature of pharmaceuticals, engineered for stability and bioactivity, complicates their breakdown and degradation. The persistence of these compounds in the environment has been linked to adverse effects on aquatic organisms and the emergence of antibiotic-resistant bacteria, underscoring the urgency of reassessing conventional waste management practices. Recognizing these challenges, there is a growing awareness within the pharmaceutical industry about the necessity for more sustainable waste management practices. This awareness is driving the sector towards embracing eco-friendly approaches that not only address the environmental impact of pharmaceutical waste but also align with broader sustainability objectives. A pivotal shift is occurring with the integration of green chemistry principles into the fabric of drug development and manufacturing (Han, 2023; Krogstad and Woodrow, 2014; Mariappan, 2019).

Green chemistry advocates for the design of chemical products and processes that minimize the use of hazardous materials and reduce environmental impact. Within the pharmaceutical context, this entails the creation of drugs with inherently lower toxicity and the adoption of manufacturing processes that are more environmentally benign. The first step towards implementing eco-friendly pharmaceutical waste management practices involves a reimagining of the design and synthesis of pharmaceutical products. By incorporating green chemistry principles, researchers are focusing on developing drugs that are not only efficacious but also environmentally sustainable from their inception. This involves a comprehensive evaluation of the entire life cycle of a pharmaceutical product, from raw material selection to synthesis processes and eventual disposal(“Abstracts of the 17th International Symposium on Bioluminescence and Chemiluminescence (ISBC 2012),” 2012).

Furthermore, the exploration of alternative solvents and sustainable manufacturing processes is gaining momentum. Traditional methods often employ solvents harmful to the environment and human health. Eco-friendly alternatives, such as water-based or supercritical fluid-based processes, are being explored to replace conventional organic solvents. These alternatives not only reduce the environmental impact but also enhance the safety of manufacturing processes for workers. In essence, the environmental impact of pharmaceutical waste is a critical concern demanding a fundamental shift in the industry's approach to waste management –(Awasthi et al., 2021; Onoda, 2020; Paritosh et al., 2017; Singh and Raj, 2020).

The adoption of eco-friendly practices, rooted in green chemistry principles, emerges as a promising avenue for mitigating the environmental footprint of pharmaceuticals. By designing drugs with reduced toxicity, optimizing manufacturing processes, and incorporating sustainable practices, the pharmaceutical industry can pioneer a more sustainable and environmentally conscious future. This exploration of eco-friendly approaches in pharmaceutical waste management signifies not only a response to current challenges but a commitment to the long-term well-being of both humanity and the planet(Ali Karasar and Oğuz, 2023; Barnhill and Fanzo, 2021; Lal, 2020; Monteiro et al., 2015).

2. REVIEW FINDINGS

2.1 Environmental Impact of Pharmaceutical Waste

Pharmaceutical waste encompasses a diverse range of materials generated throughout the drug development, manufacturing, distribution, and usage processes. This includes expired medications, unused drugs, manufacturing by-products, and packaging materials. Each of these elements contributes to the overall environmental burden, posing unique challenges in their disposals (Goldman, 2002; Rigueto et al., 2023).

2.2 Environmental Consequences

One of the primary environmental concerns associated with pharmaceutical waste is water pollution. Active pharmaceutical ingredients (APIs) and their metabolites, when improperly disposed of, can leach into water bodies, contaminating surface and groundwater. This contamination poses a threat to aquatic ecosystems, potentially disrupting the balance of aquatic flora and fauna. Pharmaceutical waste, if disposed of in landfills or through agricultural runoff, can result in soil contamination. The persistence of certain pharmaceutical compounds in soil can adversely affect plant growth and soil microbial communities(Estrela et al., 2022; García-Jiménez et al., 2021; Konopka, 2009; Segata et al., 2013).

This, in turn, may impact the overall health of terrestrial ecosystems and compromise the safety of agricultural products. Incineration, a common method of pharmaceutical waste disposal, contributes to air pollution. The combustion of pharmaceuticals releases pollutants into the atmosphere, including greenhouse gases and harmful chemicals. This can degrade air quality, posing risks to human health and contributing to the broader issue of climate change(Batt et al., 2008; Han and Lee, 2017; Schwab et al., 2005; Wilkinson et al., 2019). Common Pharmaceuticals and Environmental Impact is summarized in Table 1 while Challenges in Conventional Pharmaceutical Waste Management is summarized in Table 2.

Table 1: Common Pharmaceuticals and Environmental Impact.

Pharmaceutical	Environmental Impact
Antibiotics	Potential development of antibiotic resistance
Hormones	Disruption of endocrine systems in wildlife
Analgesics	Presence in water bodies affecting aquatic life
Chemotherapeutics	Toxicity to aquatic organisms and ecosystems

Table 2 : Challenges in Conventional Pharmaceutical Waste Management.

Waste Management Method	Environmental Challenges
Incineration	Air pollution, release of hazardous substances
Landfilling	Soil and water contamination, long-term persistence
Flushing unused drugs	Water pollution, direct exposure to ecosystems

To address the environmental impact of pharmaceutical waste, a holistic approach is necessary. This involves the adoption of eco-friendly practices throughout the pharmaceutical life cycle, from drug design to manufacturing and waste disposal. Integrating green chemistry principles, optimizing synthetic routes, and designing pharmaceuticals with reduced environmental footprints are critical steps. Understanding the environmental impact of pharmaceutical waste is paramount in developing sustainable solutions. The tables presented highlight the diverse range of pharmaceuticals contributing to environmental challenges and underscore the importance of reevaluating waste management practices. By implementing eco-friendly approaches, the pharmaceutical industry can minimize its environmental footprint and contribute to a healthier and more sustainable planet .

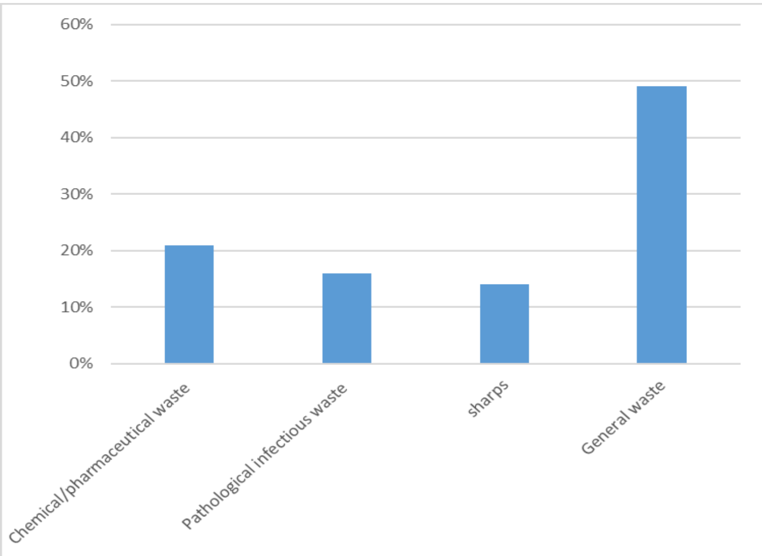


Figure 1: Percentage of pharmaceutical waste throughout the globe.

2.3 Challenges in Conventional Pharmaceutical Waste Management:

The conventional methods of pharmaceutical waste management have long been the go-to approaches for disposing of unused medications, expired pharmaceuticals, and manufacturing by-products. However, these traditional methods come with a set of challenges that warrant a critical examination. This article explores the challenges associated with conventional pharmaceutical waste management practices, shedding light on the environmental drawbacks and potential hazards posed by these methods (Costa et al., 2019; Kushwaha et al., 2021; Mustafa and Cheng, 2016).

2.3.1 Incineration

Incineration, a widely used method for disposing of pharmaceutical waste, poses significant challenges. The process involves the combustion of pharmaceuticals, releasing harmful pollutants into the air. These pollutants, including dioxins and furans, contribute to air pollution and pose health risks to both human and environmental well-being.

2.3.2 Landfilling

Landfilling is another common method for pharmaceutical waste disposal. However, this approach raises concerns about soil and water contamination. Pharmaceuticals deposited in landfills can leach into the soil, potentially reaching groundwater and contaminating water sources. The persistence of certain pharmaceutical compounds exacerbates these environmental challenges, as they may linger in the environment for extended periods.

2.3.3 Flushing Unused Drugs

The practice of flushing unused drugs down the toilet or sink is a convenient but problematic method. This contributes to water pollution, as pharmaceutical compounds enter water bodies and impact aquatic ecosystems. The direct exposure of ecosystems to these compounds can disrupt aquatic life and pose risks to the overall health of water ecosystems.

Table 3: Challenges in Conventional Pharmaceutical Waste Management.

Waste Management Method	Environmental Challenges
Incineration	Air pollution, release of hazardous substances
Landfilling	Soil and water contamination, long-term persistence
Flushing unused drugs	Water pollution, direct exposure to ecosystems

Addressing these challenges requires a shift towards more sustainable and eco-friendly approaches in pharmaceutical waste management. Integrating green chemistry principles into drug development and manufacturing, optimizing synthetic routes, and designing pharmaceuticals with reduced environmental footprints are pivotal steps. Additionally, exploring alternative disposal methods that minimize environmental impact, such as drug take-back programs and advanced waste treatment technologies, can contribute to more responsible pharmaceutical waste management'—'–'(Borchard et al., 2022; Cheng et al., 2022; Gull et al., 2023; Sarkodie and Owusu, 2021).

Conventional pharmaceutical waste management methods, while prevalent, are not without their environmental challenges. The table encapsulates the key challenges associated with incineration, landfilling, and flushing unused drugs. To pave the way for a more sustainable and environmentally conscious future, there is a pressing need to reevaluate these traditional practices and embrace eco-friendly approaches that minimize the ecological footprint of pharmaceutical waste—(Bungau et al., 2018; Hanning et al., 2022; Magagula et al., 2022; Rogowska and Zimmermann, 2022).

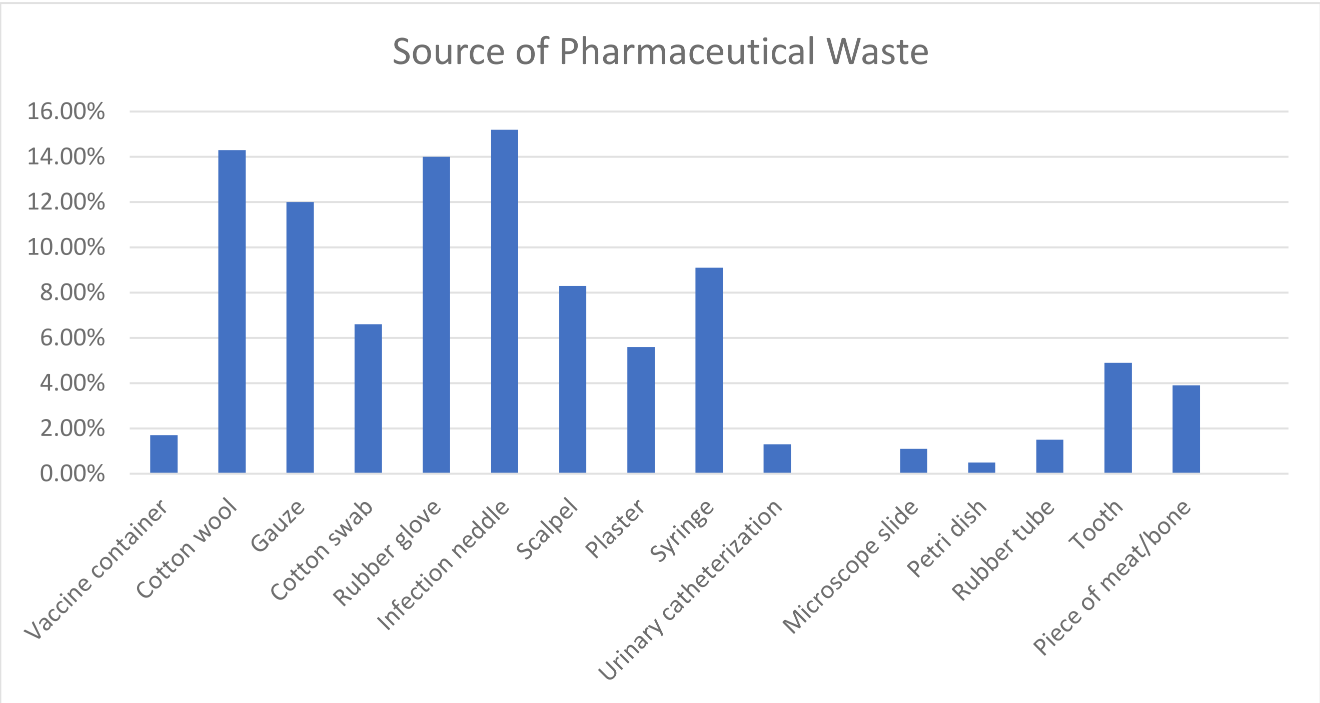


Figure 2: Different sources of pharmaceutical waste throughout the globe.

