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Assessment of the Impact of Anthropogenic Activities on the Water Quality of Tuikual River in Aizawl District, Mizoram, India

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ABSTRACT

The present research was conducted for a period of one year (October 2019 to September 2020). A total of four sampling sites were selected from upstream to downstream of river Tuikual along Aizawl city (Site 1 and 2 receive municipal waste, biomedical effluents, untreated city garbage, domestic and sewage discharges from the catchment area; Site 3 and 4 are characteristically tourist attraction). The findings reveal that there is a drastic change in water quality attributes as exposed to various kinds of pollutants. The water quality index (WQI) ranged between 111.3 during post-monsoon season and 160.5 during monsoon season at Site 1, 120.6 during post-monsoon season and 174.8 during monsoon season at Site 2, 60.66 during post-monsoon season and 84.9 during monsoon season at Site 3, 67.9 during post-monsoon season and 91.3 during monsoon season at Site 4. It indicates that the river water is not fit for drinking, as WQI values were sharply high at all sites with relatively low values during post-monsoon season. The findings reveal that there is an ample scope of proper treatment of river water before it is supplied for drinking purposes.

Keywords Physico-chemical characteristics, Pollutants, Water quality index, Water treatment.

INTRODUCTION

The dumping of domestic sewage and industrial effluents into natural water bodies such as rivers, streams and lakes has polluted around 70% of India's water (Sunar and Mishra 2016). Most rural families carry out normal activities such as fabric washing, utensil washing, bathing livestock washing near the groundwater sources due to a lack of education and awareness, which is one of the reasons for contamination of water bodies on a large scale (Reddy *et al.* 2014).

The hospitals generate large amount of waste water which is ultimately discharged into river situated in vicinity without any treatment (Kumari *et al.* 2020). Forests interact with freshwater systems in multiple directions and are in charge of regulating water quality in a variety of ways, including stability of soil and load of sediment, presence of a variety of tree species and their impact on water acidification, management of downstream water logging and sa-

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linity, influencing the water availability for irrigation systems and much more (Deka *et al*. 2021).

Assessment of the water quality Index is critical for preventing and controlling river pollution as well as obtaining trustworthy information on water quality for optimal management (Islam *et al.* 2020).

The goal of the study was to use the WQI technique to examine the impact of anthropogenic activities on all the four Tuikual river sites and compare the results to various agencies' requirements. This study could lead to further detailed investigations of the Tuikual River's water resources, as well as the formulation of water management policies and activities.

MATERIALS AND METHODS

Description of the study area and study sites

The Tuikual river (23˚ 43 ' 49.8" N latitude and 92˚ 42'26.6" E longitude) located at the center of Aizawl city is a river that runs through Aizawl city which is also known as Tuithum Lui just before emerging with Tlawng river. Fig 1 depicts the study area, which is approximately 9.45 kilometers long and carries wastewater drains, domestic waste, city garbage, municipal waste and other pollutants from many parts of Aizawl city.

The descriptions of the four selected sites are as follows.

Site 1- The chosen location was upstream of the river, close to the source (sample containing Aizawl Civil Hospital effluents).

Site 2- It was selected where the tributary meets the river to assess the impact of tributary water having domestic waste from settlement and hospital discharges (sample taken after the confluence of Aizawl Civil Hospital and Ebenezer Hospital effluents).

Site 3- Site 3 was selected at the point where the river receives sandstone quarry effluents (known as Khawhpawp River).

Site 4- It was selected downstream of the river, where it joins the Tlawng (known as Tuithum river).

The water samples were collected at monthly intervals (in triplicate) from the four selected study sites for a period of one year i.e., from October 2019 to September 2020. The findings were computed and expressed on a seasonal basis i.e., post-monsoon season (October-January), pre-monsoon season (Feb-

