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Evaluation Of Metal Contamination in Yellamma Cheruvu, Peddapalli District, Telangana

B. Rajender[1], Prof. K. Shailaja[2]

[1]Ph.D, Scholar, Department of Environmental Sciences University College of Science, Osmania University, Hyderabad
[2]Department of Botany University College of Science, Osmania University, Hyderabad

Abstract
This study presents a comprehensive assessment of the water quality of Yellamma Cheruvu, a vital water body located in Peddapalli District, Telangana State. The evaluation focuses on a detailed analysis of various metal parameters and their concentrations in the lake's water. Water samples were collected from multiple locations within Yellamma Cheruvu, covering different seasons to capture the temporal variations in water quality. This approach allows for a better understanding of how seasonal changes and human activities influence the lake's health over time.
The results reveal fluctuations in key water quality parameters, which indicate potential contamination risks during certain periods, often linked to anthropogenic activities. These activities, such as agricultural runoff, industrial discharges, and domestic wastewater, appear to contribute to the water quality degradation in the lake. The Water Quality Index (WQI) was calculated as a summary measure to evaluate the overall water quality and assess its suitability for various purposes, including drinking, agricultural use, and recreation.
The study also identifies potential sources of pollution that affect the water body. By pinpointing these sources, the research highlights the need for targeted mitigation strategies to address water quality issues and improve the ecological health of Yellamma Cheruvu. The findings underscore the importance of implementing effective water management practices and pollution control measures. This assessment is essential for local water management authorities and stakeholders in the region, providing them with the necessary information to make informed decisions about conservation efforts. The study offers valuable insights that can guide strategies for the sustainable use and protection of this crucial water resource, ensuring it remains a safe and reliable asset for the local community and surrounding ecosystems.

Keywords: water quality, water management, ecosystems, Yellamma Cheruvu, Telangana

1. INTRODUCTION

Water is a critical natural resource essential for sustaining life and the functioning of ecosystems. The quality of water in surface water bodies, such as lakes and reservoirs, is vital for various human and ecological activities, including drinking, agriculture, recreation, and providing habitat for aquatic life. Yellamma Cheruvu, located in Peddapalli District of Telangana State, is an important water body serving multiple purposes for the local population. However, increasing anthropogenic activities and rapid urbanization have raised concerns about the water quality of Yellamma Cheruvu.

Potential Pollution Sources: The study explores potential pollution sources, including agricultural runoff, industrial discharge, and domestic wastewater, and discusses their implications on water quality.

Objective: By providing a detailed analysis and comprehensive assessment, this study seeks to inform local water management authorities and stakeholders about the current status of Yellamma Cheruvu's water quality. The findings are intended to guide the development of effective mitigation strategies and conservation measures to ensure the sustainable use and preservation of this vital water resource for future generations.

2. OBJECTIVES

The objectives of this study on Yellamma Cheruvu's water quality are as follows:

1. **To conduct a comprehensive assessment of the water quality of Yellamma Cheruvu** by analyzing various physico-chemical and biological parameters. This will provide a detailed understanding of the current environmental condition of the lake and its overall health.
2. **To evaluate specific pollutants such as Zinc, Barium, Boron, Iron, Lead, Chromium, Arsenic**, as well as the concentrations of key nutrients like nitrogen and phosphorus. These substances can significantly impact water quality, aquatic life, and the overall ecological balance of the lake.
3. **To understand the current state of water quality** by identifying the primary sources of pollution (e.g., agricultural runoff, industrial discharge, domestic wastewater) and assessing how seasonal variations (e.g., monsoon, dry season) influence the water body. This will help to identify any seasonal trends in contamination and understand the dynamic nature of the lake's water quality.

Through these objectives, the study seeks to provide a comprehensive understanding of the factors affecting Yellamma Cheruvu's water quality, helping to inform conservation efforts and sustainable management practices.

3. STUDY AREA: YELLAMMA CHERUVU

Yellamma Cheruvu is a notable lake situated on the west side of Peddapalli city in Telangana State. This water body plays a crucial role in the natural environment, influencing both the landscape and its ecological functions. Lakes like Yellamma Cheruvu are significant components of the ecosystem, providing habitat for diverse aquatic life, supporting local biodiversity, and serving as an essential resource for human activities. Over the past few decades, lakes worldwide, including Yellamma Cheruvu, have become subjects of environmental investigations due to their unique characteristics and ecological importance.

