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Assessment of Water Quality of Surma River in Perspective of Water Distribution System in Sylhet City.

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Abstract: *Surma River is the prime source for water distribution system in Sylhet city. The main focus of this study is to determine four water quality index along with BOD and COD of Surma River. The control of corrosion is one of the important aspects of safe drinking water supply. The river water quality from Surma River was investigated along the river water flow path in this study. Twelve water samples have been collected from four different points of Surma River in Sylhet city and analyzed for various water quality parameters during November'16. The water quality parameters were related to chemical stability which includes pH, temperature, alkalinity as mg/l, hardness as mg/l and total dissolved solids (TDS) as mg/l, BOD, COD for different samples collected from Surma River within Sylhet city were investigated. The four water quality index Langelier Saturation Index (LSI), Ryznar stability index (RSI), Aggressiveness Index (AI), Puckorius Scaling Index (PSI) and BOD, COD were also calculated in order to monitor the quality and chemical stability of the river water samples. The results show that the river water is slightly corrosive according to water quality indices. Other water quality parameters are within the standard values except COD.*

Keywords: *Water Quality Indices, Langelier Saturation Index, Ryznar Stability Index, Aggressiveness Index, Puckorius Scaling Index, Corrosion, Scale Formation.*

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I. INTRODUCTION

Corrosion is the partial dissolution of the materials constituting the treatment, supply systems, tanks, pipes, valves, and pumps. The effects of corrosion is one of the important issues concerning both public health and economical aspects. According to WHO guidelines, corrosion control is one of the important aspect of providing safe drinking water. Drinking water distribution systems in most countries have a large amount of iron and steel pipes which are subjected to corrosion.

Corrosion cause delivering the metals (pipeline materials) to the conveyed flow. When the corrosion is rapid, it may cause pipes cavitation. When the water tended to be scaling, during the time creates thin layers in the internal parts of pipes then increase internal diameter, at result the conveyed flow will diminish. Depending upon corrosion and scaling agents, suitable methods can be used for eliminating these problems. [14]

This study was motivated by the fact that Surma River water is the prime source of water in Sylhet city. So the water of the river is being conveyed by different water distribution system or pipelines. The water quality indices determined in this study predicts about the corrosion potential and the scaling potential of the river water. This potentials indicates in which extent the river water is appropriate for the pipelines or the water distribution system. Other water quality parameters were also calculated in order to get a clear view of the river water. They shows how much the river water is applicable for different purposes. They all help us to evaluate the potential risks as well as to suggest measures for the prevention of the water pollution, corrosion and scale formation.

This study demonstrated the application of water quality indices to estimate or to understand the river water chemical stability. Other water quality parameters such as Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) was determined to find out the water pollution caused by Sylhet city to Surma River. Then we compared the study with different standards such as WHO, Bangladesh Environment Conservation Rules (1997) etc.

II. METHODOLOGY

The Surma River in Sylhet City was selected as the study area for determining water quality indices and other parameters. The Surma River is located in the northeastern region of Bangladesh. Surma River which is also named as Barak is a river in northeastern India and eastern Bangladesh which is 560 miles (900 km) in length. The Surma River flows through the central part of the Sylhet city, which plays a very important role in the economic development and water supply of the city. The water quality of the Surma River is being deteriorated gradually due to human activities, industrial effluents and many other reasons.

2.1 Selection of Sampling Locations

Twelve water samples from four points were collected from the Surma River during November'16. For this study four sampling points were selected along the water flow path of Surma River where the river enters in the Sylhet City, the river exits from Sylhet City and two other arbitrary location were selected by dividing the flow path into three segments. The four sampling locations were Kushighat, Keane Bridge, Kazir Bazar and Kumargaon, they were termed as A, B, C and D point respectively.