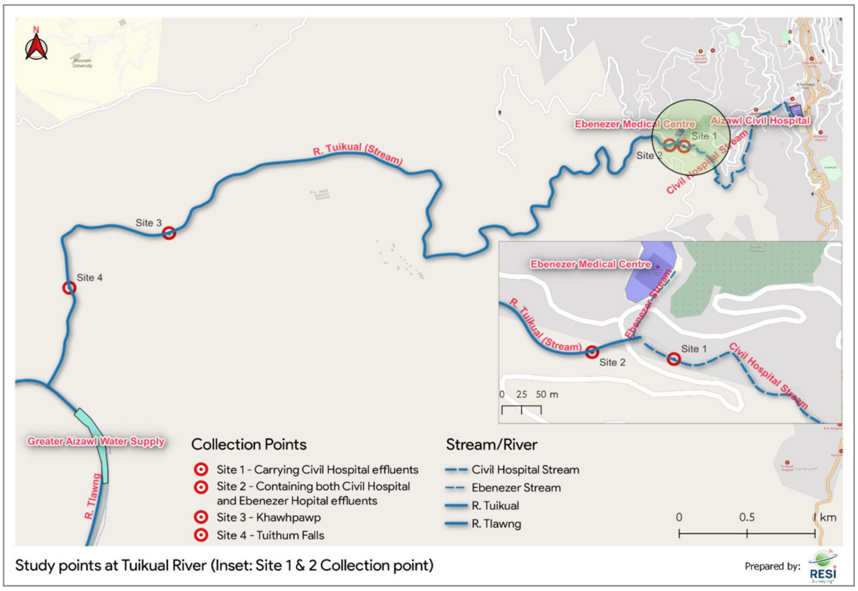

Fig. 1. Map of study area.

ruary-May) and monsoon season (June-September). The method outlined in 'Standard Methods for Examination of Water and Wastewater' as prescribed by APHA (2005) was followed for the analysis.

The findings have been compared with the standards laid down by scientific agencies like the Indian Council of Medical Research (ICMR 1996), Bureau of Indian Standards (BIS 2005), United States of Public Health (USPH 1962) and World Health Organization (WHO 2004).

Water quality index (WQI) analysis

The water quality index (WQI) was calculated by using the Weighted Arithmetic Index method. The Weighted Arithmetic Index method was calculated by using the following equation (Brown *et al.* 1972):

$$WQI = \sum_{n=1}^{n} q_n W_n / \sum_{n=1}^{n} W_n$$

Quality rating q_n and unit weight W_n are the n^{th} water quality parameter's quality rating and unit weight.

The quality rating or $q_n = 100\ [(V_n - V_{id}) / (S_n - V_{id})]$

Where n^{th} = water quality parameter

V_n = estimated value of the n^{th} water quality parameter

V_{id} = ideal value of the n^{th} parameter in pure water (pH= 7 and DO=14.6 are the only two parameters where the ideal values are not 0, other parameters are all 0)

S_n = standard permissible value for the n^{th} parameter (Table 1 represents the standard values, recommending agencies, ideal values and unit weight).

$W_n = k/S_n$

Where k is the proportionality constant

RESULTS AND DISCUSSION

pH

The pH of the water samples ranged from 7.0 during monsoon season at Site 1 to 8.02 during post-monsoon season at Site 4 (Fig. 2). The findings revealed

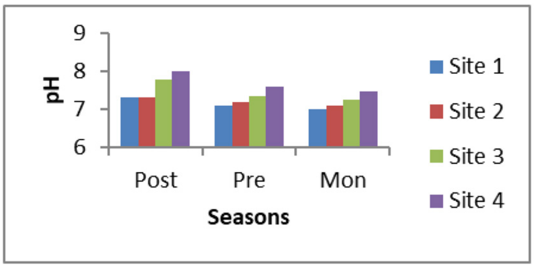

Fig. 2. Seasonal variation in water pH.

that pH was slightly lower during the monsoon season at Site 1, which may be linked to heavy rainfall that contaminates the water bodies by surface and agricultural runoff or the high decomposition rate of organic matter that release humic acid (Saikia and Gupta 2012).

Turbidity

Turbidity of water ranged from 6.5 NTU during post-monsoon season at Site 3 to 28 NTU during monsoon season at Site 2 (Fig. 3). It was discovered to be at its maximum during the monsoon, which could be due to significant rainfall that brings sediment, organic and inorganic material, suspended particles and other contaminants into the water body from the catchment area (Thasangzuala and Mishra 2014). The results show that none of the measured turbidity levels are within the BIS's prescribed range (Table 1).

