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Evaluation of Groundwater Quality Parameters Through Physico-Chemical Analysis in the Puducherry Region

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Abstract

The evaluation of the quality of drinking water in Puducherry state and its surrounding regions primarily concentrated on groundwater sources. Nine specimens were examined using standardized techniques, and their outcomes were contrasted with national standards. Nevertheless, on a worldwide scale, the quality of water is facing a growing danger from unwelcome alterations in its physical, chemical, and biological characteristics. Population growth, industrialization, fertilizer usage, and mining activities are major contributors to water pollution, introducing harmful contaminants. Water sources can also be contaminated by natural processes, such as rock weathering and soil leaching. Consistent monitoring of drinking water quality is crucial to avoid waterborne illnesses resulting from contaminated water. Having access to clean and safe water is essential in improving our health and enhancing our quality of life. Comprehending important physico-chemical factors like pH, hardness, sulphate, chloride, TDS, and alkalinity is crucial in assessing water quality. Special focus should be placed on heavy metals, such as iron (Fe) because they have the potential to result in acute or chronic poisoning in aquatic creatures and could present significant health hazards to humans. Analysis of water samples for different physical and chemical parameters are crucial in studying water quality guidelines. These evaluations offer important information on the present state of water sources and their compliance with established standards. Adhering to national guidelines ensures that drinking water is safe, minimizes health hazards, and encourages responsible resource utilization. These assessments underscore the significance of regular water quality evaluations to safeguard public health and preserve environmental health.

Keywords: Physico-chemical factors, health hazards, water quality guidelines, TDS, chronic poisoning

INTRODUCTION

Preserving the availability of drinkable water through the public system is essential to an agglomeration of people's ability to continue operating during emergencies [1]. On the surface of the earth, water is a naturally occurring resource that is widely available [2]. One important source of water is groundwater, which accounts for up to 75% of the world's total supply of drinking water [3]. For human growth and well-being, water, sanitation, and hygiene (WASH) are essential. According to resources, 663 million people and 2.4 billion people, respectively, lacked access to better sources of drinking water and sanitation in 2015 [4]. The two most important freshwater reservoirs are surface and ground water. Fresh water is a delicate resource that provides end users with high-quality, high-quantity water [5]. Water availability, on the other hand, is automatically considered unsuitable, especially when it is polluted. The

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surrounding water reservoirs are contaminated because of industrialization. A larger volume of contaminated water from household and industrial wastewater flows into the river, which in turn degrades the water system's quality [6]. But in many parts of the world, the degradation of ground water supplies brought on by various anthropogenic activities is becoming an increasing issue [7–10]. The human right to water should be recognized as the right of every individual to have access to safe, accessible, and affordable water for personal and domestic needs [11]. The purpose of the poll was to find out what consumers thought about drinking water during emergencies. Assessments of how difficult or inconvenient users thought water delivery interruptions were conducted concurrently with assessments of their satisfaction with the quantity and quality of water they got. This study aims to assess the physico-chemical quality of the water to ascertain the degree of contamination in the Puducherry district.

STUDY AREA

Details of the nine sample locations – Nonankuppam Lake (S-1), Bahour (S-2), Kalapet (S-3), Arumarthapuram (S-4), Velrampet Lake (S-5), Saram (S-6), Veerampattinum Lake (S-7), Kathirgamam (S-8), Manadipet (S-9) – where water samples were taken. These were gathered into brand-new polyethylene bottles that had been rinsed with the water for analysis two or three times. To reduce aeration, the bottles were filled to overflowing and sealed underwater. Before being transported, all bottles were meticulously labelled and numbered. The received samples were then examined for various physicochemical parameters (Figure 1 and Table 1).