Table: 1 Global Positioning of the Sampling Points

Point	Location	Latitude	Longitude
A	Kushighat	24°88'00.37"N	91°88'41.77"E
B	Keane Bridge	24°88'74.34"N	91°87'03.58"E
C	Kajir Bazar	24°88'86.80"N	91°84'97.59"E
D	Kumargaon	24°91'01.67"N	91°82'39.67"E

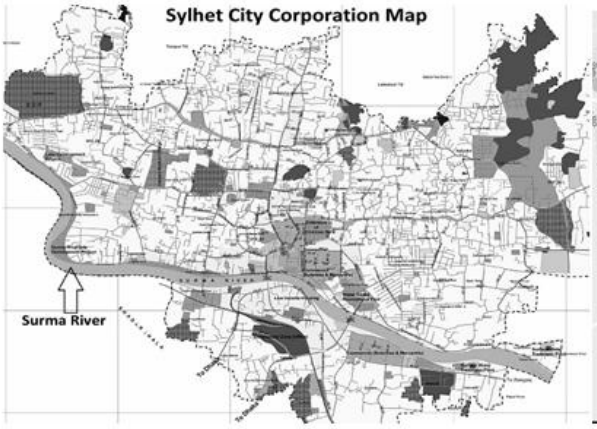

Fig: 1 Sylhet City Corporation MapFig: 2 Sampling Locations of Water Samples

2.2 Water Quality Indices

A number of indices have been developed by researchers but none of them has demonstrated the ability to accurately quantify and predict the corrosivity or scaling of water. Water Quality Indices gives us a probable indication. The most commonly used indicators are the Langelier Saturation Index (LSI), the Ryznar Stability Index (RSI), Aggressiveness Index (AI) and the Puckorius Scaling Index (PSI). Methods for calculating these indices are well documented in form of empirical equation, and approximate values can be readily obtained from tables, nomo-graphs, slide rules, and computer programs, including hand-held calculators.

2.3 Langelier Saturation Index (LSI)

Langelier Saturation Index was first introduced by Professor W. F. Langelier in 1936. It mainly represents the conditions at which water is in equilibrium with calcium carbonate ($CaCO_3$). Langelier developed an equation which predicts about the tendency of calcium carbonate ($CaCO_3$) either to precipitate or to dissolve under varying conditions. The Langelier Saturation Index was designed to measure calcite formation in municipal distribution lines at ambient temperatures but later used as a measure of corrosion. The LSI is probably the most widely used indicator of scale potential of water. It can be calculated by following equation:

Langelier Saturation Index (LSI) = $pH_a - pH_s$

Where:

- pH_a: The measured pH of water.
- pH_s: The pH at which water with a given calcium content and alkalinity is in equilibrium with calcium carbonate($CaCO_3$).

The equation expresses the relationship of pH, calcium, total alkalinity, dissolved solids, and temperature as they are related to the solubility of calcium carbonate in waters with pH of 6.5 to 9.5. This is known as the pH_s.
$pH_s = (9.3 + A + B) - (C + D)$
Where:

- $A = \frac{\log_{10}(TDS) - 1}{10}$
- $B = -13.12 * \log_{10}(Temperature\ in\ K) + 34.55$
- $C = \log_{10}(Calcium\ ion\ as\ Calcium\ Carbonate) - 0.4$
- $D = \log_{10}(Alkalinity\ as\ Calcium\ Carbonate\ or\ Total\ Alkalinity)$

Water Condition According to LSI Value:

If LSI value is negative, then the water is under saturated with calcium carbonate and will tend to be corrosive in the distribution system. If LSI value is positive, then the water is over saturated with calcium carbonate and will tend to deposit calcium carbonate forming scales in the distribution system. If LSI value is close to zero, then the water is just saturated with calcium carbonate and will neither be strongly corrosive or scale forming.