Dissolved oxygen (DO)

The DO content ranged from 4.57 mgL^{-1} during monsoon season at Site 2 to 7.90 mgL^{-1} during post-mon-

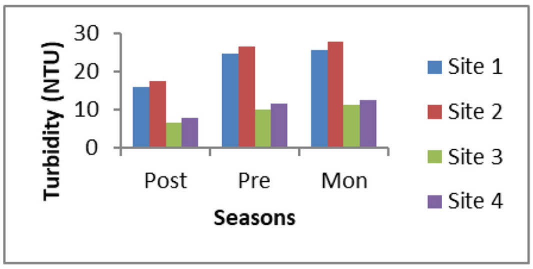

Fig. 3. Seasonal variations in water turbidity.

Table 1. Parameters with their units, standard values with their recommending agencies, ideal values and unit weight.

Sl. No.	Parameters	Units	Standard values	Recommending agencies	Ideal values	Unit weight
1	pH	-	6.5-8.5	BIS/ICMR	7	0.117
2	Turbidity	NTU	5	BIS	0	0.2
3	Dissolved oxygen	mgL^{-1}	5	BIS/ICMR	14.6	0.2
4	Biological oxygen demand	mgL^{-1}	5	ICMR/WHO	0	0.2
5	Nitrate-N	mgL^{-1}	10	USPH	0	0.1
6	Sulfate	mgL^{-1}	150	BIS/ICMR	0	0.006
7	Total suspended solids	mgL^{-1}	500	WHO	0	0.002
8	Total Hardness	mgL^{-1}	300	BIS/ICMR	0	0.003
9	Calcium hardness	mgL^{-1}	75	BIS/ICMR	0	0.013
10	Total alkalinity	mgL^{-1}	120	ICMR/USPH	0	0.008
11	Chloride	mgL^{-1}	250	ICMR	0	0.004
12	Electrical conductivity	µS	300	ICMR	0	0.003

NTU = Nephelometric Turbidity Unit; mgL^{-1} = milligram per liter.

soon season at Site 4 (Fig. 4). The influx of organic matter from the catchment region through runoff accelerates the microbial breakdown that results in high DO consumption and was also shown to lower DO levels during the monsoon season at Sites 1 and 2 (Shivayogimath *et al*. 2012). According to the research, the DO content readings do not fall within the BIS and ICMR specified limits (Table 1).

Biological oxygen demand (BOD)

The average BOD ranged from 0.60 mgL^{-1} during post-monsoon season at Site 4 to 3.27 mgL^{-1} during monsoon season at Site 2 (Fig. 5). BOD levels rose during the rainy season, owing to the addition of more biodegradable organic matter from surface runoff brought into the water body by heavy rainfall, which stimulated microbial activity (Gadhia *et al*. 2012).

Nitrate-N (NO_3^-)

According to the findings, nitrate levels in the water sample ranged from 0.18 mgL^{-1} during post-monsoon season at Site 4 to 0.37 mgL^{-1} during monsoon season at Site 2 (Fig. 6). Due to runoff from fertilized agricultural areas and septic tank leakage entering the water body, the nitrate content was at its maximum during the monsoon. At Sites 1 and 2, soil erosion and direct sewage discharge into the body of water raise the nitrate content.

Sulfate (SO_4^{2-})

The concentration of sulfate in the water sample ranged from 1.17 mgL^{-1} during post- monsoon season at Site 4 to 4.2 mgL^{-1} during monsoon season at Site 2 (Fig. 7). Due to surface runoff from sulfate-containing soils and rocks into the water body delivered by heavy

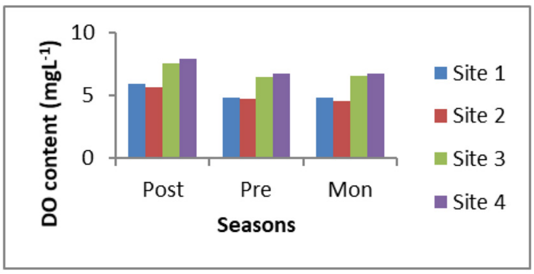

Fig. 4. Seasonal variation in water DO content.

