

WATER QUALITY ASSESSMENT OF MAYUR RIVER FOR CHECKING ITS SUITABILITY OF REUSE IN IRRIGATION PURPOSE

S. M. Moniruzzaman¹, Marzia Mustari Progga*²

¹Professor, Department of Civil Engineering, Khulna University of Engineering & Technology, Bangladesh, email: moniruzzaman@ce.kuet.ac.bd

²Undergraduate Student in Civil Engineering, Khulna University of Engineering & Technology, Bangladesh, email: progga1601090@stud.kuet.ac.bd

*Corresponding Author

ABSTRACT

River water quality is one of the foremost concerns now a days, as it plays a significant role in human and aquatic life. Mayur River, located on the northwestern side of the Khulna city, is important from numerous points of view and an essential surface water source for agriculture during dry season. Therefore, the aim of this study is to assess the water quality of Mayur River and analyze its suitability for irrigation practice. In present study, five locations were selected to collect water sample of Mayur river and they are all in Khulna. Total ten water samples were collected, two samples from each location in the dry season (End of October to November, 2021). To analyze the river water characteristics for irrigation purpose, water quality parameters BOD, COD, pH, conductivity, TS, TDS, TSS, DO, Cl⁻, NO₃⁻, SO₄²⁻, PO₄³⁻, Ca²⁺, Mg²⁺, K⁺, Alkalinity and Hardness were tested. Irrigation Water Quality Indices SAR, RSC, Na%, KI and MR were also calculated for better understanding the suitability of river water for irrigation use. By analyzing the obtained data, it can be said that, most of the parameters (pH, EC, BOD, COD, TDS, DO, Cl⁻) are within the standard limit. The higher pH values (ranges from 7.65-8.5) revealed that the water is alkaline in nature. However, in case of some samples, some usual and calculated parameters like Sodium Absorption Ratio (SAR) (28.79, 31.58, 34.82, 34.45, 37.27), Alkalinity (as HCO₃⁻) (235, 255, 285, 310, 340, 345) mg/l, TSS (340, 350, 1220, 1350) mg/l are not within the Bangladesh standard values and abstain the river water from use in irrigation. Among the major cations (Na⁺, Ca²⁺, Mg²⁺, K⁺) the concentration of Sodium ion is comparatively high in the water samples whereas Chloride is the most dominant among the major anions (Cl⁻, SO₄²⁻, PO₄³⁻, NO₃⁻). The values of sodium and chloride concentration shows no toxicity in the river water and will be tolerance for the crop if used for irrigation purpose. However due to the High Sodium absorption ratio (SAR) of most of the water samples of Mayur River, it was considered that it could not be reused for irrigation purpose directly without any further treatment.

Keywords: SAR, Conductivity, Irrigation, Suitability, River water

1. INTRODUCTION

Rivers are used all over the world as sources of irrigation water. Bangladesh is an agriculture country. River water irrigation has long been used in developing countries like Bangladesh due to its high fertility. Particularly in the dry season, river becomes the main source ((19.40%) of water supply for irrigation purpose here (BADC Bangladesh Agriculture Development Corporation), 2007). The country's surface water irrigation which increased to 27 percent from 21 percent a decade ago helps in reducing pressure on ground water. The irrigated areas have been expanded by 1.05 million hectares in the 10 years to 5.6 hectares (BADC, 2007).

Mayur River is an important channel of Bhairab–Rupsha River System. It flows through the western part of Khulna city positioned in the south-west coastal region of Bangladesh. The length of Mayur River about 11.69 km and its width varies widely at different chains. The river was very clean and once used as an important freshwater source for drinking and domestic uses, fisheries and agriculture. About one-fifth of the total land area in the river catchment (40 km²) are used for agriculture (JICA, 2010). However along with human interruption, the unplanned and untreated crude dumping of domestic, industrial and household waste into it, the natural flow of the river is totally retarded and the river water quality has been degraded on a large scale due to water pollution (IDRC, CDRI. 2010).

As there is a huge agriculture area surrounding the mayur river, the farmers of these coastal area use this river water for irrigation as good quality surface water is not available as well as higher cost in groundwater irrigation. Water with adequate quality and quantity is very important for irrigation to ensure the crop yields. Irrigation water usually contains some dissolved salts. As Mayur river is a coastal river (river located in the coastal zone Khulna, contains salinity concentration under low flow condition) the intensity of salinity, sodium hazards, chloride hazard affects the irrigation water quality ultimately that leads to its effects on soils and cultivated crops. So, checking the suitability of water used for irrigation is very important. But there is no much study conducted on Mayur River regarding this water quality assessment issue specially in the dry season. That's why Mayur River is selected as study area for checking its suitability of reuse in irrigation purpose.