3. CHALLENGES IN CONVENTIONAL PHARMACEUTICAL WASTE MANAGEMENT

The management of pharmaceutical waste presents a complex set of challenges that demand a critical examination of conventional disposal methods. This article explores the inherent drawbacks associated with incineration, landfilling, and flushing unused drugs, shedding light on the environmental challenges and potential hazards posed by these practices. Incineration, a widely employed method for pharmaceutical waste disposal, is not without its environmental challenges. The combustion of pharmaceuticals releases a cocktail of pollutants into the air, including dioxins, furans, and other hazardous substances. These airborne pollutants contribute to air pollution, compromising air quality and posing health risks to both human and environmental well-being. The following table succinctly summarizes the environmental challenges associated with incineration, Landfilling, another common practice in pharmaceutical waste disposal, introduces a different set of challenges""–' (Berenguer et al., 2023; de Campos et al., 2023; Jovanović et al., 2016; Natasha et al., 2010).

Pharmaceuticals deposited in landfills may undergo leaching, releasing their active compounds into the soil. This can lead to soil contamination and potentially contaminate groundwater, posing risks to terrestrial and aquatic ecosystems. The persistence of certain pharmaceutical compounds exacerbates these challenges, as illustrated in the table below(Costa et al., 2019):

3.1 Flushing Unused Drugs

The disposal of unused drugs by flushing them down the toilet or sink represents a convenient yet environmentally problematic method. This practice contributes to water pollution as pharmaceutical compounds enter water bodies. The direct exposure of ecosystems to these compounds can disrupt aquatic life and compromise the health of water ecosystems. The environmental challenges associated with flushing unused drugs are summarized in the table –"'(Hithesh et al., 2020; Jha et al., 2022; Kampamba et al., 2022; Martin et al., 2020):

3.2 Mitigation Strategies

Addressing these challenges necessitates a paradigm shift towards more sustainable pharmaceutical waste management practices. Integrating green chemistry principles into drug development and manufacturing processes, optimizing synthetic routes, and designing pharmaceuticals with reduced environmental footprints are crucial steps. Exploring alternative disposal methods, such as drug take-back programs and advanced waste treatment technologies, can contribute to more responsible pharmaceutical waste management. Conventional pharmaceutical waste management practices, while widely practiced, come with a suite of environmental challenges. This overview, complemented by detailed tables, highlights the key drawbacks associated with incineration, landfilling, and flushing unused drugs. As the pharmaceutical industry seeks more sustainable solutions, a collective effort is required to transition towards eco-friendly approaches that minimize the ecological impact of pharmaceutical waste (Lücker et al., 2019; Murshed et al., 2022; Nyagah et al., 2022).

3.3 Green Chemistry Principles in Pharmaceutical Waste Management

Green chemistry principles play a pivotal role in revolutionizing pharmaceutical waste management, offering sustainable alternatives to conventional practices. This approach emphasizes the design and implementation of chemical processes that prioritize environmental and human health considerations throughout the entire life cycle of pharmaceuticals. In the context of waste management, the integration of green chemistry principles seeks to minimize the generation of hazardous substances, reduce the environmental impact of pharmaceutical production, and facilitate the development of eco-friendly disposal methods(Bhardwaj et al., 2017; Datta et al., 2018; Hajam et al., 2023; R et al., 2023).

By incorporating green chemistry into drug development and manufacturing, the industry aims to design pharmaceuticals with inherently lower toxicity and environmental persistence. This involves the optimization of synthetic routes, the substitution of hazardous materials with safer alternatives, and the adoption of more sustainable solvents. The ultimate goal is to create pharmaceuticals that not only fulfill therapeutic needs but also align with broader sustainability objectives. Green chemistry principles in pharmaceutical waste management are a progressive step towards mitigating environmental impact, fostering a more sustainable pharmaceutical industry, and contributing to the global effort to achieve a healthier and eco-conscious future ––"(Kilcoyne et al., 2022; Landrigan et al., 2020).

3.4 Designing Pharmaceuticals with a Reduced Environmental Footprint:

Designing pharmaceuticals with a reduced environmental footprint is a critical aspect of green chemistry principles, aiming to minimize the ecological impact of drug development and usage. This approach encompasses a holistic perspective, considering the entire life cycle of pharmaceuticals from raw material extraction to disposal. By adopting innovative strategies and incorporating environmentally conscious practices, the pharmaceutical industry can contribute significantly to sustainability goals. One key aspect of reducing the environmental footprint lies in the selection of raw materials. Green chemistry emphasizes the use of renewable resources and sustainable starting materials to mitigate the impact on ecosystems. This involves scrutinizing the environmental implications of obtaining raw materials, considering factors such as energy consumption, waste generation, and ecological disruption (Daughton and Ruhoy, 2008).

Optimizing synthetic routes is another crucial component. Traditional manufacturing processes often involve multiple steps, each contributing to waste generation and environmental impact. Green chemistry encourages the design of streamlined synthetic routes, minimizing the number of steps, reducing energy consumption, and limiting the use of hazardous reagents. This not only enhances efficiency but also decreases the overall environmental burden associated with pharmaceutical production. Additionally, the choice of solvents plays a pivotal role in designing environmentally friendly pharmaceuticals. Conventional organic solvents can be harmful to both human health and the environment. Green chemistry promotes the substitution of these solvents with greener alternatives, such as water or supercritical fluids, which are less toxic and pose fewer environmental risks (Bennett et al., 2019; Budzinski et al., 2022; Roschangar et al., 2017).

The concept of "benign by design" is gaining prominence in pharmaceutical development. This approach involves intentionally designing pharmaceutical molecules to have minimal environmental impact while maintaining therapeutic efficacy. Researchers strategically modify molecular structures to enhance biodegradability, reduce persistence in the environment, and decrease potential ecological harm. Furthermore, the consideration of the end-of-life phase is integral to reducing the environmental footprint of pharmaceuticals. Green chemistry principles advocate for designing drugs that break down more readily, facilitating eco-friendly disposal. This aligns with the broader goal of establishing sustainable waste management practices within the pharmaceutical industry(Khetan, 2014) .
In conclusion, designing pharmaceuticals with a reduced environmental footprint is a multifaceted approach encompassing sustainable raw material selection, streamlined synthetic routes, greener solvent choices, and intentional molecular design. By adhering to these green chemistry principles, the pharmaceutical industry can pave the way for a more sustainable future, where therapeutic advancements align harmoniously with ecological responsibility. This paradigm shift not only addresses current environmental challenges but also contributes significantly to the global commitment to building a more sustainable and environmentally conscious society.(Amarakoon et al., 2022; RAMSEY et al., 2009).

Alternative solvents and sustainable manufacturing practices are integral components of the pharmaceutical industry's commitment to reducing its environmental impact. Traditionally, pharmaceutical manufacturing has relied heavily on organic solvents that pose environmental and health risks. The adoption of alternative solvents aligns with green chemistry principles, emphasizing the substitution of hazardous materials with safer and more sustainable options. Water is one of the primary alternative solvents gaining prominence in pharmaceutical manufacturing. Its abundance, low cost, and minimal environmental impact make it an attractive choice. Water-based processes not only reduce the use of organic solvents but also mitigate potential hazards associated with their disposal. Furthermore, water is often a more benign reaction medium, contributing to the overall sustainability of pharmaceutical production. Supercritical fluids, such as carbon dioxide, represent another class of alternative solvents. These fluids possess unique properties that can be tailored to specific manufacturing processes. Supercritical fluid extraction and reaction conditions offer advantages such as high selectivity, reduced waste generation, and the ability to work with temperature-sensitive compounds. The recyclability of supercritical fluids contributes to the sustainable aspect of pharmaceutical manufacturing(Arden et al., 2021; Laky et al., 2023; Li and Li, 2021; Sarkis et al., 2021).

Sustainable manufacturing in the pharmaceutical industry extends beyond solvent selection. Integrating renewable energy sources into manufacturing processes is a key element of reducing the carbon footprint. The industry is progressively adopting solar, wind, and other sustainable energy technologies to power manufacturing facilities. This not only minimizes reliance on fossil fuels but also contributes to the industry's broader commitment to environmentally friendly practices""" (Duvaleix et al., 2020; Kasim and Ismail, 2012; Mbasera et al., 2016; Namagembe, 2021). Process intensification is another facet of sustainable manufacturing. This involves optimizing and streamlining production processes to enhance efficiency and reduce resource consumption. Continuous manufacturing methods, as opposed to batch processes, are gaining traction for their potential to minimize waste, energy usage, and overall environmental impact –'—(CHRISPIM, 2021; Mączyńska, 2017).

4. CONCLUSION

The manuscript concludes by summarizing the key findings and emphasizing the pivotal role of eco-friendly approaches in pharmaceutical waste management. It underscores the importance of adopting sustainable practices, driven by green chemistry principles, and calls for a collective effort from the pharmaceutical industry, regulatory bodies, and researchers to pave the way for a more sustainable and environmentally conscious future. In conclusion, this detailed review manuscript provides a comprehensive exploration of eco-friendly approaches in pharmaceutical waste management, offering insights into the challenges, innovations, and transformative strategies that can contribute to a more sustainable pharmaceutical industry.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENT

The authors would like to thank Dayashwati laboratories and training centre, Dhaulana, District Hapur-245301, Uttar Pradesh for providing a supportive hand to complete the study.

REFERENCES

1. Abstracts of the 17th International Symposium on Bioluminescence and Chemiluminescence (ISBC 2012), 2012. Luminescence. https://doi.org/10.1002/bio.2341

2. **Ali Karasar, H., Ouz.**, 2023. Imagining a Common Horizon for Humanity and the Planet, Imagining a Common Horizon for Humanity and the Planet. https://doi.org/10.35250/kun/9786054448579

3. **Amarakoon, M., Alenezi, H., Homer-Vanniasinkam, S., Edirisinghe, M.,** 2022. Environmental Impact of Polymer Fiber Manufacture. *Macromol. Mater. Eng.* https://doi.org/10.1002/mame.202200356

4. **Arden, N.S., Fisher, A.C., Tyner, K., Yu, L.X., Lee, S.L., Kopcha, M.,** 2021. Industry 4.0 for pharmaceutical manufacturing: Preparing for the smart factories of the future. *Int. J. Pharm.* https://doi.org/10.1016/j.ijpharm.2021.120554

5. **Awasthi, A.K., Cheela, V.R.S., D'Adamo, I., Iacovidou, E., Islam, M.R., Johnson, M., Miller, T.R., Parajuly, K., Parchomenko, A., Radhakrishan, L., Zhao, M., Zhang, C., Li, J.,** 2021. Zero waste approach towards a sustainable waste management. *Resour. Environ. Sustain.* https://doi.org/10.1016/j.resenv.2021.100014

6. **Badhoutiya, A.,** 2022. Green Cloud Computing- Next Step Towards Eco-friendly Work Stations, in: 6th International Conference on Electronics, Communication and Aerospace Technology, ICECA 2022 - Proceedings. https://doi.org/10.1109/ICECA55336.2022.10009629

7. **Barnhill, A., Fanzo, J.,** 2021. Nourishing Humanity without Destroying the Planet. Ethics Int. Aff. https://doi.org/10.1017/S0892679421000046

8. **Batt, A.L., Kostich, M.S., Lazorchak, J.M.,** 2008. Analysis of ecologically relevant pharmaceuticals in wastewater and surface water using selective solid-phase extraction and UPLC-MS/MS. *Anal. Chem.* https://doi.org/10.1021/ac800066n

9. **Bennett, J.A., Campbell, Z.S., Abolhasani, M.,** 2019. Role of continuous flow processes in green manufacturing of pharmaceuticals and specialty chemicals. *Curr. Opin. Chem. Eng.* https://doi.org/10.1016/j.coche.2019.07.007

10. **Berenguer, C. V., Andrade, C., Pereira, J.A.M., Perestrelo, R., Câmara, J.S.,** 2023. Current Challenges in the Sustainable Valorisation of Agri-Food Wastes: A Review. Processes. https://doi.org/10.3390/pr11010020

11. **Bhardwaj, A., Keshav, B.K., Singh, A.,** 2017. Review Paper on Application of Waste Plastic in Modifying Bitumen Properties. *Int. J. Eng. Res. Appl.* https://doi.org/10.9790/9622-0704047981

12. **Birania, S., Kumar, S., Kumar, N., Attkan, A.K., Panghal, A., Rohilla, P., Kumar, R.,** 2022. Advances in development of biodegradable food packaging material from agricultural and agro-industry waste. *J. Food Process Eng.* https://doi.org/10.1111/jfpe.13930

13. **Borchard, R., Zeiss, R., Recker, J.,** 2022. Digitalization of waste management: Insights from German private and public waste management firms. *Waste Manag. Res.* https://doi.org/10.1177/0734242X211029173

14. **Budny, M.L., Benscoter, B.W.,** 2016. Shrub Encroachment Increases Transpiration Water Loss from a Subtropical Wetland. Wetlands. https://doi.org/10.1007/s13157-016-0772-5

15. **Budzinski, K., Constable, D., D'Aquila, D., Smith, P., Madabhushi, S.R., Whiting, A., Costelloe, T., Collins, M.,** 2022. Streamlined life cycle assessment of single use technologies in biopharmaceutical manufacture. *N. Biotechnol.* https://doi.org/10.1016/j.nbt.2022.01.002

16. **Bungau, S., Tit, D.M., Fodor, K., Cioca, G., Agop, M., Iovan, C., Cseppento, D.C.N., Bumbu, A., Bustea, C.,** 2018. Aspects regarding the pharmaceutical waste management in Romania. *Sustain.* https://doi.org/10.3390/su10082788

17. **Cheng, K.M., Tan, J.Y., Wong, S.Y., Koo, A.C., Sharji, E.A., 2022.** A Review of Future Household Waste Management for Sustainable Environment in Malaysian Cities. *Sustain*. https://doi.org/10.3390/su14116517

18. **Chrispim, M.C.,** 2021. Resource recovery from wastewater treatment: challenges, opportunities and guidance for planning and implementation. *Front. Neurosci*.