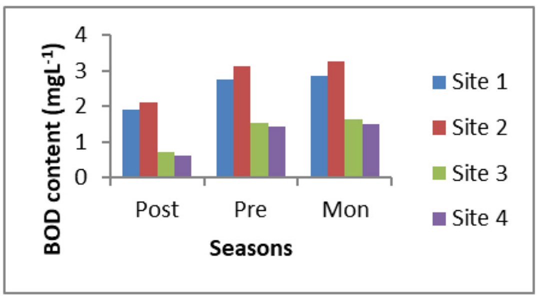

Fig. 5. Seasonal variation in water BOD content.

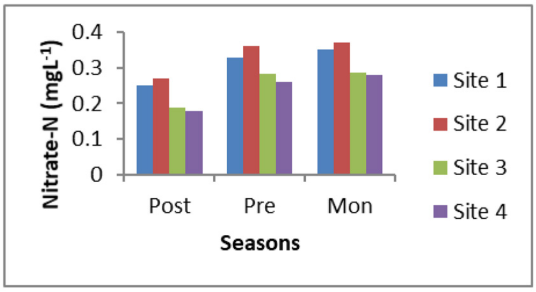

Fig. 6. Seasonal variation in water Nitrate-N content.

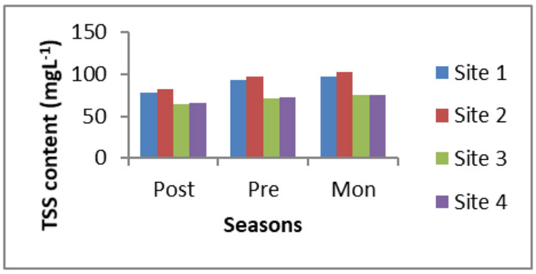

Fig. 8. Seasonal variation in water TSS content.

rainfall, sulfate concentration was maximum during the monsoon. Municipal and industrial wastewater discharges directly into the water body raise the sulfate concentration at Sites 1 and 2 (Rizvi *et al.* 2015).

Total suspended solid (TSS)

TSS levels varied between 64 mgL^{-1} during post-monsoon season at Site 3 to 102 mgL^{-1} during monsoon season at Site 2 (Fig. 8). The highest TSS concentration was found during the rainy season and may be linked to the inflow of impurities, runoff from agricultural land and soil erosion carried by heavy rainfall into the water body (Bhenila and Biswas 2018). Because of the abundance of soil and silt in the surrounding area draining into the river body, TSS levels were greater in Site 1 and Site 2.

Total hardness (TH)

The total hardness of the water ranged from 78.7 mgL^{-1} during monsoon season at Site 4 to 182 mgL^{-1} during pre-monsoon season at Site 2 (Fig. 9). The values were found to be greater during the pre-monsoon which may be linked to washing activities in the reservoir or along the bank using a detergent containing the causative agent of hardness like calcium and magnesium (Lalbiakmawia *et al.* 2020).

Calcium hardness (Ca^{2+})

The calcium hardness of the water was found to vary between 49.3 mgL^{-1} during monsoon season at Site 4 to 123.7 mgL^{-1} during pre-monsoon season at Site 2 (Fig. 10). During the pre-monsoon season, weathering of calcium-containing rocks, mineral deposits, a low water table and excessive evaporation may result in a high calcium hardness of water (Elayaraj and Selvaraju 2015). The majority of the calcium hardness readings reported do not fall within the ICMR and BIS limits (Table 1).

Total alkalinity (TA)

The study revealed that values of alkalinity ranged from 74.7 mgL^{-1} during monsoon season at Site 4 to

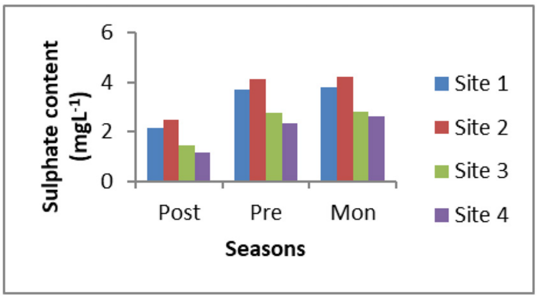

Fig. 7. Seasonal variation in water sulfate content.

