IMPACT OF INDUSTRIAL WASTEWATER DISCHARGE ON CHITRA RIVER IN SOUTHWEST BANGLADESH

Shamsun Naher Tabassum*[1], Khondoker Mahbub Hassan[2], H M Fairooz Adnan[3]

[1]*Undergraduate Student in Civil Engineering, Khulna University of Engineering & Technology, Bangladesh, email: tabassum1601087@stud.kuet.ac.bd*

[2]*Professor, Department of Civil Engineering, Khulna University of Engineering & Technology, Bangladesh, email: khmhassan@ce.kuet.ac.bd*

[3]*Undergraduate Student in Civil Engineering, Khulna University of Engineering & Technology, Bangladesh,, e-mail: adnan1601033@stud.kuet.ac.bd*

***Corresponding Author**

ABSTRACT

The Industry is one of the main resources for the economic development of a country. Sugar industries generate large amounts of wastewater with excessive levels of natural substances, nutrients and metals, which are released into the environment without proper treatment. Chitra River is an important River which passes through Kaliganj Upazila, Jhenaidah and used as a dumping site for discharging waste. Urban residents in Jhenaidah city use Chitra river water for many purposes including regular domestic use, fishing, Irrigation. This research aims to evaluate a variety of water quality parameters in the context of wastewater characterization as well as impact analysis of wastewater discharged into the Chitra River. A total of five water samples from five selected stations were collected and analyzed for pH, EC, TDS, Color, Turbidity, DO, BOD, COD, TC, FC and Heavy metals (As, Fe, Mn) and anions (Cl^-, NO_3^-). Chemical data were utilized to compute Water Quality Index (WQI) in order to characterize the Effluent Quality. The ecological risk of the Chitra River is assessed in this study using the Overall Pollution Index (OPI).The Resulted data was also compared with BIWQS standard to investigate the wastewater quality for indirect wastewater reuse in irrigation purposes. From the initial testing of raw wastewater and river water, it can be seen that pH, hardness, chloride, nitrate, TDS, DO, BOD values were within the standard limit. The observed value for the water samples is in the range of pH 8.62-8.9, Turbidity 98- 242 (NTU), EC 357-846 (µs/cm); TDS 250-650(mg/l), Cl^- 28-63(mg/l), NO_3^- 0.3-1.6(mg/l) and BOD value ranges between 3.8 mg/l to 11 mg/l. The value of heavy metal concentration is in the range of Fe 0.16-0.41(mg/l), Mn 0.2-0.7 mg/l, As 0.0mg/l. The findings revealed that the water quality index score ranges between 63.7 to 131 and the Overall pollution Index score ranges between 2.05 to 4.5. Concerning all measured parameters, it could be concluded that pollution of Chitra river water due to industrial discharges along with urban waste occurs noticeably but not so serious pollution has occurred yet. According to the findings of this study, the lack of proper management of wastewater are posing a threat to the environment. Adequate preventive measures should be implemented in industrial activities to ensure a healthy environment.

Keywords: *Industrial wastewater, Contamination, Impact assessment, Water Quality Index (WQI), Overall pollution Index (OPI).*

1. INTRODUCTION

Water is considered among the crucial substance on earth. Water plays a significant role in the world economy. Water is a great solvent for a wide variety of chemical compounds, as a result it is employed in industrial operations as well as cooking and washing.

The Chitra River is a significant source of surface water which flows through major cities in Khulna Division, Bangladesh. It flows through urban and industrial areas, carrying varying amounts of pollutant. Pollutant from household, factories, industries and other sources enters into water bodies and contaminating the surface water.

In this study, another aspect is physicochemical characteristics analysis of wastewater from industries like sugar industry. Sugar mill effluent contains a various type of chemical pollutants, including carbonate, bio carbonate, nitrate, phosphate, oil, and grease. Sugar industry wastewater is severely polluted because it exceeds the authorized limits for irrigation and domestic usage.

The nature of the contamination present in water quality must be evaluated in order to assess the environmental impact of the contamination and to determine if one treatment is more appropriate than another to eliminate pollutant properly. A characterization of the wastewater, which affords an extensive type of facts concerning the kind and awareness of the contaminants gift, ought to be achieved to decide the sort of infection concerned. In addition to preferred parameters which include pH and conductivity, the parameters that ought to be analysed are those who supply a concept of the content material of natural count number, nutrients (nitrogen and phosphorus), solids in suspension, the toxicity of the wastewater as regards microorganisms, further to greater precise parameters associated with the sort of interest generated through the effluent (metals, surfactants, sulphates etc.). Biological oxygen demand (BOD) has been extensively used to represent wastewater, despite the fact that this parameter is rather imprecise. On the contrary, the chemical oxygen demand (COD) is a simple calculation that measures all of the natural counts inside the water (each biodegradable and non-biodegradables).

