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ASSESSMENT OF PHYSIOCHEMICAL, HEAVY METALS, AND BIOLOGICAL CHARACTERISTIC OF BELLANDUR LAKE WATER BODIES IN KARNATAKA

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Abstract
The significance of water in lakes goes well beyond being just a liquid; it plays a crucial role in temperature regulation, supports aquatic ecosystems, and enables vital processes such as nutrient cycling. The study provides an in-depth examination of the lake's physical, chemical, and biological parameters in Karnataka, India, including Bellandur Lake, highlighting its overall health and pollution levels. The analysis of water quality parameters indicates differing conditions and varying degrees of pollution within these freshwater ecosystems. While specific parameters, such as pH and faecal coliform counts, meet acceptable standards, others point to potential environmental concerns, including high levels of turbidity, total dissolved solids, and chemical oxygen demand. Moreover, the presence of unpleasant odours and disagreeable tastes further emphasizes the influence of pollution sources on the sensory qualities of the water. The findings reveal the unique characteristics of heavy metal presence in Bellandur Lake, suggesting potential mineral enrichment and contamination sources in the other. The fluctuating levels of faecal coliform highlight the need for ongoing monitoring and management. This research emphasizes the urgency of adopting remedial measures to improve water quality and maintain the ecological balance of these lakes. Continuous vigilance and proactive measures are crucial to reducing pollution risks and ensuring the long-term sustainability of the region's freshwater reservoirs.

Keywords: Water; Physiochemical; Heavy metals; Biological Characteristic; Bellandur lake.

1. INTRODUCTION

Among all the resources accessible to humanity, water holds a position of utmost importance. The necessity of conserving water bodies, particularly freshwater sources, is being increasingly recognized worldwide, as water is crucial for sustaining life. Seventy-one per cent of the Earth's surface is covered by water, earning it the nickname "blue planet." However, most of this water is saline, making freshwater incredibly scarce and valuable. Freshwater exists primarily in groundwater, ice, snow, glaciers, and snowfields, comprising only about 2.5% of the Earth's total water. This freshwater is found in moist soil, seas, lakes, and flowing streams. A concern about global water scarcity has emerged, with water being considered a potential cause of future conflicts, particularly in developing nations. According to 2006 data from the WHO, around 36% of urban Indians lack access to safe drinking water, and the situation is even more dire in rural areas, where approximately 65% of the population faces the same issue [3]. As we all know, life is not possible without water, especially freshwater resources. Good-quality potable water is essential for various sectors, including agriculture, industry, and commerce. Access to water was a key factor for the first settlers, and this remains true today. The history of public water supply demonstrates that its expansion is closely tied to the growth of urban environments [1].

Although the Earth is covered with water on and beneath its surface, only a tiny fraction-around one per cent is fresh and potable. Most of the Earth's water, approximately 1.4 billion cubic kilometres (326 million cubic miles), is found in the seas or ice in glaciers and polar caps. The solids dissolved in the ocean water are approximately 35 g per liter (4.5 ounces

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per gallon). For these reasons, it cannot be used in agriculture or industry and is not edible for human beings. While the water is abundant, there is strong evidence that it is not available where and when it is required most. This means that high-quality water in many areas is scarce due to the increased city and industrial development rate and the pollution that comes with it. As the population and economic growth are rapidly growing, India stands before the significant problem of scarcity of water resources among all natural resources. As for the case of most freshwater bodies worldwide, their water quality has been degraded by pollution. Water in its various phases: oceans, seas, rivers, lakes, clouds, rain, snow, fogs, etc. is indispensable to life of any type. Water pollution has become a significant issue as population growth and advancements in agriculture, urbanization, and industrialization have limited freshwater sources. He pointed out that the shortage of this vital resource is significant in many regions of the Earth. Most wastewater undergoes little or no treatment and is dis charged into water bodies such as rivers, lakes, and estuaries. In addition to their crucial role as water reservoirs, lakes serve many other functions in Earth's biosphere: they are habitats for flora and fauna, help stabilize the microclimate, enhance the landscape's beauty, and provide countless recreational opportunities for people. Contributing to their persistence, heavy metals are relatively non-volatile and can bioconcentrate from water and sediments. Additionally, they can bio-magnify through the food chain, making heavy metals one of the most significant threats among all pollutants [2].