19. **Costa, F., Lago, A., Rocha, V., Barros, Ó., Costa, L., Vipotnik, Z., Silva, B., Tavares, T.,** 2019. A review on biological processes for pharmaceuticals wastes abatement - A growing threat to modern society. *Environ. Sci. Technol*. https://doi.org/10.1021/acs.est.8b06977

20. **Crane, K., Cuthbert, R.N., Ricciardi, A., Kregting, L., Coughlan, N.E., MacIsaac, H.J., Reid, N., Dick, J.T.A.,** 2021. Gimme Shelter: differential utilisation and propagule creation of invasive macrophytes by native caddisfly larvae. *Biol. Invasions.* https://doi.org/10.1007/s10530-020-02358-7

21. **Datta, P., Mohi, G., Chander, J.,** 2018. Biomedical waste management in India: Critical appraisal. *J. Lab. Physicians*. https://doi.org/10.4103/jlp.jlp_89_17

22. **Daughton, C.G., Ruhoy, I.S.,** 2008. The afterlife of drugs and the role of pharmEcovigilance. *Drug Saf.* https://doi.org/10.2165/0002018-200831120-00004

23. **de Campos, E.A.R., de Paula, I.C., Caten, C.S. ten, Tsagarakis, K.P., Ribeiro, J.L.D.,** 2023. Logistics performance: critical factors in the implementation of end-of-life management practices in the pharmaceutical care process. *Environ. Sci. Pollut. Res.* https://doi.org/10.1007/s11356-022-24035-z

24. **Duvaleix, S., Lassalas, M., Latruffe, L., Konstantidelli, V., Tzouramani, I.,** 2020. Adopting environmentally friendly farming practices and the role of quality labels and producer organisations: A qualitative analysis based on two european case studies. *Sustain*. https://doi.org/10.3390/su122410457

25. **Estrela, S., Vila, J.C.C., Lu, N., Baji, D., Rebolleda-Gómez, M., Chang, C.Y., Goldford, J.E., Sanchez-Gorostiaga, A., Sánchez, Á.,** 2022. Functional

attractors in microbial community assembly. *Cell Syst.* https://doi.org/10.1016/j.cels.2021.09.011

26. **García-Jiménez, B., Torres-Bacete, J., Nogales, J.,** 2021. Metabolic modelling approaches for describing and engineering microbial communities. *Comput. Struct. Biotechnol. J.* https://doi.org/10.1016/j.csbj.2020.12.003
27. **Goldman, L.R.,** 2002. Preventing Pollution? U.S. Toxic Chemicals and Pesticides Policies and Sustainable Development. *Environ. Law Rev. News Anal.*
28. **Gull, A.A., Atif, M., Hussain, N.,** 2023. Board gender composition and waste management: Cross-country evidence: Board gender diversity and waste management. *Br. Account. Rev.* https://doi.org/10.1016/j.bar.2022.101097
29. **Hajam, Y.A., Kumar, R., Kumar, A.,** 2023. Environmental waste management strategies and vermi transformation for sustainable development. Environ. Challenges. https://doi.org/ 10.1016/j.envc.2023.100747
30. **Han, E.J., Lee, D.S.,** 2017. Significance of metabolites in the environmental risk assessment of pharmaceuticals consumed by human. *Sci. Total Environ.* https://doi.org/10.1016/j.scitotenv.2017.03.044
31. **Han, H.R.,** 2023. Hybrid Fiber Materials according to the Manufacturing Technology Methods and IOT Materials: A Systematic Review. Materials (Basel). https://doi.org/10.3390/ma16041351
32. **Hanning, S.M., Hua, C., Baroutian, S., Burrell, R., Taylor, M., Wright, L.J., Svirskis, D.,** 2022. Quantification and composition of pharmaceutical waste in New Zealand. *J. Mater. Cycles Waste Manag.* https://doi.org/10.1007/s10163-022-01410-z
33. **Hithesh, I., Nisha, B., Jain, T.,** 2020. Practice of storage, reuse and disposal of unused medications among semi-urban households of Northern Tamil Nadu – a community based cross-sectional study. *Int. J. Res. Pharm. Sci.* https://doi.org/ 10.26452/ijrps.v11iSPL2.2252
34. **James, A., Yadav, D.,** 2021. Valorization of coconut waste for facile treatment of contaminated water: A comprehensive review (2010–2021). *Environ. Technol. Innov.* https://doi.org/10.1016/j.eti.2021.102075
35. **Jha, N., Kafle, S., Bhandary, S., Shankar, P.R.,** 2022. Assessment of knowledge, attitude, and practice of disposing and storing unused and expired medicines among the communities of Kathmandu, Nepal. *PLoS One.* https://doi.org/10.1371/journal.pone.0272635
36. **Jovanovi, V., Manojlovi, J., Jovanovi, D., Matic, B., onovi, N.,** 2016. Management of pharmaceutical waste in hospitals in Serbia – Challenges and the potential for improvement. *Indian J. Pharm. Educ. Res.* https://doi.org/10.5530/ijper.50.4.22
37. **Kampamba, M., Maingaila, V., Akapelwa, T.M., Mudenda, S., Biete, L., Mufwambi, W., Banda, M., Phiri, M., Hikaambo, C.N.,** 2022. Assessment of Knowledge, Attitude and Practices towards the Disposal of Unused and Expired Medications among Students of Private Medical Universities in Lusaka, Zambia. *Pharmacol. & Pharm.* https://doi.org/10.4236/pp.2022.132004
38. **Kasim, A., Ismail, A.,** 2012. Environmentally friendly practices among restaurants: Drivers and barriers to change. *J. Sustain. Tour.* https://doi.org/10.1080/09669582.2011.621540
39. **Khetan, S.K.,** 2014. Endocrine Disruptors in the Environment, Endocrine Disruptors in the Environment. https://doi.org/10.1002/9781118891094
40. **Kilcoyne, J., Bogan, Y., Duffy, C., Hollowell, T.,** 2022. Reducing environmental impacts of marine biotoxin monitoring: A laboratory report. *PLOS Sustain.* Transform. https://doi.org/ 10.1371/ journal.pstr.0000001
41. **Konopka, A.,** 2009. What is microbial community ecology. *ISME J.* https://doi.org/10.1038/ismej.2009.88
42. **Krogstad, E.A., Woodrow, K.A.,** 2014. Manufacturing scale-up of electrospun poly (vinyl alcohol) fibers containing tenofovir for vaginal drug delivery. *Int. J. Pharm.* https://doi.org/10.1016/j.ijpharm.2014.08.039
43. **Kushwaha, A., Goswami, S., Hans, N., Singh, A., Vishwakarma, H.S., Devi, G., Mishra, P., Bhan, U., Hussain, C.M.,** 2021. Sorption of pharmaceutical and personal care products from the wastewater by carbonaceous materials, in: Emerging Trends to Approaching Zero Waste: *Environmental and Social Perspectives.* https://doi.org/10.1016/B978-0-323-85403-0.00012-8
44. **Laky, D.J., Casas-Orozco, D., Abdi, M., Feng, X., Wood, E., Reklaitis, G. V., Nagy, Z.K.,** 2023. Using PharmaPy with Jupyter Notebook to teach digital design in pharmaceutical manufacturing. *Comput. Appl. Eng. Educ.* https://doi.org/10.1002/cae.22660
45. **Lal, R.,** 2020. Managing soil quality for humanity and the planet. *Front. Agric. Sci. Eng.* https://doi.org/10.15302/J-FASE-2020329
46. **Landrigan, P.J., Stegeman, J.J., Fleming, L.E., Allemand, D., Anderson, D.M., Backer, L.C., Brucker-Davis, F., Chevalier, N., Corra, L., Czerucka, D., Bottein, M.Y.D., Demeneix, B., Depledge, M., Deheyn, D.D., Dorman, C.J., Fénichel, P., Fisher, S., Gaill, F., Galgani, F., Gaze, W.H., Giuliano, L., Grandjean, P., Hahn, M.E., Hamdoun, A., Hess, P., Judson, B., Laborde, A., McGlade, J., Mu, J., Mustapha, A., Neira, M., Noble, R.T., Pedrotti, M.L., Reddy, C., Rocklöv, J., Scharler, U.M., Shanmugam, H., Taghian, G., Van De Water, J.A.J.M., Vezzulli, L., Weihe, P., Zeka, A., Raps, H., Rampal, P., 2020.** Human health and ocean pollution. *Ann. Glob. Heal.* https://doi.org/10.5334/aogh.2831

47. **Li, Z., Li, X.,** 2021. Will Innovation of Pharmaceutical Manufacturing Improve Perceived Health? Front. Public Heal. https://doi.org/10.3389/fpubh.2021.647357

48. **Lücker, F., Seifert, R.W., Biçer, I.,** 2019. Roles of inventory and reserve capacity in mitigating supply chain disruption risk. *Int. J. Prod. Res.* https://doi.org/10.1080/00207543.2018.1504173

49. **MczyDska, E.,** 2017. The economy of excess versus doctrine of quality. Kwart. Nauk o Przedsi'biorstwie. https://doi.org/10.5604/01.3001.0010.0142

50. **Magagula, B.K., Rampedi, I.T., Yessoufou, K.,** 2022. Household Pharmaceutical Waste Management Practices in the Johannesburg Area, South Africa. *Int. J. Environ. Res. Public Health.* https://doi.org/10.3390/ijerph19127484

51. **Mariappan, N.,** 2019. Recent trends in nanotechnology applications in surgical specialties and orthopedic surgery. *Biomed. Pharmacol. J.* https://doi.org/10.13005/bpj/1739

52. **Martin, K., Martin, N., Hanzooma, H., Davies, K., Christabel, N.H.,** 2020. Assessment of household knowledge, attitude and practices on disposal methods of expired and unused medicines among residents of Lusaka City, Zambia. *African J. Pharm. Pharmacol.* https://doi.org/10.5897/ajpp2020.5165

53. **Mbasera, M., Du Plessis, E., Saayman, M., Kruger, M.,** 2016. Environmentally-friendly practices in hotels. Acta Commer. https://doi.org/10.4102/ac.v16i1.362

54. **Monga, D., Kaur, P., Singh, B.,** 2022. Microbe mediated remediation of dyes, explosive waste and polyaromatic hydrocarbons, pesticides and pharmaceuticals. *Curr. Res. Microb. Sci.* https://doi.org/10.1016/j.crmicr.2021.100092

55. **Monteiro, C.A., Cannon, G., Moubarac, J.C., Martins, A.P.B., Martins, C.A., Garzillo, J., Canella, D.S., Baraldi, L.G., Barciotte, M., Da Costa Louzada, M.L., Levy, R.B., Claro, R.M., Jaime, P.C.,** 2015. Dietary guidelines to nourish humanity and the planet in the twenty-first century. A blueprint from Brazil. *Public Health Nutr.* https://doi.org/10.1017/S1368980015002165

57. **Murshed, M., Salim, M., Boyd, B.J.**, 2022. Existing and emerging mitigation strategies for the prevention of accidental overdose from oral pharmaceutical products. *Eur. J. Pharm. Biopharm.* https://doi.org/10.1016/j.ejpb.2022.10.002

58. **Mustafa, K., Cheng, K.,** 2016. Managing complexity in manufacturing changeovers: A sustainable manufacturing-oriented approach and the application case study, in: ASME 2016 11th International Manufacturing Science and Engineering Conference, MSEC 2016. https://doi.org/10.1115/MSEC2016-8744

59. **Namagembe, S.,** 2021. Enhancing environmentally friendly practices in SME agri-food upstream chains. *Int. J. Qual. Reliab. Manag.* https://doi.org/10.1108/IJQRM-10-2018-0289

60. **Natasha, S., Dilip, A., Mahaveer, K., Gupta, M.K., Shradha, B.,** 2010. Pharmaceutical waste management: a challenge to make environment ecofriendly. *Int. J. Res. Ayurveda Pharm.*

61. **Nyagah, D., Njagi, A., Nyaga, M.,** 2022. Expired drugs: statistics, factors and mitigation strategies of med-gatepharmaceuticals and tan pharmacy up to 31/07/2021. *J. Pharm. Policy Pract.*

62. **Onoda, H.,** 2020. Smart approaches to waste management for post-COVID-19 smart cities in Japan. *IET Smart Citie*s. https://doi.org/10.1049/iet-smc.2020.0051

