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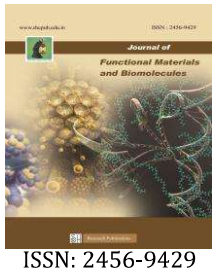

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Assessment of Physico-chemical Properties of Ground Water in Tirupattur District of Tamil Nadu, India

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Abstract

Groundwater quality is a critical determinant of public health, especially in regions like Tirupattur District, Tamil Nadu, India, where it serves as the primary water source. In this study, five groundwater samples were collected from different locations in Tirupattur, and their physico-chemical properties were assessed. Notably, the sample from Pudhupet (S3) exhibited high levels of Total Dissolved Solids (TDS), warranting further analysis. Histopathological studies on zebrafish exposed to this sample for 30 days revealed significant organ-specific toxicity, including hypertrophy and hyperplasia in intestinal tissues, hyperemia, vacuolization, and necrosis in liver tissues, and aneurysms with epithelial displacement in gill tissues. To mitigate this contamination, a biofilter was developed, effectively reducing TDS levels from 1800 ppm to 500 ppm. Additionally, microbial analysis confirmed the absence of coliforms, validating the treated water as potable. This study underscores the necessity of routine groundwater quality assessment and offers an innovative biofiltration solution for ensuring safe drinking

Keywords: Groundwater quality, physico-chemical analysis, Tirupattur, TDS, histopathology.

1 Introduction

Access to safe drinking water is critical for maintaining public health, yet millions globally face challenges due to poor water quality, inadequate sanitation, or scarcity of water. According to the World Health Organization, up to 80% of illnesses and diseases worldwide are attributed to these factors (WHO, 2019). A critical parameter for assessing water quality is Total Dissolved Solids (TDS), which indicates the presence of dissolved organic and inorganic substances, including essential minerals and harmful contaminants. TDS often comprises ions such as magnesium, calcium, potassium, bicarbonates, and chlorides, but it can also contain hazardous elements like bacteria, viruses, fluoride, and heavy metals such as lead and chromium (Mishra et al., 2020). Elevated TDS levels in drinking water have been linked to gastrointestinal distress, respiratory irritation, and long-term risks, including chronic diseases like cancer and liver or kidney disorders (WHO, 2017).

The increasing contamination of water due to industrialization, urbanization, and anthropogenic activities exacerbates the problem. Water quality is often compromised by both physical and chemical pollutants, posing significant health risks (Kaur et al., 2021). While high TDS levels are harmful, excessively low TDS can also deplete the body of essential minerals, affecting cellular functions (Rahman et al., 2018).

Thus, maintaining an optimal TDS level is crucial for safe and sustainable water consumption. Zebrafish (Danio rerio), a freshwater teleost native to South Asia, has emerged as an ideal model organism for environmental and biomedical research due to its small size, genetic similarity to humans (~70%), and rapid life cycle (Zon & Peterson, 2005). Its transparency during embryonic and larval stages facilitates developmental observations, while its

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high fecundity and ease of maintenance make it a cost-effective choice for laboratory studies. Zebrafish have been extensively used for toxicological studies, particularly to evaluate water contaminants and their effects on organ systems (Kimmel et al., 1995).

This study aims to assess the physico-chemical properties of groundwater in Tirupattur District, Tamil Nadu, and its toxicity using zebrafish as a model organism. Additionally, the research seeks to explore the removal of heavy metals and harmful contaminants through a biofilter using microorganisms and activated carbon, thus addressing both water quality analysis and remediation strategies.

2.Experimental

2.1.Physico-chemical parameters of ground water samples:

The ground water samples were collected from five different regions of Tirupattur District namely S1-Pachal; S2-Karupanur; S3-Pudhupet; S4-Adiyur and S5-Madavalam during the month of October 2022 and analyzed for physic-chemical parameters like Temperature, pH, Dissolved Oxygen (ppt), Dissolved solids (ppt), The Electric conductivity (ms), Salinity

(g of salt per litre) and Fluoride(ppt) using Water Quality Tester (HM Digital, India).

2.2. Histopathology:

Histopathology was used to detect potentially deleterious effects of compounds to a particular organ or tissue. In this study Gut, Liver and Gill of Zebrafish was evaluated for histopathology. The ground water sample S3 collected from Pudhupet region was checked for toxicity in the organs of Zebrafish for a duration of 30 days.