In undertaking this study, there were three specific objectives, 1) to find out water quality parameters value 2) to compare the standards and represented in graphical form 3) to analyze water suitability for irrigation purpose according to BIWQS (Bangladesh Irrigation Water Quality Standard) (DoE,1997).

2. METHODOLOGY

2.1. Study Area

The Mayur River is one of the important channels of the Bhairab-Rupsha River system located in the south-west part of Bangladesh and in the downstream of the well-known Ganges delta. It is about 100 km north of the coast line of the Bay of Bengal. Geographically, the River Mayur is located at 22°47' to 22°50' N latitudes and 89°31' to 89°34' E longitudes in the north-south direction. The river originates from the Beel Dakatia and meets with the Rupsha River at Dosh Gate Bridge near Labanchora.

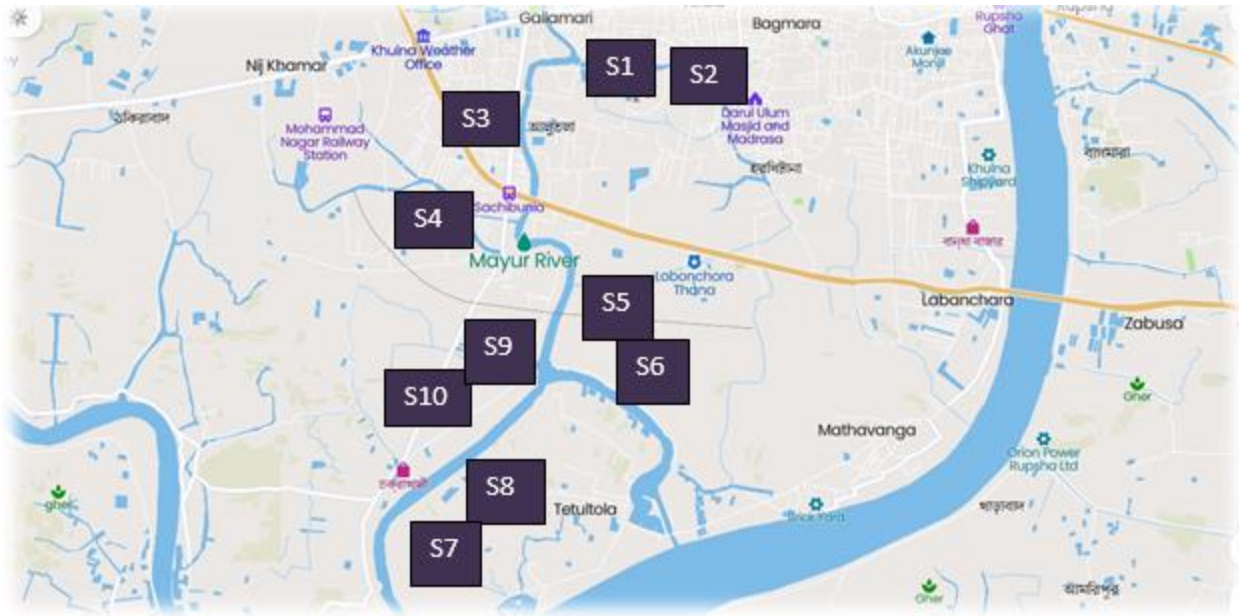


Figure1: Location map of the water sampling spots on the Mayur River

1. Location 01: It is located in Sonadanga Bypass, Under Mayur Bridge. The longitude and latitude is $89^{\circ}32'12''E$ and $22^{\circ}48'56''N$ respectively. Two samples S1 and S2 were collected from this location.
2. Location 02: It is located in Gollamari under the old bridge. It lies between $89^{\circ}32'19''E$ $22^{\circ}48'19''N$. Sample S3 and S4 were collected from here.
3. Location 03: It is located in Gollamari near the S.B Argo. Many agriculture areas are surrounding here. It lies between $89^{\circ}32'25''E$ $22^{\circ}36'19''N$. Sample S5 and S6 were collected from here.
4. Location 04: It is located in Dosh Gate, Labanchora where Mayur River meets with Rupsha. It lies between $89^{\circ}55'15''E$ $22^{\circ}75'83''N$. Sample S7 and S8 were collected from this location
5. Location 05: It is located in Khulna Bypass under a bridge. It lies between $89^{\circ}53'08''E$ $22^{\circ}76'46''N$. Sample S9 and S10 were collected from this location.

2.2 Sample Collection

The samples were collected from each selected location from the end of October to November. 2 litre bottles were used for collecting the water of the river. The bottles were completely filled with water in a way so that no air remains above the surface. The opening of these bottles was closed tightly to prevent leakage of water. The bottles were kept in black coloured bag so that sun rays or day light could not reach to the samples.

