Uttar Pradesh Journal of Zoology

Volume 45, Issue 19, Page 148-160, 2024; Article no.UPJOZ.4043
ISSN: 0256-971X (P)

Assessment of Heavy Metal of Water and Its Impact on Fishes of Kachpoor Lake, Kamareddy, Telangana, India

Malsoor Thirumala [a++], S. Jithender Kumar Naik [b#*], K. Vanaja [c†*] and Kalikota Pavan kumar [d‡]

[a] Osmania University, India.
[b] Department of Zoology, University College of Science, Osmania University, Hyderabad – 500007, India.
[c] Department of Zoology, Osmania University, Hyderabad - 500007, India.
[d] Department of Fisheries, Government Arts & Science College, Kamareddy, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.56557/upjoz/2024/v45i194511

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/4043

Review Article

Received: 12/07/2024
Accepted: 18/09/2024
Published: 04/10/2024

ABSTRACT

This research article provides a comprehensive analysis of bioaccumulation and its impacts on freshwater fish. It examines the gradual buildup of heavy metals including mercury, lead, zinc, cadmium, and arsenic in fish tissues as a consequence of industrial pollution, agricultural runoff,

[++] Assistant Professor of Zoology, Research Scholar;
[#] Senior Professor Toxicology Lab;
[†] Lecturer of Zoology;
[‡] Lecturer of Fisheries;
**Corresponding author: Email: drnaik8777@yahoo.com, karamvanaja3@yahoo.com;*

Cite as: *Thirumala, Malsoor, S. Jithender Kumar Naik, K. Vanaja, and Kalikota Pavan kumar. 2024. "Assessment of Heavy Metal of Water and Its Impact on Fishes of Kachpoor Lake, Kamareddy, Telangana, India". UTTAR PRADESH JOURNAL OF ZOOLOGY 45 (19):148-60. https://doi.org/10.56557/upjoz/2024/v45i194511.*

and atmospheric deposition. The study highlights the adverse effects of bioaccumulation on fish health, including impaired reproductive capabilities, abnormal development, and organ damage. Furthermore, it emphasizes the risks associated with the consumption of contaminated aquatic food, which poses significant threats to human health. The paper advocates for addressing heavy metal contamination in aquatic ecosystems through the adoption of effective waste management strategies, the reduction of industrial emissions, sustainable agricultural practices, and the continuous monitoring of fish populations. Such measures are critical in minimizing the accumulation of heavy metals in freshwater fish, thereby protecting both aquatic life and public health.

Keywords: Water quality; bioaccumulation; heavy metals; Kachpoor Lake; Telangana State.

1. INTRODUCTION

The introduction of the research paper is mainly dealing with the issue of bioaccumulation which is the acquiring of toxins or chemicals by aquatic or terrestrial organisms which get in direct contact with water. In the past, this process had been a very important topic in the study of environmental bioaccumulation and toxic effects on biota, more so in the case of fish (Tripathi and Qureshi, 2017). This research paper scrutinizes the most frequent heavy metals that fish may cope with such as arsenic, cadmium, lead, zinc, and mercury. These metals can arise from various sources, such as emission from the industrial sector and burial from agroecosystems, and esp. the runoff from the agricultural sector. The crucial area that heavy metals expose consumers to and how they affect the health of fish are discussed in this section [1-4]. This underlines how crucial the enactment of any sort of preventive measures to avoid metal pollution would be to the sea. The ways of implementation that were listed are sustainable agricultural practices, waste management strategies, the reduction of industrial emissions, and fish populations should be carefully monitored on a regular basis. The introduction provides a background story to the whole study of the buildup of heavy metals in freshwater ecosystems which is insisted by the authors in the introduction is provided thereby [5-9].

Bioaccumulation is the process whereby certain substances such as the toxic heavy metals are deposited in the tissues of the living things continuously over time. The fact that the term bioaccumulation refers to the phenomenon that takes place at different trophic levels of the food chains is called biomagnification [10-13]. On the other hand, bioaccumulation is of great concern to the natural environment, which has the potential of forming detrimental substances. Such substances may then breed wild-causing pathogens which are more dangerous than the pathogens that were already in the environment. Please, study the metabolic pathways which are the cause of the contamination of the fishes, specifically on the web. The bacterial overload in the water bodies would have to be identified as arsenic, cadmium, lead, and mercury are released into the water abrasive by man-made activities [14-17].

Address the origin of these pollutants like air deposition, agricultural practices, and industrial waste. Describe in more detail the route followed by the heavy metals to reach the water bodies and then take the body of the aquatic organisms. Assess the impacts of the specific heavy metals on the physiological status of the fish [18-20]. Here, the various mechanisms by which these substances influence the biological processes, the organs' damages, the reproductive capacities will be examined. It is important to support the argument by using a relevant example like an article or reflected by scientists. Explain the negative impact on human health. The dangers of eating aqua life containing various metals that are hazardous to human health can be described in a very detailed manner focusing on the symptoms, problems and provide solutions. Else, add the facts about the merits in details regarding human being’s health [21-26]. Learn about the effects of the bioaccumulation of the metals in the aquatic ecosystem. Consider how it affects the interrelatedness of the different species in the food chain, the biodiversity of the ecosystems, and natural aquatic settings. Lastly, the analysis will also describe ways to address the problem like regulation or ban on the usage of heavy metals or the treatment of industrial effluents, to mention a few. Here, the merits are of adopting the efficient waste management techniques, reducing emissions from the industries, the need for applying sustainable agricultural methods, and the benefits of assessing fish populations and water quality on a regular basis are mentioned.

