Assessment of Surface Water Quality using the Water Quality Index (WQI) : A Case Study of the Dharatana River, Bagerhat

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Abstract:- It is indisputable that all life forms on Earth are dependent on water for survival. However, water sources such as rivers, lakes, ponds, glaciers, and rainfall are threatened by urbanization, population growth, household refuse, and industrialization. The Dharatana River plays an essential role in meeting the diverse water requirements of the surrounding communities, including those for bathing, irrigation, domestic use, and fishing. However, the rapid expansion of minor industries and poultry farms may threaten the river's water quality. Therefore, a thorough evaluation regarding the river's water quality or various purposes is required. The influx of pollutants has had a significant impact on the Dharatana River, resulting in a progressive decline in its water quality. For data collection, a 10-kilometer segment of the river from Narasingh Datterber to Rastar Mhatha Launch Ghat, five sampling points were established. Monthly water samples collected and analyzed in a laboratory throughout 2022. Twenty water quality parameters, including physical, chemical, and biological aspects, were investigated using standard procedures. Twelve of these parameters were discovered to exceed the Bangladeshi drinking water standards. The purpose of this research is to evaluate the water quality of the Dharatana River by collecting water samples from five sampling sites and analyzing them in a laboratory. Temperature, pH, turbidity, conductivity, and color are some of the twenty water parameters. Other parameters include alkalinity, hardness, TS, TDS, BOD, COD, manganese, TSS, phosphate, nitrite, nitrate, chloride, DO, fecal coliform, and total coliform were among the twelve essential water quality parameters measured. The obtained values of the parameters were compared to WHO Standard and ECR'97 drinkable water standards. Calculating the WQI according to the National Sanitary Foundation (NSF) method, the water quality was evaluated. The correlations between chloride, IDS, and conductivity were identified as significant by the research. This correlation analysis aids in the management and monitoring of water Quality. The 2014 average WQI indicated comparable water quality in both the temporal (12-month) and spatial (5-station) dimensions, with scores near to one another. Five stations along the Dharatana River yielded water samples with WQI values of 66.80, 64.50, 67.80, 68.50, and 65.50 indicatingmoderate water quality. In 2014, the average WQI was 64 based on temporal analysis and 65 based on spatial analysis, indicating similar trends. The river water is undrinkable without purification. While the WQI simplifies complex variables, it is unable to differentiate between sources of pollution. Effective water management strategies are indispensable for enhancing the Dharatana River's water quality and suitability for a variety of purposes.

Keywords:- *Water Quality Index (WQI; Dharatana River; NSF-WQI.*

I. INTRODUCTION

75% of the human body is composed of water, which covers two-thirds of the Earth's surface. It has substantial aesthetic value as a source of nourishment, beauty, relaxation, and refreshment. Water is essential for the survival of many economic sectors, including agriculture, forestry, industrial activities, livestock production, hydroelectric generation, creative endeavors, and fisheries. Nonetheless, factors such as population growth, urbanization, and industrialization are diminishing the availability and integrity of water resources.

Bangladesh, situated at the confluence of the Ganges, Brahmaputra, and Meghna rivers, confronts distinct water management challenges. The country's 580 km of coastline is vulnerable to cyclones due to the numerous rivers passing through its territory, including those originating domestically and those entering from upper riparian countries.

Furthermore, Bangladesh experiences significant variation in water availability, which is distinguished by monsoon floods and droughts throughout the dry season, resulting in the intrusion of salt into the interior. These difficulties have been exacerbated by the intensifying effects of climate change, which have resulted in rising temperatures and greater water variability.

Surface waters are the primary source of water in Bangladesh such as rivers, lakes, reservoirs, channels, and ponds, as well as groundwater from shallow and deep aquifers. However, Surface and groundwater sources both are confronted with significant pollution issues. Groundwater throughout Bangladesh is contaminated with arsenic and iron, while rivers, the primary source of surface

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water, are becoming increasingly polluted due to urbanization and industrialization. In addition to the discharge of industrial and urban effluents, the application of chemical fertilizers and pesticides in agriculture also contributes to deterioration of water quality.