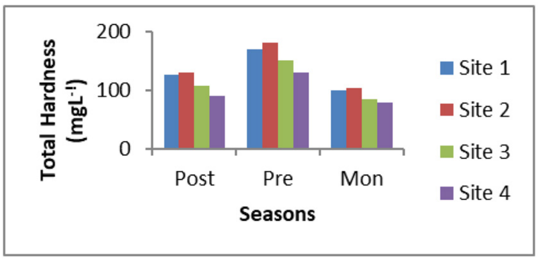

Fig. 9. Seasonal variation in water TH content.

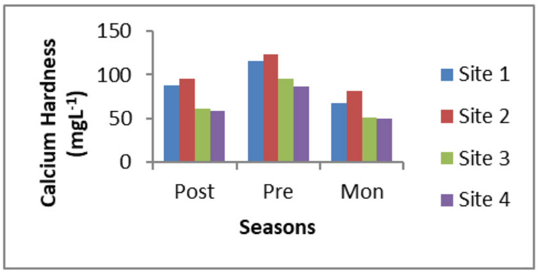

Fig. 10. Seasonal variation in water Ca^{2+} hardness content.

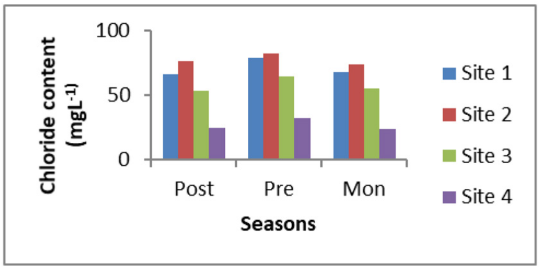

Fig. 12. Seasonal variation in water Cl^{-1} content.

270.5 mgL^{-1} during pre-monsoon at Site 2 (Fig.11). Higher values of alkalinity during the pre-monsoon may be attributable to the laundering of clothes and bathing in the reservoir by using detergents and soap (containing dissolved carbonates and bicarbonates) during the dry period. Site 2 displays the greatest overall alkalinity values, indicating sewage infiltration directly into the water body (Elayaraj and Selvaraju 2015, Lalbiakmawia *et al.* 2020). The results show that the majority of the total alkalinity values recorded were above the ICMR and USPH acceptable limits (Table 1).

Chloride (Cl^{-1})

The lowest chloride content was 23.5 mgL^{-1} at Site 4 during monsoon season and the highest was 82 mgL^{-1} at Site 2 during pre-monsoon season (Fig. 12). Low water levels, fecal waste and an increase in the release of another chloride-rich sewage effluent all contributed to the highest chloride levels at Site 2 during the pre-monsoon season (Elayaraj and Selvaraju 2015). Water dilution caused by excessive rainfall could explain the lower results during the monsoon season.

Electrical conductivity (EC)

The results indicate that EC ranged from 137.5 µS during monsoon season at Site 4 to 564.2 µS during pre-monsoon season at Site 2 (Fig. 13). The EC value was found higher during the pre-monsoon and post-monsoon periods, possibly due to the increased concentration of salts and low water table (Thasangzuala and Mishra 2014). The results show that the EC recorded values were greater than the ICMR's permitted level (Table 1).

Water Quality Index (WQI)

Using Table 2 and the Weighted Arithmetic Water Quality Index, Fig. 14 shows that Site 1 scored 111.3 (unfit for consumption) during post-monsoon season, 158.3 (unfit for consumption) during pre-monsoon season and 160.5 (unfit for consumption) during monsoon season, Site 2 scored 120.6 (unfit for consumption) during post-monsoon season, 169.7 (unfit for consumption) during pre-monsoon season, 174.8 (unfit for consumption) during monsoon season, Site 3 scored 60.66 (poor) during post-monsoon season,

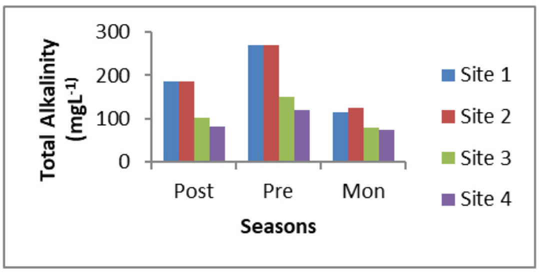

Fig. 11. Seasonal variation in water TA content.