2.4 Ryznar Stability Index (RSI)

The Ryznar Stability Index was first introduced by John Ryzner in 1944. Ryznar Stability Index correlates a relationship between saturation of calcium carbonate and scale formation. The Ryznar Stability Index is mainly used for the prediction of scaling or corrosion tendencies of water. As the decrease of this index occurs, the scaling tendency of water increases. Ryznar Stability Index can be calculated by following equation:
Ryznar Stability Index (RSI) = 2(pH_s)-pH
Where,

- pH: The measured pH of water.
- pH_s: The pH at which water with a given calcium content and alkalinity is in equilibrium with calcium carbonate($CaCO_3$). Which is already described in Langelier Saturation Index.

Table: 2 Water Condition According to RSI Value

No.	RSI value	Water Condition
1.	RSI<5.5	Heavy scale will form
2.	5.5 < RSI < 6.2	Scale will form
3.	6.2 < RSI < 6.8	No difficulties
4.	6.8 < RSI < 8.5	Water is aggressive
5.	RSI > 8.5	Water is very aggressive

2.5 Aggressiveness Index

Aggressiveness Index is a corrosion index calculated from pH of sample, calcium hardness and total alkalinity. This index is calculated by adding the measured pH of water sample, hardness variable and alkalinity variable
Aggressiveness Index (AI) = pH_{actual} + C + D
C and D are found from table and they are known as Alkalinity and Hardness Variable respectively.

Table: 3 Water Condition According to Aggressiveness Index (AI) Value

No.	AI value	Water Condition
1.	AI > 12	Water is Non-Aggressive
2.	12 > AI > 10	Water is Moderately Aggressive
3.	AI < 10	Water is Very Aggressive

[8]

2.6 Puckorius Scaling Index

The buffering capacity of water and the maximum quantity of precipitate that can form to bring water into equilibrium are the two main parameters during the calculation of Puckorius Scaling Index. If carbonate ions are consumed to form calcium carbonate then the solution pH decreases. When the decrease of pH is very fast, water is known as having low buffering capacity. Such things happens when water have high Ca^{2+} concentration and relatively low CO_3^{2-}. The calculation of Puckorius Scaling Index (PSI) is almost similar to the calculation of Ryznar Stability Index (RSI) except one difference as Puckorius Scaling Index (PSI) takes into

account the equilibrium pH based on total alkalinity value while Ryznar Stability Index (RSI) uses the system pH. Puckorius Scaling Index (PSI) can be calculated by following equation:

Puckorius Scaling Index (PSI)= 2(pH_s)-pH_{eq}

Where,

- pH_s: The pH at which water with a given calcium content and alkalinity is in equilibrium with calcium carbonate($CaCO_3$). Which is already described in Langelier Saturation Index.
- pH_{eq}: The equilibrium pH of water based on total alkalinity value. It can be calculated by following equation:

$pH_{eq} = 1.465*log[Alkalinity] + 4.54$

Table: 4 Water Condition According to PSI Value

No.	PSI value	Water Condition
1.	6.5 < PSI < 7	Saturated, $CaCO_3$ is in equilibrium
2.	PSI > 8.0	Under saturated, tend to dissolve solid $CaCO_3$
3.	PSI < 6.5	Super saturated, water tends to be scale forming

2.7 Required Parameters for Determining Water Quality Indices

From the above discussion we can talk about the required parameters for determining these water quality indices. To determine water quality indices these parameters was used along with some empirical equation and some data tables. The parameters are Temperature, pH, Total Dissolved Solids (TDS), Total Alkalinity, Calcium Hardness, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD).

III. RESULTS AND DISCUSSION

This section presents the results of the water quality parameter determination and analysis of the particular reach of Surma River which was selected as study area. The control of water quality in the distribution and plumbing systems seek to preserve the basic characteristics of water during its conveyance from the point of source to the point of treatment. The conveyance system and accessory structures such as pipelines, distributing reservoirs should be reactively inert to the water being conveyed. Most water quality parameters affect the corrosion process in some extent and each pipe material is affected differently. Water quality changes in drinking water distribution systems occur due to complex and often interrelated with chemical and biological processes. The chemical instability of water quality shows the existence of scale deposition and corrosion which can cause secondary pollution of water quality and increase energy consumption of water transportation and decrease service life of pipe networks. [1] Longevity of pipelines and water distribution system is on danger and probability of health hazard increased.