1.1 Review of Literature

1.1.1 Quantification of heavy metal levels in *Labeo rohita* and *Tilapia* Fish species

The presence of high levels of heavy metals in aquatic ecosystems is a major issue since it can negatively affect the health of fish and the safety of human consumption (Ahmed et al., 2016). *Labeo rohita* (Rohu) and *Tilapia* are widely consumed fish species in India, therefore it is of utmost importance to regularly evaluate the levels of heavy metals in these fish (Kumar et al., 2016).

Prevalent Heavy Metal Detected: The distribution of heavy metals in certain tissues is as follows: Lead (Pb) (Kumar et al., 2015), Mercury (Hg) (Rajesh et al., 2017), Arsenic (As) (Singh et al., 2018), Cadmium (Cd) (Gupta et al., 2019), Chromium (Cr) (Sharma et al., 2020).

Gills are specialized organs found in aquatic animals that allow them to extract oxygen from water and release carbon dioxide. The highest concentration of heavy metals occurs in the primary site of absorption (Jain et al., 2017).

In this study, Amany M. J. et al. (2013) examined the bioaccumulation of ammonia, nitrite, and nitrate in freshwater, as well as the concentration of heavy metals (lead, copper, cadmium, manganese, and zinc) in both water and tissues of *Tilapia* Niloticus. The study focused on *Tilapia* Niloticus chosen from El-marryotia cana.

Hepatic organ: The process of significant accumulation is crucial as it plays a key role in detoxification, as stated by Kumar et al. (2018).

Muscle tissue: Although present in smaller quantities, it remains a matter of concern for human ingestion (Singh et al., 2019).

Kidneys: The levels are moderate due to their involvement in the excretion process (Gupta et al., 2020).

Fluctuation in the concentration of heavy metals: Labeo rohita, often known as Rohu, is a species of fish. In general, the levels of Pb, Hg, and Cd are greater when compared to *Tilapia* (Kumar et al., 2016).

Tilapia exhibits elevated concentrations of arsenic (As) and chromium (Cr) in comparison to Labeo rohita, as reported by Sharma et al. in 2020.There is no text provided.

Factors Affecting the Absorption of Heavy Metals: The study conducted by Rajesh et al. in 2017 focused on the quality of water.

The topic of discussion is "Diet" as mentioned in the study conducted by Jain et al. in 2018.

Fish size and age (Gupta et al., 2019).

Fluctuations that occur in different seasons (Singh et al., 2020).

Wetzel, R.G. [27]. Limnology: Lake and River Ecosystems is a thorough and detailed exploration of the scientific field of limnology, which focuses on the study of inland waterways. It comprehensively addresses the ecological, biological, and physical processes occurring in lakes and rivers. This book offers comprehensive and in-depth analysis of the mechanisms and interconnections occurring in freshwater ecosystems, with a particular focus on their environmental importance. This resource is essential for comprehending the intricacies of freshwater ecosystems, making it very helpful for students, researchers, and environmental professionals with an interest in limnology and aquatic ecology.

APHA (American Public Health Association). [28]: The text refers to the established procedures used to analyze and assess the quality of water and wastewater. This is an essential resource for the examination of water and wastewater. This reference provides standardized protocols and methodology for testing and assessing the quality of water. The improved procedures used in this include methods for physical, chemical, and biological evaluations, which guarantee precision and uniformity in water testing. This study article is crucial for specialists in the fields of environmental science, public health, and water management. It offers dependable techniques for evaluating the safety and quality of water.

Boyd, C.E. [29]. Water Quality: An Introduction offers a fundamental comprehension of water quality. The book examines the various properties of water, including its physical, chemical, and biological attributes, in both natural and man-made settings. This text examines the various elements that affect the quality of water, the techniques used to evaluate it, and the importance of water quality in relation to environmental health. This work is highly beneficial for students and professionals in the field of environmental sciences and engineering, providing a concise and comprehensible overview of the intricate domain of water quality management.

Talling, J.F., and Lemoalle, J. [30]: Ecological Dynamics of Tropical Inland Waters is a comprehensive and authoritative work that specifically examines the ecological characteristics of tropical inland water basins. This resource offers a thorough examination of the distinct physical, chemical, and biological attributes found in tropical inland waterways, with a particular focus on their ecological dynamics. This book is highly beneficial for students and researchers specializing in ecology, limnology, and environmental science. It provides valuable knowledge on the intricate relationships and environmental difficulties that are unique to tropical aquatic ecosystems.

Kalff, J. [31]. Limnology: Study of Ecosystems in Inland Water Bodies: The publisher is Prentice Hall. This work is a crucial exploration of the study of inland water habitats. The book provides an in-depth examination of the biological and environmental elements of lakes and rivers, incorporating both theoretical and practical viewpoints. This resource is highly important for students and researchers in the fields of environmental science, biology, and limnology. It offers a comprehensive grasp of the intricate dynamics and intricacies of freshwater ecosystems.

1.2 Challenges

The main aim of this research is to focus on the bioaccumulation of heavy metals in freshwater ecosystems particularly in fish as the major detriment. Among the key challenges are understanding the heavy metal dynamics such as through the release of air pollutants, agricultural runoff, and disposal of industrial waste. Besides environmental pollution, the harmful impact of contaminants on fish and the consequent significant risks on human health pose further problems. Moreover, discussing the potential links of human health and fish as the other major hazards also become more complications. However, the research shows how can kill two birds at once. It tackles the problems ecosystems encounter, also the progress made in waste management, pollution reduction, as well as testing new methods like ecosystem monitoring.