63. **Paritosh, K., Kushwaha, S.K., Yadav, M., Pareek, N., Chawade, A., Vivekanand, V.,** 2017. Food Waste to Energy: An Overview of Sustainable Approaches for Food Waste Management and Nutrient Recycling. *Biomed Res. Int.* https://doi.org/10.1155/2017/2370927

64. **Perry, C.T., Murphy, G.N., Kench, P.S., Smithers, S.G., Edinger, E.N., Steneck, R.S., Mumby, P.J.,** 2013. Caribbean-wide decline in carbonate production threatens coral reef growth. *Nat. Commun.* https://doi.org/10.1038/ncomms2409

65. **R, J.K., S, S., N, P., K, N.D.,** 2023. E-WASTE MANAGEMENT USING MACHINE LEARNING. INTERANTIONAL *J. Sci. Res. Eng. Manag.* https://doi.org/10.55041/ijsrem25725

66. **RAMSEY, E., SUN, Q., ZHANG, Z., ZHANG, C., GOU, W.,** 2009. Mini-Review: Green sustainable processes using supercritical fluid carbon dioxide. J. Environ. Sci. https://doi.org/10.1016/S1001-0742(08)62330-X

67. **Rigueto, C.V.T., de Oliveira, R., Gomes, K.S., Alessandretti, I., Nazari, M.T., Rosseto, M., Krein, D.D.C., Loss, R.A., Dettmer, A.,** 2023. From waste to value-added products: A review of opportunities for fish waste valorization. *Environ. Qual. Manag.* https://doi.org/10.1002/tqem.22040

68. **Rogowska, J., Zimmermann, A.,** 2022. Household Pharmaceutical Waste Disposal as a Global Problem—A Review. *Int. J. Environ. Res. Public Health.* https://doi.org/10.3390/ijerph192315798

69. **Roschangar, F., Colberg, J., Dunn, P.J., Gallou, F., Hayler, J.D., Koenig, S.G., Kopach, M.E., Leahy, D.K., Mergelsberg, I., Tucker, J.L., Sheldon, R.A., Senanayake, C.H.,** 2017. A deeper shade of green: Inspiring sustainable drug manufacturing. *Green Chem. https://doi.org/10.1039/c6gc02901a*

70. **Sarkis, M., Bernardi, A., Shah, N., Papathanasiou, M.M.,** 2021. Emerging challenges and opportunities in pharmaceutical manufacturing and distribution. Processes. https://doi.org/10.3390/pr9030457

71. **Sarkodie, S.A., Owusu, P.A.,** 2021. Impact of COVID-19 pandemic on waste management. *Environ. Dev. Sustain.* https://doi.org/10.1007/s10668-020-00956-y

72. **Schwab, B.W., Hayes, E.P., Fiori, J.M., Mastrocco, F.J., Roden, N.M., Cragin, D., Meyerhoff, R.D., D'Aco, V.J., Anderson, P.D.,** 2005. Human pharmaceuticals in US surface waters: A human health risk assessment. *Regul. Toxicol. Pharmacol.* https://doi.org/10.1016/j.yrtph.2005.05.005

73. **Segata, N., Boernigen, D., Tickle, T.L., Morgan, X.C., Garrett, W.S., Huttenhower, C.,** 2013. Computational meta'omics for microbial community studies. *Mol. Syst. Biol.* https://doi.org/10.1038/msb.2013.22

74. **September, L.A., Kheswa, N., Seroka, N.S., Khotseng, L.,** 2023. Green synthesis of silica and silicon from agricultural residue sugarcane bagasse ash - a mini review. RSC Adv. https://doi.org/10.1039/d2ra07490g

75. **Singh, A.K., Raj, A.,** 2020. Emerging and eco-friendly approaches for waste management: a book review. *Environ. Sci. Eur.* https://doi.org/10.1186/s12302-020-00383-w

76. **Vallejos, M.A.V., Padial, A.A., Vitule, J.R.S., Monteiro-Filho, E.L. de A., 2020.** Effects of crowding due to habitat loss on species assemblage patterns. *Conserv. Biol.* https://doi.org/10.1111/cobi.13443

77. **Wilkinson, J.L., Boxall, A.B.A., Kolpin, D.W.,** 2019. A novel method to characterise levels of pharmaceutical pollution in large-scale aquatic monitoring campaigns. *Appl. Sci.* https://doi.org/10.3390/app9071368

International Journal of Environment and Health Sciences (IJEHS)
2024, VOL. 6, NO. 3, 41-52
https://doi.org/10.47062/1190.0601.04

SUSTAINABLE SOLUTIONS: BRIDGING HEALTH AND ENVIRONMENT THROUGH TRADITIONAL MEDICINE REPURPOSING AND BIOFUEL ADOPTION

Rustam Ekbbal[1]*, Pradeep Kumar[2], Abhishek Gautam[3] and Manju Singh[4]

[1]Department of Pharmacy, IIMT College of Medical Sciences, IIMT University, O Pocket, Ganga Nagar-250001, Meerut, Uttar Pradesh.
[2,3]Dayashwati Laboratory and Training Centre (DLTC), Dhaulana, District Hapur-245301, Uttar Pradesh, India.
[4]Department of Pharmaceutics, Dr. K. N. Modi Institute of Pharmaceutical Education & Research Opposite SBI Main Branch, Delhi Meerut Road, Modinagar-Ghaziabad, Uttar-Pradesh- 201204, INDIA

Received on: 10.07.2024 **Revised on:** 23.07.2024 **Accepted on:** 30.07.2024

Abstract
Traditional medicines, deeply rooted in cultural practices, offer a vast repository of natural compounds with therapeutic properties. By repurposing and reimagining these age-old remedies, we can tap into a wealth of knowledge to address contemporary health challenges. Simultaneously, the adoption of biofuels as an eco-friendly strategy responds to urgent environmental concerns. Derived from renewable biological sources, biofuels present a cleaner and sustainable alternative to traditional fossil fuels. This duality of repurposing traditional medicines for therapeutic innovation and embracing biofuels for environmental sustainability creates a holistic approach to global challenges. The interconnectedness of human health and the environment is emphasized, promoting a comprehensive strategy that addresses both medical needs and environmental stewardship. This review advocates for a multidimensional approach where traditional wisdom contributes to modern healthcare, while environmentally friendly practices, such as biofuel adoption, pave the way for a greener and healthier future.

Keywords
Traditional medicine, Therapeutic innovation, Biofuels, Environmental sustainability, Global health, Interconnected strategies

1. INTRODUCTION

In the face of global challenges such as climate change, environmental degradation, and the increasing burden of disease, there is a growing imperative to explore innovative and sustainable solutions that harmonize the well-being of both humanity and the planet. This paper endeavors to delve into the intersection of health and environmental sustainability, proposing a novel approach that combines the repurposing of traditional medicine and the widespread adoption of biofuels. By synergistically addressing health needs and environmental concerns, this integrated strategy not only promotes holistic well-being but also advances the principles of circular economies ' (Che et al., 2023; Dhianawaty et al., 2023; Radovanović et al., 2023; Shi et al., 2021).

Traditional medicine, rooted in ancient practices and local wisdom, offers a wealth of untapped potential for addressing contemporary health challenges. Harnessing the knowledge embedded in traditional healing systems can not only provide alternative and affordable healthcare options but also contribute to biodiversity conservation. The repurposing of traditional medicines aligns with sustainable practices, emphasizing the importance of preserving ecosystems and leveraging nature's resources responsibly –" (Divyashree et al., 2022; Lara Flores & Florencia Romero, 2023; Qureshi et al., 2024; V. Singh & Supriya Kurane Singh, 2023).

Furthermore, as the world grapples with the escalating consequences of fossil fuel consumption, the urgent need for cleaner and renewable energy sources cannot be overstated. Biofuels, derived from organic materials such as plants and algae, present a promising avenue for sustainable energy production. The adoption of biofuels not only mitigates the

CONTACT *Corresponding author: *rustamekbbal@gmail.com, rustam_pharma@iimtindia.net*
Color versions of one or more of the figures in this article can be found online at www.stenvironment.org

environmental impact of conventional fossil fuels but also creates opportunities for rural development and reduces dependency on finite resources. This paper seeks to explore the interconnectedness of these two realms, advocating for a holistic approach that not only addresses immediate health concerns but also contributes to the long-term well-being of our planet. Through the exploration of traditional medicine repurposing and the widespread adoption of biofuels, we aim to pave the way for a harmonious coexistence between human health and environmental sustainability.

2. REVIEW FINDINGS

2.1 Traditional aspects of medicinal plants

In an era defined by the confluence of escalating health crises and mounting environmental challenges, the imperative to seek innovative and interconnected solutions has never been more critical. This paper embarks on a journey into the realms of repurposing traditional medicines for modern therapeutics and the adoption of biofuels as an environmentally friendly strategy, presenting a holistic approach to address the intricate interplay between human health and the well-being of the planet "(Cabada-Aguirre et al., 2023; Mahomoodally, 2013; Nath & Mukherjee, 2023; Zhou et al., 2023).

Traditional medicines, deeply embedded in cultural practices, represent an ancient pharmacopeia, offering a vast repository of natural compounds endowed with therapeutic properties. The wisdom encapsulated in these age-old remedies has the potential to revolutionize modern healthcare by providing alternative, culturally sensitive, and sustainable approaches to address contemporary health challenges. By systematically repurposing and reimagining traditional medicines, we can tap into a wealth of knowledge, fostering therapeutic innovation that aligns with the principles of ecological responsibility. Simultaneously, the urgency to address environmental concerns has driven the exploration of sustainable energy alternatives, leading to the adoption of biofuels. Derived from renewable biological sources, biofuels offer a cleaner and more sustainable alternative to conventional fossil fuels, mitigating the detrimental impact on the environment. This duality of repurposing traditional medicines for therapeutic innovation and embracing biofuels for environmental sustainability sets the stage for a comprehensive and interconnected strategy to tackle global challenges (Chan et al., 2021; Chen et al., 2021; Jia et al., 2024; Lu et al., 2020; Mukherjee et al., 2022).

The interconnectedness of human health and the environment is at the forefront of this exploration, emphasizing the need for a cohesive and multifaceted approach. By promoting a comprehensive strategy that addresses both medical needs and environmental stewardship, this paper advocates for a paradigm shift towards a more sustainable and resilient future. As we delve into the multidimensional landscape where traditional wisdom contributes to modern healthcare, and environmentally friendly practices, such as biofuel adoption, pave the way for a greener and healthier world, we embark on a journey towards transformative solutions for the well-being of both humanity and the planet (Datta, 2021; Kunwar et al., 2018; McAlvay, 2017; Redwan, 2018).

Figure 1: Traditional aspects of medicinal plants.

2.2. Historical significance of traditional medicines

Traditional medicines, with roots deeply embedded in cultural practices and historical knowledge, offer a unique avenue for therapeutic innovation. The accumulated wisdom of generations has endowed these remedies with a diverse array of natural compounds that exhibit medicinal properties. As we stand on the precipice of an era marked by evolving healthcare challenges, the reevaluation of traditional medicines becomes imperative. By repurposing and reimagining these age-old remedies, we can unlock a wealth of knowledge that holds the potential to address contemporary health challenges (Barzola Baez et al., 2024; Mdhluli et al., 2023; Nie et al., 2023; H. Wang et al., 2023).

Throughout history, diverse cultures have relied on traditional healing practices, ranging from herbal remedies and acupuncture to Ayurveda and traditional Chinese medicine. These practices have not only provided relief for various ailments but have also contributed to the cultural identity and well-being of communities. In the context of modern medicine, tapping into this rich heritage offers a unique opportunity for therapeutic discovery. The natural compounds found in traditional remedies may hold the key to novel drugs, providing effective and sustainable solutions for prevalent health issues (Aditya Sharma et al., 2023; Haq et al., 2023; Ilyas et al., 2021; Pradhan et al., 2023; Sarma, 2021).

3.1. THERAPEUTIC INNOVATION THROUGH TRADITIONAL MEDICINES

The repurposing of traditional medicines for modern therapeutics involves a paradigm shift in how we perceive and utilize these age-old remedies. It requires a comprehensive understanding of the chemical composition of traditional remedies and their potential applications in addressing contemporary health challenges. The integration of traditional wisdom with modern scientific approaches allows for the identification and isolation of bioactive compounds with therapeutic properties. Recent advancements in analytical techniques and molecular biology have facilitated the elucidation of the pharmacological mechanisms underlying traditional medicines. This has led to the identification of specific compounds that exhibit anti-inflammatory, anti-microbial, and anti-cancer properties, among others. By incorporating these bioactive compounds into modern drug development processes, traditional medicines can contribute significantly to therapeutic innovation. Furthermore, the holistic nature of traditional medicine aligns with the current shift towards personalized and holistic healthcare. Traditional medicines often consider the interconnectedness of physical, mental, and spiritual well-being. Integrating these aspects into modern healthcare practices can lead to more patient-centric and comprehensive treatment approaches' (Baumgart, 2024; Bi et al., 2024; Khalid et al., 2023; Puri et al., 2024).