This study focuses on assessing the water quality of Bellandur Lake in Bangalore, Karnataka, India. The aim was to gather information on the contamination status of the lake, including physicochemical contamination and the presence of selected heavy metals.

2. STUDY AREA

Bangalore, the capital of Karnataka, is over 400 years old. The city was founded by the late Magadi Kempegowda in 1537. Bangalore is the state's capital today and is a major cultural, economic, administrative, and industrial hub. Bangalore, located in southern India, sits 920 meters above mean sea level. Geographically, it lies at a latitude of 12° 95' north and a longitude of 77° 57' east. The city experiences a temperate climate, making the weather favourable throughout the year. The growth in population, particularly among working-age individuals, can be attributed to the infrastructural developments that accompanied the rise of the software industry in the early 1990s. As a result, the city has earned the title of the "Silicon Valley of India," the country's leading exporter of IT services [4]. Bangalore had a population of 16,391 at the start of the twentieth century (1901), and by 2001, this number had grown to 5,686,844. The city's population density of 11,000 people per square kilometre reached 8,425,970, according to the preliminary reports of the 2011 Census of India. According to recorded history and traditions, the Kempe Gowdas, who first established Bangalore, constructed the city's initial tanks with the help of bunds. These bunds were created by blocking the natural valley systems in the area. In addition to enhancing the city's aesthetic appeal, most of the lakes and tanks were artificial to meet the needs of irrigation, water supply, and fishing. In ancient Indian culture, the water from these lakes was also used as "Dhobi Ghats," where clothes were washed and sun-dried by dhobis, or washermen. The lakes have also contributed to replenishing the water sources, such as wells, that people in the surrounding areas depend on for their water supply. Unfortunately, the lakes typically seen in Bangalore have fallen victim to urban development. This vast reserve is the largest in Bangalore, covering an area of 892 acres. Located at 12°58' north latitude and 77°35' east longitude, the dam sits 921 meters above mean sea level. It has a catchment area of 287.33 square kilometres and an extent of 110.94 square miles. Bellandur Lake spans over 3 km in length and 2.75 km in width, with a storage capacity of 17.66 million cubic feet. Located about 20 km southeast of Bangalore in a notable bio-geographical isolated region, it is one of the largest artificial lakes in Southeast Asia. Bellandur Lake once symbolized Bangalore's beautiful and healthy water supply. The lake's aquatic life functioned as a natural treatment plant for the storm runoff that accumulated there. In this sense, Bellandur Lake acted as the city's organ, preventing the bioaccumulation of organic waste. Indeed, the lake was home to a remarkable diversity of animals and aquatic life, attracting migratory birds from across the country. In addition to being a historic hub for the fish trade, the lake served as a crucial source of drinking water for half of the city's population. In other words, the area surrounding Bellandur Lake in Bangalore was a sensitive and fragile ecosystem. The Bellandur Lake is part of the broader Bellandur drainage system, which drains the southern and southeastern parts of the city. The current Bellandur Lake can be seen as a receptor for three generations of tanks. The eastern stream, originating from the northern end near Jayamahal, drains the entire eastern area. Another significant network is the central stream, historically located in the centre of the city's transportation maps, particularly around the K.R. Market area. This stream extends into the middle part of the city, playing a key role in the drainage system. The second chain is the western stream, which flows through the southwest and ultimately drains into Bellandur Lake. Further down the plateau, water from the Varthur Lake, located to the east, flows into the Pinakani River basin. As far back as three decades ago, eighteen different villages relied on the water from Bellandur Lake for their sustenance. The supplying tanks of Bellandur Lake suffered from link breakage in the 1980s due to urbanization. As a result of this chain failure and unchecked commercial, residential, and industrial expansion, the lake no longer collected sufficient rainwater. Instead, it became overloaded with water containing untreated sewage and effluents. The reduced fish population in the lake led to problems for fishermen and other aquatic life. In the 1990s, some property near the lake was designated as a bike route. Bangalore's IT boom also rose during this time, contributing to rapid urbanization. Recently, weeds have invaded a large portion of Bellandur Lake. The water has become opaque and dark in colour, accompanied by a foul smell. It is important to note that most birds once inhabited the area are now rarely seen. The significant foaming at the outflows suggests that effluents are downstream of the lake. Exploration of the lake has primarily focused on the levels of physicochemical parameters, and some selected heavy metals [5-6].