Bangladesh's deteriorating water quality has grave consequences for human health, ecosystems, and sustainable development. Bangladesh, a country in the early stages ofindustrialization, encounters negative consequences stemming from urbanization and industrialization. The pollution levels in water bodies and rivers have reached alarming levels, with toxic organic and inorganic substances causing long-term contamination.

Continuous monitoring of water quality parameters is necessary to resolve these concerns and advance sustainable water resource management. Nevertheless, the conventional method of manual data processing and analysis is labor-and time-intensive. To develop mathematical relationships and facilitate the interpretation of water quality parameters, alternative statistical correlation-based methods have been employed.

Evaluating the Dharatana River's physicochemical parameters in Khulna region of Bangladesh is the focus of the present investigation. The city of Khulna, which is encompassed by the Rupsha and Dharatana Rivers and canals, is plagued by pollution from a variety of industrial and domestic sources. Understanding the Dharatana River's current water quality is essential for instituting effective pollution control measures and ensuring sustainable water management practices.

By integrating multiple parameters into a single value, water quality indices, such as WQI, offer a comprehensive evaluation of the water quality. This makes water quality data easier to interpret and communicate, making it more accessible to policymakers and the general public. The WQI has been modified and refined over the years to increase its applicability and accuracy in numerous countries where it has been extensively implemented.

Every system of manufacturing depends on water. Bangladesh's Department of Environment (DoE) has been keeping an eye on surface water quality since 1973 due to its importance (Department of Environment, 2014). In order to make decisions about environmental and public health issues, Water quality monitoring is required for rivers and lakes (Myers, 2018).

There hasn't been any research done on the water quality of the Dharatana River. Policymakers will benefit from knowing the river's water quality state as they decide how to proceed with regard to future environmental and public health issues.

The aim of this research is to assess the overall water quality state of the Dharatana River using two WQIs: the National Sanitation Foundation Water Quality Index (NSF-WQI). And another one is the Weighted Arithmetic WQI According to Sharma et al. (2014), the WQI simplifies presentation of a substantial amount of information regarding water quality by reducing it to a single phrase that is straightforward to comprehend. By understanding the WQI, it is simple to find out the river water's are suitable for various uses (Brown et al., 1972).

The WQI provides a comprehensive description of the water's quality and suitableness for various uses, such as drinking, fishing, industry, and irrigation (Abbasi, 2012). In recent decades, numerous researchers have used the WQI method to research the quality of both surface and groundwater (Sharma & Kansal, 2011).

II. METHODOLOGY

A. Sample Collection

In post-monsoon season (November 2022) samples were collected from five distinct stations. Clear weather prevailed during sampling. The sampling stations were chosen at random. Table 1 contains information on these stations. Table 2 outlines the sampling methods and parameters analyzed for water quality.

Each station's water sample was collected in a one-liter plastic receptacle. Before collecting samples, the previously cleaned vessels were given a final rinsing with water from the location itself three times. After collection, samples were placed in the chiller box for storage. The following day, collected samples were analyzed by the Environmental Engineering Laboratory of various parameters.

Table 1 Details Sampling Location Station of Dharatana River

SamplingLocation	**North Latitude**	**East Longitude**	**Sampling PointName**
S1	22°37’ 02”	89° 47’53”	Narasingh Datterber
S2	22° 36’ 15”	89° 47’ 18”	Pancha Malerber
S3	22° 35’ 12”	89° 47’ 19”	Bara Banshbaria
S4	22° 34’ 21”	89° 46’ 46”	Mandradia
S5	22° 33’ 18”	89° 46’ 12”	Rastar Mhatha
			Launch Ghat