3.2. Biofuels as an Eco-Friendly Strategy

Simultaneously, the global community faces a pressing need to address environmental concerns, particularly in the context of energy consumption and greenhouse gas emissions. The adoption of biofuels represents a pivotal step towards achieving environmental sustainability. Derived from renewable biological sources such as crops, algae, and organic waste, biofuels offer a cleaner and more sustainable alternative to traditional fossil fuels. Unlike conventional fossil fuels, biofuels release carbon dioxide during combustion, but this is offset by the carbon dioxide absorbed by the plants during their growth, creating a closed carbon cycle. This significantly reduces the net carbon emissions associated with energy production, mitigating the impact on climate change. The use of biofuels also holds the potential to decrease dependence on finite fossil fuel resources, contributing to energy security and resilience (Waryono, 2019).

3.3. Interconnectedness of Human Health and the Environment

This study underscores the intricate link between human health and the environment, emphasizing the need for a holistic approach to global challenges. The repurposing of traditional medicines for therapeutic innovation and the adoption of biofuels as an environmentally friendly strategy represent two sides of the same coin—a multidimensional approach that acknowledges the interconnectedness of human well-being and the health of our planet. Environmental degradation and climate change can have direct and indirect impacts on human health. From the spread of infectious diseases to the exacerbation of respiratory conditions, the consequences of environmental issues are far-reaching. Conversely, the pursuit of sustainable practices, such as the use of biofuels, not only addresses environmental concerns but also contributes to a healthier planet, thereby indirectly benefiting human health '–(Adnyana et al., 2023; Cella et al., 2023; Janzik et al., 2024; Jones, 2022).

The critical link between human health and environmental well-being necessitates a holistic approach to global challenges. Environmental degradation and climate change can have profound implications for human health, influencing the spread of infectious diseases, air and water quality, and overall well-being. Conversely, adopting environmentally sustainable practices, such as the use of biofuels, can contribute to a healthier planet, indirectly benefiting human health.

Integrated studies that examine the dual impact of traditional medicine repurposing and biofuel adoption on both human health and the environment are emerging. These studies explore the potential synergies between therapeutic interventions derived from traditional remedies and the environmental benefits associated with biofuel use. By acknowledging the interconnectedness of these strategies, researchers aim to develop comprehensive solutions that address the complex challenges faced by societies globally.

3.4. Advocating for a Multidimensional Approach

This abstract advocates for a comprehensive strategy where traditional wisdom contributes to modern healthcare, and environmentally friendly practices, such as biofuel adoption, pave the way for a greener and healthier future. The interconnected strategies proposed in this paper aim to bridge the gap between the fields of medicine and environmental science, fostering a synergistic relationship that addresses pressing global challenges. The repurposing of traditional medicines for therapeutic innovation and the adoption of biofuels as an environmentally friendly strategy represent promising avenues for sustainable solutions. This multidimensional approach embraces the rich cultural heritage of traditional medicines while responding to the urgent need for environmental stewardship. As we navigate the complexities of the 21st century, this review paper seeks to contribute to the ongoing dialogue on how best to integrate traditional wisdom and modern advancements for the betterment of global health and the environment (Ahmad et al., 2023; Cella et al., 2023; Hassan-Kadle et al., 2024; Lokmic-Tomkins et al., 2024).

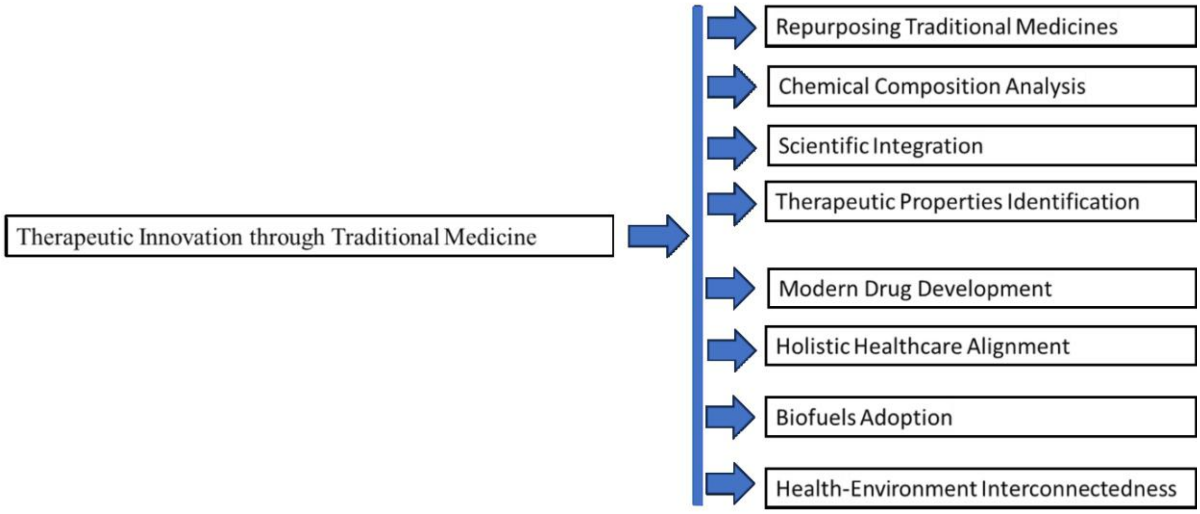


Figure 2: Therapeutic Innovation through Traditional Medicines.

4. Traditional Medicine Repurposing

Preservation of biodiversity traditional medicines often utilize a diverse range of plant species, many of which are sourced from local ecosystems. The sustainable harvesting and cultivation of medicinal plants for traditional medicine repurposing contribute to the preservation of biodiversity. Efforts are made to prevent over-harvesting and promote sustainable practices that ensure the continued health of ecosystems. In Cultural preservation the repurposing of traditional medicines not only contributes to healthcare innovation but also plays a role in preserving cultural knowledge and practices. Recognizing the value of traditional healing methods encourages the sustainable use of medicinal plants and fosters a connection between human health and cultural heritage. Ethical sourcing and fair trade as the demand for traditional medicines increases, there is a growing emphasis on ethical sourcing and fairtrade practices. This ensures that communities involved in the cultivation and harvesting of medicinal plants receive fair compensation, promoting social equity and environmental stewardship "(Adhikari et al., 2020; Kumar Verma et al., 2021; Low et al., 2023; R. Singh et al., 2021).

4.1. Correlation between Traditional Medicine and Biofuel Adoption

Its interconnected solutions the correlation between traditional medicine repurposing and biofuel adoption lies in their shared goal of promoting environmental sustainability. Both strategies recognize the importance of embracing natural, renewable resources while minimizing adverse impacts on ecosystems. That is Holistic Approach Integrating traditional medicines and biofuels into a comprehensive strategy acknowledges the interdependence of human health and the environment. A holistic approach considers not only the immediate health benefits of traditional remedies but also the long-term environmental consequences of energy choices. Its community involvement Both traditional medicine practices and biofuel production can involve local communities. Engaging communities in sustainable practices, whether through the cultivation of medicinal plants or the production of biofuels, strengthens the connection between human well-being and environmental stewardship '(Garrido Ojeda, 2021; Portela, 2019).

In the environmental-friendly strategy, as manifested through the correlation between traditional medicine repurposing and biofuel adoption, embodies a commitment to sustainable, responsible practices. This strategy recognizes the intrinsic link between human health and the health of the planet, fostering a symbiotic relationship where advancements in healthcare contribute to environmental conservation, and environmentally friendly practices support improved human health (de Jesus et al., 2024; Jiang et al., 2021; Vaghela & Gohel, 2023; Zohra et al., 2022).

5. Renewable Energy Source

While the term "Renewable Energy Source" primarily refers to sustainable sources of power generation, such as solar, wind, hydro, and geothermal energy, we can draw parallels between the principles of renewable energy and the broader concept of bridging health and the environment through traditional medicine repurposing and biofuel adoption. Renewable energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. Let's explore these connections in detail Renewable energy Source, by definition, is derived from sources that are naturally replenished on a human timescale. Solar energy harnesses the power of the sun, wind energy captures the motion of the wind, hydro energy relies on the movement of water, and geothermal energy taps into the Earth's internal heat. These sources operate within natural cycles, promoting sustainability and minimizing environmental impact. Similarly, traditional medicine repurposing and biofuel adoption align with natural cycles. Traditional medicines often leverage the healing properties of plants and minerals that are naturally occurring and renewable. Biofuels, derived from organic materials, represent a cycle where carbon is absorbed during plant growth and released during combustion, creating a closed-loop system that minimizes net carbon emissions –(Bendaoud et al., 2022; de Jesus et al., 2024; Gebrehiwot et al., 2022; NUGROHO et al., 2022).

5.1. Reduced Environmental Impact

Compared to traditional fossil fuels, renewable energy sources generally have lower environmental impact. They produce fewer greenhouse gas emissions, reduce air pollution, and contribute to mitigating climate change. The adoption of biofuels as an environmentally friendly strategy aligns with the reduced environmental impact seen in renewable energy sources. Biofuels contribute to lower net carbon emissions, supporting a cleaner and more sustainable alternative to conventional fossil fuels. This shift in energy sources has a positive impact on air quality and addresses environmental concerns - (Abbas et al., 2023; Khare et al., 2023; Khosravi et al., 2024; D. Wang et al., 2022).

5.2. Holistic Approach to Health and Environment

The pursuit of renewable energy often involves a holistic approach to environmental conservation. It recognizes the interconnectedness of ecosystems and aims to promote a balanced coexistence with nature and similarly, the repurposing of traditional medicines emphasizes a holistic approach to health. Traditional healing practices often consider the interconnectedness of physical, mental, and spiritual well-being. By integrating traditional medicine into modern healthcare practices, there is an acknowledgment of the holistic nature of human health (Ashebo, 2019; Kamsu-Foguem & Foguem, 2014; Kansal & Mishra, 2023; Woldearegay & Regassa, 2023).

5.3. Promotion of Sustainable Practices

The utilization of renewable energy promotes sustainable practices in energy production. It encourages the development and implementation of technologies that harness natural resources without depleting them, fostering long-term sustainability. The sustainable use of medicinal plants in traditional medicine aligns with the principles of renewable resources. Practices that emphasize ethical sourcing, fair trade, and conservation contribute to the longevity of traditional medicine knowledge and its beneficial impact on health (Abere et al., 2022; Katoch et al., 2017; G. Wang et al., 2022).

5.4. Community Involvement and Cultural Preservation

In renewable energy source, many projects involve community engagement. Additionally, they often respect the cultural and environmental sensitivities of local communities. Traditional medicine, deeply rooted in cultural practices, involves communities in the preservation and continuation of knowledge. The sustainable use of herbal remedies ensures that cultural practices are maintained, contributing to the well-being of communities. While the term "Renewable Energy Source" traditionally applies to forms of sustainable energy, there are clear correlations with the broader strategies of bridging health and the environment through traditional medicine repurposing and biofuel adoption. Both approaches recognize the importance of sustainable, natural practices in promoting the well-being of both humanity and the planet. The interconnectedness of these strategies underscores the need for comprehensive, holistic solutions to global challenges (Abid Ghafoor Chaudhry *et al*., 2014; ODonnell *et al*., 2018; Ozkan, 2006).

6. Diversification of Energy Mix

The "Diversification of Energy Mix" refers to the strategic integration of various energy sources to create a balanced and resilient portfolio. This approach aims to reduce reliance on a single energy source, promoting sustainability, energy security, and environmental stewardship. Correlating the concept of diversifying the energy mix with bridging health and the environment through traditional medicine repurposing and biofuel adoption involves recognizing the interconnected strategies that contribute to a more holistic and sustainable future. Let's explore these connections in detail "(Ariyanto, 2019; Kinicki & Fugate, 2020; Lutfiah, 2019).

6.1. Reducing Environmental Impact

The incorporation of renewable energy sources, such as solar, wind, hydro, and geothermal, in the energy mix is a key component of reducing the environmental impact of energy production. These sources generate electricity with lower carbon emissions, contributing to efforts to mitigate climate change and improve air quality. Biofuel adoption as an environmentally friendly strategy aligns with the goal of reducing the environmental impact of energy production. Biofuels, derived from renewable biological sources, release carbon dioxide during combustion, but this is offset by the carbon dioxide absorbed during plant growth, creating a closed carbon cycle. This aligns with the broader objective of minimizing the environmental footprint of energy consumption (Bratti et al., 2014; Jamwal et al., 2023; Titik Wijayanti et al., 2023).

6.2 Promoting Energy Security

A diverse energy mix enhances energy security by reducing dependence on a single energy source. This resilience is crucial in mitigating the impact of supply disruptions, price fluctuations, or geopolitical tensions associated with a specific energy resource. Traditional medicine repurposing contributes to health security by diversifying the sources of therapeutic agents. By exploring traditional remedies alongside modern pharmaceuticals, there is a broader range of treatment options, reducing dependence on a singular approach. This diversification contributes to a more resilient healthcare system (Andersen & Østergaard, 2018; Do et al., 2023; Ma et al., 2024; Suman et al., 2022).

6.3 Cultural and Community Engagement

In many cases, the deployment of renewable energy projects involves community engagement, considering the cultural and environmental sensitivities of local populations. This approach fosters social acceptance and ensures that the benefits of energy projects are shared. Traditional medicine, deeply rooted in cultural practices, also involves community engagement. The sustainable use of medicinal plants and the integration of traditional healing practices in modern healthcare strategies contribute to the preservation of cultural heritage and community well-being "(Haenssgen et al., 2021; Nelson et al., 2022; Pertiwi et al., 2024; Vaishnavi Narsingrao Patange, 2023).

