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Comparative Study on Water Quality Index Values of Different Rivers of Damak, Jhapa, Nepal

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Abstract **- Standard procedures APHA methods had been used to measure the parameters such as pH, TDS, TSS, sulfate, chloride, total hardness, total phosphorus, calcium, magnesium, sodium, iron, nitrate, electrical conductivity, manganese, potassium, color, dissolved oxygen, total alkalinity, fluoride to compute the water quality index value (WQI). In Betani, Ratuwa and Dipeni concentration of iron was above the desirable range prescribed by Nepal Drinking Water Quality Standard (NDWQS) and WHO. The WQI for Betani, Dipeni, Haatkhola, Dhukure and Ratuwa were 95.444, 443.067, 54.426, 42.729, and 162.577 respectively. Water of Dhukure is suitable for drinking according to the parameters we have measured. On the basis of the parameters we have taken into account the water of Dipeni and Ratuwa rivers are not suitable even for fish farming. Due to concentration of iron and electrical conductivity above the permissible ranged defined by WHO and NDWQS, the water quality of Betani is very poor. Ratuwa and Dipeni rivers are in the extreme state of pollution. Haatkhola is significantly contaminated by the domestic and municipal wastes, so its water quality is poor. The main parameter responsible to increase the WQI is iron. Higher the concentration of iron, higher is the WQI value.**

Keywords **- pollution, domestic waste, WQI**

I. INTRODUCTION

Water is an elixir of life. With an increased understanding of the importance of drinking water quality to public health and raw water quality to aquatic life, there is great need to assess surface water quality [1]. Apart from source of fresh water, rivers play major role in assimilation or transportation of municipal and industrial waste water [2]. The chemistry of natural surface water is controlled primarily by atmospheric precipitation, chemical weathering and evapo-crystallization and secondarily by tributaries, ground water discharge and anthropogenic interferences [3]. The water quality from the rivers has a considerable importance for the reason that these water resources are generally used for multiple matters such as: drinking domestic and residential water supplies, agriculture (irrigation), hydroelectric power plants, transportation and infrastructure, tourism, recreation, and other human or economic ways to use water [4]. Urbanization, Industrialization and many other anthropogenic activities as well as few natural processes affect the water resources badly [5].

WQI is a mathematical instrument used to transform large quantities of water characterization data into a single number, which represents the water quality level [1].Sener in 2016 evaluated the water quality of Aksu River, based on the WQI developed by U.S. National Sanitation Foundation in 1970. Pant in 2018 made a study on spatiotemporal variations of hydro geochemistry in Gandaki River Basin. Studies focusing on water quality of water bodies from Nepal and especially on Eastern Region are scarce, so this study has a great importance for the reason. It describes the suitability of surface water sources from this area for human consumption being useful for communication of overall water quality information to the concerned citizens and policy makers.

To determine the reasons of major polluting sources that contribute to water quality depletion in the study area, an analysis has been made in order to evaluate the water quality of different rivers (Betani, Dipeni, Haatkhola, Dhukure, Ratuwa), using the water quality index (WQI) method, which is one of the most reliable indicators of the watercourses

pollution and the most convenient way to express the water quality at the same [4].

II. MATERIAL AND METHODS

The water quality index (WQI) is a mathematical instrument which provides a single number that expresses overall water quality at a certain location and time, based on several water quality parameters [6].In this study weighted arithmetic method has been used for the estimation of water quality index. Weighted arithmetic water quality index method classified the water quality according to the degree of purity by using most commonly measured water quality variables. Horton (1965) has first used the concept of WQI then developed by Brown *et.al*. (1970) and improved by Deininger (Scottish development department, 1975).

It is calculated as given in the equation (1).

$$WQI = \frac{\sum q_n W_n}{\sum W_n} \ldots\ldots\ldots \quad (1)$$

Where, q_n =quality rating for the n^{th}quality parameter and W_n= unit weight of the $n^{th}water$ quality parameter.

The quality rating (q_n) is calculated using equation (2).

$$q_n = \left[\frac{(V_n - V_{io})}{(S_n - V_{io})}\right] \times 100 \quad \ldots\ldots \ (2)$$

WhereV_n, V_{io} and S_n be the estimated value, ideal value, and standard permissible values of the n^{th} parameter. For all parameters ideal values (V_{io}) are taken zero for drinking water except for pH=7 and DO=14.6mg/L.