2.3 Laboratory Tests of Surface Water Quality Parameters

The surface water quality parameters of the collected samples were tested in the laboratory. The parameters were BOD5, COD, pH, Conductivity, TS, TDS, TSS, DO, Hardness, Alkalinity, Chloride, Nitrate, Sulfate, Sodium, Calcium, Magnesium and Irrigation Water Quality Indices were SAR, KI, Na% and MR.

2.4 SAR Index

The sodium adsorption ratio (SAR) is a measure of the quality of irrigation water. It is a measure of a water's appropriateness for agricultural irrigation based on the concentrations of the primary alkaline and earth alkaline cations present in the water. SAR index of the river water were determined by following relation:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \quad (1)$$

2.5 RSC Index

The residual sodium carbonate (RSC) index of irrigation water or soil water is used to indicate the alkalinity hazard for soil. The RSC index is used to find the suitability of the water for irrigation in clay soils which have a high cation exchange capacity. When dissolved sodium in comparison with dissolved calcium and magnesium is high in water, clay soil swells or undergoes dispersion which drastically reduces its infiltration capacity. RSC is calculated using Eq. 2 (Richards, L.A, 1954)

$$RSC = [(Alkalinity) - (Ca^{2+} + Mg^{2+})] \quad (2)$$

2.6 MR Index

Paliwal (1972) introduced an important ratio called index of magnesium hazard (Magnesium Ratio MR), MR of more than 50% would adversely affect the crop yield as the soils would become more alkaline. MR is widely used to evaluate the water quality for the irrigation, it was given as:

$$MR = (Mg^{2+} \times 100) / (Ca^{2+} + Mg^{2+})$$

2.7 Soluble Sodium Percentage Na%

The percentage of sodium (Na %) which is also named soluble sodium percentage (SSP) was used to assess the water quality for irrigation purpose. The high content of Na in the irrigation water cause direct impact on the plant growth and soil quality as well [16]. Irrigation water with Na% > 60% may result in Na accumulation and possibly a deterioration of soil structure, infiltration, and aeration. The calculation of Na% can be done by using the equation 4 (Wilcox (1948)

$$Na\% = ((Na^+ + K^+) \times 100) / (Ca^{2+} + Mg^{2+} + Na^+ + K^+) \quad (4)$$

3. RESULT AND DISCUSSION

Water quality parameters in 5 different locations of the Mayur River during the dry season (End of October to November, 2021)

Table 1: Basic Parameters Value from lab test

Location	Sample ID	TS (mg/l)	TDS (mg/l)	TSS (mg/l)	BOD5 (mg/l)	COD (mg/l)	DO (mg/l)
1. Sonadanga Bypass (Under Mayur Bridge)	S1	1530	1190	340	5	94.88	6.3
	S2	1560	1210	350	4	88.45	6.2
2.Gollamari (Under Gollamari Bridge)	S3	660	640	20	6.4	145.23	7.9
	S4	680	630	50	6	139.68	7.9
3. Gollamari (Near S.B Argo)	S5	690	650	40	4.7	120.807	6
	S6	680	510	170	4.5	113.506	6
4.Dosh Gate Bridge	S7	280	160	120	2.8	78.437	7.1
	S8	310	210	100	3	88.67	7
5. Khulna City Bypass	S9	2190	840	1350	6	136.37	7.6
	S10	2050	830	1220	5.4	128.33	7.4
Maximum Value		2190	1210	980	6.4	145.23	7.9
Minimum Value		280	160	120	2.8	78.437	6
Average Value		1063	687	376	4.78	113.436	6.9
Allowable Limit		-	2100	150	50	200	4.5-8

Table 2: Basic Parameters Value from lab test

Location	Sample ID	pH	Alkalinity mg/l (as HCO ₃ ⁻)	Hardness (mg/l)	EC (uS/cm)
1. Sonadanga Bypass (Under Mayur Bridge)	S1	7.82	285	69.45	1138
	S2	7.65	310	87.34	1120
2.Gollamari (Under Gollamari Bridge)	S3	7.75	320	106.49	1555
	S4	8.34	345	98.67	1765
3. Gollamari (Near S.B Argo)	S5	8.3	325	92.4	1236
	S6	7.9	235	90.56	1543
4.Dosh Gate Bridge	S7	8.53	135	50.93	324
	S8	8.32	120	67.45	576
5. Khulna City Bypass	S9	8.43	255	111.2	969
	S10	8.5	340	134.45	1234
Maximum Value		8.53	345	134.45	1765
Minimum Value		7.65	135	50.93	324
Average Value		8.154	267	90.894	1146
Allowable Limit		8.5	150	150	2250