6.4 Economic Opportunities and Innovation

The development of diverse energy sources creates economic opportunities and fosters innovation. It stimulates job creation in emerging sectors and promotes the growth of a green economy. The exploration of traditional medicine for therapeutic innovation and the adoption of biofuels creates economic opportunities. Research and development in these areas contribute to job creation, knowledge exchange, and the growth of sustainable industries, aligning with the economic aspects of energy mix diversification —— (Anggraeni et al., 2023; de Oliveira et al., 2023; Lewandrowski et al., 2023; Nursanty et al., 2023).

6.5 Holistic Approach to Health and Environment

A diversified energy mix is part of a holistic approach to environmental stewardship. It acknowledges the interdependence of human well-being and the health of the planet, seeking solutions that balance ecological sustainability with societal needs. The repurposing of traditional medicines and the adoption of biofuels represent a holistic approach to addressing health and environmental challenges. Integrating traditional wisdom into modern healthcare practices and embracing environmentally friendly energy sources contribute to a comprehensive strategy that considers both human health and the ecological well-being of the planet. The diversification of the energy mix and the correlated strategies of traditional medicine repurposing and biofuel adoption share common principles of sustainability, resilience, and a holistic approach to addressing global challenges. By recognizing and leveraging these interconnected strategies, we move towards a more balanced, secure, and sustainable future that prioritizes the well-being of both humanity and the environment '(Betancourt et al., 2021; Hadapad et al., 2020; Kamsu-Foguem & Foguem, 2014).

7. Promotion of Agricultural Sustainability and challenges

The concept of "Promotion of Agricultural Sustainability" involves adopting practices and technologies in agriculture that contribute to long-term environmental health, social well-being, and economic viability. Correlating this idea with bridging health and the environment through traditional medicine repurposing and biofuel adoption reveals a set of interconnected strategies that collectively address global challenges. Let's explore these connections in detail (Abd El-Aziz et al., 2023; Kumar et al., 2023; Supentri et al., 2022; Suwardi et al., 2020).

Agricultural sustainability emphasizes the importance of agroecological practices that maintain and enhance ecosystem health. This includes practices such as organic farming, crop rotation, and agroforestry, which promote biodiversity, soil fertility, and water conservation. Traditional medicine often relies on plants and herbs, many of which are sourced from agricultural practices. The sustainable cultivation of medicinal plants aligns with agroecological principles, contributing to the health of ecosystems. By promoting agroecological practices, traditional medicine repurposing becomes intertwined with sustainable agriculture. Promotion of Agricultural Sustainability: Sustainable agriculture prioritizes the conservation of biodiversity. Diverse crop rotations, cover cropping, and integrated pest management contribute to the health of ecosystems by fostering a variety of plant and animal species. Traditional medicine often relies on a wide variety of plant species. The sustainable cultivation and harvesting of these plants contribute to biodiversity conservation. By promoting the responsible use of medicinal plants, traditional medicine practices align with the broader goal of maintaining a diverse and resilient environment.

Ethical sourcing and fair-trade practices are crucial components of sustainable agriculture. They ensure that farmers receive fair compensation, promote social equity, and discourage environmentally harmful practices. Traditional medicine repurposing involves the sourcing of medicinal plants. By emphasizing ethical sourcing and fair trade, the traditional medicine industry contributes to sustainable agriculture. This approach ensures that communities involved in the cultivation of medicinal plants benefit economically and that the environment is treated responsibly. Sustainable agriculture aims to minimize reliance on synthetic chemicals and pesticides. Integrated pest management, organic farming, and other sustainable practices reduce the environmental impact of chemical inputs '(Krishna et al., 2021; Reza & Khouzani, 2022; ul Haq et al., 2022).

The cultivation of medicinal plants for traditional medicine often aligns with organic farming practices. By reducing reliance on synthetic chemicals, traditional medicine practices contribute to the overall goal of minimizing the environmental footprint of agriculture. This shared emphasis on reduced chemical inputs underscores the connection between traditional medicine repurposing and agricultural sustainability —(Ojha et al., 2022; Raghav et al., 2022; Rana et al., 2022).

Sustainable agriculture not only focuses on environmental health but also on the nutritional well-being of communities. Diverse and nutrient-rich crops contribute to improved community health. Traditional medicines, derived from various plants and herbs, often have nutritional benefits. The integration of traditional medicine into healthcare practices contributes to community health and nutrition. By promoting the use of diverse plant species, both traditional medicine repurposing and sustainable agriculture contribute to holistic community well-being. Some biofuels are derived from crops, such as sugarcane, corn, or switchgrass. Sustainable biofuel production involves responsible land use, avoiding deforestation, and promoting efficient crop management. The adoption of biofuels as an environmentally friendly strategy involves the cultivation of biofuel feedstock crops. By promoting sustainable practices in biofuel feedstock production, the correlation with agricultural sustainability is evident. Both traditional medicine repurposing and biofuel adoption contribute to sustainable agricultural practices –(Kala, 2022; Ojha et al., 2022; Silverio et al., 2022).

8. CONCLUSION

Sustainable solutions that bridge health and environment are pivotal for a resilient future. Repurposing traditional medicine offers a dual advantage: it preserves cultural heritage and provides eco-friendly health alternatives. Integrating these time-tested practices into modern healthcare can enhance global health outcomes while reducing the environmental footprint of conventional pharmaceuticals. Concurrently, adopting biofuels derived from organic waste and sustainable sources presents a viable path to mitigate climate change. By reducing reliance on fossil fuels, biofuels can significantly lower greenhouse gas emissions, contributing to a cleaner, healthier planet. Together, these strategies underscore the synergy between traditional wisdom and modern innovation in addressing contemporary challenges. Embracing such holistic approaches not only fosters environmental sustainability but also promotes public health, paving the way for a balanced and harmonious coexistence of human societies with nature.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENT

The authors would like to thank Dayashwati laboratories and training centre, Dhaulana, District Hapur-245301, Uttar Pradesh for providing a supportive hand to complete the study.

REFERENCE

1. **Abbas, H., Ali, H., Khan, S. W., Hussain, N., Haider, T., Ismail, M., Noor, A., Khadim, S., & Haider, S.** (2023). PHYTOCHEMICAL INVESTIGATION OF HIGH POTENTIAL MEDICINAL PLANTS FOR FRIENDLY INSECT PEST MANAGEMENT AT HERAMOSH, DISTRICT GILGIT. *Plant Protection.* https://doi.org/10.33804/pp.007.03.4884
2. **Abd El-Aziz, A., Abo Ghanima, M., Mota-Rojas, D., Sherasiya, A., Ciani, F., & El-Sabrout, K.** (2023). |Bee Products for Poultry and Rabbits: Current Challenges and Perspectives. *In Animals*. https://doi.org/10.3390/ani13223517
3. **Abere, M., Eshete, A., & Alemu, A.** (2022). Traditional uses and local management practices of Adansonia digitata L. in different ethnic groups of Quara wereda, North West low land of Ethiopia. *Trees, Forests and People.* https://doi.org/10.1016/j.tfp.2021.100188
4. **Abid Ghafoor Chaudhry, Ahmed, A., & Farooq, H.** (2014). Indigenous Knowledge and Sustainable Agricultural Development: A Case History of the Indus Valley, Pakistan. European Academic Research.
5. **Adhikari, A., Darbar, S., Das, M., Mondal, S., Sankar Bhattacharya, S., Pal, D., & Kumar Pal, S.** (2020). Rationalization of a traditional liver medicine using systems biology approach and its evaluation in preclinical trial. *Computational Biology and Chemistry.* https://doi.org/10.1016/j.compbiolchem.2019.107196
6. **Aditya Sharma, Neha Chauhan, P. Hemantha Kumar, Suman Sharma, & Lokendra Pahadiya.** (2023). Agnikarma - Understanding the process from Past to the Present. *International Journal of Ayurveda and Pharma Research*. https://doi.org/10.47070/ijapr.v11i8.2897
7. **Adnyana, I. M. D. M., Utomo, B., Eljatin, D. S., & Sudaryati, N. L. G.** (2023). One Health approach and zoonotic diseases in Indonesia: Urgency of implementation and challenges. *In Narra J.* https://doi.org/10.52225/narra.v3i3.257
8. **Ahmad, N., Joji, R. M., & Shahid, M.** (2023). Evolution and implementation of One Health to control the dissemination of antibiotic-resistant bacteria and resistance genes: A review. *In Frontiers in Cellular and Infection Microbiology*. https://doi.org/10.3389/fcimb.2022.1065796
9. **Andersen, A. N., & Østergaard, P. A.** (2018). A method for assessing support schemes promoting flexibility at district energy plants. *Applied Energy*. https://doi.org/10.1016/j.apenergy.2018.05.053
10. **Anggraeni, Y., Rahman, A., & Yuhastina, Y.** (2023). STRATEGI SENTRA INDUSTRI TENUN TRADISIONAL SARUNG GOYOR DESA POJOK DALAM MENDUKUNG PROGRAM PEMBANGUNAN BERKELANJUTAN DESA. JISIP (Jurnal Ilmu Sosial Dan Pendidikan). https://doi.org/10.58258/jisip.v7i1.4485

11. **Ariyanto, A. B.** (2019). ANALISIS STRATEGI PEMASARAN DENGAN MENGGUNAKAN METODE MARKETING MIX 7P (Studi Kasus : CV. NGREMBOKO KLATEN). Molecules.\

12. **Ashebo, T.** (2019). *International Journal of Environmental Sciences & Natural Resources*.

13. **Barzola Baez, M. L., Maribel Ramos, S., & Del Valle Vasquez, E.** (2024). Traditional Medicine in Latin America: a holistic approach to health. Community and Interculturality in Dialogue. https://doi.org/10.56294/cid2024120

14. **Baumgart, D. C.** (2024). An intriguing vision for transatlantic collaborative health data use and artificial intelligence development. *Npj Digital Medicine*. https://doi.org/10.1038/s41746-024-01005-y

15. **Bendaoud, A., Lahkimi, A., Kara, M., Moubchir, T., Assouguem, A., Belkhiri, A., Allali, A., Hmamou, A., Almeer, R., Sayed, A. A., Peluso, I., & Eloutassi, N.** (2022). Field Study and Chemical Analysis of Plant Waste in the Fez-Meknes Region, Morocco. *Sustainability* (Switzerland). https://doi.org/10.3390/su14106029

16. **Betancourt, M. I. F., López Domínguez, D. M., Rodríguez, J. V., & Garrido, A. S.** (2021). Public health in pluricultural contexts. Advances and setbacks. In Boletin de Malariologia y Salud Ambiental. https://doi.org/10.52808/bmsa.7e5.614.002

17. **Bi, Y. J., Ma, D. J., Peng, L. P., Zhou, Z. Q., Zhao, J., Zhu, H. J., Zhong, Q. H., & Yang, Y. X**. (2024). Strategy and significance of Chinese medicine combined with medical hydrogel for disease treatment. Chinese *Journal of Tissue Engineering Research*. https://doi.org/10.12307/2023.971

18. **Bratti, C., Vieira, M. C., Zárate, N. A. H., Oliveira, A. P. A., Marafiga, B. G., & Fernandes, S. S. L.** (2014). Levantamento de Plantas Medicinais Nativas da Fazenda Azulão em Dourados-MS. *Revista Brasileira de Plantas Medicinais*. https://doi.org/10.1590/S1516-05722013000500008

19. **Cabada-Aguirre, P., López López, A. M., Mendoza, K. C. O., Garay Buenrostro, K. D., Luna-Vital, D. A., & Mahady, G. B.** (2023). Mexican traditional medicines for women's reproductive health. *Scientific Reports*. https://doi.org/10.1038/s41598-023-29921-1

20. **Cella, E., Giovanetti, M., Benedetti, F., Scarpa, F., Johnston, C., Borsetti, A., Ceccarelli, G., Azarian, T., Zella, D., & Ciccozzi, M.** (2023). Joining Forces against Antibiotic Resistance: The One Health Solution. In Pathogens. https://doi.org/10.3390/pathogens12091074

21. **Chan, Y. T., Wang, N., & Feng, Y.** (2021). The toxicology and detoxification of Aconitum: traditional and modern views. In Chinese Medicine (United Kingdom). https://doi.org/10.1186/s13020-021-00472-9

22. **Che, C. T., George, V., Ijinu, T. P., Pushpangadan, P., & Andrae-Marobela, K.** (2023). Traditional medicine. In Pharmacognosy: Fundamentals, Applications, and Strategies, Second Edition. https://doi.org/10.1016/B978-0-443-18657-8.00037-2

23. **Chen, Q., Springer, L., Gohlke, B. O., Goede, A., Dunkel, M., Abel, R., Gallo, K., Preissner, S., Eckert, A., Seshadri, L., & Preissner, R.** (2021). SuperTCM: A biocultural database combining biological pathways and historical linguistic data of Chinese Materia Medica for drug development. Biomedicine and Pharmacotherapy. https://doi.org/10.1016/j.biopha.2021.112315