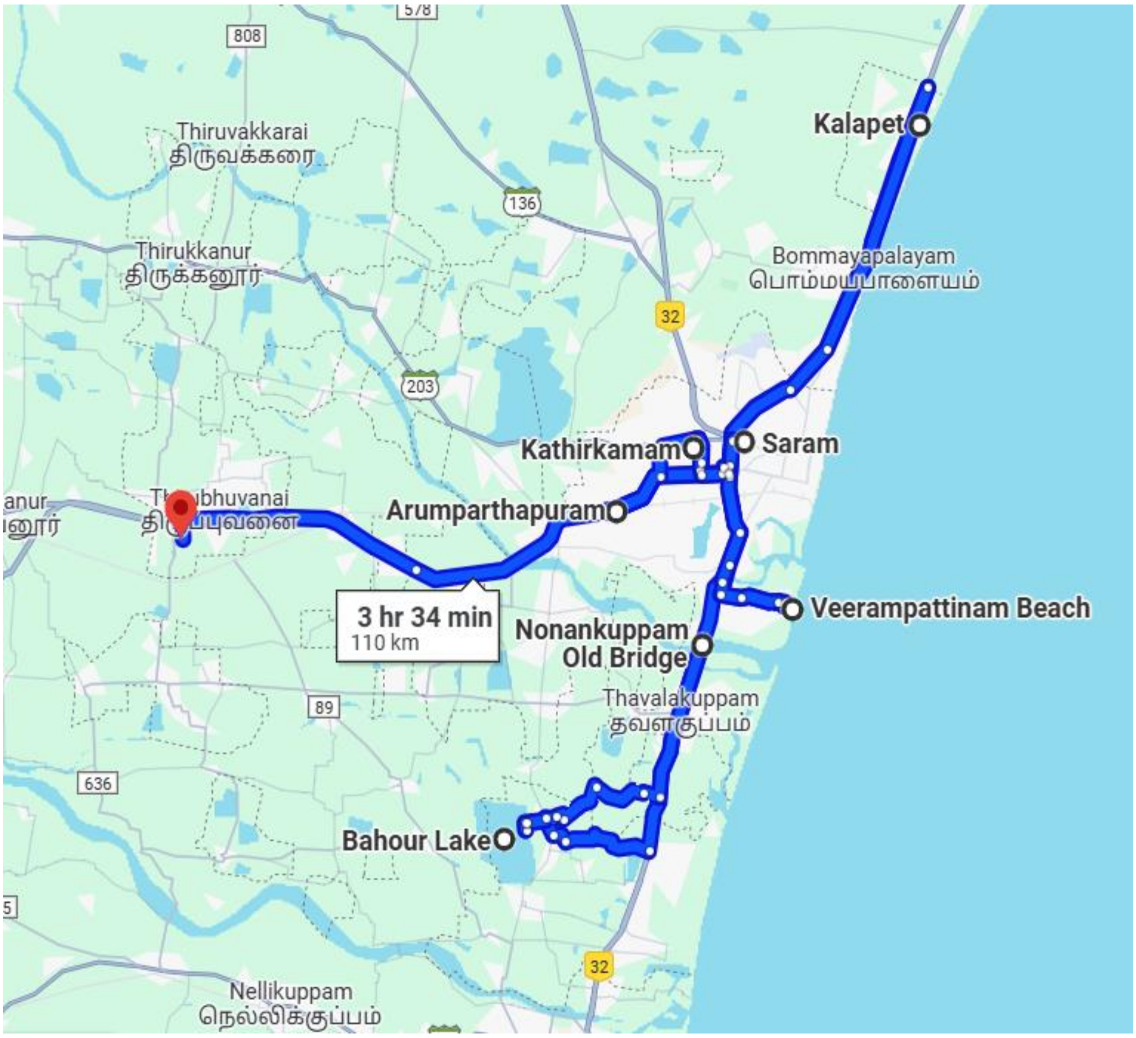

Figure 1. Map representation of sample collected areas.

Table 1. Map representation of sample collected areas.

S. N.	Places	Latitude	Longitude
1.	Nonankuppam river	11.884528° N	79.797606° E
2.	Bahour	11.8070° N	79.7429° E
3.	Kalapet	12.0370° N	79.8552° E
4.	Arumarthapuram	11.9207° N	79.7722° E
5.	Velrampet lake	11.9111° N	79.7982° E
6.	Saram	12.2808° N	79.7064° E
7.	Veerampattinum lake	11.8924° N	79.8270° E
8.	Kathirgamam	11.9393° N	79.7964° E
9.	Manadipet	11.9845° N	79.6236° E

PARAMETERS

pH

The pH is a measurement of the intensity of acidity or alkalinity and measures the concentration of hydrogen ions in water. It has no direct adverse effect on health, however, a low value, below 5.0 will produce sour taste and higher value above 8.5 shows alkaline taste [13]. According to Figure 1, none of the samples had a pH lower than 5 or created a sour taste. Every sample has an alkaline flavour due to its pH value.