The table 1 and 2 shows some water quality parameters with minimum, maximum and average value. These parameters include BOD, COD, TDS, TSS, TS, pH, EC, DO, Hardness, Alkalinity etc. By analyzing the parameters, pH value ranges from 7.65 to 8.53 with an average of 8.15. This shows that, the river water is alkaline in nature and the dissolved carbonates are predominantly in the HCO₃ form (Nagarajan et al, 2010). The EC (in $\mu\text{S/cm}$) of water samples varied in the range from 324 to 1765. The EC is used to estimate the salinity of river water used for irrigation. It is used as a proxy measure for TDS concentration in water. Based on the EC classification, salinity is quite higher in this river. According to USSSL Staff 1954 high salinity water has the EC of range 750-2250 $\mu\text{S/cm}$. Here most of the samples (1138, 1120, 1555, 1765 mg/l) come under the type of high salinity water (C3).

TDS (in mg/l) was found in the range of 160mg/l to 1210 mg/l. According to classification of Don (1995), <175 mg/l; Excellent: 175-525 mg/l; good and up to 1400 mg/l it is permissible to use. Here, TDS values are all within the limit with an average of 687 mg/l. All sample water come under good type for reuse in irrigation purpose in this case.

The hardness of the river water ranges from 50.93 mg/l to 134.45 mg/l with a mean value of 90.894 mg/l. All the sample water has a bearable hardness value which is within the limit. The variation of hardness is more or less similar to the other parameters. By analyzing the value of alkalinity in various points, it can be said that, the river water has high range of alkalinity value (from 135 to 345 mg/l) with an average of 267 mg/l. This shows that the water quality is alkaline in nature. The highest value of alkalinity is recorded 345 mg/l in location 2 Gollamri (under bridge. Also this point is in the middle of the city. So waste dumping is a regular activity in this point of river.

Table 3: Major Cation concentration (mg/l)

Location	Sample ID	Sodium Na ⁺ (mg/l)	Potassium K ⁺ (mg/l)	Calcium Ca ²⁺ (mg/l)	Magnesium Mg ²⁺ (mg/l)
1. Sonadanga Bypass (Under Mayur Bridge)	S1	144.54	8.99	37.8	12.6
	S2	156.78	8.87	36.5	12.8
2.Gollamari (Under Gollamari Bridge)	S3	169	9.78	34.4	12.72
	S4	163.56	9.65	33.4	11.67
3. Gollamari (Near S.B Argo)	S5	160.97	10.56	34.2	12.6
	S6	178.56	9.89	32.8	13.1
4.Dosh Gate Bridge	S7	44.35	3.91	21.8	8.16
	S8	57.78	3.88	20.6	7.54
5. Khulna City Bypass	S9	116.62	8.6	29.8	12.12
	S10	124.57	8.54	31.5	11.87
Maximum Value		178.56	10.56	37.8	13.1
Minimum Value		57.78	3.91	20.6	7.54
Average Value		131.69	8.27	31.28	11.52
Allowable Limit			-	-	

Table 4: Major Anion concentration (mg/l)

Location	Sample ID	Chloride Cl ⁻ (mg/l)	Nitrate (mg/l)	Sulfate (mg/l)	Phosphate (mg/l)
1. Sonadanga Bypass (Under Mayur Bridge)	S1	220	0.4	10	1.54
	S2	235	0.4	11	1.89
2. Gollamari (Under Gollamari Bridge)	S3	257.5	0.3	0	3.87
	S4	251.7	0.2	2	3.23
3. Gollamari (Near S.B Argo)	S5	245	0.9	8	3.93
	S6	248	0.85	7	3.95
4. Dosh Gate Bridge	S7	67.5	0.4	10	0.3
	S8	78.9	0.43	10.5	0.4
5. Khulna City Bypass	S9	177.5	0.2	9	3.17
	S10	180.6	0.2	8	2.66
Maximum Value		257.5	0.9	11	3.93
Minimum Value		67.5	0.2	0	0.3
Average Value		196.2	0.428	7.55	2.49
Allowable Limit		350			

Table 3 and table 4 shows the concentration of major cations and anions respectively. The concentration of sodium ranges from 57.78 mg/l to 178.56 mg/l. The highest value was recorded 178.56 mg/l near S.B Argo point. This high sodium value shows that the water has ingress of salinity and also wastewater discharge to it.