These lakes exhibit substantial diversity based on factors such as their origin, geographical location, hydrological regimes, and substrate conditions. Yellamma Cheruvu, in particular, has attracted attention in studies aimed at understanding its environmental status and the impacts of various anthropogenic activities. The lake's geographical positioning within Peddapalli District further emphasizes its role as a critical water resource for the surrounding communities.

Yellamma Cheruvu supports multiple uses, including drinking water, agriculture, and recreational activities. However, like many lakes, it faces significant challenges due to pollution sources such as agricultural runoff, industrial discharge, and domestic wastewater. These pollutants pose serious threats to the water quality and ecological balance of the lake. As such, it is crucial to assess and monitor the health of this water body regularly to address any potential environmental concerns.

This study aims to provide a comprehensive assessment of Yellamma Cheruvu's water quality by analyzing various physico-chemical parameters. The goal is to offer valuable insights into the current environmental status of the lake and inform strategies for its conservation and sustainable management. The findings of this study will be instrumental for local authorities and stakeholders in devising effective measures to protect and improve the health of this vital natural resource, ensuring that it continues to benefit the local community and support biodiversity in the region.

4. SURFACE WATER METHODOLOGY

4.1 SAMPLE LOCATION

In the study area of Yellamma Cheruvu, approximately eight surface water samples were collected from strategic locations around the lake to ensure a comprehensive assessment of its water quality. The sampling strategy was designed to capture a representative snapshot of the lake's water quality by covering different areas. To achieve this, two samples were taken from each cardinal direction: North, East, West, and South. This approach was carefully selected to account for potential variations in water quality across different parts of the lake, considering local environmental factors, such as water flow, proximity to pollution sources, and variations in human activities. By sampling from diverse locations around the lake, the study aims to offer a well-rounded understanding of the lake's overall water quality, including the influence of both natural processes and anthropogenic impacts.

4.2 SAMPLE COLLECTION

Sample collection for this study was carried out following established procedures to ensure the accuracy and reliability of the data. The methodology adhered to standard protocols for surface water sampling, which included using sterilized bottles to prevent contamination, applying appropriate preservation techniques to maintain sample integrity, and ensuring the timely transportation of samples to the laboratory for analysis.

To capture the seasonal variations in water quality, samples were collected from the same locations during two distinct seasons: Post-Monsoon and Summer. This seasonal sampling approach allowed for the assessment of how various water quality parameters fluctuate throughout the year, providing valuable insights into the ecological dynamics of Yellamma Cheruvu.

By systematically collecting samples from all sides of the lake during different seasons, the study aimed to provide a thorough evaluation of the water quality across different times of the year. This comprehensive data is essential for identifying sources of pollution, understanding temporal variations in water quality, and informing effective management and conservation strategies for the lake. The findings will be vital in guiding decisions that can help protect and maintain the ecological health and sustainability of Yellamma Cheruvu for future generations.

Sample Locations and collection area

Table 1 Surface Water Sampling Locations

Station Code	Name of the Stations	Latitude	Longitude	Date of sampling	
				Post Monsoon	Summer
SW-1	Yellammacheruvu Point-1 Nimanapalli	N 18˚60'88.9"	E 79˚36'51.2"	23.10.2023	17.03.2024
SW-2	Yellammacheruvu Point-2	N 18˚60'82.6"	E 79˚36'57.8"	23.10.2023	17.03.2024
SW-3	Yellammacheruvu Point-3	N 18˚61'13.8"	E 79˚36'99.2"	23.10.2023	17.03.2024
SW-4	Yellammacheruvu Point-4	N 18˚61'19.6"	E 79˚36'81.1"	23.10.2023	17.03.2024
SW-5	Yellammacheruvu Point-5	N 18˚61'88.4"	E 79˚37'08.8"	23.10.2023	17.03.2024
SW-6	Yellammacheruvu Point-6	N 18˚60'05.1"	E 79˚36'84.6"	23.10.2023	17.03.2024
SW-7	Yellammacheruvu Point-7	N 18˚62'06.9"	E 79˚36'87.1"	23.10.2023	17.03.2024
SW-8	Yellammacheruvu Point-8	N 18˚62'11.7"	E 79˚36'87.1"	23.10.2023	17.03.2024

5. MATERIALS AND METHODS:

5.1 INTRODUCTION OF ICP-OES:

Inductively Coupled Plasma Optical Emission Spectrophotometers (ICP-OES) are among the most versatile techniques used for inorganic analysis, particularly for detecting and analyzing trace metals in liquid samples. Unlike Atomic Absorption Spectrophotometers (AAS), which use air-acetylene flame excitation temperatures of 6000 to 8000K, ICP-OES utilizes argon plasma with excitation temperatures of 6000 to 8000K. These high temperatures enable the effective excitation of a wide range of elements, including those that are harder to detect with other techniques. Additionally, the use of inert argon gas in ICP-OES reduces the likelihood of producing oxides and nitrides, which can interfere with the analysis.