Turbidity

Turbidity is defined as a fluid's cloudiness bought by particles that often imperceptible to the unaided eye. It measures the quantity of light that shines through the sample and is an optical property of water [14]. From the given Figure 2, the highest turbidity value is seen in Nonankuppam River.

TDS

The amount of inorganic materials dissolved in water is measured by the total dissolved solids. TDS shows the overall salinity or quality of the water [15]. According to the given graph in Figure 3, Bahour area has the highest TDS value.

Sulphate

Sulphates are found naturally in a variety of minerals, including gypsum ($CaSO_4 \cdot 2H_2O$), barite ($BaSO_4$), and epsomite ($MgSO_4 \cdot 7H_2O$) (Greenwood & Earnshaw, 1984). These dissolved minerals affect the mineral composition of different drinking waters.

Chloride

Groundwater containing chloride from natural sources and industrial effluent sewage. There is no suggested health-based guideline value for drinking water chloride. Using the titration method, $AgNO_3$ performed a volumetric analysis of chloride [16]. According to the given graph from Figure 4, Bahour area has the highest chloride value.

Iron

Iron levels in various types of water were found to be between 0 and 1.0 mg/l. According to the provided graph in Figure 5, at 0.75 mg/l Saram area has the highest Iron content, and in Kalapet area it is found lowest around 0.05 mg/l. Potential risk to aquatic creatures is high in Saram area as it can cause chronic disorders.

Nitrate

Nitrate concentrations in various water types range from 0 mg/l to 100 mg/l, which, as shown in Figure 7 [17], ranges between 0 mg/l and 75 mg/l in the Bahour area and between 2 mg/l and 5 mg/l in the Manadipet area as mentioned in Figure 7 [17].

Magnesium

In addition, it is measured using complexometric titration with a standard EDTA solution and Eriochrome black T as an indicator in a pH 10.0 buffer. Ammonium hydroxide and ammonium chloride are used to make the buffer solution. During titration, the solution resists pH changes [18].

Alkalinity

Another important factor influencing water quality is alkalinity, which mostly neutralizes pH. Water's ability to act as a buffer is assessed using alkalinity testing [19].

Hardness

Hardness, which is often stated as the unit mg/l of $CaCO_3$ concentration, is a measure of the water's ability to withstand the concentration of calcium and magnesium (Table 2) [20].

Table 2. Hardness.

Region	**Parameters**										
		pH	**Turbidity**	**TDS**	**Sulphates**	**Chloride**	**Iron**	**Nitrate**	**Magnesium**	**Alkalinity**	**Hardness**
Nonankuppam River	SAMPLE 1	7.51	10	542	45	142	0.2	7	19.4	75	135
	SAMPLE 2	7.2	9.5	529	55	149	0.2	2.4	18	52	131
	SAMPLE 3	7.35	9.75	535.5	50	145.5	0.2	4.7	18.7	63.5	133
Bahour	SAMPLE 1	7.32	1.1	1041	84	414	0.1	14	2.5	2.5	123
	SAMPLE 2	7.84	2	28000	2314	20400	0.1	46	4.4	4.4	410
	SAMPLE 3	7.58	1.55	14520	1200.5	10407	0.1	30	2	200	520
Kalapet	SAMPLE 1	6.01	0.01	262	8	97	0.05	3.5	5	3.5	80
	SAMPLE 2	6.67	0.02	194	6	58	0.05	1.8	5	1.8	70
	SAMPLE 3	7.04	0.1	566	66	121	0.05	3	14	3	290
Arumarthapuram	SAMPLE 1	7.43	0.1	958	62	388	0.1	6.4	17	7	620
	SAMPLE 2	7.71	0.2	1026	73	394	0.1	6	20	6.8	240
	SAMPLE 3	7.67	0.1	870	57	401	0.1	6.2	23	7	201
Velrampet Lake	SAMPLE 1	7.71	5.2	240	3.5	500	0.4	18	3	75	55
	SAMPLE 2	7.68	6	305	7.8	430	0.5	22	7	122	250
	SAMPLE 3	7.54	6.2	290	6.6	56	0.3	17	10	135	452
Saram	SAMPLE 1	7.44	4.5	540	8	1263	0.75	6.2	1.5	124	620
	SAMPLE 2	7.56	5.2	156	9.5	924	0.45	6	8	166	560
	SAMPLE 3	8.34	0.4	210	10	214	0.62	7.2	5.5	164	210
Veerampattinum Lake	SAMPLE 1	6.81	1	22	2	4	0.34	6.2	0.5	120	124
	SAMPLE 2	7.04	1	226	7	58	0.23	6	9.7	45	423
	SAMPLE 3	8	1	280	9	75	0.32	7.2	11	100	321
Kathirgamam	SAMPLE 1	8.11	6.1	686	4.4	127	0.61	4.1	3	152	190
	SAMPLE 2	8.34	6.2	688	7.6	214	0.4	5.2	8	164	210
	SAMPLE 3	7.44	5.2	701	6.9	130	0.41	4.3	2	124	220
Manadipet	SAMPLE 1	7.01	1.2	42	2.1	4.8	0.33	5.1	1	6	10
	SAMPLE 2	7.31	0.5	754	62	212	0.25	3	20	226	420
	SAMPLE 3	7.67	2.5	642	44	148	0.35	2.1	22	220	410

