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Seasonal Dynamics of Physico-Chemical Parameters and Heavy Metal Pollution in Bandra Lake, Mumbai: A 30-Day Interval Assessment

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Abstract: *The primary physico-chemical water pollution metrics in Bandra Talao, Mumbai, India, are the Assessment of pH, conductance, total dissolved solids (TDS), turbidity, biochemical oxygen demand (BOD), and total hardness. Water samples were carefully collected before and after three distinct seasonal periods to evaluate temporal changes and the impact of anthropogenic and environmental factors on water quality. Although there were notable fluctuations in all the observed measures, overall trends indicated improvements in Conductance, TDS, Turbidity, BOD, and Total Hardness after each season, suggesting a reduction in the pollution load and better water clarity. The findings demonstrate that maintaining Bandra Talao's ecological health and ensuring its sustainability as an urban water source requires regular monitoring and effective Management Strategies. This study provides helpful baseline data for Governments and Environmental Organizations trying to address the issues of water pollution in urban lakes.*

Keywords: Bandra Talao, Water Quality, Physical and Chemical factors, and Water pollution.

I. INTRODUCTION

It is believed that water, the essential component of life, is a medium required for the formation and upkeep of life (Anil K Dwivedi 2017). As the population grows, there is an increasing need for water (Postel et al., 1997). Policymakers are paying increasing attention to sustainable development, which meets human needs without exceeding the Planet's long-term carrying capacity (Ganesh Ji 2024). When contaminants enter water bodies directly or indirectly and are not appropriately cleaned to remove potentially harmful compounds, the environment suffers (Dr. A. Royal et al., 2018). Globally, the deterioration of water quality is a serious issue. This happens because of the massive amount of raw sewage that mixes with surface water (Lingshi et al., 2019). Globally, the deterioration of water quality is a serious issue. This happens because of the massive amount of raw sewage that mixes with surface water (Y. Wadaet al., 2016). For human survival, the world's water resources must be managed because they are under stress. It is necessary to have information to make sensible decisions that will benefit people as much as possible. Therefore, accurate and trustworthy information about the water resource system may be beneficial for resource management plans. India has long relied on lakes and ponds as a traditional source of water. However, sewage outlets, solid waste, detergents, car oil waste, fishing grounds, and agricultural pesticides from farmlands are the primary sources of pollution in ponds, lakes, and rivers (Prabhu et al., 2015 and Bhuiyan, S. Gupta 2007).

To implement appropriate policies and programs to measure the amount of pollution in lake water caused by dangerous heavy metals, assess the effectiveness of current pollution control measures, determine the type and extent of pollution control that is required, plan out pollution control strategies, and logically prioritize them, the study's objectives were to gather pollution load data from standard scientific research (P. U. Singare et al., 2013).

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II. MATERIALS AND METHODS:

The field of study: Mumbai, the Commercial and Capital of Maharashtra, is situated on India's western coast and spans 437.71 square kilometers. There are roughly 20.7 million residents there (Census, 2011) . In addition to its practical application, the "talao" has cultural and environmental significance. The widespread usage of rainwater collection systems in the region promotes environmentally responsible methods of managing water resources. Due to its convenient location close to Bandra Station, it is also well-liked by people looking for a break from the bustle of the city (https://www.knocksense.com).

A Grade II historic property, the lake was formerly known as Lotus Tank. "Motha Sarovar" was another name for the lake. This total area is seven and a half acres. This lake offered fishing and paddle boat rentals in the 1990s. The lake was also known as "Motha Sarovar" and was built 200 years ago by a wealthy Muslim Konkani from the nearby village of Navpada (Census, 2011).

III. WATER CONSERVATION AND COLLECTION:

At Bandra Talao, water sampling entails gathering water from numerous representative locations from the lake to precisely evaluate its quality, particularly considering the lake's ongoing repair and pollution issues. Samples were taken in clean, contamination-free containers, and each sample's location was meticulously noted. Temperature and pH are important factors were assessed on-site soon after collection because they might vary rapidly. Water samples are frequently filtered and acidified with a few drops of strong nitric acid for chemical analysis, particularly for heavy metals, to maintain sample integrity until laboratory testing.

Water samples were labelled with all pertinent information after collection and preservation. They were delivered to the lab in a cold environment, preferably within a day, to avoid compositional changes. This procedure guaranteed that the Bandra Talao samples appropriately represent the water quality of the lake, offering trustworthy information for continuous pollution monitoring, environmental management, and restoration projects.