2.3. Formation of biofilter:

Consortium of seven bioremediation bacteria consisting of Pseudomonas spp. (four species); Bacillus spp. (two species), and Achromobacter sp. (one species) are co-cultured in nutrient broth at pH 7.0. Co-cultured cells were mixed with sodium alginate and treated against 0.1 CaCl2 to form microencapsulated beads. Beads were closely packed in a glass column of diameter 100 mm above several layers of activated carbon (from charred groundnut shell) and crab shell chitosan to form filtered bed. The filter bed was covered with glass wool on either end within the water column and frozen under refrigeration to make closely packed filtration bed.

3. Results and Discussion

3.1. Physico-chemical parameters of ground water samples:

The ground water samples were collected from five different regions of Tirupattur District namely S1-Pachal; S2-Karupanur; S3-Pudhupet; S4-Adiyur and S5-Madavalam and analyzed for physic-chemical parameters. In the sample S3 collected from Pudhupet region had high TDS (Total Dissolved Solids) of more than 1800 (Table 1). The pH of the water sample was 7.8, dissolved oxygen was found to 0.8 ppt, dissolved solids was around 1.91, electrical conductivity was found to be 2.64 ms, salinity was found to be 0.8 g/L and a high fluoride content of about 1.2 ppt. The sample also contained coli form bacterial species. The results implicated that the ground water sample contained TDS level and other parameters above the permissible limit. Hence, the sample was used for further toxicity studies in Zebra fish.

Table 1. Physico-chemical properties of ground water samples in Tirupattur region.

S.No.	Parameters	S1	S2	S3	S4	S5
1.	Temperature	27.5°C	28.3°C	**28.5°C**	27.7°C	28.2°C
2.	pH	7.3	7.1	**7.8**	7.6	7.5
3.	Dissolved Oxygen (ppt)	0.8	0.82	**0.8**	0.86	0.85
4.	Dissolved solids (ppt)	0.91	1.11	**1.91**	1.43	1.31
5.	The Electric conductivity (ms)	1.87	1.47	**2.64**	2.23	1.98
6.	Salinity (g of salt per litre)	0.5	0.7	**0.8**	0.5	0.6
7.	Fluoride(ppt)	0.9	0.7	**1.2**	0.5	0.5

S1-Pachal; S2-Karupanur; S3-Pudhupet; S4-Adiyur; S5-Madavalam.

Figure 1. Physico-chemical properties of ground water sample S1 collected from Pachal in Tirupattur district.

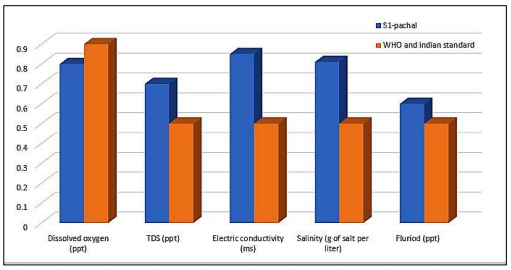


Figure 2. Physico-chemical properties of ground water sample S2 collected from Karupanur in Tirupattur district.

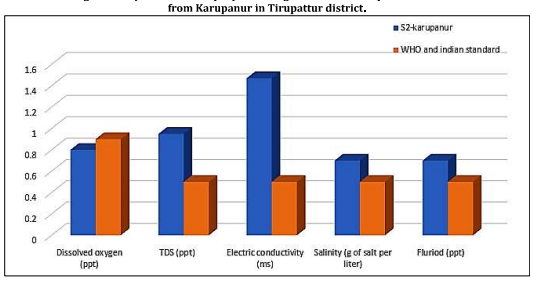


Figure 3. Physico-chemical properties of ground water sample S3 collected from Pudhupet in Tirupattur district.

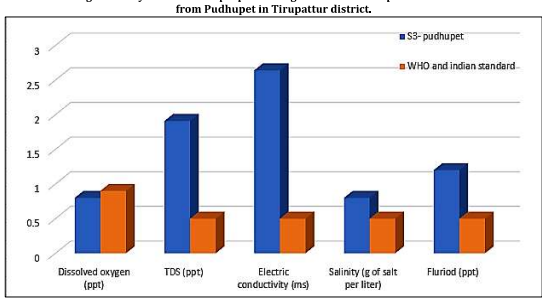


Figure 4. Physico-chemical properties of ground water sample S4 collected from Adiyur in Tirupattur district.