TABULAR COLUMN

All details are shown in the Figures 2–11 below.

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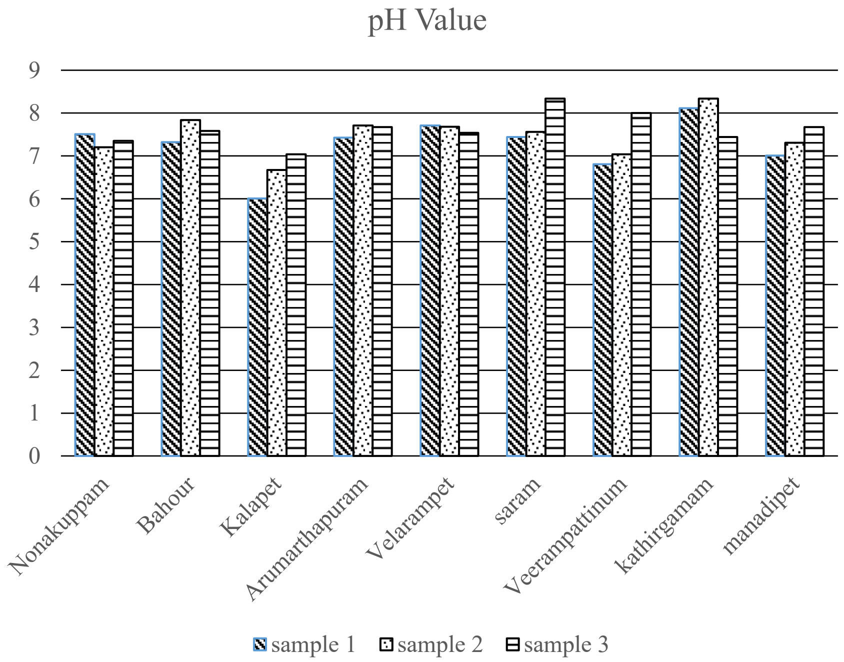

Figure 2. Graph interpretation of pH values taken from different regions of Puducherry.

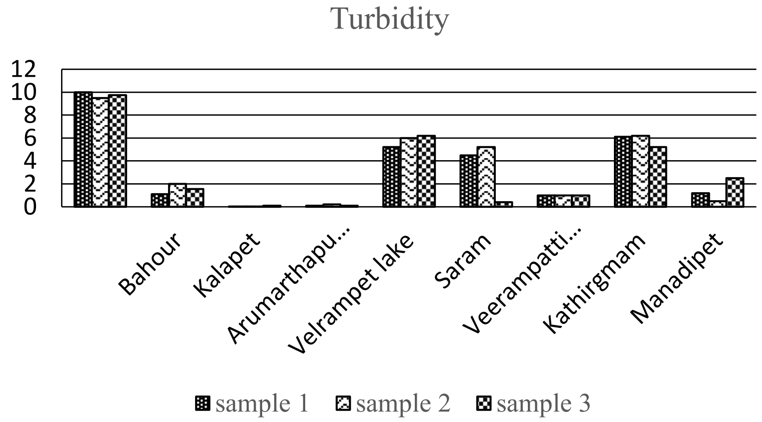

Figure 3. Graph interpretation of Turbidity values taken from different regions of Puducherry.