ICP-OES technology is especially effective in detecting and analyzing heavy metals in various samples, such as water, soil, food, and biological materials. One of its main advantages is the ability to eliminate interferences between elements, allowing researchers to analyze a broader range of elements more quickly while maintaining accurate detection levels. This capability is particularly valuable in environmental monitoring and regulatory testing, where accurate and rapid analysis is critical.

The technique works by injecting a liquid sample into an argon gas plasma, which is maintained by a high magnetic field. The high energy from the plasma excites the elements in the sample, causing the electrons of the atoms to move to higher energy states. When these electrons return to their ground state, they emit light at characteristic wavelengths specific to each element. The emitted light is then measured using optical spectrometry, which allows for the quantification of various elements in the sample.

ICP-OES is highly sensitive and capable of detecting concentrations of elements at levels ranging from parts per million (ppm) to parts per billion (ppb). In some cases, detection limits below ppb can be achieved, depending on the specific element being analyzed and the sensitivity of the equipment used.

This makes ICP-OES an essential tool for monitoring the presence of both toxic and essential elements in a wide variety of samples, such as food safety assessments, environmental testing, and quality control in industrial applications.

Overall, the reliability and sensitivity of ICP-OES make it a preferred method for multi-element analysis, providing accurate and efficient detection of a wide array of harmful, nutritive, and essential elements.

5.2 ICP-OES PRINCIPLE:

Inductively Coupled Plasma (ICP) is a powerful technique used in optical emission spectrometry to analyze and detect various elements in a sample. In this process, the component elements (atoms) of an analytical sample are excited when plasma energy is applied externally. This excitation causes the atoms to move to higher energy states. As the excited atoms return to their lower energy states, they release photons of light at specific wavelengths, known as emission rays or spectrum rays. The wavelength of these photons determines the type of element, and the intensity of the emitted light corresponds to the concentration of that element in the sample.

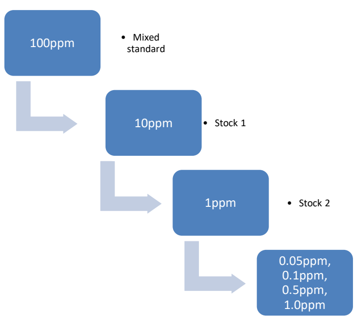
In the ICP system, argon gas is first introduced into the torch coil. A high-frequency electric current is then applied to the work coil located at the tip of the torch tube, which generates a plasma. The argon gas is ionized, and plasma is formed due to the electromagnetic field created by the high-frequency current. This plasma has a very high electron density and temperature, reaching approximately 10,000 K, which provides enough energy to excite the atoms of the sample and induce the emission of light.

The solution sample, which is atomized, is injected into the plasma through a small tube at the center of the torch tube. The atomized sample is then exposed to the high-energy plasma, where its atoms are excited, and the emission spectra are produced. By measuring the wavelengths and intensities of the emitted light, ICP can identify and quantify the elements present in the sample with high sensitivity and precision.

ICP is widely used for multi-element analysis in various fields, including environmental monitoring, food safety, and industrial applications, due to its ability to provide rapid, accurate, and reliable results for a broad range of elements at trace levels.

Preparation of Standard Solutions:

- Stock solution of 100ppm mixed standard is already available (CRM solution) i.e. certified reference material.
- From the above standard solution 10 ppm stock-1 solution was prepared.
- Similarly, again from stock-1 solution 1ppm stock-2 solution was prepared.
- From stock-2 solution working standards i.e. 0.05ppm, 0.1ppm, 0.2ppm, 0.5ppm, 1.0ppm was prepared.



(LOQ)

The **Limit of Quantification (LoQ)**, also known as **LOQ**, is defined as the lowest concentration of an analyte in a sample that can be determined with acceptable accuracy and precision using a particular analytical method. It represents the point at which the analyte can be reliably quantified and distinguished from the background noise, ensuring that measurements at or near this concentration are reproducible and meaningful.