3.1 Values of Water Quality Indices

Corrosion and scaling may cause pipe blocking. As a result it may reduce the flow and create some other problems in the pipelines. It can also damage the pipeline. If it occurs, water leakage increases and so water loss will be high.

From calculation we have found that the Langelier Saturation Index (LSI) value varies from -0.91 to -1.43. As the LSI value is negative so the water is under saturated, the water will dissolve $CaCO_3$. The found values of Ryznar Stability Index (RSI) varies from 9.54 - 10.36. The results of Ryznar Stability Index (RSI) showed that the river water is very aggressive. The measured values of Aggressiveness Index (AI) differs from 10.06 – 10.61. The results of Aggressiveness Index (AI) indicated that the river water is moderately aggressive. The calculated values of Puckorius Scaling Index (PSI) fluctuates from 10.16 – 10.88. The values of Puckorius Scaling Index (PSI) revealed that the river water is under saturated which will tend to dissolve solid $CaCO_3$.

Table: 5 Values of Water Quality Indices

Point	Location	LSI Value	RSI Value	AI Value	PSI Value
A	Kushighat	-1.26	10.1	10.22	10.72
B	Keane Bridge	-1.43	10.36	10.06	10.88
C	Kajir Bazar	-1.04	9.74	10.45	10.36
D	Kumargaon	-0.91	9.54	10.61	10.16

Table: 6 Comment over Water Quality Index Values of Four Locations

Water Quality Index	Value	Comment
Langelier Saturation Index	-0.91 to -1.43	Water is under saturated with respect to calcium carbonate. Under saturated water has a tendency to remove existing calcium carbonate protective coatings in pipelines and equipment. So water will tend to be corrosive.
Ryznar stability index	9.54 - 10.36	Water is very aggressive and under saturated, tend to dissolve $CaCO_3$. Mild steel corrosion becomes an increasing problem.
Aggressiveness Index	10.06 - 10.61	Water is Moderately Aggressive.
Puckorius Scaling Index	10.16 - 10.88	Water is under saturated, tend to dissolve solid CaCO3.

3.2 Other Water Quality Parameters

Our main objective was to determine water quality indices of the river water sample. On the way we had to determine some other parameters such as pH, Total Dissolved Solids (TDS), Total Alkalinity and Total Hardness. We also determined Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) to get a better view of the water. We discussed these parameters with various standards.

Table: 7 Values of Other Water Quality Parameters

Point	Location	pH Value	TDS Value (mg/l)	Alkalinity Value (mg/l)	Hardness Value (mg/l)	BOD Value (mg/l)	COD Value (mg/l)
A	Kushighat	7.58	100	45	25	1	5.3
B	Keane Bridge	7.5	100	46	20	1	5.2
C	Kajir Bazar	7.66	100	51	30	1	5.5
D	Kumargaon	7.72	200	56	35	1.6	5.6