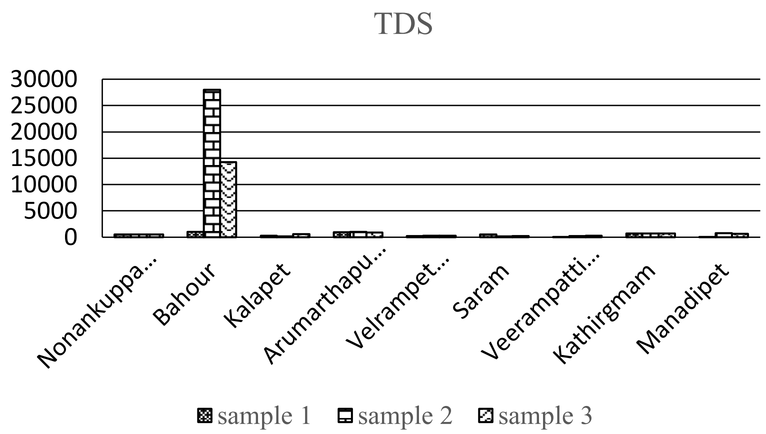

Figure 4. Graph interpretation of TDS values taken from different regions of Puducherry.

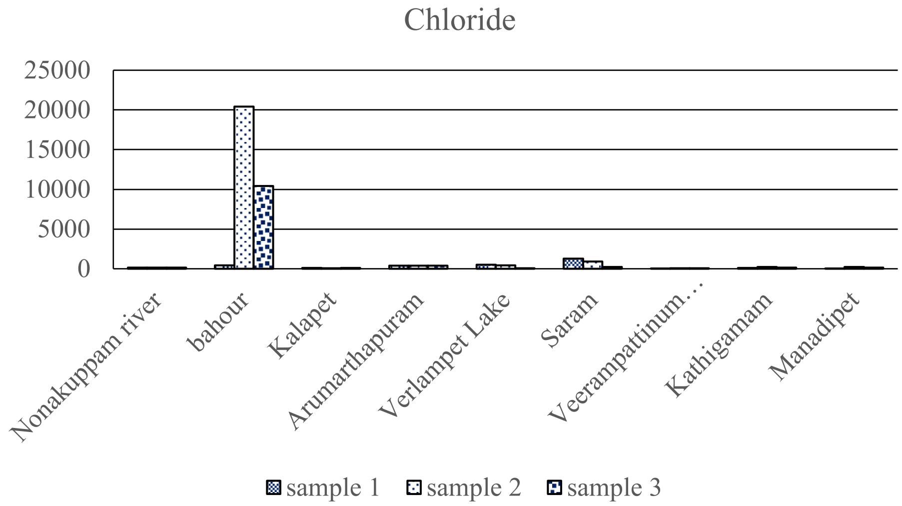

Figure 5. Graph interpretation of pH values taken from different regions of Puducherry.

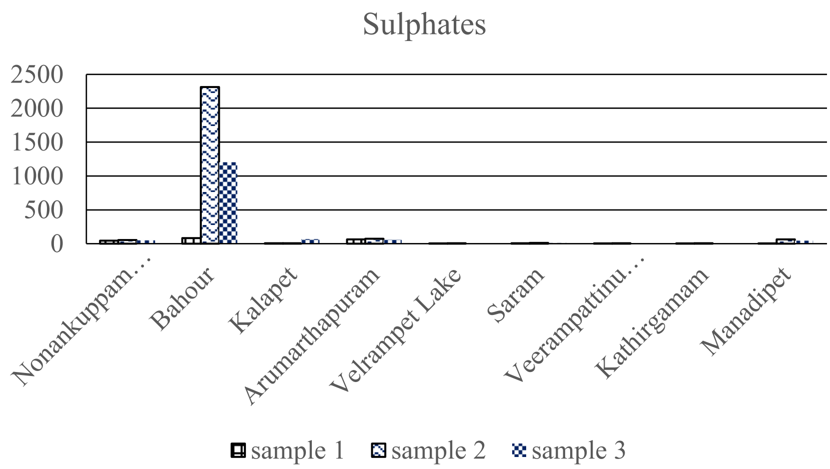

Figure 6. Graph interpretation of chloride content values taken from different regions of Puducherry.