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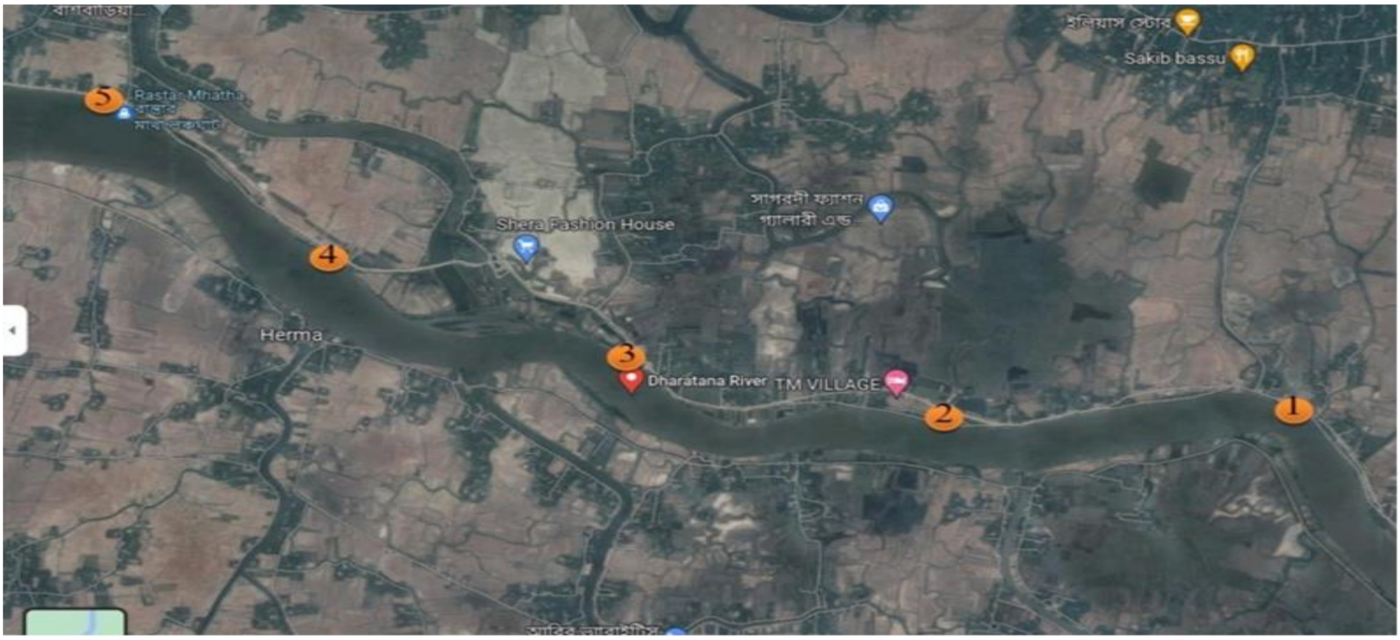

Fig 1 Details Sampling Location Station of Dharatana River

Table 2 Water Quality Parameters and Analysis Methods

S No.	Parameter	Unit	Method ofanalysis	Measurement
1	Total Coliform	cfu/ 100ml	Membrane filtering method	Laboratory
2	BOD	mg/l	Incubation andWinkler	Laboratory
3	Turbidity	NTU	Turbidimeter	Laboratory
4	Phosphate	mg/l	PhosVer 3 Phosphate reagent	Laboratory
5	Hardness	mg/l	Titration	Laboratory
6	Sulfate	mg/l	Sulfaver 4 sulfatereagent	Laboratory
7	TotalSolids	mg/l	Gravimetric	Laboratory
8	Nitrate	mg/l	Nitrite reagentNitriVer 3	Laboratory
9	Temperature	°C	Temperaturemeter	On-site
10	EC	µS/cm	Conductivitymeter	On-site
11	Alkalinity	mg/l	Titration	Laboratory
12	pH	-	pH meter	On-site
13	Chloride	mg/l	Titration Method	Laboratory
14	TDS	mg/l	GravimetricMethod	Laboratory
15	DO	mg/l	DO meter	Laboratory