1.3 Problem Statement

This research specifically examines the problem of heavy metal contamination in Kachapoor Lake, Sarampally Lake, and Kamareddy Lake, and its detrimental effects on aquatic ecosystems, particularly fish. The pollution originates from several sources such as domestic garbage, agricultural runoff, and industrial effluent. Consequently, fish are experiencing stunted development, reproductive complications, and organ impairment. The research emphasizes the immediate need to implement measures to preserve these lakes from further contamination in order to conserve both the ecosystem and the well-being of the fish inhabiting there.

2. METHODOLOGY

The study was carried out by the random sampling method in which samples of water were collected from Kachapoor Lake located on the Kamareddy district of Telangana state. The samples were collected from Kachapoor Lake at different points in time from the months of 2021-2022 and 2022-2023 that preceded and followed the monsoon season respectively. A total of four routes were used, and each route was traversed by every fifteen days across every single month and season. The obtained figures were then set aside for later scrutiny. Water samples were taken from Kachapoor Lake, a lake that is mainly used for agricultural purposes, to be carried out on a water analysis. They were collected from designated site1, site 2, and site 3 (Figs. 1 and 2) and examined for pollutants using a water analysis kit. This was done with the help of through purging with chemicals of AR-grade and double-distilled water. It served as important guiding information to know if the water was usable for a residential or industrial setting, as well as drinking. Every two weeks, water samples were collected from the three specified sites, namely S1, S2, and S3, using the 5-litre plastic jerry cans. Thermo, pH meters, and electrical conductivity meters were the equipment used to monitor the parameters such as temperature, pH, and electrical conductivity. The sampling containers were meticulously washed and labelled, and the physical samples were garnished to avoid interference. The on-site measurements were conducted to study brief alterations in the temperature, pH, and electrical conductivity. The samples of water were stored in a cold and dim place at first and then they were either treated or analyzed as early as possible so that the chance of biodegradation could be minimized. With the use of a mercury-filled surface thermometer encased in a metallic shell, this research managed to gauge the temperature of the surface water. Temperature is employed as a means of finding pollution sources, comparing water alkalinity, and measuring heat transfer in different water systems. Clearwater is a good bio-indicator of aquatic ecosystems and a vital component that controls the chemical and biological formation of these systems. The user has mentioned the APHA Method No 2250B. The water sample becomes the turbidity meter through light scattering and absorption due to suspended and colloidal matters like clay, silt, organic particles, and plankton. The results, thus, were evaluated as nephelometric units (NTU) in the application of the APHA Method No 2130B. Chemical Parameters The pH is a critical factor in water analysis as it influences the acidity alkalinity and some other procedures like coagulation, disinfection, and corrosion control. The choice of coagulants for water purification is crucial. The pH of a sample may be determined using either an electrometric or calorimetric method. Electrolyte is a form of substance, which convey electric current and it depends on the concentration of ions and other species. Freshwater usually is of conductance low 0 to 1,500 µS/cm while seawater on the other hand is normally of conductance more than 50,000 µS/cm. The study estimated the electrolyte conductivity by using the portable meter at 25°C. The research employed the APHA (2012) approach to the calculation of the amount of total dissolved solids (TDS) in a sample by the evaporation of the filtered samples at 180°C. The technique involves the filtration of the 100 mL of water sample, the evaporation, and drying of the filtrate. Next, the residue left is measured. Hard water contains calcium, magnesium, and polyvalent metals. The hardnes is the dependency of the concentration of calcium and magnesium ions, which is given as the amount of CaCO3 per liter. The situation, under such conditions, is to have a higher hardness than the one carbonates represent (called non-carbonate hardness then). If only organic compounds participate in hardness, the term would change to carbonate hardness. The research uses the APHA (2012) method that involves: Calcium is necessary from the nutritional point of view and for the plants and animals which grown in varieties of rock such as limestone, dolomite, and gypsum. The use of the APHA (2012) technique for the analysis of calcium hardness. Introduction of EDTA into a mixture of solutions of calcium and magnesium, calcium ions under alkaline conditions are then quantified, and then using a specific indicator for measuring the calcium is the stages of this procedure. The APHA (2012) method is the one chosen here, to calculate and present the calcium hardness, which is one of the variants of the hard water term. The method is carried out by dividing the sum of total out timber and sum of calcium timbers, by the level of calcium. This research did not omit the implementation of the APHA (2012) technique, the output was the measurement of alkalinity in a manner that the acid-content hydroxide- and carbonate ions can be taken into account. The nitrate-I will be converted into nitrate by the natural process of bacterial oxidation and capture it into the water body from the decaying of the organic pile up. It has the potential to infiltrate surface water via cesspools or chemical fertilizer facilities. Elevated concentrations may lead to eutrophication, proliferation of algae, and subsequent contamination. This research used the APHA (2012) methodology. Phosphate, a vital biological element, is necessary for the development of organisms and may enter water bodies via leaching, decomposition of organic waste, and human activities. An overabundance of phosphates, in addition to nitrates and potassium, may lead to the growth of excessive algae, the process of eutrophication, and the occurrence of secondary pollution. This research used the ammonium molybdate technique to quantify phosphates. Sulphates, which are often found in natural waters, may lead to gastrointestinal discomfort and add to the level of water hardness. Sulphur compounds, gypsum leaching, or industrial operations may give rise to their formation. This research used the APHA (2012) methodology. Chloride, a prominent negatively charged ion found in water, may have an impact on water hardness and flavor when present in significant amounts. This research used the APHA (2012) technique to determine the concentration of chloride ions by using a standardized solution of silver nitrate for titration. The reaction results in the formation of a white solid of silver chloride, whereas an excess of silver nitrate leads to the formation of a reddish-brown solid of silver chromate, which indicates the point at which the reaction is complete. Adequate levels of dissolved oxygen (DO) are essential for the survival of aquatic organisms and for maintaining water quality. Water is penetrated via the processes of absorption, aeration, and photosynthesis. The dissolved oxygen (DO) levels may be influenced by factors like as temperature, salinity, and the presence of organic materials. The research used the APHA (2012) methodology, which utilizes the Winkler technique to measure dissolved oxygen (DO), by stabilizing it with manganese sulphate and potassium iodide. Biological Oxygen Demand (BOD) is an essential factor used to evaluate the influence of effluents on aquatic ecosystems. It quantifies the oxygen consumption by microorganisms during the breakdown of organic materials in water. This research used the APHA (2012) technique to ascertain the Biological Oxygen Demand (BOD) by quantifying the reduction in Dissolved Oxygen (DO) levels in a sample that is kept at a temperature of 20°C for a duration of 5 days. The ultimate dissolved oxygen (DO) value is determined by comparing the original and final DO levels, taking into account any dilution that may have occurred. Excessive amounts of fluoride, a naturally occurring element in water, may lead to the development of fluorosis. Precise assessment of fluoride content is essential due to the increasing prevalence of fluorosis as a public health concern. The SPADNS technique is used for the quantification of fluoride content in water samples by the reaction of fluoride with zirconium-dye Lake. As the concentration of fluoride rises, the hue gets paler. The process is introducing SPADNS and zirconyl-acid reagent into a 50 mL water sample, then measuring the absorbance at 570 nm.