IV. PHYSICOCHEMICAL ANALYSIS:

1. Temperature: Since temperature directly affects pH and dissolved oxygen (DO) and controls the river's ability to purify itself, it is crucial to the research of water quality (Saikh et al., 2003). Organisms' biological and metabolic processes are influenced by the temperature of the water; greater temperatures cause these processes to rise, which in turn requires more oxygen for respiration (Watzel, et a., 2001).

2. pH: Both biotic and abiotic biological systems depend on pH for growth, maintenance, and management. pH is a measure of water corrosiveness and has a negative correlation with pH. Everybody's water has a different pH throughout the year due to a few factors that either directly or indirectly affect the pH value as the seasons change (Ishaq, F. & Khan 2013 and E.O. Lawson 2015).

3. Conductance: The quantity of ions in water can be easily estimated using its electrical conductivity (EC). Increased conduct is a sign of a higher ion concentration and vice versa. Anions and cations are two types of ions. TDS and EC have a link and are complementary to each other (Pratap et al., 2018).

4. Total dissolved solids: TDS, is the measurement of all soluble substances, organic compounds, and inorganic salts found in a body of water (Weber-Scannell 2007). The main constituents of TDS are often Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, SO_4^{2-}, Cl^{-}, HCO^{3-}, and so forth. The acceptable range is 500 mg/L (Indian Standard for Drinking Water 2012).

5. Turbidity: A measure of the purity and clarity of any body of water [20]. To restrict light penetration and control the rate at which plants in water carry out photosynthesis, water turbidity is essential (Vishal et al., 2019).

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6. Biological Oxygen Demand (BOD): Similar to DO, BOD is a crucial metric for evaluating water contamination. There are more organic contaminants in the body of water when the BOD value is greater (Miroslav et al., 2006).

The water quality has been categorized as follows based on a five-day BOD test. BOD levels are classified as extremely clean if they are less than 1 mg/L, clean if they are between 1.1 and 1.9 mg/L, moderately polluted if they are between 2 and 2.9 mg/L, polluted if they are between 3 and 3.9 mg/L, very polluted if they are between 4 and 10 mg/L, and extremely polluted if they are more than 10 mg/L (Keith et al., 2002).

7. Total Hardness of Water: "Water hardness" refers to the concentration of calcium and magnesium salts in the water. Normal freshwater typically contains very tiny amounts of other cations, which also contribute to the overall hardness of the water. The amount of calcium carbonate ($CaCO_3$) in the water is often measured using commercially available test kits to evaluate its hardness. The words parts per million (ppm) or milligrams per liter (mg/liter) are frequently used in water quality reports to denote the hardness levels (M. H. Saier Jr. & J. T. Trevors 2010).

V. THE PURPOSE OF PHYTOREMEDIATION:

Phytoremediation is a low-cost, environmentally safe technique that uses plants and allied microorganisms to remove or detoxify heavy metals and other harmful compounds from soil and water. Vacuolar sequestration, oxidation, chelation, and enzymatic reduction are some of the ways that plants might absorb, store, or alter toxins. Hyperaccumulator species can concentrate lead, cadmium, and mercury well above normal levels, which offers benefits for both therapy and protection. This eco-friendly process produces useful biomass and helps with environmental restoration, even though it takes time and is influenced by environmental conditions. Phytoremediation has greater potential for large-scale pollution control now that genetic engineering has enhanced plant detoxifying capacities.