The unit weight (W_n) is calculated by using equation (3).

$$W_n = \frac{K}{S_n} \qquad \ldots\ldots \qquad (3)$$

Where K=constant for proportionality. The value of K is calculated by using equation (4).

$$K = \frac{1}{\sum\left(1/S_{n=1,2,3\ldots\ldots\ldots}\right)} \ldots\ldots (4)$$

Damak is one of the developing cities of eastern part of Nepal located between 26°10′41″N latitude and 87°41′46″E longitude. In the northern side of it there is a very big forest named as "Hamsey Dhumsey Samudhaik Baan" which makes the environment suitable for many wetlands. These wetlands are the origin of different rivers in Damak except Ratuwa River. The origin of Ratuwa River is Chure Pahad somewhere in Ilam, Nepal. Ratuwa River serves as the eastern border of Damak. People in this area are benefited by this river in various ways. This river water is used for agricultural and drinking purpose by many peoples. Municipal wastages are also deposited on the river bank. It originates from Siwalik hill of Nepal and merges with the Kankai River in Bihar, India. In Bihar it merges with Mahananda and finally merges with holy river Ganga. Other rivers Betani, Dhukure, Haatkhola and Dipeni have the origin somewhere in the wetlands. Ratuwa is a source of income for many families. Fishing and bathing are the recreational activities which has also made the river polluted.

The physico-chemical parameters of five different perennial rivers namely, Ratuwa, Haatkhola, Dipeni, Betani and Dhukure Khola had been studied. Among them only Ratuwa river is originated from Siwalik hill. The samples were collected on 16 April 2018 in clean one-liter plastic bottles for physico-chemical analysis. The bottles were rinsed first, tightly sealed after collection and labeled on the spot. The samples were taken by pumping from a depth of 5-10 cm below to avoid contamination from the surface of river basin. The collected samples were brought to Nepal Batabaraniya Sewa Kendra, Biratnagar.

In order to calculate Water Quality Index value, we had selected nineteen different physico-chemical parameters and their methods of measurement are depicted in table I.

III. RESULTS AND DISCUSSION

In order to access the water quality of different rivers of Damak, the WQI of different rivers was calculated on the basis of nineteen parameters (Table II). The water quality index (WQI) is the valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues [4-5]. The computed WQI values

are classified into five types, from "excellent water" to "water, unsuitable for drinking" (Table III) [7].

At Betani river, the physicochemical parameters EC and iron were above the desirable range prescribed by WHO and Nepal Standards for drinking purpose which are responsible for very poor water quality of the river. The water quality of Betani is influenced by the organic conducting species from soaps and detergents, as the river is used for laundry place [8]. Discharging of untreated wastes from household is the major cause of high iron in the river [4].

At the sampling station, just below the East-West Highway of Dipeni river, the WQI was 446. The main factors that contribute to high WQI of this river are color, iron and manganese. The concentration of color, iron, manganese and electrical conductivity of the river were above the desirable range prescribed by WHO and Nepal Standards for drinking purpose. The disposal of domestic wastes had elevated the level of color in the river, as the color is mainly due to dissolved organic matter which originates from soil and decaying vegetable matters [9]. As the river passes through the residential area, the disposal of construction materials on the river bank might have increased the iron concentration in the river [10-15]. The anthropogenic activities, disposal of domestic and municipal wastes had increased the concentration of manganese in Haatkhola river, which has direct influence on the quality of water [16-20]. Physicochemical parameters color, fluoride and electrical conductivity were above the desirable range prescribed by Nepal and WHO Standards for drinking purpose. The high concentration of dissolved solids in the river has attributed to high conductivity in the river [21-26]. The river has been loaded with decaying plants and vegetables matters which has increased the pollution level in Haatkhola. So for the river water to make suitable for drinking some treatment should be done.

Dhukure river has good water quality. All the nineteen physicochemical parameters measured to calculate WQI were within the permissible range prescribed by WHO and Nepal Standards. Among the nineteen physicochemical parameters iron and nitrate were below the detection limit in Dhukure. It can be suggested the river was not loaded with water from urban and agricultural runoff.