Site 1 **Site 2**

Fig. 1 (a,b). Images showcase the lake's current state and environment

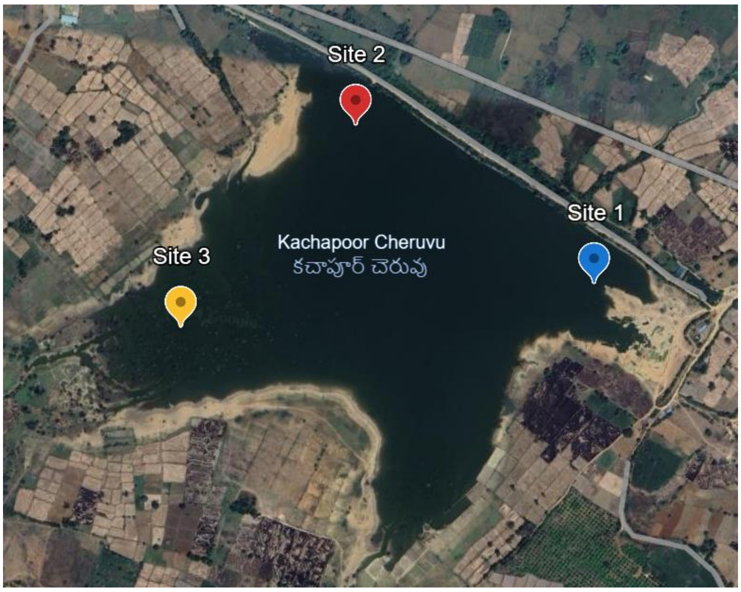

Fig. 2. Kachapoor lake google map landmark

Site 1: Heavy metal bioaccumulation in freshwater fish in Kachapoor Lake's complex ecosystem. One important point is that there are three different paths that meet the lake. We will concentrate on Route 1, which is close to the MSN Pharmaceuticals facility in Kamareddy. Notably, drug products have been shown to include trace metals such arsenic, cadmium, lead, and mercury. These elements are more likely to enter the manufacturing chain naturally. This presents a serious risk as the water from Route 1, which is richer with these trace metals, enters Kachapoor Lake's intricate ecology, perhaps having an impact on the environment and public health.

The fish population and the lake's natural biodiversity may suffer as a result of pharmaceutical businesses' waste. An important concern to aquatic ecosystems is the pharmaceutical waste that enters the lake through Route 1 and contains trace metals including arsenic, cadmium, lead, and mercury. These heavy metals have the ability to bioaccumulate in the tissues of freshwater fish, which may have detrimental consequences on the fish's health. The reproductive, physiological, and behavioural features of fish may be disrupted by exposure to such toxins, which might have an overall negative effect on their lifestyles. Furthermore, by upsetting the delicate balance of the lake's natural biodiversity, the discharge may have long-term ecological repercussions and impact other aquatic animals. Maintaining the health and sustainability of the aquatic life in the lake requires reducing the negative effects of pharmaceutical waste on freshwater ecosystems.

Site 2: The Kachapoor Lake natural habitat is further endangered by the existence of Cagial Poultry next to Route 2. In addition to the chemical injections used in poultry growth, the garbage from poultry industries adds other pollutants to the lake environment. The environmental damage is exacerbated when dead chickens are disposed of in the lake. The ecological balance of Kachapoor Lake may be threatened by this collective outflow from chicken operations along Route 2, which might affect the water quality. Poultry manure introduces organic debris and toxins that are hazardous to fish and other aquatic life. These introductions can have a domino effect on the lake's general health and biodiversity. The preservation and viability of the environment of Kachapoor Lake depend on addressing these numerous sources of contamination.