3. METHODS AND MATERIALS

The water samples from Bellandur Lake were collected in December 2024 and will be used in subsequent calculations by researchers. Water samples from the lake were collected using the grab sampling method with a 500 ml polyethene bottle. The collected samples were promptly delivered to the analytical laboratory for testing. The analytical laboratory promptly received all collected samples, initiating analysis without delay. Some of the heavy metals, along with various physicochemical parameters, were analyzed using standard methods. The Color and temperature were recorded on the spot.

4. RESULTS AND DISCUSSION

Water temperature is important because it determines the metabolic processes organisms in water can undergo. In water, the rate of chemical reactions increases with temperature while the solubility of gases decreases. Additionally, flavours and odours intensify as the temperature rises. The water temperature ranged between 24.2 and 24.4 ^{o} C. Due to the abundance of weeds and algae, the current investigation found that the lake water had a brownish-black tint. Turbidity refers to the measure of how cloudy or murky the water appears. In simple terms, water appears turbid when particles are suspended in it. Various factors contribute to turbidity, including tiny animals and plants, organic matter, fine sand particles, small clay particles, and plankton. Turbidity is recognized as a limiting factor in the biological productivity of water bodies. In this investigation, turbidity values were recorded at 14.89 NTU. This exceeds the acceptable consumer limit below 5 NTU across all sites examined. The electrical conductivity of water is influenced by the total dissolved solids present. According to international drinking water quality standards set by the World Health Organization, the electrical conductivity of drinking water should not exceed 500 µS/cm. Total dissolved solids (TDS) are a critical criterion for assessing potable water quality, as they directly influence its suitability for consumption. TDS contributes a distinct taste to water; at higher concentrations, it can render the water unpleasant to drink. Daily water consumption containing more than 450-500 mg/L of TDS may lead to gastrointestinal discomfort. Typically, high TDS levels impart a repulsive taste that dominates the sensory perception of the water. Additionally, elevated TDS levels are associated with the apparent hardness of water, often leading to precipitation within pipes, plumbing fixtures, water valves, and filters. The findings from this research indicate that the TDS levels significantly exceed the BIS-prescribed limit of 765 mg/L. The Bureau of Indian Standards (BIS) recommends a working pH range of 6.0 to 8.7 for most applications, sectors, and industries, along with other probable maximum contaminant levels for water quality. The pH of the water samples analyzed in this study ranged from 7.56 to 7.58, falling within the acceptable range prescribed by BIS standards. Additionally, the total hardness of all sampling sites was tested and found to comply with the BIS standard, measuring 235.4 mg/L. According to BIS standards, the calcium hardness was measured at 53.98 mg/L in the sample, within the permissible limit [7-8]. Similarly, magnesium hardness at these locations was recorded at 29.32 mg/L, meeting the acceptable standards. If hardness levels increase significantly, such as forming encrustations in water delivery systems, it can produce undesirable effects on domestic water usage. According to BIS standards, sampling points with alkalinity levels exceeding 457.21 mg/L are considered safe and ideal. Excessive alkalinity can negatively affect food taste, which can be particularly problematic when preparing food products. In this study, the permissible limit set by the BIS standard was exceeded, as sulfate levels were found to be 52.43 mg/L. Additionally, dissolved oxygen plays a crucial role in influencing nitrate content, as it is affected by the activity of nitrifying bacteria in the water. In this research, nitrate levels ranged from 12.61 mg/L, exceeding the recommended limit set by BIS standards. Such elevated nitrate levels can potentially lead to health issues like methemoglobinemia, commonly known as blue baby syndrome. The high nitrate concentration could be attributed to the lake's evaporation, which concentrates nutrients, decaying macrophytes and increased phytoplankton production. Chloride levels were within the recommended range at the sample stations according to the BIS standard, at 183.4 mg/L. The phosphate concentration was recorded at 6.7 mg/L. According to the BIS standard, the fluoride concentration at the sample site is 5.2 mg/L, above the allowable limit. An increase in dissolved oxygen concentrations to about 4.9 mg/L is likely due to effluent discharge, which introduces oxidizable organic matter. This organic matter consumes dissolved oxygen through biochemical oxygen demand (BOD) processes and vegetation degradation, especially at higher temperatures. Biomass can thrive and sustain itself only when dissolved oxygen concentrations reach at least 4-5 mg/L, while fish risk dying when concentrations drop to or remain below 2-3 mg/L. Therefore, it is recommended to use more environmentally safe and efficient materials in construction to prevent oxygen concentrations from falling below specified levels. Wastewater typically has low dissolved oxygen content, and while previous studies using ICMR standards may have detected higher DO levels, the levels observed in this study are lower. Biomass can thrive and sustain itself only when dissolved oxygen concentrations reach at least 4-5 mg/L, while fish risk dying when concentrations drop to or remain below 2-5 mg/L. Therefore, it is recommended that more environmentally safe and efficient materials be used in construction to prevent oxygen concentrations from falling below specified levels. Wastewater typically has low dissolved oxygen content, and while previous studies using ICMR standards may have detected higher DO levels, the levels observed in this study are lower. The reduction in dissolved oxygen levels can be attributed to the high biochemical oxygen demand (BOD) readings, which were above the recommended 5.0 mg/L according to ICMR standards. The chemical oxygen demand (COD) value was also 72.56 mg/L. The COD test measures the amount of oxygen required to neutralize all reagents in the water, including non-biodegradable ones, indicating the extent of pollution and the potential impact on water quality. COD is a key parameter for evaluating the overall pollution level of water. As the concentration of organic materials rises, the COD of the water also increases. Research in this area found that the iron levels in the analyzed lake water samples were 1.5 mg/L, exceeding the permissible limit of 1.0 mg/L and the desirable limit of 0.3 mg/L. This excess iron can result in undesirable taste and appearance of the water, promote the growth of iron bacteria, and negatively impact water supply structures and domestic usage. Nickel concentrations ranging from 0.1 mg/L exceed the BIS standard of 0.02 mg/L, posing a risk of allergic reactions. Similarly, chromium concentrations between 0.06 mg/L surpass the BIS standard of 0.05 mg/L, with higher carcinogenic levels. The measured copper concentrations, ranging from 0.08 mg/L, exceed the permissible BIS limit of 0.05 mg/L. Copper levels above this threshold can cause side effects such as discolouration, corrosion, and an unpleasant taste in food and beverages. Additionally, the BIS standard sets the acceptable dissolved lead limit at 0.01 mg/L. However, within the observed range of 0.04 to 0.08 mg/L, lead in water becomes hazardous. Zinc and Arsenic were absent in the sample collection [9-10].