B. Methodological Approach

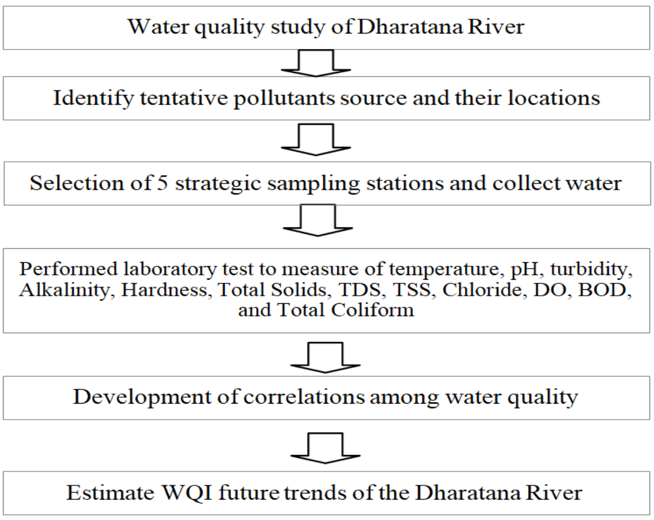

Fig 2 Methodological Approach

C. Weighted Arithmetic WQI

With weighted arithmetic index approach, the WQI is computed by multiplying concentration value of each water parameter by the 'unit weight factor' that is assigned to each parameter. This results in the calculation of the WQI. In order to find out the unit weight, the defined standard value for each parameter is used in computation. The purpose of establishing a 'unit weight' is to convert all of the water quality metrics to ascale that is standardized. If the value of a parameter's unit weight is increased, then that parameter will have a higher impact on the WQI.

During the process of producing the weighted arithmetic WQI, a total of twelve parameters are selected. According to Bora and Goswami (2017), these metrics include of fecal coliform, total solids, DO, pH, BOD, temperature, total hardness, turbidity, chloride, and alkalinity. Calculating thewater quality index allows one to ascertain current quality state of the water as well as any prospective uses it may have.

Table 3 The Parameters of Unit Weights (Wi), which are used to Calculate the WQI.

Parameter	**ECR'97 Standard**	**WHO standard**
Turbidity	25 NTU	10 NTU
EC	400 µS/cm	-
BOD	5 mg/l	0.2 mg/l
pH	6.5 - 8.5	6.5 - 8.5
TDS	500mg/l - 1000mg/l	1000 mg/l
TSS	500 mg/l	-
Temperature	20°C -30°C	20°C -30°C
Sulphate	250 mg/l	400 mg/l
Alkalinity	120 mg/l	-
Chloride	250 mg/l	150 mg/l - 600mg/l
Hardness	500 mg/l	200 mg/l -500mg/l
DO	5 mg/l	6 mg/l

➢ *The following Analytics Method was used to Figure out theWQI:*

$$WQI = \frac{\Sigma WiQi}{\Sigma Wi} \quad (1)$$

$$Qi = 100\left[\frac{(Vi - Vo)}{(Si - Vo)}\right] \quad (2)$$

- Where,
- Wi = Unit weight of i^{th} parameter. Wi = i^{th} parameter's unit weight.
- Qi = i^{th} parameter's sub-index value. Vi = i^{th} parameter concentration.
- Vo = i^{th} parameter's ideal value (Vo=7 for pH and 14.6 mg/lfor DO). Vo = 0 for all other values).
- Si = i^{th} parameter standard value.

➢ *Unit weight can be finding out by the formula:*

$$Wi = \frac{K}{Si} \quad (3)$$

$$K = \frac{1}{\Sigma \frac{1}{Si}} \quad (4)$$

Table 4 Water Quality Status and Applications with Respect to WQI Range (After Brown Et Al., 1972)

WQI	**Water quality**	**Applications**
0 to 25	Excellent	Drinking water, irrigation,and industrial applications
26 to 50	Good	Drinking water, irrigation,and industrial applications
51 to 75	Poor	Irrigation and industrialapplications
76 to 100	Very poor	Irrigation
Over 100	Unfit for drinking or fishculture	Prior to use, proper treatment is required.

D. National Sanitation Foundation Water Quality Index(NSF-WQI)

The nine critical criteria used in the creation of the NSF- WQI were the following: fecal coliform (FC), pH, DO, nitrate, BOD, turbidity, TS, temperature, and phosphate. Each parameter was given the same weight (in units). In addition, the

Table 5 Classification of the NSF-WQI

NSF-WQI Range	**Criteria**
0 to 25	Very Bad
26 to 50	Bad
51 to 70	Medium
71 to 90	Good
91 to 100	Excellent

III. RESULT AND DISCUSSION

Table 6 shows that water quality in Dharatana River doesn't change much along five sampling stations. DO, PH, BOD, TDS, Chloride, and Temperature were all within acceptable ranges at all sampling sites.