Site 3: Another area of concern is the proximity of agricultural fields to Route 3, which is where water flows into Kachapoor Lake. The ecology of the lake is at risk from fertilizer usage because runoff from farms can introduce too many nutrients into the water. This influx of nutrients may cause the lake to become eutrophic, which will encourage the excessive growth of algae and other aquatic plants. This might thereby lower the water's oxygen content, which would be harmful to fish and other aquatic life. The multiplicity of contaminants from Route 1 and the fertilizer runoff from farmland underscore the difficult task of preserving Kachapoor Lake's water quality. It is imperative to incorporate sustainable agriculture practices and watershed management measures to alleviate the detrimental impacts on the ecosystem of the lake.

Fertilizer usage in the agricultural areas around Route 3, where water finally empties into Kachapoor Lake, can have a significant impact on the aquatic ecosystems and native species in the lake. Although fertilizers are meant to promote agricultural development, they can also pollute water when runoff brings extra nutrients into lakes. The increased development of algae and aquatic plants caused by this nutrient inflow is referred to as eutrophication. Fish and other aquatic species at Kachapoor Lake suffer as a result of these plants' ongoing decomposition, which lowers oxygen levels in the water. The ecology of the lake may suffer from negative effects on its general health and biodiversity as a result of the disturbed ecological balance brought on by fertilizer-induced eutrophication. Maintaining Kachapoor Lake's delicate equilibrium requires addressing the effect of fertilizers on water quality.

3. RESULTS

The study investigates the physical and chemical parameters of water in Kachapoor Lake, a vital water resource in Kamareddy district, Telangana. These parameters, including temperature, turbidity, total dissolved solids, pH, dissolved oxygen, biochemical oxygen demand, nutrients, and heavy metals, determine the health and sustainability of aquatic ecosystems. Monitoring these parameters helps guide conservation and management efforts, as they affect aquatic life, biodiversity, water usability, and public health.

The study found no significant variation in temperature values between different months of the lake during 2021-2023. Turbidity values showed varying levels of variability in pre-monsoon season, with Site 1 showing the highest variability. Water turbidity (NTUs) and hydrogen ion concentration (pH) varied between sites, with the mean values at site 1 being 7.07±0.093, site 2 being 7.087±0.0242, and site 3 being 76.997±0.106. All samples were within acceptable ranges and safe for drinking and home use. No significant variation was observed in water pH values between different months.

The study of Kachapoor Lake from 2021 to 2023 assessed various water quality parameters. Total alkalinity ranged from 185.87 mg/L to 285.25 mg/L across seasons. Calcium concentrations were highest at 187.57 mg/L during the monsoon and lowest at 150.75 mg/L, with variations across sites. Calcium hardness peaked at Site 1 and decreased during the monsoon. Magnesium hardness and non-carbonate hardness increased from pre-monsoon to monsoon, with Site 3 showing the highest overall hardness. Potassium levels ranged from 2.85 mg/L to 5.75 mg/L, with no significant monthly variations. Fluoride and chloride levels were consistent with their typical ranges, while phosphorus levels were stable. Dissolved oxygen (DO) levels were within the 3 to 8 mg/L range, indicating good water quality. Correlation analysis showed temperature negatively correlated with turbidity and other factors but positively with sodium and chloride ions. Turbidity positively correlated with pH, conductivity, and other parameters.

Electroconductivity showed a strong positive correlation with alkalinity, non-carbohydrates hardness, TDS, calcium carbonates hardness, colour of the water, potassium ions, and BOD. The color of the water showed a significant positive correlation with TDS, alkalinity, Potassium ions, calcium carbonates hardness, non-carbohydrates hardness, and sulphate ions. The color of the water showed a strong negative correlation with DO, BOD, nitrate ions, chloride ions, sodium ions, and calcium carbonates. The water temperature at site 1 showed negative correlation with pH, EC, CACO3, and NCH, while positive correlations were observed with dissolved oxygen, BOD, Mg hrd, and fluoride. The turbidity of the water showed weak positive or negative correlation with all factors studied in the study area. The pH showed a significant strong positive correlation with EC, CaCo3 and NCH, while strong negative correlation with CaCo3. The correlation matrix between various water quality metrics at site 2 in Kachapoor Lake, Kamareddy district, Telangana state, recorded during 2021-2023. The results showed that temperature (TPP) was strongly positively correlated with Total Dissolved Solids (TDS), Calcium Carbonate Hardness (CaCO3), Non-Carbonate Hardness (NCH), and BOD (0.880), while negatively correlated with pH (-0.960), Turbidity (TRB), and Mg hrd (-0.911). Turbidity (TRB) was strongly positively correlated with PH (0.928) and F (0.954), while negatively correlated with EC (-0.980), Alk (-0.977), and TDS (-0.961). The physicochemical parameters of water samples during pre-monsoon in Kachapoor Lake, Kamareddy district, Telangana state, showed weak correlations with most parameters, indicating little to no strong relationship. Oxygen Demand (OD) was strongly positively correlated with Mg hrd and negatively correlated with Cl- (-0.946). Biochemical Oxygen Demand (BOD) was strongly positively correlated with TMP (0.880) and NCH, while Chemical Oxygen Demand (COD) was strongly positively correlated with Mg hrd and BOD. The study analysed the correlations among various physico-chemical parameters during the Monsoon season 2021-2023. The results showed that temperature (TMP) was weakly correlated with most parameters, while SO4- and BOD were positively correlated with most parameters. Turbidity (TRB) was also weakly correlated with most parameters, while PH positively correlated with Cl-, Colour, and Alk, but negatively correlated with Mg hrd and F. Electrical conductivity (EC) was strongly positively correlated with TDS, CH, and Colour, but negatively correlated with Mg hrd and F. Color was positively correlated with Alk, TDS, and Cl-, but negatively correlated with Mg hrd and F. Total Dissolved Solids (TDS) was positively correlated with EC, CH, and Colour, while negatively correlated with Mg hrd and F. Calcium carbonate hardness was positively correlated with NO3 and EC, while negatively correlated with Na+ and Mg hrd. Magnesium hardness was positively correlated with F and negatively correlated with EC, color, and TDS. Non-Carbonate Hardness was positively correlated with color, EC, and Alk, while negatively correlated with Mg hrd and F. Sulphate had weak correlations with most parameters, showing little to no strong relationship. Dissolved Oxygen (DO) was positively correlated with Na+ and F, while negatively correlated with