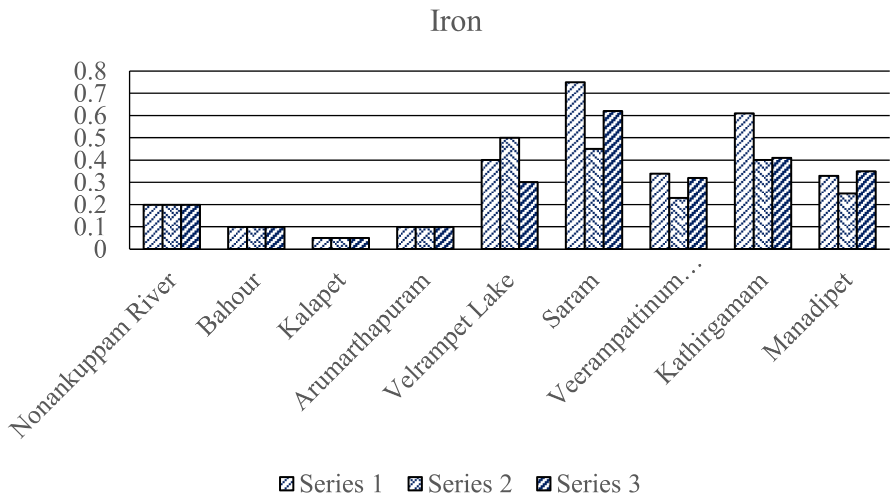

Figure 7. Graph interpretation of Iron content values taken from different regions of Puducherry.

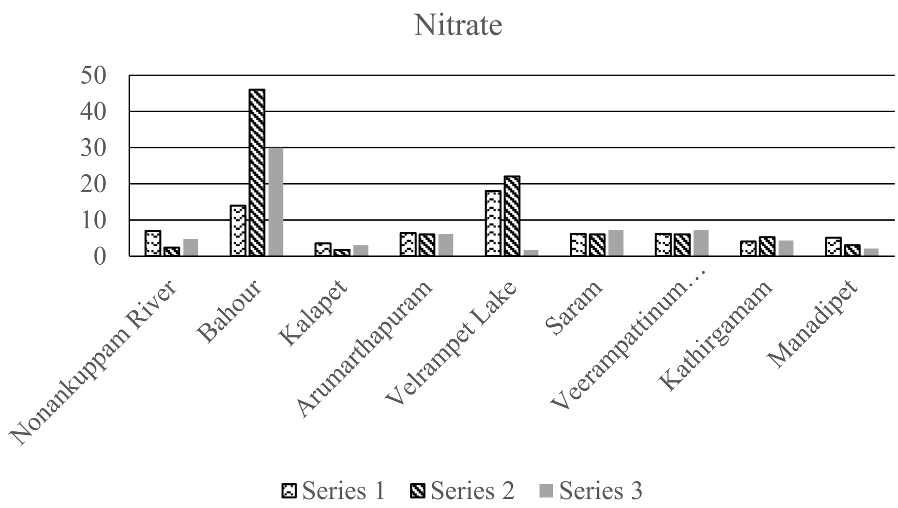

Figure 8. Graph interpretation of Nitrate content values taken from different regions of Puducherry.

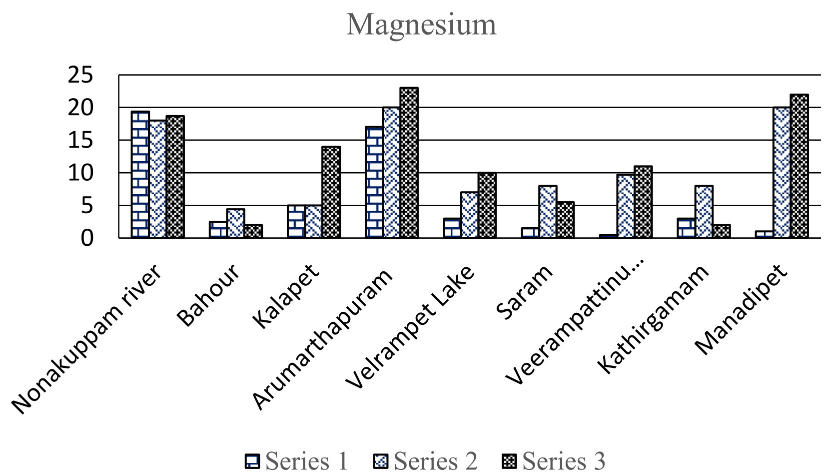

Figure 9. Graph interpretation of Magnesium content values taken from different regions of Puducherry.