The concentration of potassium (mg/l) was found to be in the range of 3.91 mg/l to 10.56 mg/l with an average of 8.267 mg/l. The variation of potassium is observed to be more or less similar to EC, TDS and hardness. Highest potassium concentration found in sample five, which is in the location Gollamri near S.B Argo. The reason is location has some surrounding urban areas that discharge waste water to the river.

The concentration of calcium (mg/l) was found to be in the range of 20.6 mg/l to 37.8mg/l with an average of 31.28 mg/l. The variation of calcium is observed to be more or less similar to EC, TDS and hardness. Highest calcium concentration found in sample five which is in the location Gollamri near S.B Argo.

Among the cations Sodium was the most dominant cation (average 131.68 mg/l) during the dry season period. Cation chemistry indicates that water samples of the Mayur River (during dry season) is in the sequence of Na⁺> Ca²⁺> Mg²⁺>K⁺

In table 4, sulfate content in mg/l, the ranges were found to be 0 to 11 mg/l with mean concentration of 7.55 mg/l. The variation was more or less similar to EC, TDS, hardness, potassium and chloride. The highest sulfate content found in sample 2 which in the location Sonadanga bypass under the mayur bridge. The reason of such increased sulfate in water is mainly the result of municipal and local discharge of wastes.

The nitrate concentration in the study area ranges from 0.2 mg/l to 0.9 mg/l. The highest nitrate content found in the location 3 Gollamari near S.B argo. Average nitrate content is 0.428 mg/l of all the selecting points which is within the limit <2 mg/l. All the sample water come under the type of good quality for this

parameter. Another major anion phosphate is also found in the samples with an average value of 2.49 mg/l and is in permissible limit.

Other major anion is Chloride ion. The chloride anion occurs in all water. Chlorides are soluble and leach readily to drainage water. That's why water should be analyzed for chloride concentration when assessing water quality. According to (cf. Ludwick et al.1990, Bauder et al.2011) the allowable limit of chloride content is 350 mg/l. In table 4, it shows that, all the samples come under the allowable limit and moderately tolerant for plants usually show slight to substantial injury if used as irrigation water. Anion chemistry reveals that the sequence of the anions was found $Cl^- \rightarrow SO_4^{2-} \rightarrow PO_4^{3-} \rightarrow NO_3^-$ in the sampling period.

Table 5: Calculated parameters to evaluate water quality of the Mayur River for irrigation

Location	Sample	SAR	Na%	RSC mg/l	MR %
Sonadanga Bypass (Under Mayur Bridge)	S1	28.79	75	235	25
	S2	31.58	77	261	26
Gollamari (Under Gollamari Bridge)	S3	34.82	79	273	27
	S4	34.45	79	300	26
Gollamari (Near S.B Argo)	S5	33.28	79	278	27
	S6	37.27	81	189	29
Dosh Gate Bridge	S7	11.46	62	105	27
	S8	15.4	67	92	27
Khulna City Bypass	S9	25.47	75	213	29
	S10	26.25	76	297	27
Maximun Value		37.27	81	300	29
Minimum Value		11.46	62	92	25
Average Value		27.88	75	224.3	27
Allowable Limit		26	60	310	50

Table 5 presents the calculated parameters SAR, Na%, RSC and MR to evaluate water quality of the Mayur River for irrigation. For assessing sodium hazard of irrigation water SAR and Na% are need to be considered. By analyzing the data, maximum SAR value was found 37.27 and minimum value is 11.46. Average SAR value for the samples is 27.87. According to Table 6 these value shows a restriction for sample water to use in irrigation purpose. Because almost all location's SAR value are over the permissible limit 26 and classified as S4. So the water of Mayur River come under the type of unsuitable in this regards. There is another approach RSC which is empirical in nature (Eaton,1950). To predict the additional sodium hazard which is associated with $CaCO_3$ and $MgCO_3$ precipitation, RSC is calculated. Maximum RSC is found 300 mg/l and minimum RSC is 92 mg/l. According to table 6, the obtained RSC value shows that the water quality is moderate (150-310 mg/l) (BIWQS Standard). The percentage of sodium (Na %) was calculated for all the samples and an average value of 75% was found which come under a doubtful type water quality to use in irrigation practice. The excess quantity of magnesium in water affects soil quality, which can lead to a decrease in crop yields (Joshi et al. 2009) that's why MR (Magnesium Ratio) is calculated. From table 5, the MR value ranges from 25% to 29% with an average of 27%. In table 6, samples are classified for irrigation use according to Irrigation water quality assessment with respect to BIWQS Standard.