Cl- and BOD. Biochemical Oxygen Demand (BOD) was positively correlated with CH, NCH, and EC, while negatively correlated with Mg hrd and Na+. The study examined the correlation between physico-chemical parameters and heavy metal accumulation in fishes (*Lebeo rohita* and *Tilapia*) during the Post-Monsoon 2021-2023 period. The results show that turbidity, EC, TDS, Alk, CaCO3, Mg hrd, NCH, F, Cl-, and NO3 are strongly correlated with the accumulation of heavy metals in fishes.

The study also analyzed the phosphorus levels in Kachapoor Lake, a lake in Telangana State, India. Phosphore, a form of phosphorus, is found in soil, decomposing remains, and living forms. The study found no significant difference in phosphate values reported between different months of the lake. Seasonal variations of phosphate and sulphate values were observed at three study sites during the 2021-2023 period. Sulphate minerals, also known as heavy metal sulphides, are found in igneous, metamorphic, or sedimentary rocks and can be used to describe groundwater and can be eliminated by bacteria and gypsum precipitation. However, sulphate salts dissolve in water, leading to digestive problems and an unpleasant taste. Chloride values were significantly different between different months of the lake. The study found no significant difference in phosphate and sulphate values between different months of the lake. The study highlights the importance of understanding the physicochemical parameters of water samples at these sites and their potential impact on human health. The study analysed the correlation matrix between various water quality metrics at site 2 in Kachapoor Lake, Kamareddy district, Telangana state, recorded during 2021-2023. The correlation matrix showed strong positive and negative connections between several water quality metrics, illustrating how changes in one parameter may be connected with changes in another. The temperature (TPP) had a positive correlation with K+ (0.963), F (0.959), DO (0.947), and BOD (0.876), while negatively correlated with PH (0.916) and NCH (-0.871). Turbidity (TRB) had a substantial positive correlation with color (0.974), TDS (0.843), alkalinity (0.900), and chloride ions (0.955), but a strong negative correlation with NO3. PH significantly positively associated with Na+ (0.915) but significantly negatively correlated with CH (-0.834), K+ (-0.908), F (-0.900), and OD (0.897). Electrical conductivity (EC) positively correlated with color (0.667), TDS (0.630), and Alkalinity (0.706) and negatively correlated with NO3 (-0.640). The physicochemical parameters of water samples during pre monsoon in Kachapoor Lake, Kamareddy district, Telangana state, were analysed. The results showed that temperature (TPP) was strongly positively correlated with Total Dissolved Solids (TDS), Calcium Carbonate Hardness (CaCO3), Non-Carbonate Hardness (NCH), and BOD (0.880), while negatively correlated with pH (-0.960), Turbidity (TRB), and Mg hrd (-0.911). Turbidity (TRB) was also weakly correlated with most parameters, while PH positively correlated with Cl-, Colour, and Alk, but negatively correlated with Mg hrd and F. Electrical conductivity (EC) was strongly positively correlated with TDS, CH, and Colour, but negatively correlated with Mg hrd and F. Calcium carbonate hardness was positively correlated with NO3 and EC, while negatively correlated with Na+ and Mg hrd. Magnesium hardness was positively correlated with F and negatively correlated with EC, color, and TDS. Non-carbonate hardness was positively correlated with color, EC, and Alk, while negatively correlated with Mg hrd and F. Sulphate had weak correlations with most parameters, showing little to no strong relationship. Dissolved Oxygen (DO) was positively correlated with Na+ and F, while negatively correlated with Cl- and BOD. Biochemical Oxygen Demand (BOD) was positively correlated with CH, NCH, and EC, while negatively correlated with Mg hrd and Na+. The correlation matrix showed strong positive and negative correlations between several water quality parameters, indicating how changes in one parameter may be connected with changes in others. The findings suggest that water can get contaminated by trace metal quantities below detection limits, even though the concentrations are relatively low. The study investigates the concentration of heavy metals in various tissues of *Labeo rohita* in Kachapoor Lake, Kamareddy district, Telangana state. The liver consistently has the highest copper concentration across all seasons with minimal variability. The kidney has moderate copper levels with slight seasonal variation. The gills, muscle, and intestine show significant increases in copper concentration during winter, with higher variability compared to the liver and kidney. The muscle has the lowest concentration of arsenic with the largest variability, while the liver consistently has the highest concentration with the least variability throughout all seasons. Moderate quantities of arsenic, with some seasonal change, are found in the kidney, gills, and intestine. The liver consistently shows the highest concentrations of heavy metals across all seasons, likely due to its role in detoxifying and metabolizing substances, including heavy metals. Muscle tissue generally contains the lowest concentrations of heavy metals, which is important for human consumption. In summer, lead is highest in the liver (1.880 mg/kg), suggesting elevated exposure or accumulation during this period. Cadmium and zinc levels are similar, with the liver showing the highest concentrations (0.522 mg/kg). Copper levels are low compared to other metals, indicating minimal accumulation. Arsenic levels are highest in the liver and intestine, indicating potential seasonal increases or changes in environmental conditions. The study also examines the concentration of lead (Pb) in various tissues of 1 kg of *Tilapia* in different seasons. The liver shows the highest mean concentration of lead across all seasons, indicating its significant role in accumulating lead. The kidney has the second-highest mean concentration of lead, with a notable increase in winter. Gills show moderate lead accumulation, with similar levels across seasons. Muscle and intestine have the lowest lead concentrations, with minimal seasonal fluctuations. The study also assesses the concentrations of heavy metals (lead, cadmium, zinc, copper, and arsenic) in various tissues of 1 kg of *Tilapia* during three seasons (summer, monsoon, winter) in Kachapoor Lake, Kamareddy district, Telangana state. The liver consistently shows the highest concentration of arsenic across all seasons, with the kidney having relatively high concentrations. The gills, muscle, and intestine show relatively stable concentrations across seasons, with minor fluctuations. The liver of *Labeo rohita*, a fish species, consistently shows the highest concentrations of heavy metals across all seasons, indicating it is a primary site for metal accumulation. Seasonal variations indicate that heavy metal concentrations are generally highest in summer, with some decreases during the monsoon and slight increases in winter. This raises concerns about the potential health risks associated with consuming *Labeo rohita* from Kachapoor Lake due to elevated heavy metal levels. The study found that the liver, kidney gill, muscle intestine, lead, cadmium, zinc, copper, and arsenic were the most common heavy metals in *Labeo rohita* during the summer and winter periods. Lead concentrations are highest in the liver (1.418 mg/kg), followed by the kidney (0.546 mg/kg). The gills, muscle, and intestine have lower concentrations of lead, with the highest concentration in the gills during winter. Cadmium concentrations are highest in the liver (0.633 mg/kg), followed by the gills (0.395 mg/kg) and muscle (0.316 mg/kg). The kidney (0.261 mg/kg) and intestine have lower mean concentrations, reinforcing the liver's role as the primary accumulation site. The study also highlights the importance of nutrient availability in the diet of *Labeo rohita*, highlighting the need for improved nutrient availability in the diet. The liver of *Labeo rohita* accumulates primarily cadmium, with significant differences in concentrations across various tissues. This raises questions about environmental sources and potential implications for fish health and human consumption. The statistical analysis confirms that tissue type significantly affects cadmium concentrations, warranting further research into the environmental factors contributing to this accumulation and its implications for human health. The liver is the primary site for zinc accumulation in *Labeo rohita*, with the highest mean concentration of 1.048 mg/kg. Significant differences in zinc concentrations are observed among various tissues, as confirmed by the ANOVA results. The kidney also shows substantial zinc levels, while the gills, muscle, and intestine have lower concentrations. The presence of zinc in these fish highlights their nutritional value, but it also raises questions about environmental sources and potential health risks for consumers.