VI. ABOUT WATER MIMOSA (NEPTUNIA OLERACEA):

Aquatic plants are natural candidates for detoxifying contaminated soil and water, as they accumulate heavy metals in their tissues (Shukla et al., 2019). In the last five decades, the pantropical mimosoid legume genus Neptunia has sparked tremendous interest, primarily due to the aquatic habitat of several of its members (Bhunia, et al., 2012). The water mimosa (*Neptunia oleracea Lour*.) is an invasive and aggressive aquatic plant unique to Southeastern Asia, tropical Africa, and India (Visoottivisethe et al., 2002). *N. oleracea* has been widely used to decontaminate or reduce toxins in seas surrounding certain Asian countries, including Malaysia, Thailand, Indonesia, the Philippines, and Vietnam (Wahab et al., 2018). *N. oleracea* is suitable for phytoremediation because of its short life cycle and easy growth, making it appropriate for planting in contaminated water areas (Anokhina et al., 2004). A summary of research on water mimosa. Water mimosa effectively removes soluble solids and reduces both BOD and COD (Veschasit et al., 2013). Water mimosa can acquire heavy metals like lead (Pb), copper (Cu), cadmium (Cd), and zinc (Zn), and it is particularly good at accumulating Cd and Cu. Heavy metals are primarily collected in the roots, with lower quantities seen in the stems and leaves (Mishra et al., 2008). *Neptunia oleracea*, or water mimosa, is a wetland plant capable of removing metals from contaminated water (Veschasit et al., 2013 and Mishra et al., 2008).

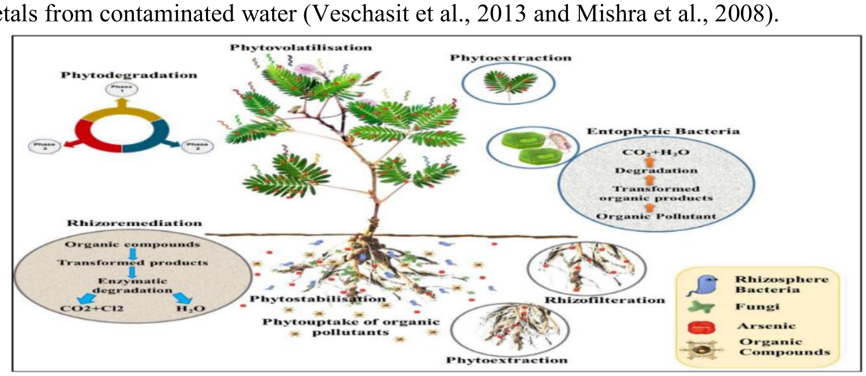

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FIG 1: Methods for phytoremediation. The interactions between pollutants and the rhizosphere of plants are the foundation of phytoremediation technology. Metals in the rhizosphere are absorbed by plants. Through mobilization, roots absorb heavy metals. The collected metals are then moved to the aerial tissues of the plants, where they are sequestered in accordance with the plants' tolerance, modified from (Narges et al., 2020, Prabakaran et al., 2016 and Oniosun et al., 2019).

VII. RESULTS AND DISCUSSION: (PHYSICO CHEMICAL PARAMETERS)

TABLE **1, 2**, and **3** show the physical-chemical characteristics of Bandra Talao in the rainy, winter, and summer seasons, respectively.

Season 1 (Rainy) (TABLE - 1)

Sr no	Parameters	Season 1 Before (Phytoremediation)	Season 1 After (30 days) (Phytoremediation)
1.	Temperature	27.4 oC	27.4 oC
2.	Colour	Light green	Light green
3.	Odour	Bad odour unpleasant	Bad odour unpleasant
4.	pH	6.37	7
5.	Conductance (µs)	503.1	502.2
6.	Total dissolved solid (ppm)	1000	835
7.	Turbidity (NTU)	235	134
8.	Calcium(mg/lit)	125	59.18
9.	BOD (mg/lit)	218	119
10.	Total hardness of water (mg/lit)	330	317

Before and after Season 1, there was a noticeable improvement in the Bandra Talao water quality metrics. The temperature remained constant at 27.4°C, but the pH increased from 6.35 to 7, suggesting a shift towards neutral conditions. Conductance reduced from 503.1 to 502.2 µS and total dissolved solids declined from 1000 to 835 ppm due