For drinking water, the DO concentration should be greater than 6 mg/l, according to ECR'97. Every station measured ranged from 5-6.5 milligram per liter.

The (BOD) ranged from 2.1 to 2.4 milligram per liter, exceeding the ECR'97 standard (0.2 mg/l).

Every sample station had too much fecal coliform, which was between 500 and 740 cfu/100 ml. At every station, the fecal coliform level was higher than the limit for drinking water (0 cfu/100 ml). Coliform germs grew

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because people dumped trash and did other things that made them grow.

The ECR'97 standard value (10 NTU) was exceeded by turbidity values ranging from 20 to 34 NTU. The station with the highest turbidity (34 NTU) was Station 4 (Mandradia).

Alkalinity values were between 165 and 290 mg/l. The alkalinity value of 5 stations exceeds the 120 mg/l ECR'97 standard value. Value of the i^{th} sub-index (Qi) was multiplied by the unitweight of the i^{th} parameter (Wi).

There are a total of nine rating curves (Brown et al., 1970) that can be used to evaluate the value of Qi relative to the concentration of the i^{th} parameter. Sub-index values used in this work were calculated using the online calculator of NSF-WQI. Once the value of Qi was determined, it was multiplied by the value of a unit of weight (Wi) and the resulting products were added together using the formula:

$$NSF - WQI = \Sigma WiQi \qquad (5)$$

- Where,
- Wi = i^{th} parameter's unit weight
- Qi = i^{th} parameter's sub-index value

The Hardness value ranged from 57.95 to 70.78 milligram per liter, that is below the range of the WHO standard value(500 mg/l) and the ECR'97 standard (200-500 mg/l)

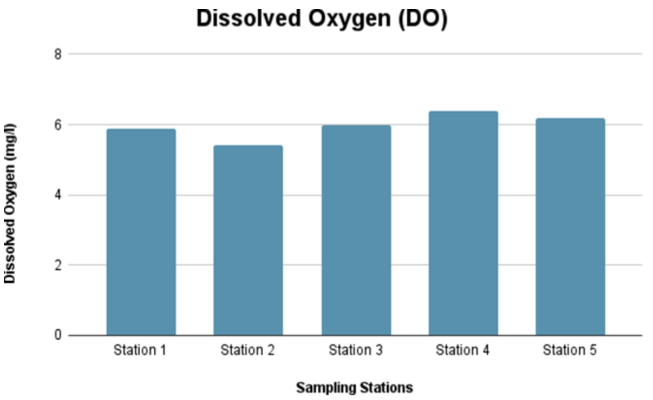

Fig 3 Dissolved Oxygen (DO)