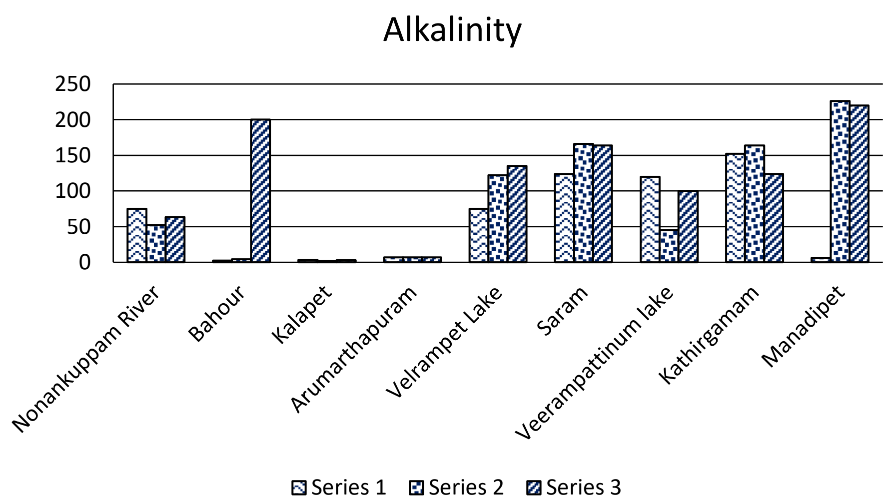

Figure 10. Graph interpretation of Alkalinity values taken from different regions of Puducherry.

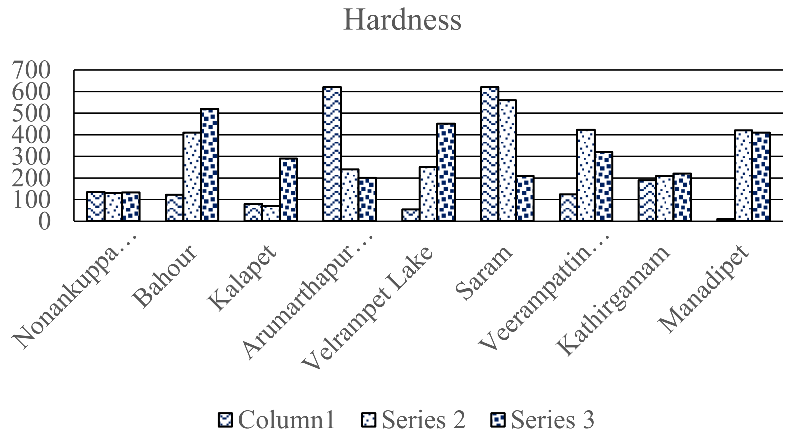

Figure 11. Graph interpretation of Hardness values taken from different regions of Puducherry.

CONCLUSIONS

This analysis highlights significant variation in wastewater discharge quality, with elevated TDS levels and deteriorating water quality downstream, especially in industrial zones. The widespread contamination of shallow groundwater necessitates continuous monitoring of deep aquifer systems.

The study addresses water pollution from natural and human activities, including industrial waste, agricultural practices, and climate change, alongside natural geological processes and surface-groundwater interactions. Despite existing research on pollution sources, there is limited focus on contamination pathways and specific pollutant types.

Urgent action is needed to implement policies that reduce effluent discharge, improve water quality, and conserve freshwater and marine ecosystems. Effective water management, pollution reduction, and addressing both natural and human-driven contamination are critical to protecting aquatic life and ensuring the availability of clean water for future generations. This is a situation in several regions and one such region is Puducherry which is terribly damaged due to these factors.

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