24. **Datta, S. C.** (2021). IMMEDIATE APPLY COST-EFFECTIVE EASILY PREPARABLE-AVAILABLE 21STCENTURY POTENTIAL-AYURVEDIC-HERBAL-INTEGRATIVE-MEDICINAL-VACCINE OF COVID-19: ACHIEVED AGRICULTURE HEALTHCARE-SOCIO-ECONOMY SCIENCE TECHNOLOGY COMMUNICATION MECHANISM! *International Journal of Research -GRANTHAALAYAH*. https://doi.org/10.29121/granthaalayah.v9.i1.2021.2972

25. **de Jesus, R. A., de Assis, G. C., Oliveira, R. J. de, Costa, J. A. S., da Silva, C. M. P., Iqbal, H. M. N., & Ferreira, L. F. R.** (2024). Metal/metal oxide nanoparticles: *A revolution in the biosynthesis and medical applications. In Nano-Structures and Nano-Objects*. https://doi.org/10.1016/j.nanoso.2023.101071

26. de Oliveira, W., Batista, J. O. R., Novais, T., Takashima, S. T., Stange, L. R., Martucci, M., Cugnasca, C. E., & Bressan, G. (2023). OpenCare5G: O-RAN in Private Network for Digital Health Applications. *Sensors*. https://doi.org/10.3390/s23021047

27. **Dhianawaty, D., Dwiwina, R. G., Mayasari, W., & Achadiyani.** (2023). Preliminary Exploration of Traditional Medicine Formulas as A Basis of Effort and Support Toward Traditional Medicines Developing Use and Implementation in The Government Healthcare Program. *Pharmacognosy Journal*. https://doi.org/10.5530/pj.2023.15.75

28. **Divyashree, J., Tomar, S., & Singh, A. P.** (2022). Hepatoprotective action of vegetables. International Journal of Health Sciences. https://doi.org/10.53730/ijhs.v6ns2.7507

29. **Do, G. T., Son, E. T., Oh, B. C., Kim, H. J., Ryu, H. S., Cho, J. T., & Kim, S. Y.** (2023). Technical Impacts of Virtual Clean Hydrogen Plants: Promoting Energy Balance and Resolving Transmission Congestion Challenges. *Energies*. https://doi.org/10.3390/en16227652

30. **Garrido Ojeda, V. V.** (2021). Perceptions of Traditional Medicine in Ecuador. In Frontiers in Neuroscience.

31. **Gebrehiwot, H., Dekebo, A., & Endale, M.** (2022). Chemical Composition, Pharmacological Activities, and Biofuel Production of Eichhornia crassipes (Water Hyacinth): A Review. In Journal of the Turkish Chemical

Society, Section A: Chemistry. https://doi.org/10.8596/jotcsa.1033493

32. **Hadapad, B. S., Nayak, A. V., & Mishra, C. S.** (2020). Experiencing the ancient indian healthcare science of ayurveda through the immersive experiential prism of a scholar from the global north west visiting an ayurveda centre in coastal Karnataka. *Indian Journal of Forensic Medicine and Toxicology*. https://doi.org/10.37506/ijfmt.v14i4.12326

33. **Haenssgen, M. J., Charoenboon, N., Thavethanutthanawin, P., & Wibunjak, K.** (2021). Tales of treatment and new perspectives for global health research on antimicrobial resistance. *Medical Humanities*. *https://doi.org/10.1136/medhum-2020-011894*

34. **Haq, S. M., Waheed, M., Khoja, A. A., Amjad, M. S., Bussmann, R. W., & Ali, K.** (2023). A cross-cultural study of high-altitude botanical resources among diverse ethnic groups in Kashmir Himalaya, India. Journal of Ethnobiology and Ethnomedicine. https://doi.org/10.1186/s13002-023-00582-8

35. **Hassan-Kadle, A. A., Osman, A. M., Ibrahim, A. M., Mohamed, A. A., de Oliveira, C. J. B., & Vieira, R. F. C.** (2024). One Health in Somalia: Present status, opportunities, and challenges. *One Health*. https://doi.org/10.1016/j.onehlt.2023.100666

36. **Ilyas, A., Tanvir, R., & Rehman, Y.** (2021). Indo-Pak Medicinal Plants and Their Endophytes: An Emphasis on Nutraceutical and Bioactive Potential. In Endophytes: Potential Source of Compounds of Commercial and Therapeutic Applications. https://doi.org/10.1007/978-981-15-9371-0_4

37. **Jamwal, M., Puri, S., Radha, Sharma, N., Prakash, S., & Pundir, A.** (2023). Altitudinal variation in phytochemical, physicochemical, and morphological aspects of Justicia adhatoda L. plant growing wildly in Western Himalayas. *Journal of Applied Biology and Biotechnolog*y. https://doi.org/10.7324/JABB.2023.99265

38. **Janzik, R., Koch, S., Zamariola, G., Vrbos, D., White, M. P., Pahl, S., & Berger, N.** (2024). Exploring public risk perceptions of microplastics: Findings from a cross-national qualitative interview study among German and Italian citizens. *Risk Analysis*. https://doi.org/10.1111/risa.14184

39. **Jia, Y., Wang, M., Lambers, P. H., & van Andel, T.** (2024). The catalogue of the Westhoff collection of Chinese materia medica (c. 1870): Evidence of interaction between a Chinese medicine practitioner and the Dutch in Indonesia. *Journal of Ethnopharmacology*. https://doi.org/10.1016/j.jep.2023.116987

40. **Jiang, F., Gong, T., Chen, J., Chen, T., Yang, J., & Zhu, P.** (2021). Synthetic biology of plants-derived medicinal natural products. In Shengwu Gongcheng Xuebao/*Chinese Journal of Biotechnology*. https://doi.org/10.13345/j.cjb.210138

41. **Jones, A.** (2022). The health impacts of climate change: why climate action is essential to protect health. Orthopaedics and Trauma. https://doi.org/10.1016/j.mporth.2022.07.001

42. **Kala, C. P.** (2022). Traditional Ecological Knowledge of Tribal Communities and Sustainability of Nature and Natural Resources in Pachmarhi Biosphere Reserve in India. *International Journal of Ecology*. https://doi.org/10.1155/2022/5979024

43. **Kamsu-Foguem, B., & Foguem, C.** (2014). Could telemedicine enhance traditional medicine practices? *European Research in Telemedicine*. https://doi.org/10.1016/j.eurtel.2014.08.001

44. **Kansal, K., & Mishra, P. K.** (2023). The Influence of Greenery on Eye Health: A Botanical Perspective. *In Indian Journal of Agricultural Biochemistry*. https://doi.org/10.5958/0974-4479.2023.00019.9

45. **Katoch, D., Sharma, J. S., Banerjee, S., Biswas, R., Das, B., Goswami, D., Harwansh, R. K., Katiyar, C. K., & Mukherjee, P. K.** (2017). Government policies and initiatives for development of Ayurveda. *Journal of Ethnopharmacology*. https://doi.org/10.1016/j.jep.2016.08.018

46. **Khalid, R., Mahmood, S., Mohamed Sofian, Z., Hilles, A. R., Hashim, N. M., & Ge, Y.** (2023). Microneedles and Their Application in Transdermal Delivery of Antihypertensive Drugs—A Review. *In Pharmaceutics*. https://doi.org/10.3390/pharmaceutics15082029

47. **Khare, S., Singh, N. B., Niharika, Singh, A., Amist, N., Azim, Z., Bano, C., Yadav, V., & Yadav, R. K.** (2023). Salinity-Induced Attenuation in Secondary Metabolites Profile and Herbicidal Potential of Brassica nigra L. on Anagallis arvensis L. Journal of Plant Growth Regulation. https://doi.org/10.1007/s00344-022-10607-3

48. **Khosravi, H., Rashidi, A., & Shourkaei, M. A.** (2024). Life cycle assessment of medicinal plant extract drying methods. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-023-02940-8

49. **Kinicki, A., & Fugate, M.** (2020). Organizational behavior. McGraw Hill Education.

50. **Krishna, G. K. S., Janardhan, S., Tran, D. D., Quang, C. N. X., Tien, P. D., Tran, P. G., Long, P. K., Van Hoa, H., Giang, N. N. H., Ha, L. T. T., Singh, D. P., Prabha, R., Renu, S., Sahu, P. K., Singh, V., Sgroi, F., Candela, M., Di Trapani, A. M., Foderà, M., … Singh, S.** (2021). Producer companies in India A study of legislative policy and judicial trend. *Journal of Sustainable Agriculture.*

51. **Kumar, C., Kotra, V., Kumar, N., Singh, K., & Singh, A. K.** (2023). Biodiversity and bioresources: impact of biodiversity loss on agricultural sustainability. In Biodiversity and Bioeconomy: Status Quo, Challenges, and Opportunities. https://doi.org/10.1016/B978-0-323-95482-2.00008-0

52. **Kumar Verma, A., Kumar, V., Singh, S., Goswami, B. C., Camps, I., Sekar, A., Yoon, S., & Lee, K. W.** (2021). Repurposing potential of Ayurvedic medicinal plants derived active principles against SARS-CoV-2 associated target proteins revealed by molecular docking, molecular dynamics and MM-PBSA studies. *Biomedicine and Pharmacotherapy*. https://doi.org/10.1016/j.biopha.2021.111356

53. **Kunwar, R. M., Fadiman, M., Cameron, M., Bussmann, R. W., Thapa-Magar, K. B., Rimal, B., & Sapkota, P.** (2018). Cross-cultural comparison of plant use knowledge in Baitadi and Darchula districts, Nepal Himalaya. *Journal of Ethnobiology and Ethnomedicine*. https://doi.org/10.1186/s13002-018-0242-7

54. **Lara Flores, G., & Florencia Romero, R.** (2023). Curanderismo in Argentina: a view to diversity. Community and Interculturality in Dialogue. https://doi.org/10.56294/cid202378

55. **Lewandrowski, K. U., Elfar, J. C., Li, Z. M., Burkhardt, B. W., Lorio, M. P., Winkler, P. A., Oertel, J. M., Telfeian, A. E., Dowling, Á., Vargas, R. A. A., Ramina, R., Abraham, I., Assefi, M., Yang, H., Zhang, X., Ramírez León, J. F., Fiorelli, R. K. A., Pereira, M. G., de Carvalho, P. S. T., … Novellino, P.** (2023). The Changing Environment in Postgraduate Education in Orthopedic Surgery and Neurosurgery and Its Impact on Technology-Driven Targeted Interventional and Surgical Pain Management: Perspectives from Europe, Latin America, Asia, and The United States. *Journal of Personalized Medicine*. https://doi.org/10.3390/jpm13050852

56. **Lokmic-Tomkins, Z., Borda, A., & Skouteris, H.** (2024). Climate conscious health equity is essential to achieve climate-resilient digital healthcare. *Journal of Climate Change and Health*. https://doi.org/10.1016/j.joclim.2024.100301

57. **Low, Z., Lani, R., Tiong, V., Poh, C., AbuBakar, S., & Hassandarvish, P.** (2023). COVID-19 Therapeutic Potential of Natural Products. *In International Journal of Molecular Sciences*. https://doi.org/10.3390/ijms24119589

58. **Lu, Y., Wu, H., Yu, X., Zhang, X., Luo, H., Tang, L., & Wang, Z.** (2020). Traditional Chinese Medicine of Angelicae Pubescentis Radix: *A Review of Phytochemistry, Pharmacology and Pharmacokinetics*. *In Frontiers in Pharmacology*. https://doi.org/10.3389/fphar.2020.00335

59. **Lutfiah, A.** (2019). MARKETING MIX CAFE CARLOS DALAM PENINGKATAN MINAT KONSUMEN DI KOTA PAREPARE. Molecules.

60. **Ma, X., Xu, J., Zhao, X., Qu, L., Gao, Y., Huang, W., Han, D., Dang, B., Xu, Z., & Jia, W.** (2024). Selenium Improves the Control Efficacy of Phytophthora nicotianae by Damaging the Cell Membrane System and Promoting Plant Energy Metabolism. *Journal of Agricultural and Food Chemistry*. https://doi.org/10.1021/acs.jafc.3c07277

61. **Mahomoodally, M. F.** (2013). Traditional medicines in Africa: An appraisal of ten potent African medicinal plants. In Evidence-based Complementary and Alternative Medicine. https://doi.org/10.1155/2013/617459

62. **McAlvay, A.** (2017). Plants and Health: New Perspectives on the Health-Environment-Plant. In Ethnbiology Letters.