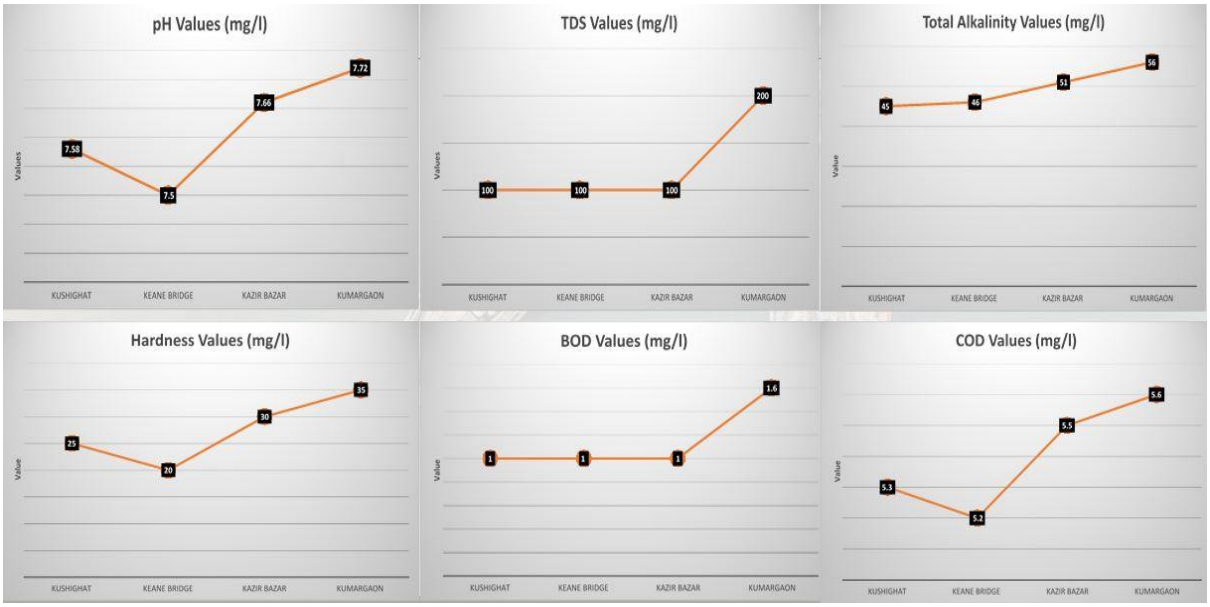

Fig: 3 Graphical Representation

3.3 Discussion over Found Results

pH: The variations of pH at different points are very small. The found results shows that pH value of river water varies from 7.5-7.72 which indicates slightly alkaline water. pH 6.5-8.5 is the WHO standard for drinking water quality. According to The Environment Conservation Rules, Bangladesh (1997) standards for inland surface water is 6.5-8.5.

Total Dissolved Solids (TDS): The found values of Total Dissolved Solids (TDS) varies from 100-200 mg/l. WHO standard for drinking water quality is 1,000 mg/l of TDS. According to The Environment Conservation Rules, Bangladesh (1997) standard for drinking water purpose is 1,000 mg/l of total dissolved solids.
Total Alkalinity: The measured values of total alkalinity varies from 45-56 mg/l for four sampling points.
Hardness: The found values of hardness fluctuates from 20-35 mg/l for four sampling points. According to The Environment Conservation Rules, Bangladesh (1997) standards for hardness (as CaCO3) is 200 – 500 mg/l for drinking water.
Biochemical Oxygen Demand (BOD): The measured values of Biochemical Oxygen Demand (BOD) varies from 1-1.6 mg/l for the selected sampling points. So all the values are within standards of The Environment Conservation Rules, Bangladesh (1997) and WHO .
Chemical Oxygen Demand (COD): From calculation we have found that the Chemical Oxygen Demand (COD) varies from 5.2 to 5.6. According to The Environment Conservation Rules, Bangladesh (1997) standards for Chemical Oxygen Demand (COD) is 4 mg/l for drinking water. So the Chemical Oxygen Demand (COD) exceeds the standards.

IV. CONCLUSION

From the study of water quality indices it was found that the most of these indices in river water from Surma River have moderate corrosion potential or slight scale formation. The indices so far employed for evaluating the water quality indices are based on empirical relationships. From those water quality indices it can be said that the river water is corrosive. So the river water need to pay attention to achieve national water quality standards and reduce corrosion with corrective action that should be implied to prevent corrosion in water supply networks. The found results shows that pH value indicates slightly alkaline water but the value is within standard. The found values of Total Dissolved Solids (TDS), Alkalinity, Hardness, Biochemical Oxygen Demand (BOD) is also within standard. But the Chemical Oxygen Demand (COD) exceeds the standards. The results show that, the water is undoubtedly unhealthy for drinking purposes without any form of treatment, but for various other surface water usage purposes, it is somewhat satisfactory.

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