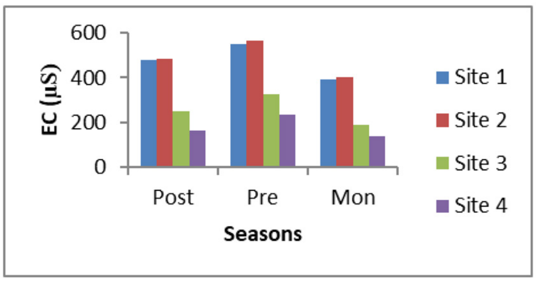

Fig. 13. Seasonal variation in water EC content.

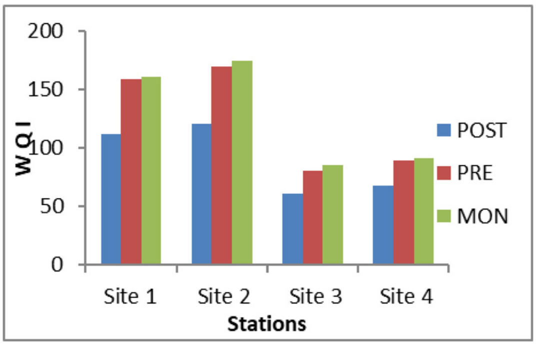

Fig. 14. Seasonal variations of WQI of Tuikual.

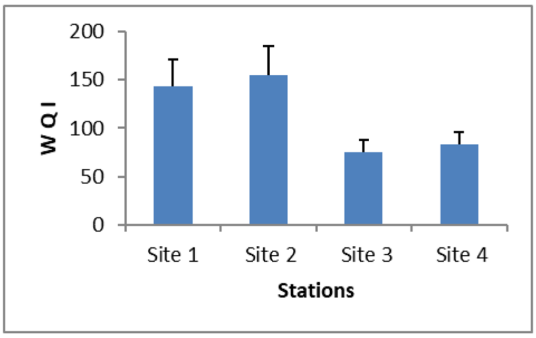

Fig. 15. The overall WQI of Tuikual river.

80.6 (very poor) during pre-monsoon season and 84.9 (very poor) during monsoon season, Site 4 scored 67.9 (poor) during post-monsoon season, 88.9 (very poor) during pre-monsoon season and 91.3 (very poor) during monsoon season. The lowest value was recorded during the post-monsoon season, while the highest value was recorded during the monsoon season. The high value during the monsoon season could be attributed to surface run-off from the catchment area containing municipal waste from random disposal. The findings are in conformity with the work of Sunar *et al.* (2020), Lalbiakmawia *et al.* (2020), Thasangzuala and Mishra (2014).

CONCLUSIONS

As per the Weighted Arithmetic Water Quality Index-(WAWQI), Fig. 15 shows that the overall quality of river water at Site 1 (WQI-143.3) and Site 2 (WQI-155) was found to be unsuitable for drinking, Site 3 (WQI-75.3) and Site 4 (WQI-82.7) as very poor water quality. The unplanned and direct discharge of waste from various sources has resulted in deterioration of water quality to a great extent at all the study sites.

Table 2. WQI and status of water quality (Brown *et al.* 1972).

Water quality index	Water quality status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
>100	Unfit for consumption

The turbidity, DO, calcium hardness, TA and EC levels exceeded the allowable limits set by various agencies. The monsoon season shows higher values in most of the studied parameters that is linked to high rainfall that washes nearby fertilized agricultural fields, municipal waste and other pollutants from the catchment area into the river water body.

Hence, there is an ample scope for formulating appropriate Tuikual River management strategies. Moreover, awareness of environmental education, a legal safeguard for rivers, solid waste and sewage management within the catchment area are urgently needed in order to save the Tuikual river. The river water needs proper treatment before supply for drinking purpose.

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