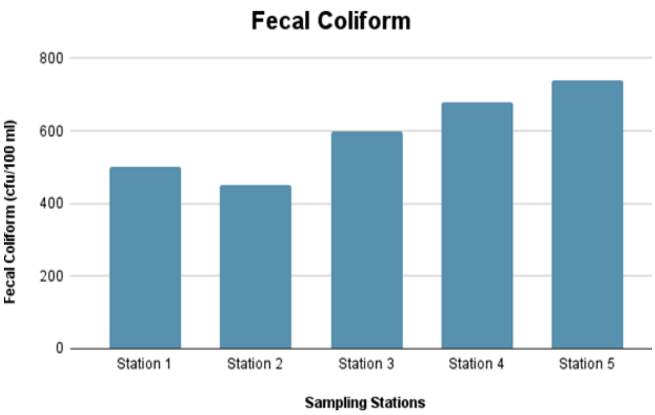

Fig 4 Fecal Coliform

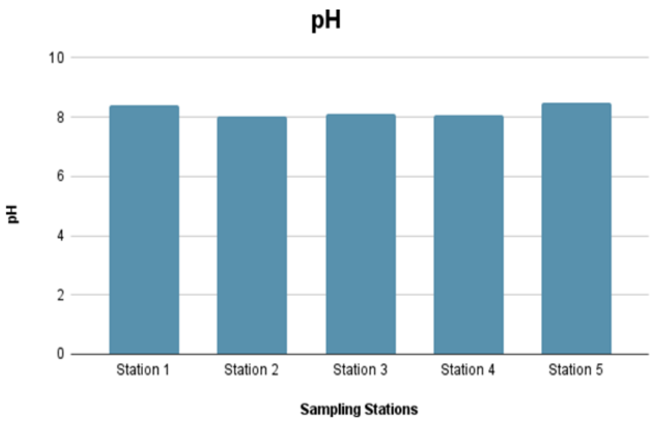

Fig 5 pH

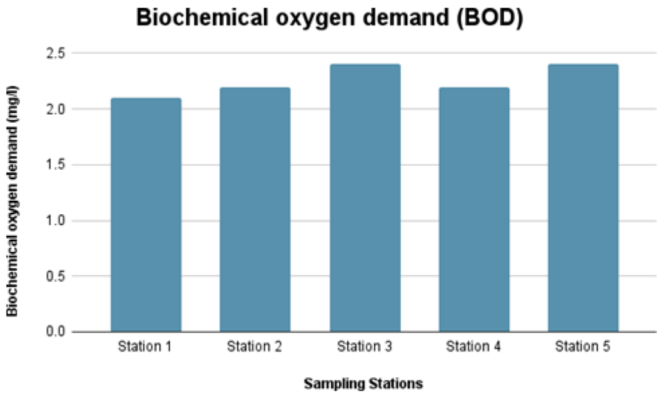

Fig 6 Biochemical Oxygen Demand (BOD)