The liver, kidney, gills, muscle, and intestine of *Tilapia* fish collected from Kachapoor Lake, Kamareddy district, Telangana state, show significant differences in arsenic concentrations. The liver consistently accumulates the highest levels of lead across all seasons, followed by the kidney. The gills, muscle, and intestine show lower concentrations, with the muscle being the least affected.

The liver and kidney show the highest zinc levels across all seasons, with the liver generally having the highest values. The gills, muscle, and intestine exhibit much lower copper levels, indicating less accumulation in these tissues. The one-way ANOVA results demonstrate a statistically significant difference in copper concentrations among the different tissues, confirming that tissue type significantly affects copper retention in *Tilapia*. In conclusion, the liver, kidney, gills, muscle, and intestine of *Labeo rohita*, *Tilapia*, and other fish species in

Kachapoor Lake, Kamareddy district, Telangana state, are all significant sites for heavy metal accumulation. Monitoring and further research into the sources of arsenic and its implications for fish health and human consumption are warranted.

The study reveals that the liver is a primary site for lead accumulation in *Labeo rohita*, with concentrations ranging from 1.162±0.185 mg/kg in summer to 1.548±0.218 mg/kg in monsoon and 1.536±0.216 mg/kg in winter. Kidney, gills, muscle, and intestine showed moderate levels of lead, with the highest concentration in winter. The gills showed a notable increase in cadmium concentration from summer to winter, while the muscle had the lowest levels. Zinc concentrations were highest in the liver across all seasons, with the lowest concentration in summer and the highest in winter. Copper concentrations were highest in the liver, with the kidney, gills, and intestine having moderate levels. Arsenic concentrations were highest in the liver, particularly during winter, suggesting that the liver is a key organ for arsenic detoxification and storage in *Labeo rohita*. The study also reveals that *Labeo rohita* fish, taken from Kachapoor Lake, Kamareddy during the summer and monsoon periods, have moderate arsenic levels, with the muscle having the lowest concentrations. However, even the lowest arsenic concentrations observed in the muscle are notable, indicating a risk of arsenic exposure through consumption of the fish. Across all heavy metals, there is a noticeable trend of higher concentrations in the liver during winter, suggesting that seasonal factors may influence metal accumulation in fish tissues. The liver consistently shows the highest accumulation of all heavy metals, which is typical due to its role in detoxification. The kidney also plays a significant role, particularly in the accumulation of lead and cadmium. The study examines the concentration of heavy metals in various tissues of 2 kg of *Labeo rohita* in Kachapoor Lake, Kamareddy district, Telangana state. The liver consistently showed the highest copper concentration, with values of 1.032 in summer, 1.062 in monsoon, and 1.086 in winter. The kidney had a mean concentration of 0.243 ± 0.029, while the gill, muscle, and intestine tissues had lower concentrations. The standard deviations indicate variability, particularly in the gill and muscle tissues, which have the highest SD values. Overall, the data suggests that the liver accumulates the highest levels of copper across all seasons, while other tissues have significantly lower concentrations.