Key Characteristics of LOQ:

1. **Quantification with Acceptable Precision and Accuracy**: The LOQ is the lowest value at which the analyte can be quantified with sufficient confidence, meaning the results are consistent (precise) and reflect the true value (accurate).
2. **Statistical Distinction from Background**: At LOQ, the signal generated by the analyte is significantly higher than the background noise or baseline signal, allowing the analyte to be differentiated from potential interference or noise.
3. **Measured as a Multiple of Standard Deviation (SD)**: Typically, LOQ is defined as **10 times the standard deviation (SD)** of the blank or the noise level in the measurement system. This threshold ensures that the signal is statistically distinguishable from the background noise, with a high degree of certainty.

In summary, the **LOQ** provides a benchmark for the lowest reliable quantifiable concentration in an analysis, ensuring that measurements made at or above this level are meaningful and reproducible.

Sl. No	Parameters	Unit	WHO Limits	RESULT							
				SW-1		SW-2		SW-3		SW-4	
				Post Monsoon	Summer	Post Monsoon	Summer	Post Monsoon	Summer	Post Monsoon	Summer
1.	Zinc as Zn	mg/L	4	0.44	0.26	0.18	0.25	0.42	0.51	0.30	0.19
2.	Iron as Fe	mg/L	0.3	**3.4**	**2.4**	0.86	0.74	**3.8**	**2.1**	0.69	0.42
3.	Arsenic as As	mg/L	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
4.	Lead as Pb	mg/L	0.01	**0.04**	BDL	BDL	BDL	**0.03**	BDL	BDL	BDL
5.	Cadmium as Cd	mg/L	0.03	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
6.	Total Chromium as Cr	mg/L	0.05	**0.10**	0.05	**0.07**	0.04	**0.15**	0.04	0.04	0.05
7.	Nickel as Ni	mg/L	0.07	BDL	BDL	BDL	BDL	0.06	BDL	BDL	BDL

8.	Copper as Cu	mg/L	2	0.10	0.08	0.04	0.05	0.09	0.08	0.07	0.05
9.	Manganese as Mn	mg/L	0.08	**1.3**	**0.15**	**0.22**	**0.11**	**0.10**	**0.09**	0.06	**0.10**
10.	Barium	mg/L	1.3	0.14	0.10	0.24	0.15	0.28	0.12	0.16	0.09

Sl. No	**Parameters**	**Unit**	**WHO Limits**	**RESULT**							
				SW-5		**SW-6**		**SW-7**		**SW-8**	
				Post Monsoon	Summer	Post Monsoon	Summer	Post Monsoon	Summer	Post Monsoon	Summer
1	Zinc as Zn	mg/L	4	0.18	0.24	0.32	0.26	0.25	0.18	0.32	0.20
2	Iron as Fe	mg/L	0.3	**0.52**	**1.21**	**0.46**	**0.56**	**0.74**	**0.87**	**0.58**	**0.66**
3	Arsenic as As	mg/L	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
4	Lead as Pb	mg/L	0.01	BDL	BDL	**0.04**	BDL	BDL	BDL	BDL	BDL
5	Cadmium as Cd	mg/L	0.03	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
6	Total Chromium as Cr	mg/L	0.05	**0.06**	0.04	0.04	0.03	0.04	BDL	0.05	BDL
7	Nickel as Ni	mg/L	0.07	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
8	Copper as Cu	mg/L	2	0.09	0.08	0.11	0.07	0.15	0.07	0.09	0.06
9	Manganese as Mn	mg/L	0.08	**0.15**	**0.11**	**0.18**	**0.12**	0.05	0.08	**0.13**	0.07
10	Barium	mg/L	1.3	0.19	0.12	0.24	0.10	0.13	0.07	0.11	0.10