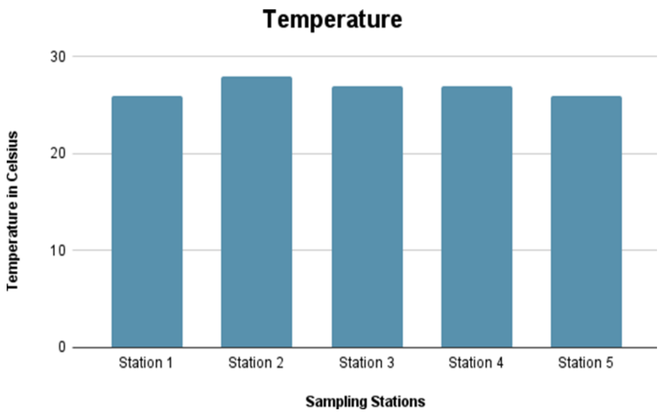

Fig 7 Temperature

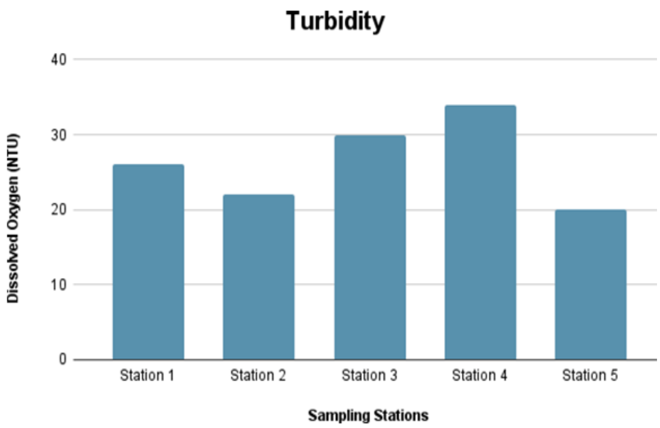

Fig 8 Turbidity

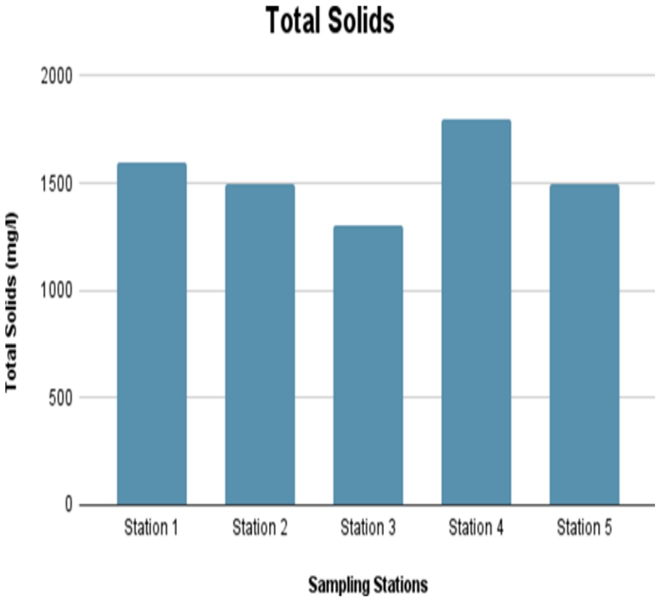

Fig 9 Total Solids

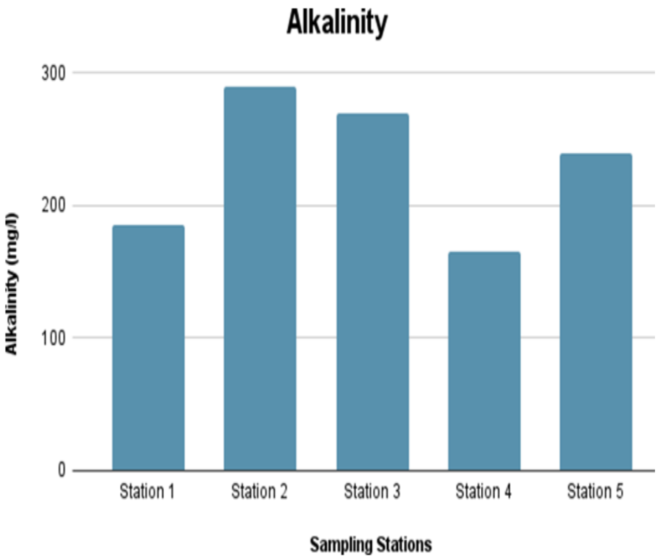

Fig 10 Alkalinity

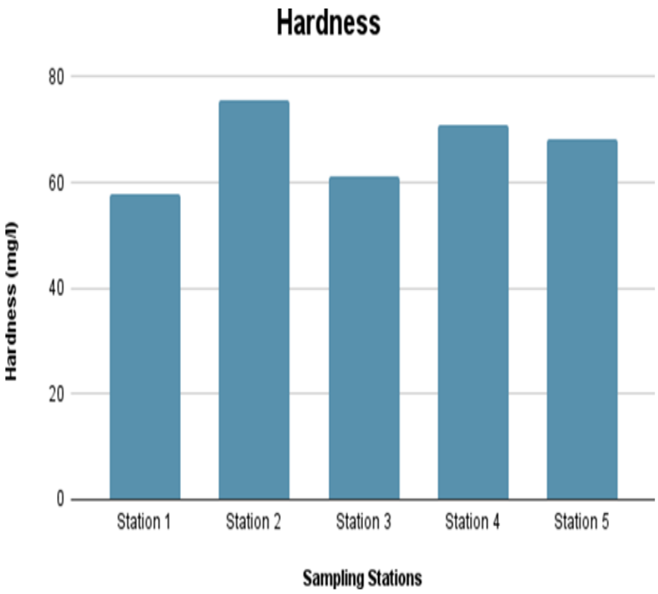

Fig 11 Hardness

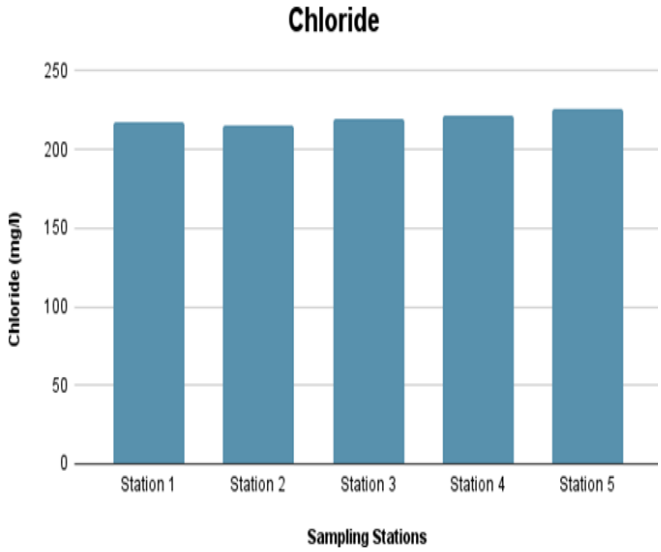

Fig 12 Chloride

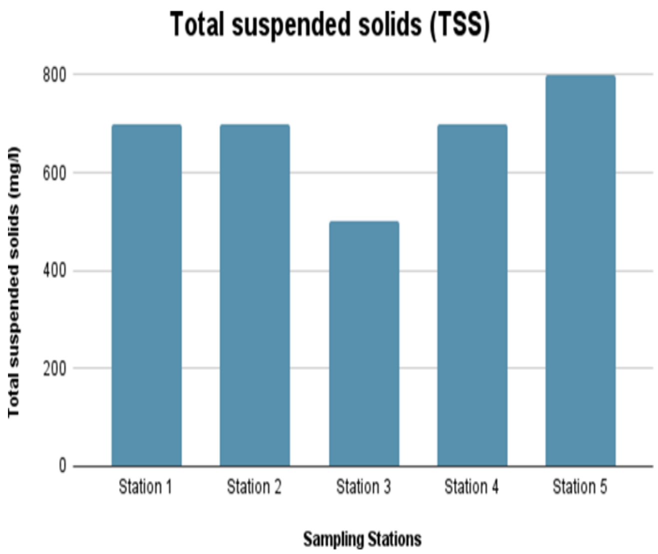

Fig 13 Total Suspended Solids (TSS)

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Table 6 Physiochemical Features of Dharatana RiverWater Samples Taken at Five Different Locations

Parameters	Unit	S1	S2	S3	S4	S5
DO	mg/l	5.9	5.4	6	6.4	6.2
Fecal Coliform	cfu/100 ml	500	450	600	680	740
pH	-	8.40	8.02	8.12	8.05	8.48
BOD	mg/l	2.1	2.3	2.4	2.2	2.4
Temperature	0C	26	28	27	27	26
Turbidity	NTU	26	22	30	34	20
Total Solids	mg/l	1600	1500	1300	1800	1500
Alkalinity	mg/l	185	290	270	165	240
Hardness	mg/l	57.95	75.53	61.28	70.78	68.4
TDS	mg/l	185	800	800	1100	700
Chloride	mg/l	57.95	215.5	219.5	221.5	225.5
TSS	mg/l	900	700	500	700	800

➢ *Weighted Arithmetic Water Quality Index*

All of the stations have nearly identical weighted arithmeticWQI values, that is regarded as “poor."

Table 7 Dharatana River's Weighted Arithmetic WQI Value

Stations	WQI Score	Waterqualitystatus	Possible usage
S1	66.80	Poor	Irrigation and Industrial
S2	64.50	Poor	Irrigation and Industrial
S3	67.80	Poor	Irrigation and Industrial
S4	68.50	Poor	Irrigation and Industrial
S5	65.50	Poor	Irrigation and Industrial

Table 8 Dharatana River's NSF Water Quality Index Value

Station	NSF-WQI Score	Water qualitystatus
S1	61.33	Medium
S2	59.70	Medium
S3	64.50	Medium
S4	64.80	Medium
S5	63.50	Medium

IV. CONCLUSION

➢ *The following are the Major findings of this paper:*

- The weighted arithmetic WQI method classifies the Pangunchi River's water quality as "poor" and the NSF-WQI method as "medium."
- The water in Pangunchi river is unsafe to drink. However, no treatment is required for use in irrigation or industrial applications.

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