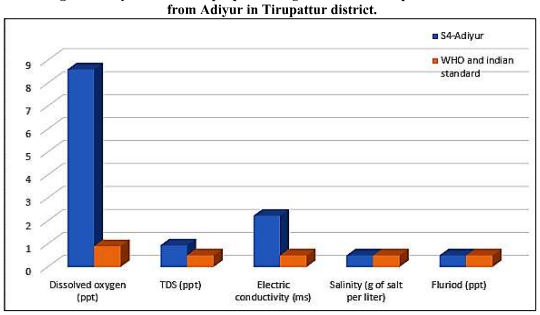
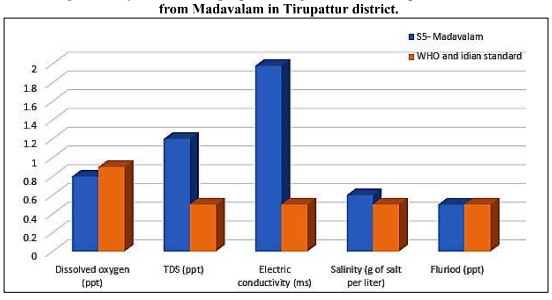


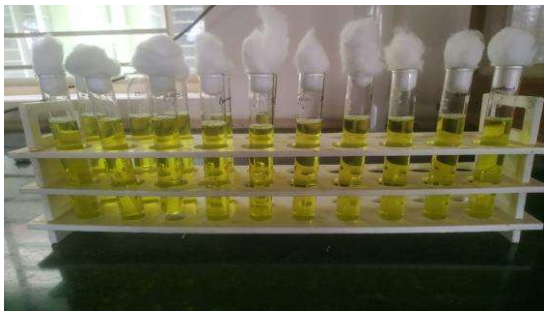
Figure 5. Physico-chemical properties of ground water sample S5 collected from Madavalam in Tirupattur district.



3.2. Total Viable Counts and Most Probable Number (MPN) of ground water sample:

By simulating liquid broth development in tenfold dilution, MPN is used to calculate the number of viable microorganisms present in the sample S3 collected from Pudhupet region. It is frequently used to calculate the microbial populations in farm goods, waterways, and soils. For samples having particles that obstruct plate count enumeration methods, the MPN test is particularly helpful. The most common application of MPN is for testing the quality of water, which establishes the safety of the water based on the existence of bacteria. The biomarker of feces contamination in water is a group of microorganisms called faecal coliforms. As opposed to the discovery of a large amount of faecal coliform bacteria, which would indicate an elevated risk that the water consists of disease-causing organisms and is unsafe for consumption, the presence of very few fecal coliform bacteria would suggest that the water is likely free of disease-causing organisms. MPN stands for the most likely number. It alludes to a sensory and quantitative analysis of water which can spot faecal coliforms. Ingesting E. coli, a common faecal pollution found in water, can cause serious illness. Escherichia coli are therefore used as a "Pollution indicator" within the MPN technique to assess the water's quality. Three different sets of methods, which include three steps presumptive, completed and confirmatory processes, make up the most likely number. Since the test for the presence of coliform bacteria was successful and there was gas in the broth tube non-spore forming rods on the Na slant as well as presence of gram negative bacteria in the ground water sample S3 collected from Pudhupet region (Fig. 6).

Figure 6. MPN test for ground water sample S3 collected from Pudhupet region.



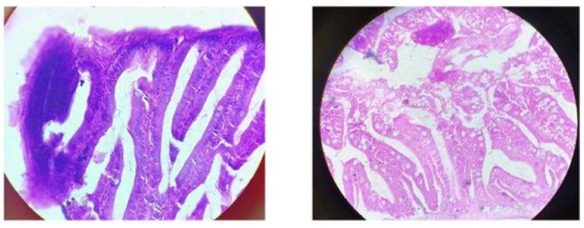
3.3. Histopathology as a tool to assess toxicity in adult Zebrafish(Danio rerio):

The study of tissue alterations is defined as histopathology. This method is useful to detect potentially deleterious effects of compounds to a particular organ or tissue. In this study Gut, Liver and Gill of Zebrafish was evaluated for histopathology (Fig. 7). The ground water sample S3 collected from Pudhupet region was checked for toxicity in the organs of Zebrafish for a duration of 30 days.