***Test Method: AHPA 23rd Edition 2023-**3120. B

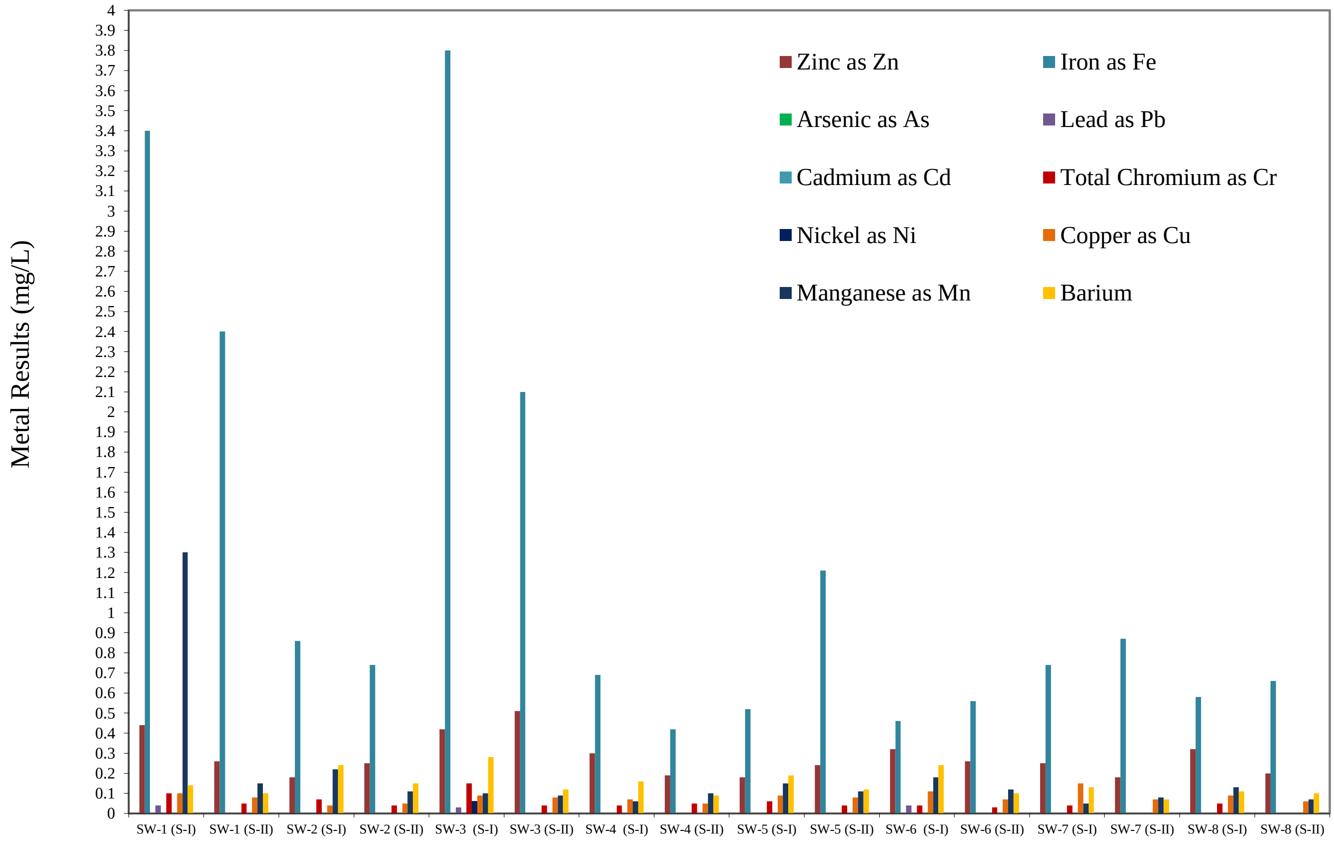


Fig:1 Graphical presentation of Metals Concentrations in Surface Water Locations

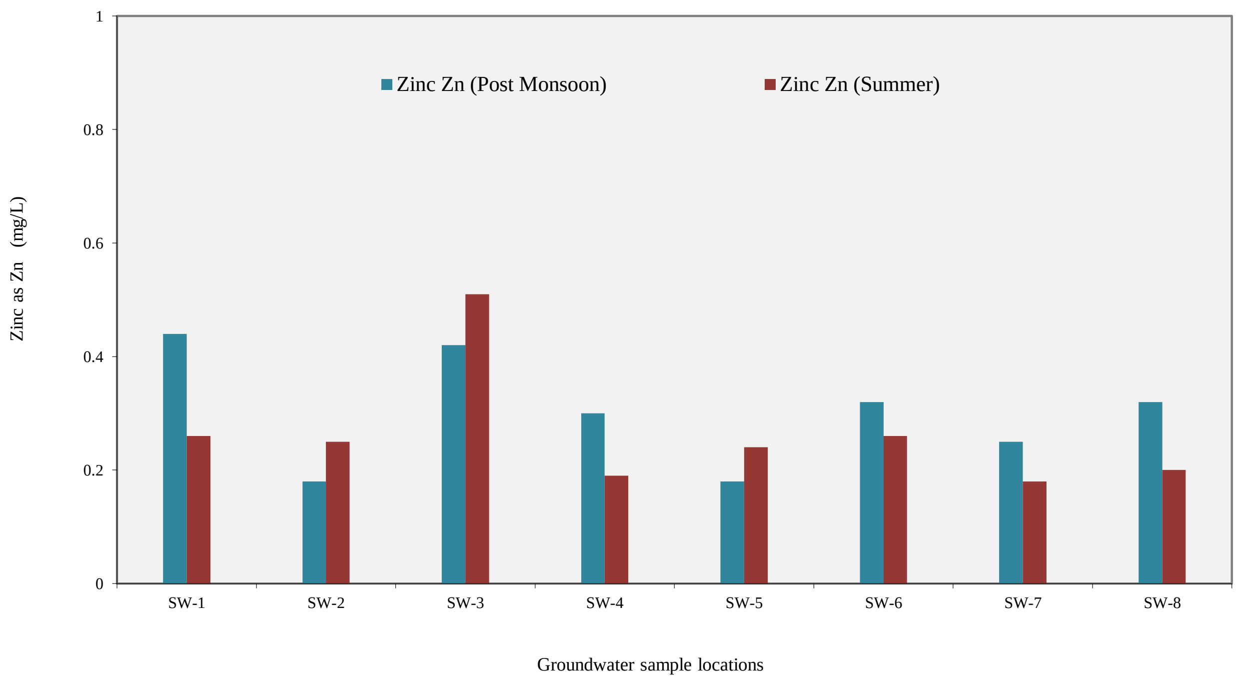


Fig:1.1 Graphical presentation of Zinc as Zn Concentrations

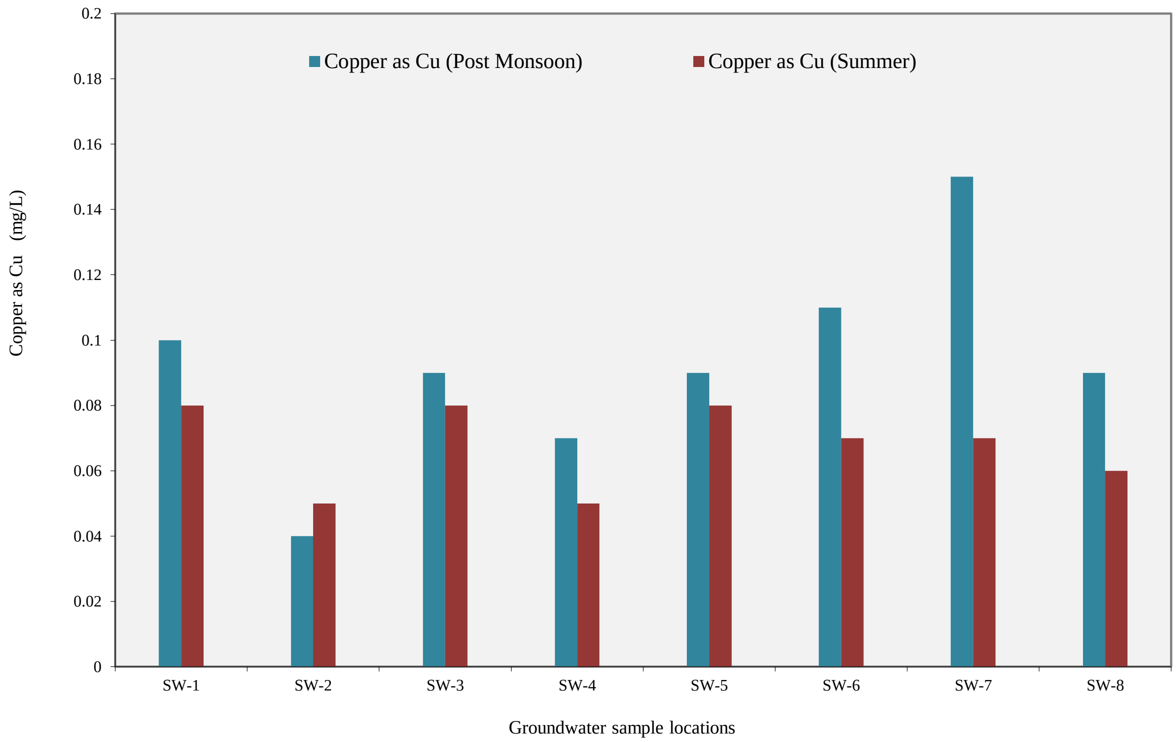


Fig:1.3 Graphical presentation of Copper as Cu Concentrations

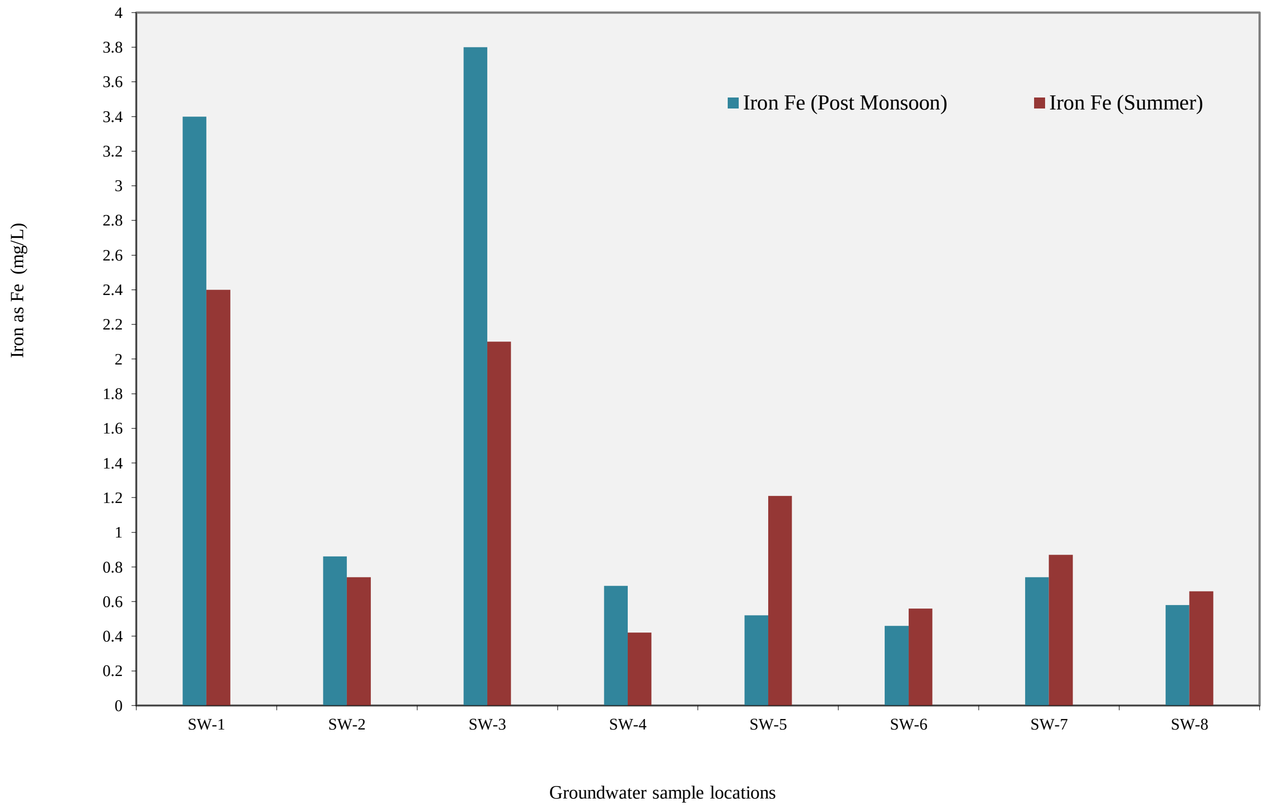


Fig:1.2 Graphical presentation of Iron as Fe Concentrations

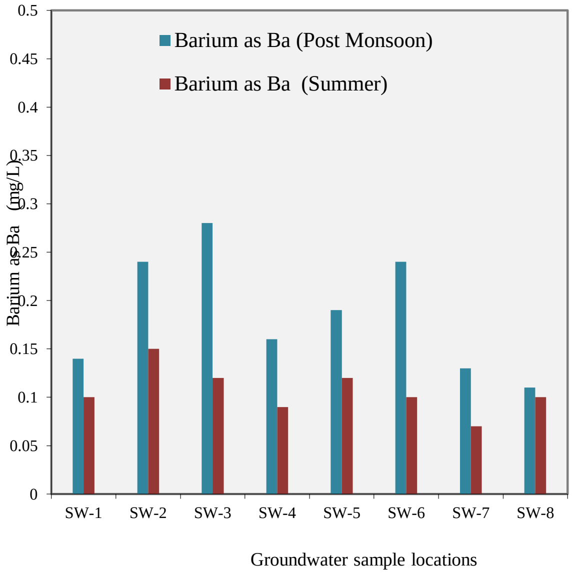


Fig:1.5 Graphical presentation of Barium as Ba Concentrations

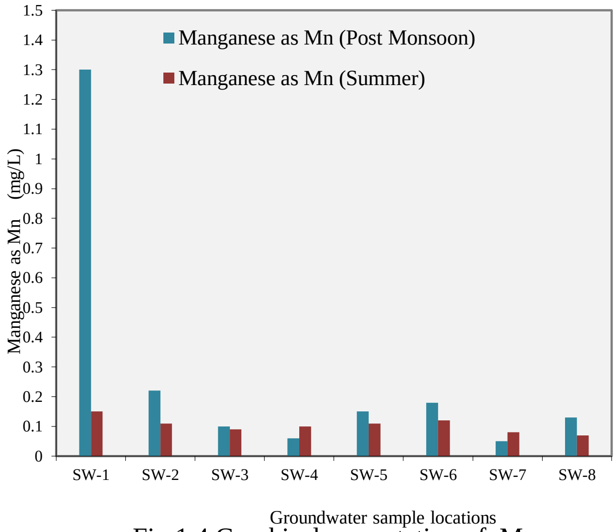


Fig:1.4 Graphical presentation of Manganese as Mn Concentrations

6.2 CONCLUSION AND DISCUSSIONS:

All the parameters are well within the limits except Iron, Lead, Chromium, and Manganese in some locations.

Iron: IS 10500 stipulates that 1mg/l as maximum concentration and more than that there is no relaxation. The presence of iron can be due to geogenic in nature and there is no harm when this parameter exceeds the limits. As iron levels are high it may cause staining to clothes and affects palatability of water. Sediment