The water of Ratuwa river is unsuitable for drinking and agriculture. The major physicochemical parameters that influence the WQI of Ratuwa river was iron. The concentration of iron was above the desirable range prescribed by Nepal Standards and WHO for drinking purpose. In this river the concentration of nitrate and manganese were below the detection limit. The river serves as the boarder for Damak Municipality which makes the river as dumping station of domestic and municipal wastes which had increase the concentration of iron in the river.

IV. CONCLUSION

The WQI for Betani, Dipeni, Haatkhola, Dhukure and Ratuwa were 95.4, 443.1, 54.4, 42.7, and 162.6 respectively. The result shows that none of them is excellent for the drinking purpose however, Dhukure is quite reasonable for drinking. The quality of Ratuwa and Dipeni is severely damaged and unfit for any purpose like domestic, drinking, irrigation and industrial due to its higher value of iron.

The high value of WQI has been found to be mainly due the higher values of iron; manganese is responsible to increase the WQI. Both anthropogenic activities and geochemical process may have enhanced the iron and manganese level in the study area. In order to protect the aquatic environment and aquatic resources, an immediate step by the municipality is essential. On the basis of fluctuated data, we can suggest that intense focus for monitoring the physicochemical properties and water quality index is essential in Ratuwa and Dipeni Rivers.

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Table I

Different physicochemical parameters and methods of measurement

SN.	Parameters	Unit	Method
1.	pH	-	APHA-4500 H^+
2.	Conductivity	µs/cm	APHA-2510
3.	Color	Hazen	APHA-2120C
4.	Total Dissolved Solids	mg/L	APHA-2540C
5.	Total Suspended Solids	mg/L	APHA-2540D
6.	Fluoride (F)	mg/L	APHA-4500
7.	Nitrates as (NO_3-N)	mg/L	APHA-4500
8.	Chloride as (Cl)	mg/L	APHA-2500B
9.	Total Hardness ($CaCO_3$)	mg/L	APHA-2340
10.	Total alkalinity as ($CaCO_3$)	mg/L	APHA-2320
11.	Iron (Fe)	mg/L	APHA-3111B
12.	Manganese (Mn)	mg/L	APHA-3111B
13.	Sulphate (SO_4)	mg/L	APHA-4500 SO_4^{-2} C
14.	Total Phosphorus	mg/L	APHA-4500
15.	Dissolved Oxygen	mg/L	APHA-5520 B
16.	Calcium (Ca)	mg/L	APHA-3500
17.	Magnesium (Mg)	mg/L	APHA-3500
18.	Potassium (K)	mg/L	APHA-3500
19.	Sodium (Na)	mg/L	APHA-3500

Table II Water Quality Parameters, WQI Values and Quality Grading of different rivers

Water Quality Parameters	Betani	Dipeni	Haat Khola	Dhukure	Ratuwa
Color	4	14	7	2.5	1.5
EC	358	313	432	127.4	207.8
TDS	179	156.5	216	63.7	103.9
TSS	4	8	4	4	4
Cl	10	19	36.98	5	3
Sulphate	10	25	11	15	20
Fe	0.35	2.61	<.05	<0.05	0.62
Nitrate	<0.05	<0.05	<0.05	<.05	<.05
TP	0.08	0.09	0.07	0.05	0.06
TH	17	84	113	15	63
TA	37.4	110.5	139.4	22.1	88.4
Ca	3.61	17.63	22.4	2.81	14.03
Mg	1.46	9.48	13.85	1.7	6.56
K	2.12	5.36	8.35	2.14	3.82
DO	2.96	2.86	3.06	2.86	2.76
pH	6.72	6.41	6.92	6.98	7.89
Na	6.76	10.86	13.06	6.56	6.23
Mn	<0.05	0.5	<.05	0.09	<.05
F	0.18	0.32	0.32	0.17	0.3
WQI Values	95.444	443.067	54.426	42.729	162.577
Quality Grading	Very Poor	Unsuitable for Drinking and agriculture	Poor	Good	Unsuitable for Drinking

Table III
Water Quality Index, Status and Grading

Water Quality Index Level	Water quality status	Grading	Rivers
0-25	Excellent water quality	A	
26-50	Good water quality	B	Dhukure
51-75	Poor water quality	C	Haatkhola
76-100	Very poor water quality	D	Betani
Above 100	Unsuitable for drinking and fish culture	E	Ratuwa and Dipeni