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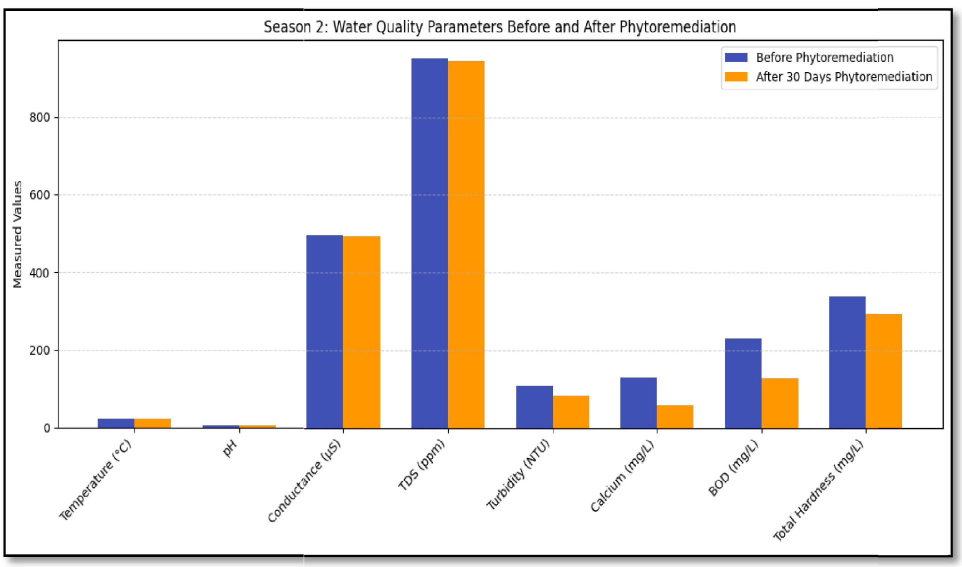
to fewer dissolved ions and better water clarity. While turbidity improved from 235 to 134 NTU, the biochemical oxygen demand (BOD) decreased from 218 to 119 mg/lit, indicating reduced organic pollution. The total hardness dropped from 330 to 317 mg/lit, indicating a decrease in mineral content. Given the circumstances, these changes imply that after Season 1, Bandra Talao's water quality increased.

Season 2 (Winter) (TABLE - 2)

Sr no	Parameters	Season 2 Before (Phytoremediation)	Season 2 After (30 days) (Phytoremediation)
1.	Temperature	24.7 ^{o}C	24.7 ^{o}C
2.	Colour	Light green	Light green
3.	Odour	Bad odour unpleasant	Bad odour unpleasant
4.	pH	7.37	7.5
5.	Conductance (µs)	494.5	493.5
6.	Total dissolved solid (ppm)	950	943
7.	Turbidity (NTU)	108	83.5
8.	Calcium(mg/lit)	130	60.25
9.	BOD (mg/lit)	230	128
10.	Total hardness of water (mg/lit)	340	295



Prior to and following Season 2, Bandra Talao's water quality metrics showed improvements. The temperature remained constant at 24.7°C. The pH decreased slightly but remained neutral from 7.37 to 6.81. The conductance decreased from 494.5 to 493.5 µS, indicating a decrease in dissolved ions. Total dissolved solids significantly decreased from 950 to 943 ppm, indicating improved water clarity. When the turbidity rose slightly from 108 to 83.5 NTU, the water seemed clearer. A decrease in organic pollutants is shown by a decline in biochemical oxygen demand (BOD) from 230 to 128 mg/lit. Furthermore, total hardness dropped from 340 to 295 mg/lit, indicating a drop in the mineral

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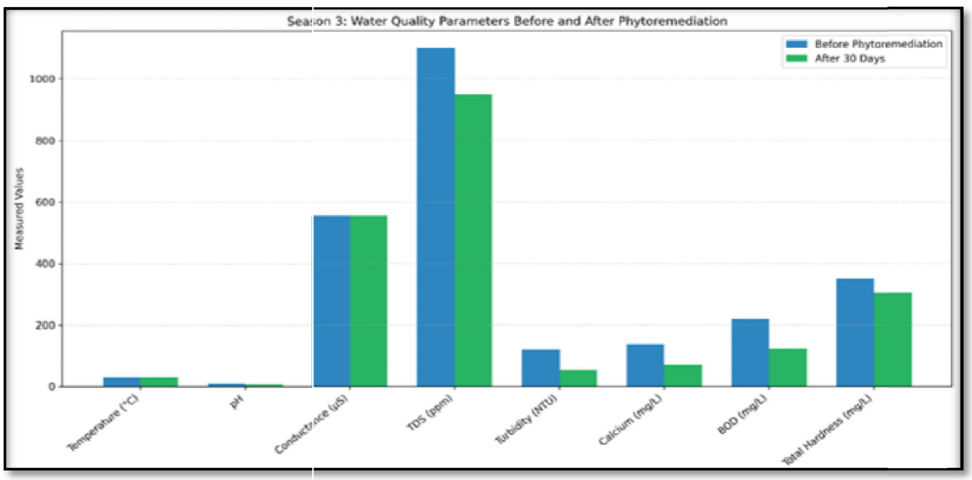
content. Given the circumstances, these changes demonstrate that after Season 2, Bandra Talao's water quality improved.