Table 6: Water Quality classes of the Mayur River for irrigation use (According to, Irrigation water quality assessment with respect to BIWQS Standard)

Parameters	Rate of Hazards	Water Class	Sample ID
pH	6.5-8.5	No problem	S1,S2,S3,S4,S5,S6,S8,S9,S10
	8.5-9.5	Moderate	S7
	9.5+	Severe	-
EC (uS/cm)	<250	Excellent	-
	250-750	Good	S7, S8
	750-2250	Permissible	S1,S2,S3,S4,S5,S6,S9,S10
	>2250	Unsuitable	-
Hardness mg/l	0-60	Soft	S7
	60-120	Moderately Hard	S1,S2,S3,S4,S5,S6,S9,S8
	120-180	Hard	S10
	>180	Very hard	-
Alkalinity mg/l	0-60	Very Low	-
	60-150	Low	-
	150-200	Moderately High	S7, S8
	200-240+	Very High	S1,S2,S3,S4,S5,S6,S9,S8
Na ⁺ mg/l	<69	No problem	S7, S8
	69-207	Moderate	S1,S2,S3,S4,S5,S6,S9
	>207	Severe	-
Cl ⁻ mg/l	<140	No problem	S7, S8
	140-350	Moderate	S1,S2,S3,S4,S5,S6,S9
	>350	Severe	-
SO ₄ ²⁻ mg/l	<192	Excellent	S1,S2,S3,S4,S5,S6,S9,S8, S10,S7
	192-576	Good to injurious	-
	>576	Injurious to unsuitable	-
Na%	<20	Excellent	-
	20-40	Good	-
	40-60	Permissible	-
	60-80	Doubtful	S1,S2,S3,S4,S5,S9,S8, S7, S10
	>80	Unsuitable	S6
SAR	<10	Excellent	-
	10.0-9.0	Good	-
	18-26	Doubtful	S7, S8, S9
	>26	Unsuitable	S1,S2,S3,S4,S5,S6,S10
RSC mg/l	<155	Safe	S7, S8
	155-310	Permissible	S1,S2,S3,S4,S5,S6,S10,S9
	>310	Unsuitable	-
MR %	<50	Suitable	S1,S2,S3,S4,S5,S6,S7, S8, S9, S10