filter, carbon filter, or water softeners can remove small amounts of iron. Whenever these concentrations exceed the permissible limit, by deploying reverse Osmosis, Electro Dialysis Distillation, Ion-Exchange procedures and Solar Still, they may be removed.

Lead: Lead is above the limit of 0.01mg/l in Post monsoon of SW-1, SW-3 & SW-6 locations.

Lead in surface water is a dangerous pollutant that harms both the environment and human health. Even low levels of lead exposure can have long-term consequences on physical and mental development. Monitoring total chromium levels, enforcing regulations, and implementing pollution control measures are vital to protecting both the environment and public health.

Chromium: Chromium is above the limit of 0.05mg/l in Post monsoon of SW-1, SW-2, SW-3 & SW-5 locations.

Chromium is highly toxic to aquatic organisms. It can bio-accumulate in the tissues of aquatic organisms, which means that as fish or other species ingest contaminated water, chromium can build up over time. This leads to higher concentrations in species higher up the food chain, including predators and humans who consume contaminated fish.

Manganese: Manganese is above the limit of 0.08mg/l in SW-1, SW-2, SW-3, SW-5, SW-6 both seasons, Summer in SW-4 & post monsoon in SW-8 locations.

The presence of manganese in surface water is an important parameter. In surface water it is generally not harmful at low concentrations, but elevated levels especially from industrial or agricultural activities can pose risks to aquatic life and human health. Treatment technologies such as oxidation**,** filtration**,** and ion exchange can remove excess manganese from water.

The analysis of water quality in Yellamma Cheruvu reveals both the ecological importance and the challenges facing the lake. The lake, located in Peddapalli District, Telangana, serves multiple functions, providing vital resources such as drinking water, irrigation for agriculture, and a recreational space for the local population. Given these roles, maintaining the lake's health is crucial for the sustainability of the community and its ecosystem.
However, the study also highlights significant concerns regarding the lake's water quality, particularly the impact of anthropogenic activities. Sources of pollution such as agricultural runoff, industrial waste, and domestic effluent contribute to the contamination of the lake. These pollutants lead to changes in key water quality parameters, including an increase in harmful substances like heavy metals and nutrients, which can have detrimental effects on both aquatic life and human health. Seasonal variations further complicate the situation, as water quality fluctuates throughout the year, with certain periods showing higher contamination levels.
The study emphasizes the need for targeted pollution control measures to address the primary sources of contamination. This includes improving waste management practices, regulating industrial discharges, and controlling agricultural runoff. By taking these actions, the health of Yellamma Cheruvu can be improved, ensuring its long-term sustainability as a valuable natural resource. Measures to mitigate these effects include upgrading infrastructure (such as replacing lead pipes), improving water treatment systems (e.g., filtration), and regulating pollution sources more strictly. Cleanup efforts may also involve removing contaminated sediments from water bodies.

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