Season 3 (Summer) (TABLE – 3)

Sr no	Parameters	Season 3 Before (Phytoremediation)	Season 3 After (30 days) (Phytoremediation)
1.	Temperature	31.3 °C	31.3 °C
2.	Colour	Light green	Light green
3.	Odour	Bad odour unpleasant	Bad odour unpleasant
4.	pH	7.28	5.66
5.	Conductance (µs)	554.7	553.8
6.	Total dissolved solid (ppm)	1100	950
7.	Turbidity (NTU)	120	53
8.	Calcium(mg/lit)	136	69.5
9.	BOD (mg/lit)	220	124
10.	Total hardness of water (mg/lit)	350	305



Season 3 (Summer) shows several changes in the physicochemical properties. The temperature remained constant at 31.3 °C, and the water colour stayed light green, indicating no visual improvement. The odour persisted as a bad, unpleasant smell, suggesting phytoremediation did not affect it. The pH dropped from 7.28 to 5.66, making the water more acidic after treatment. Conductivity decreased from 554.7 µS to 553.8 µS, showing a reduction of 100 µS, which indicates removal of ions. Total dissolved solids (TDS) reduced (from 1100 to 950 ppm), and turbidity fell by 9.4 NTU (from 120 to 53 NTU), making the water clearer. Calcium concentration decreased by 30.57 mg/lit (from 136 to 69.5 mg/lit), and biochemical oxygen demand (BOD) dropped by 5 mg/lit (from 220 to 124 mg/lit), signifying a lower organic load. Total hardness also reduced by 20 mg/lit (from 350 to 305 mg/lit). Overall, phytoremediation improved several parameters like conductivity, TDS, turbidity, calcium, BOD, and hardness, but did not affect temperature, colour, or odour, while shifting the pH to acidic.

VIII. HEAVY METAL ANALYSIS BY EDX METHOD:

Season 1 (Rainy) (TABLE - 1)

Sr no	Metals	Season 1 Before (Phytoremediation)	Season 1 After (30 days) (Phytoremediation)
1.	Lead	27.6	24.9
2.	Mercury	3.6	2.3
3.	Copper	2.4	0.3
4.	Cadmium	0.6	0.5
5.	Nickel	0.5	0.2

Season 2 (Winter) (TABLE - 2)

Sr no	Metals	Season 2 Before (Phytoremediation)	Season 2 After (30 days) (Phytoremediation)
1.	Lead	34	32.8
2.	Mercury	6.9	1.0
3.	Copper	1.1	Below detectable limit
4.	Cadmium	Below detectable limit	Below detectable limit
5.	Nickel	Below detectable limit	Below detectable limit

Season 3 (Summer) (TABLE – 3)

Sr no	Metals	Season 3 Before (Phytoremediation)	Season 3 After (30 days) (Phytoremediation)
1.	Lead	60	0.6
2.	Mercury	4.7	3.3
3.	Copper	3.0	1.3
4.	Cadmium	13.6	0.6
5.	Nickel	2.1	0.6

IX. CONCLUSION

The phytoremediation capacity of border water mimosa (*Neptunia oleracea)* on physico-chemical parameters and heavy metals in 30 days of Bandra Talao, Mumbai is effective in rainy, winter and summer seasons. A meaningful reduction in conductance from 503.1 to 502.2 µS (rainy), TDS from 1000 to 835 ppm (rainy), turbidity from 150 to 31 NTU (rainy), BOD from 218 to 59.18 mg/L (rainy), total hardness from 330 to 317 mg/L (rainy), calcium content and a drastic reduction in heavy metals through EDX analysis such as lead from 60 to 0.6 (summer), mercury from 6.9 to 1.0 (winter), copper from 2.4 to 0.3 (rainy), cadmium from 13.6 to 0.6 (summer), nickel from 0.5 to 0.2 (rainy) et al without meaningful variation in temperature, colour and odour indicates the role of hyperaccumulation of the water mimosa through its root system in detoxifying the urban lake and is a low-cost, green approach to restore it from anthropogenic pollution through sewage and other waste. Considering the results, continued monitoring and gradual implementation seems to be the way forward for Mumbai's water bodies.

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