63. **Mdhluli, T. D., Kugara, S. L., Matshidze, P. E., & Netshandama, V. O.** (2023). Perceptions on the Inclusion of Traditional Medicine in Primary Health Care in Allandale Village in Mpumalanga Province in South Africa. African Journal of Development Studies (Formerly AFFRIKA Journal of Politics, Economics and Society). https://doi.org/10.31920/2634-3649/2022/v12n4a8

64. **Mukherjee, P. K., Singha, S., Kar, A., Chanda, J., Banerjee, S., Dasgupta, B., Haldar, P. K., & Sharma, N.** (2022). Therapeutic importance of Cucurbitaceae: A medicinally important family. *In Journal of Ethnopharmacology*. https://doi.org/10.1016/j.jep.2021.114599

65. **Nath, S., & Mukherjee, A. K.** (2023). Ethnomedicines for the treatment of scorpion stings: A perspective study. *In Journal of Ethnopharmacology*. https://doi.org/10.1016/j.jep.2022.116078

66. **Nelson, L., Squetemkin-Anquoe, A., Ubay, T., King, V., Taylor, E., Masciel, K., Black Bear, L., Buffalomeat, S., Duffing-Romero, X., Mahinalani-Garza, C., Clifasefi, S., & Collins, S.** (2022). Content Analysis Informing the Development of Adapted Harm Reduction Talking Circles (HaRTC) with Urban American Indians and Alaska Natives Experiencing Alcohol Use Disorder. *International Journal of Indigenous Health*. https://doi.org/10.32799/ijih.v17i2.36677

67. **Nie, X., Ma, M. Z., Ji, J. Q., & Zheng, L. X.** (2023). The spatial distribution of traditional intangible cultural heritage medicine of China and its influencing factors. *Heritage Science*. https://doi.org/10.1186/s40494-023-00929-0

68. **NUGROHO, G. D., WIRAATMAJA, M. F., PRAMADANINGTYAS, P. S., FEBRIYANTI, S., LIZA, N., MD. NAIM, D., ULUMUDDIN, Y. I., & SETYAWAN, A. D.** (2022). Review: Phytochemical composition, medicinal uses and other utilization of Nypa fruticans. *International Journal of Bonorowo Wetlands*. https://doi.org/10.13057/bonorowo/w100105

69. **Nursanty, E., Rusmiatmoko, D., Destiawan, W., Husni, M. F. D., & Yuliati, Y.** (2023). Kampung Jamu: Pilar Peningkatan Kemampuan Bersaing Kota Semarang. Perigel: Jurnal Penyuluhan Masyarakat Indonesia. https://doi.org/10.56444/perigel.v2i3.1050

70. **O'Donnell, O., Kananura, R. M., Kiwanuka, S. N., Ekirapa-Kiracho, E., Waiswa, P., Hunter, B. M.,**

Murray, S. F., Makacha, L., Makanga, P. T. P. T., Dube, Y. P., Bone, J., Munguambe, K., Katageri, G., Sharma, S., Vidler, M., Sevene, E., Ramadurg, U., Charantimath, U., Revankar, A., … Addai-Donkor, K. (2018). Qualitative study on maternal referrals in rural Tanzania: decision making and acceptance of referral advice. BMC Pregnancy And Childbirth.

71. **Ojha, S. N., Anand, A., Sundriyal, R. C., & Arya, D.** (2022). Traditional Dietary Knowledge of a Marginal Hill Community in the Central Himalaya: Implications for Food, Nutrition, and Medicinal Security. *Frontiers in Pharmacology*. https://doi.org/ 10.3389/fphar.2021.789360

72. **Ozkan, A.** (2006). Medicinal plants and conservation efforts in the buffer zone of Kure Mountains National Park (Bartin – Turkey), particularly in Ulus region. *Planta Medica*. https://doi.org/10.1055/s-2006-950105

73. **Pertiwi, G. N., Agustina, S. Z., & Rosmilawati, I.** (2024). Ethnopedagogical Approach In Educating Elementary School Students On The Implementation Of Clean And Healthy Behaviour. Ideguru: *Jurnal Karya Ilmiah Guru*. https://doi.org/10.51169/ideguru.v9i2.899

74. **Portela, L. K.** (2019). The Relationship Between Social Networking and Student-athlete Well-Being. Molecules.

75. **Pradhan, S., Rituparna, S., Dehury, H., Dhall, M., & Singh, Y. D.** (2023). Nutritional profile and pharmacological aspect of Houttuynia cordata Thunb. and their therapeutic applications. In Pharmacological Research - Modern Chinese Medicine. https://doi.org/10.1016/j.prmcm.2023.100311

76. **Puri, A., Mohite, P., Maitra, S., Subramaniyan, V., Kumarasamy, V., Uti, D. E., Sayed, A. A., El-Demerdash, F. M., Algahtani, M., El-kott, A. F., Shati, A. A., Albaik, M., Abdel-Daim, M. M., & Atangwho, I. J**. (2024). From nature to nanotechnology: The interplay of traditional medicine, green chemistry, and biogenic metallic phytonanoparticles in modern healthcare innovation and sustainability. *In Biomedicine and Pharmacotherapy*. https://doi.org/10.1016/j.biopha.2023.116083

77. **Qureshi, K. A., Parvez, A., Uzzaman Khan, M. M., Aspatwar, A., Atiya, A., Elhassan, G. O., Khan, R. A., Erattil Ahammed, S. Y., Khan, W. U., & Jaremko, M.** (2024). Exploring nature's hidden treasure: Unraveling the untapped phytochemical and pharmacological potentials of Clinopodium vulgare L. – A hidden gem in the Lamiaceae family. *In Heliyon*. https://doi.org/10.1016/j.heliyon.2024.e24781

78. **Radovanović, K., Gavarić, N., & Aćimović, M.** (2023). Anti-Inflammatory Properties of Plants from Serbian *Traditional Medicine. In Life*. https://doi.org/10.3390/life13040874

79. **Raghav, P., Priyvart, Singh, A., Sharma, R., & Sharma, N.** (2022). Phytochemical and Medical Perspective of an Endangered Plant Angelica glauca: Review on its Current Status and Future Research. *In Asian Journal of Chemistry*. https://doi.org/10.14233/ajchem.2022.23786

80. **Rana, C. S., Negi, Y. S., Sawant, L. P., & Raturi, P. P.** (2022). Commercial Cultivation and Sustainability of Pushkarmool (Inula racemosa), A Case Study from Keylong, Lauhal & Spiti, Himachal Pradesh, India. *Journal of Mountain Research*. https://doi.org/10.51220/jmr.v17i2.3

81. **Redwan, Z.** (2018). Alternative crop for tobacco farming in Lebanon - an effective tool to change and educate on tobacco environmental and economical impact. *Tobacco Induced Diseases*. https://doi.org/10.18332/tid/84630

82. **Reza, M., & Khouzani, Z.** (2022). Assessing Indigofera tinctoria L. as a forgotten medicinal industrial plant and the importance of its revitalization for the sustainability of Iran's agricultural ecosystems. *Central Asian Journal of Environmental Science and Technology Innovation*.

83. **Sarma, N. D.** (2021). Review of Medicinal Foods as Potential Therapies for Type-2 Diabetes and Associated Diseases. The Chemical and Pharmacological Basis of Their Actions. *Journal of Natural Products*. https://doi.org/10.1021/acs.jnatprod.1c00216

84. **Shi, Y., Zhang, C., & Li, X.** (2021). Traditional medicine in India. *Journal of Traditional Chinese Medical Science*s. https://doi.org/10.1016/j.jtcms.2020.06.007

85. **Silverio, C. E., Ornos, E. D. B., & Tantengco, O. A. G.** (2022). Investigating the global research landscape, barriers, and facilitators of scientific productivity in ethnomedicinal research in diabetes mellitus. *Obesity Medicine*. https://doi.org/10.1016/j.obmed.2022.100419

86. **Singh, R., Goel, S., Bourgeade, P., Aleya, L., & Tewari, D.** (2021). Ayurveda Rasayana as antivirals and immunomodulators: potential applications in COVID-19. *In Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-021-16280-5

87. **Singh, V., & Supriya Kurane Singh.** (2023). The effect of Marma therapy in Student's Elbow i.e., Olecranon Bursitis with special reference to Pain - A Single Case Study. *Journal of Ayurveda and Integrated Medical Sciences*. https://doi.org/10.21760/jaims.8.8.40

88. **Suman, J., Rakshit, A., Ogireddy, S. D., Singh, S., Gupta, C., & Chandrakala, J.** (2022). Microbiome as a Key Player in Sustainable Agriculture and Human Health. *In Frontiers in Soil Science*. https://doi.org/10.3389/fsoil.2022.821589

89. **Supentri, S., Faisal Zam, M., Martin Giovanny, R., Eka Putri, S., Atikah Merlinda, A., Prameswari Utami, P., Mesa Lestari, A., Adilah Isdawati, N., Simbolon, E., Sinaga, C., & Safitri, Y.** (2022). MENINGKATKAN DAYA JUAL SECARA KOMERSIAL JAMU TRADISIONAL DESA

KEMUNING MUDA KECAMATAN BUNGARAYA. COVIT (Community Service of Health). https://doi.org/10.31004/covit.v2i2.6798

90. **Suwardi, A. B., Navia, Z. I., Harmawan, T., Syamsuardi, & Mukhtar, E.** (2020). Ethnobotany and conservation of indigenous edible fruit plants in south Aceh, Indonesia. *Biodiversitas*. https://doi.org/10.13057/biodiv/d210511

91. **Titik Wijayanti, Nurmala Hindun, & Erfitra Rezqi Prasmala.** (2023). Edukasi Pemanfaatan Tanaman Obat Keluarga (TOGA) di Pekarangan Taman Dasawisma RT 37 Perumahan Green View Regency Malang. Jurnal Pengabdian Kepada Masyarakat Indonesia (JPKMI). https://doi.org/10.55606/jpkmi.v3i3.2430

92. **ul Haq, Z., Rasheed, S., Manan, F., Kamran, S., Shah, S. A., & Ahmad, H.** (2022). Phytosociological Studies, Economic Value, and Sustainable Use of Alnus nitida: A Monophyletic Species of the Western Himalayas and Hindu Kush Region of the Sino-Japanese Belt of Pakistan. In Biodiversity, Conservation and Sustainability in Asia: Volume 2: Prospects and Challenges in South and Middle Asia. https://doi.org/10.1007/978-3-030-73943-0_16

93. **Vaghela, N., & Gohel, S.** (2023). Medicinal plant-associated rhizobacteria enhance the production of pharmaceutically important bioactive compounds under abiotic stress conditions. *In Journal of Basic Microbiology*. https://doi.org/10.1002/jobm.202200361

94. **Vaishnavi Narsingrao Patange.** (2023). International Developments Related to Protection of Traditional Knowledge. *International Journal of Advanced Research in Science, Communication and Technology*. https://doi.org/10.48175/ijarsct-12426

95. **Wang, D., Shi, C., Alamgir, K., Kwon, S. M., Pan, L., Zhu, Y., & Yang, X.** (2022). Global assessment of the distribution and conservation status of a key medicinal plant (Artemisia annua L.): The roles of climate and anthropogenic activities. *Science of the Total Environment*. https://doi.org/10.1016/j.scitotenv.2022.153378

96. **Wang, G., Ren, Y., Bai, X., Su, Y., & Han, J.** (2022). Contributions of Beneficial Microorganisms in Soil Remediation and Quality Improvement of Medicinal Plants. In Plants. https://doi.org/10.3390/plants11233200

97. **Wang, H., Chen, Y., Wang, L., Liu, Q., Yang, S., & Wang, C.** (2023). Advancing herbal medicine: enhancing product quality and safety through robust quality control practices. *In Frontiers in Pharmacology*. https://doi.org/10.3389/fphar.2023.1265178

98. **Waryono, T.** (2019). RINGKASAN Puding merah (Gruptophyllum pictum L Griff). Jurnal Farmasi Galenika (Galenika Journal of Pharmacy) (e-Journal).

99. **Woldearegay, M., & Regassa, A.** (2023). Medicinal Plants of Ethiopia: Conservation, Traditional Knowledge, and Sustainable Use. *Ecological Insights*. https://doi.org/10.59411/721y5z60

100. **Zhou, H., Zhang, J., Kirbis, B. S., Mula, Z., Zhang, W., Kuang, Y., Huang, Q., & Yin, L**. (2023). Ethnobotanical study on medicinal plants used by Bulang people in Yunnan, China. *Journal of Ethnobiology and Ethnomedicine*. https://doi.org/10.1186/s13002-023-00609-0

101. **Zohra, T., Khalil, A. T., Saeed, F., Latif, B., Salman, M., Ikram, A., Ayaz, M., & Murthy, H. C. A.** (2022). Green Nano-Biotechnology: A New Sustainable Paradigm to Control Dengue Infection. *In Bioinorganic Chemistry and Applications*. https://doi.org/10.1155/2022/3994340

SAVE THE ENVIRONMENT (STE) was founded and registered on 19th November 1990. In 1992 with the collaboration of WWF (India), the organization started working to combat arsenic poisoning problem of water in the arsenic prone areas of West Bengal. Since then STE has been involved in various projects related to combat arsenic problem in India.

Our Vision

To protect present and future generations from various environmental hazards.

Our Mission

To create awareness and motivation among rural communities & provide cost effective, energy efficient & environment friendly technologies.

Our Activities

Conducting interactive sessions, workshops/ seminars, awareness programs, field operations through projects, science fairs, posters & quiz competitions.

Please join us and become part of our family by enrolling yourself as Life Member of STE Family

Mail us at
info@stenvironment.org
save1990env@yahoo.co.in

Know about us at
www.stenvironment.org