3.1 Eutrophication

The ecosystems of Kachapoor Lake is seriously threatened by eutrophication, a process that results in an excessive enrichment of nutrients in bodies of water. Understanding how elevated nutrient levels, especially those of nitrogen and phosphorus, promote algal blooms and upset the natural equilibrium of these aquatic habitats requires an understanding of the processes of eutrophication. The effects of eutrophication affect natural creatures and jeopardize fish livelihoods along these lakes' entire lengths. Algal overgrowth results from rising nutrition levels, which lowers oxygen levels and may cause fish deaths. To lessen the negative effects of eutrophication throughout Kachapoor Lake, an extensive analysis and focused interventions are required due to this cascading influence on the entire aquatic environment.

4. CONCLUSION

This research highlights the substantial influence of heavy metal bioaccumulation in freshwater fish, exposing extreme levels of pollution that provide severe hazards to both the environment and public welfare. The results underline the pressing need for increased public awareness about the ingestion of polluted fish and underscore the adverse impacts on the health and biodiversity of freshwater ecosystems. Existing mitigating measures, such as industrial rules and waste management programs, demonstrate limitations in adequately tackling these problems. Adopting more stringent environmental legislation, using advanced monitoring methods, and conducting new research on ecosystem restoration are crucial for enhancing results. Subsequent investigations should prioritize extended-term examinations of ecological resilience, novel approaches to pollution management, and sophisticated monitoring technology. It is imperative that governments, environmental agencies, and the general people actively participate in the implementation of these suggestions to protect the health of our world. Effectively managing bioaccumulation is essential to maintain the long-term viability of freshwater ecosystems and safeguard human health for future generations.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Moss B. Ecology of fresh waters: A view for the twenty-first century. Wiley-Blackwell; 2010.
2. Dudgeon D. Tropical stream ecology. Academic Press; 2010.
3. Sommer TR et al. The response of fish populations to limnological features of lakes and reservoirs. Environmental Biology of Fishes; 1993.
4. Boulton AJ, et al. Freshwater biodiversity: Importance, threats, status and conservation challenges. Biological Reviews; 2008.
5. Yasmin F, Hossain T, Shahrukh S, Hossain ME, Sultana GNN. Evaluation of seasonal changes in physicochemical and bacteriological parameters of Gomti River in Bangladesh. Environmental and Sustainability Indicators. 2023;17 :100224.
6. Dodds WK, Whiles MR. Freshwater ecology: Concepts and environmental applications.Academic Press; 2010.
7. Smith VH. Eutrophication of freshwater and coastal marine ecosystems. Environmental Science & Policy; 2003.
8. Bartram J, Balance R. Water Quality Monitoring: A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes. UNEP/WHO; 1996.
9. Chapman D. (Ed.). Water quality assessments: A guide to the use of biota, sediments and water in environmental monitoring. CRC Press; 1996.
10. Horne AJ, Goldman CR. Limnology, 2nd Edition. McGraw-Hill; 1994.
11. Likens GE. (Ed.). Encyclopedia of Inland Waters. Elsevier; 2009.
12. Cole JJ. Aquatic Ecology. Academic Press; 1994.
13. Allan JD, Castillo MM. Stream ecology: Structure and function of running waters. Springer; 2007.
14. Hauer FR, Lamberti GA. (Eds.). Methods in stream ecology. Academic Press; 2007.
15. Schindler DW. Recent advances in the understanding and management of eutrophication. Limnology and Oceanography; 2006.
16. Wetzel RG, Likens GE. Limnological analyses, 3rd Edition. Springer; 2000.
17. Margalef R. Limnology now: A paradigm of planetary problems. Elsevier; 1983.
18. Lewis WM. Basis for the protection and management of tropical lakes. Lakes & Reservoirs: Research and Management; 2000.
19. Søndergaard M et al. (Eds.). Lake and Reservoir Management. Developments in WaterScience, Elsevier; 2005.
20. Thornton KW et al. Perspectives on Reservoir Limnology. Wiley-Interscience; 1990.
21. Hammer MJ. Water and Waste-Water Technology. Wiley; 1986.
22. Stumm W, Morgan JJ. Aquatic chemistry: Chemical equilibria and rates in natural waters. Wiley-Interscience; 1996.
23. Paul MJ, Meyer JL. Streams in the Urban Landscape. Annual Review of Ecology andSystematics; 2001.
24. Jones JR, Bachmann RW. Prediction of phosphorus and chlorophyll levels in lakes. Journal of the Water Pollution Control Federation; 1976.
25. Fergusson J.E. The heavy elements: Chemistry, environmental impact and health effects.Pergamon Press; 1990.
26. US. EPA (United States Environmental Protection Agency). Guidelines for Water Reuse; 2002. EPA/625/R-0.
27. Wetzel RG. Limnology: Lake and River Ecosystems. Academic Press; 2001.
28. APHA (American Public Health Association). Standard methods for the examination of water and wastewater; 2017.
29. Boyd CE. Water quality: An introduction. Springer; 2015.

30. Talling JF, Lemoalle J. Ecological dynamics of tropical inland waters. CambridgeUniversity Press; 1998.
31. Kalff J. Limnology: Inland water ecosystems. Prentice Hall; 2002.

Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.mbimph.com/review-history/4043