3.3.1. Histopathology of Intestine:

Zebrafish have villi that are encircled by a layer of mucous and make up their intestine. Figure 7 shows the comparison between control and ground water exposed intestine tissues. Control and ground water exposed intestinal sections are contrasted. Normal villi, goblet cells, and muscle layer are visible in control intestinal mucosa. GW exposed intestinal tissue that exhibited normal enterocyte and goblet cell hyperplasia as well as other histopathological changes (X100).

Figure 7. Histopathology of control and ground water exposed intestine tissues.

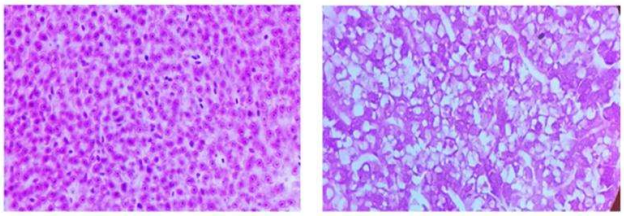


Control GW Exposed

3.3.2. Histopathology of Liver:

Figure 8 shows the comparison between control and ground water exposed liver tissues. Control and ground water exposed liver sections are contrasted. Normal blood arteries, bile ducts, and hepatocytes are visible in the control liver tissue. Liver tissue exposed by GW had the usual histopathological changes of hyperemia, vacuolization, and necrosis. (X100).

Figure 8. Histopathology of control and ground water exposed liver tissues.

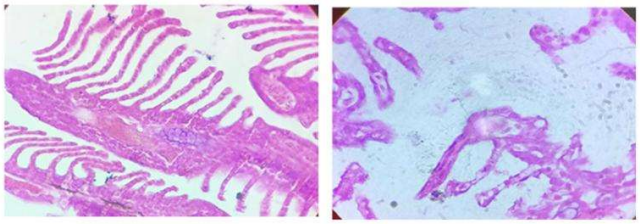


Control GW Exposed

3.3.3. Histopathology of Gill:

Figure 9 shows the comparison between control and ground water exposed gill tissues. Control Gill tissue showing normal primary lamellae, secondary lamellae and cartilage supporting the venous sinusoids. Groundwater exposed gill tissue with typical histopathological changes, such as aneurysm and displacement of epithelial cells (X100).

Figure 9. Histopathology of control and ground water exposed gill tissues.



Control GW exposed

3.4. Formulation of Bio-Filter:

Water containing high Total Dissolved Solids (TDS) of more than 1800 ppm was allowed to pass through the filter column bed at the rate of 1 mL per minute (Fig. 10). When filtration was completed, the filtrate was estimated for TDS and found to be between 300 and 500 ppm.

In addition, the pH of the initial water sample was basic between 8.0 and 9.0 due to presence and decomposition of organic matter contributing the increased TDS content.

However, after filtration bacterial encapsulates,activated carbon, and chitosan polymers reduced the total organic matter and the final pH was reduced 6.8 which is desirable suitable for drinking purpose.

The collected filtered water was estimated for the presence of coliforms. Results indicated that no coliforms are present and hence,resultant water is potable drinking water as an outcome of this study.

Figure 10. Ground water passed through bio-filter column.

4. Conclusion

In this study, five different water samples were collected from Tirupattur region and evaluated for its physico-chemical properties. It was found that in the S3 sample collected from Pudhupet region was having high TDS and the sample was further selected for histopathological studies in Zebrafish. The ground water samples were checked for toxicity in the above organs of Zebrafish for a duration of 30 days. Control intestine tissue showing normal villi, goblet cells and muscle layer. GW exposed intestine tissue with typical histopathological changes, such as hypertrophy of enterocytes and hyperplasia of goblet cells. Control liver tissue showing normal hepatocytes; blood vessels and bile ducts. GW exposed Liver tissue with typical histopathological changes, such as hyperemia, vacuolization and necrosis. Control Gill tissue showing normal primary lamellae, secondary lamellae and cartilage supporting the venous sinusoids. GW exposed Gill tissue with typical histopathological changes, such as aneurysm and displacement of epithelial cells. A bio-filter was formulated which showed decrease of TDS from 1800 to 500 ppm. Results indicated that no coliforms are present and hence, resultant water is potable drinking water as an outcome of this study.

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