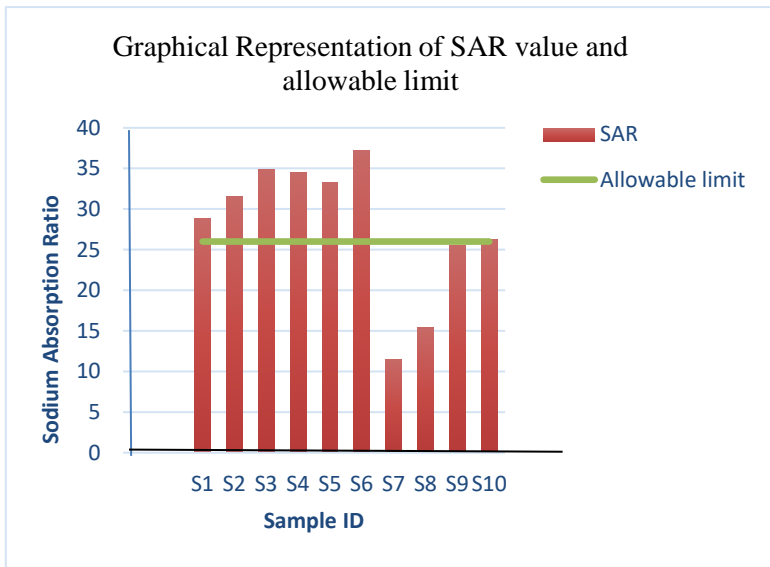


Figure 2: Comparison of SAR value with irrigation allowable limit

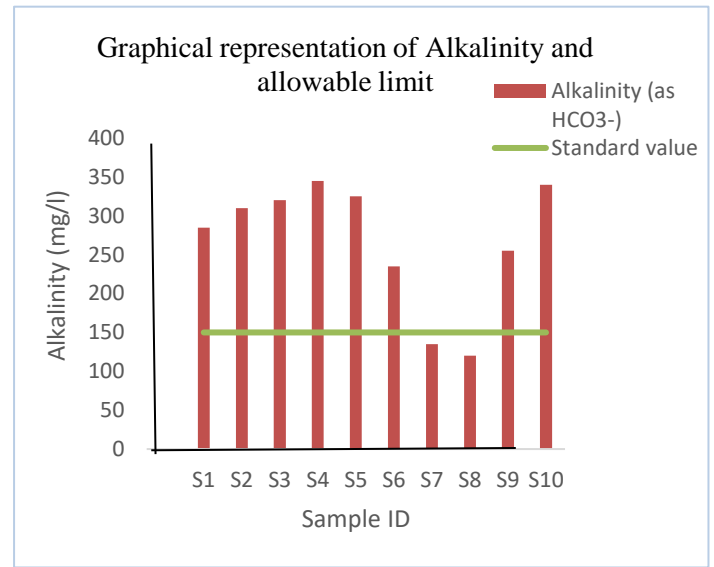


Figure 3: Comparison of Alkalinity concentration with irrigation allowable limit

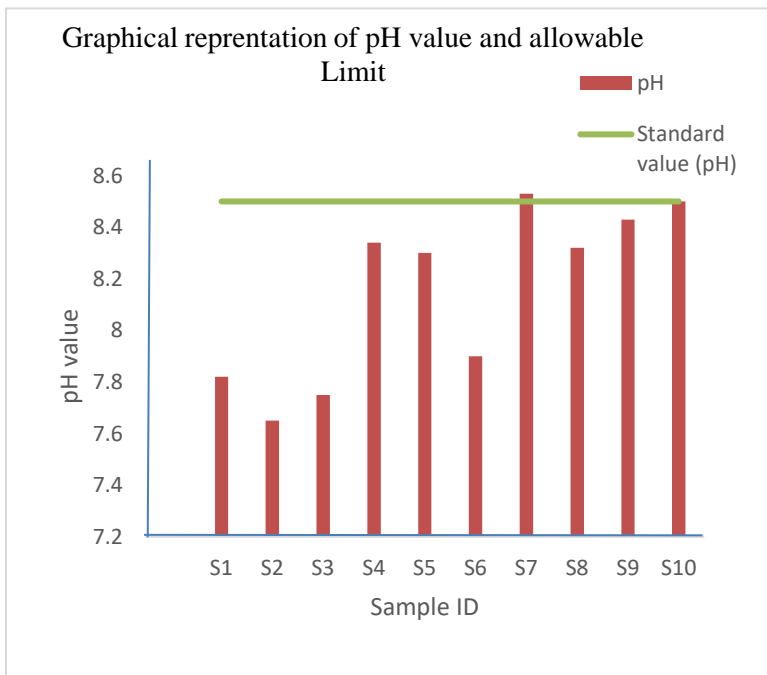


Figure 4: Comparison of pH value with irrigation allowable limit

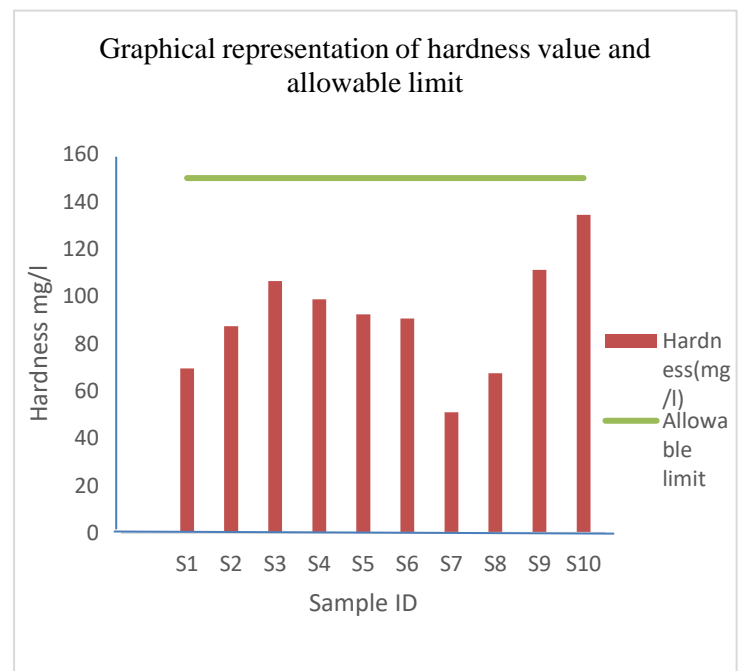


Figure 5: Comparison of Hardness concentration with irrigation allowable limit

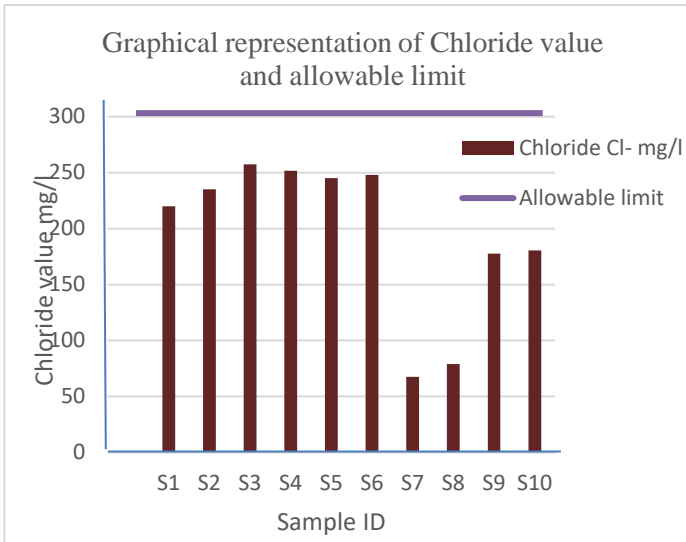


Figure 6: Comparison of Chloride concentration with irrigation allowable limit

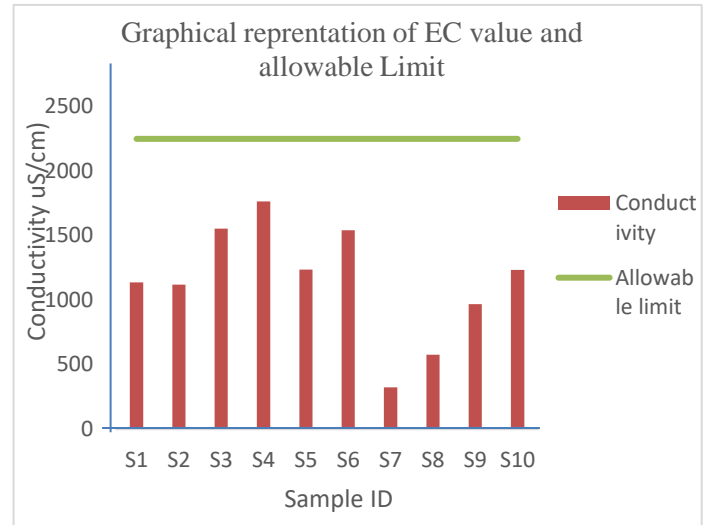


Figure 7: Comparison of EC value with irrigation allowable limit

In the figure 2,3,4,5,6,7 the obtained data of the parameter SAR, Alkalinity, pH, Hardness, Chloride, EC respectively were plotted in the graph and compared to the allowable limit according to BIWQS (Bangladesh Irrigation Water Quality Standard) (DoE, Department of Environment, 1997).

3. CONCLUSION

The major conclusion of this study follows that,

- The values of certain parameters such as SAR (28.79, 31.58, 34.82, 34.45, 37.27), Alkalinity (as HCO_3^-) (235, 255, 285, 310, 340, 345) mg/l, TSS (340, 350, 1220, 1350) mg/l exceed the Irrigation standard value BIWQS (DoE, 1997).
- Comparing the suitable values for irrigation water according to BIWQS (DoE, 1997), it can be concluded that the water of Mayur River cannot be reused directly due to very high Alkalinity, SAR and Sodium Hazard (Na%) value.

ACKNOWLEDGEMENT

We are grateful to Khulna University of Engineering and Technology for providing financial and laboratory assistance for this research project for the B.Sc. Engineering (Civil) Degree.