Table 1: Characteristics of Lake water.

Sample Parameters	Bellandur Lake sample
T (°C)	24.2
pH	7.56
Colour	Brownish Black
EC	1132
Turbidity	14.89
Total hardness (mg/l)	235.4
TDS (mg/l)	765
DO (mg/l)	4.9
COD (mg/l)	72.56
BOD (mg/l)	25.42
Mg^{+2} (mg/l)	29.32
Alkalinity (mg/l)	457.21
Ca^{+2} (mg/l)	53.98
Cl- (mg/l)	183.4
SO_4^{-2} (mg/l)	52.43
$PO4^{-3}$ (mg/l)	6.7
NO_3^- (mg/l)	12.61
F- (mg/l)	5.2
Pb_{+2} (mg/l)	0.12
Cd_{+2} (mg/l)	0.4
Fe_{+2} (mg/l)	1.5
Ar_{+2} (mg/l)	0
Zn_{+2} (mg/l)	0
Cu_{+2} (mg/l)	0.08
Cr_{+2} (mg/l)	0.03
Ni_{+2} (mg/l)	0.1

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CONFLICT OF INTERESTS
No conflicts of interests were disclosed.

5. CONCLUSION

Based on the findings of this study, it can be concluded that the lake water quality exhibits significant deviations from standard guidelines. Turbidity and electrical conductivity exceed the permissible limits recommended by BIS and WHO, respectively. TDS are above the desirable limit but remain within the permissible range per BIS standards. At specific sampling points, hardness and nitrate concentrations surpass the desirable limits, while alkalinity and fluoride levels exceed permissible limits according to BIS standards. Dissolved oxygen levels fall below ICMR recommendations, and elevated values of BOD and COD indicate higher organic pollution. While iron is a significant contaminant, other heavy metals such as zinc, cadmium, nickel, chromium, copper, and lead were detected in a few samples, raising concerns about localized pollution hotspots.

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