REFERENCES

- BIWQS (Bangladesh Irrigation Water Quality Standard) DoE, Department of Environment, 1997).
- Garg, Shantos kumar, Irrigation Engineering and Hydraulic Structures, 19th edition, Sh. Romesh Chander Khanna for Khanna Publisher, year of publication 1976, Edited Publication 2005
- Kushal Roy, Md. Rezaul Karim, Article 2015, Irrigation Water Quality Assessment and Identification of River Pollution Sources in Bangladesh, Environmental Science Discipline, Khulna University, Khulna Bangladesh.

Md. Ali Akber, Dilip Kumar Datta and M Shah Alam Khan, 2009, Recent Geomorphological Changes of Mayur River, Khulna, Bangladesh, Environmental Science Discipline Khulna University Khulna, Bangladesh

APHA, (1998), Standard methods for the examination of water and wastewater, 20th ed. American Public Health Association, Washington, DC.

Ayers, R. S. and Westcot, D. W., (1994), Water quality for agriculture. FAO Irrigation and Drainage Paper 29, Rev. 1, Rome.

JICA, (2010), Feasibility study for Khulna water supply improvement project in the people's republic of Bangladesh. Ministry of finance, Dhaka, Bangladesh.

IDRC, CDRI. 2010 Analysis of Impact of Development Projects on Water Security of The 308 Mayur River in Khulna. Water Security in Peri Urban South Asia. Environment Engineering 309 Discipline, Khulna University; 2010.

Kelley, W.P., (1963), Use of saline irrigation water, Soil science, 95, pp 355-391.

Kelly, W.P., (1940), Permissible composition and concentration of irrigated water Proceedings of the ASCF 66, p. 607.