In Bangladesh, due to rapid industrialization and urbanization, the problem of water contamination has increased tremendously so much so that a huge portion of total rivers have been found contaminated. The majority of rivers in underdeveloped nations near major cities serve as key drains for industrial pollution (Suthar *et al*., 2009). Wastewater from cities, drains, and industries degrades water resources, diminishes agricultural production, and has a negative impact on community wellbeing (Gomez-Baggethun *et al.*, 2013). Heavy metal pollution in river ecosystems, particularly in metropolitan areas, is a major problem across the world. The concentration of metals varies depending on the topography (Kumar *et al*. 2014). Industrial effluents, urban sewage, and agricultural runoff, among other things, are the principal contributors of heavy metal contamination. Heavy metal fixation in river water is used as an indicator of anthropogenic impact, and heavy metals represent a potential environmental hazard (Islam *et al*., 2015).

Rivers are a very dynamic ecology, and estimating water quality is a difficult undertaking. Prerequisites for any pollution reduction techniques are to estimating water quality. Some studies for estimating river water quality, Identification of the distribution of heavy metals, and identifying their specific impacts on aquatic ecosystems have been conducted on different Indian rivers by various researchers (Kaushik *et al*. 2009; Purkait et al. 2009; Jindal and Sharma, 2011; Banerjee and Gupta 2013; Haldar et al. 2014; Varekar *et al.* 2015).

The water quality index is the most dependable indicator of surface and groundwater contamination, and it may be used to carry out water quality monitoring programs (Dore, 2015). This index reflects the country's overall evaluation. The ability of a stream to sustain life is affected on many levels by its quality. Various experts in India have conducted several studies on surface or river water quality data. (Vasanthavigar *et al*. 2010; Jindal and Sharma 2011; Sharma and Kansal 2011; Sharma *et al*. 2014; Mishra *et al*. 2015a; Srivastava *et al*. 2017).

To have a better understanding of the water quality and natural state of the study area, a multivariate statistical approach analysis was conducted to discover potential sources assigning water bodies. The River Chitra contains numerous nonpoint and point sources of Contamination. It was found that the river water quality is deteriorating, but the actual factors may not be identified.

As a result, the assessment of changes in river water quality over time and space has been employed as a reliable technique for water quality assessment. It is necessary to provide a full spatial–temporal estimation of the water fine of the Chitra River in southwest Bangladesh.

Every river body has a variety of water quality metrics that may be used to assess its condition. Weighted arithmetic index approach (Brown, McClelland, Deininder, & Tozer, 1970), National Sanitation Foundation Water Quality Index (NSFWQI) (Hoseinzadeh et al., 2014), Overall Index of Pollution (OIP) (Sargaonkar & Deshpande, 2003), and others are the most often used water quality indexes. The OIP aids in determining the water quality of surface water sources, particularly in Indian settings (Sargaonkar & Deshpande, 2003). The current study is the first of its kind in disclosing the surface water quality of the Chitra River based on the OIP to riverine system restoration, and recreational activities.

Therefore, this study aims at determining the physicochemical characteristics of wastewater from a sugar industry as well as impact analysis of wastewater discharged into the Chitra River. Another objective of this study is to investigate the wastewater quality for indirect wastewater reuse in irrigation purposes.

2. METHODOLOGY

2.1 Study Area

Prior to deciding on a study area, a reconnaissance survey was done to understand the background of this region's seasonal influences on the environment. The Chitra River basin is located at the southwest coastal section of Bangladesh, between latitude 29° 13′ 30″ N and longitude 77° 32′ 45″ E, and runs through Kaliganj upazila in Jhenaidah district and other parts of southwest Bangladesh. The Chitra River flows southeast from the lower Chuadanga and Darsana upazilas, passing through Darsana, Kaliganj, Jessore, Salikha, and Kalia upazilas before joining the Nabaganga in Gazirhat, Narail district. The combined flow then flows into the Bhairab river in Khulna's Daulatpur upazila. It has an average temperature of 11.2°C to 37.1°C and an annual rainfall of 1467 mm.

The majority of our country's industries are located near rivers and streams, allowing for unlimited water use. Sugar Industries, Brick manufacturing factory, food processing industries and urban wastewater are identified as the primary point sources of pollution along the Chitra river's banks that dump untreated effluents into the river in an indirect or direct manner. Due to the lack of a functional wastewater and sewage infrastructure in this area, wastewater generated by households and commercial establishments is also dumped directly and through its connecting channels into the river.
The study area's location was chosen based on the following environmental significance:

- Along the river's stretch, there are industrial complexes, local companies, and eateries.
- Discharge of industrial and municipal waste together.
- Consequences for downstream consumers.

Table 1: Description of sampling stations

Sampling Stations	Sampling Description	Latitude	Longitude
Sampling site-1	Effluent from the Industry.	23°23'38.0"N	89°08'09.4"E
Sampling site -2	Wastewater from industry area	23°23'43.8"N	89°08'12.2"E
Sampling site-3	Point of mixing wastewater with surface water	23°23'46.9"N	89°08'26.9"E
Sampling Site-4	Point of mixing wastewater with surface water	23°23'48.3"N	89°08'26.8"E
Sampling Site-5	Downstream of the river	23°23'45.5"N	89°08'28.1"E

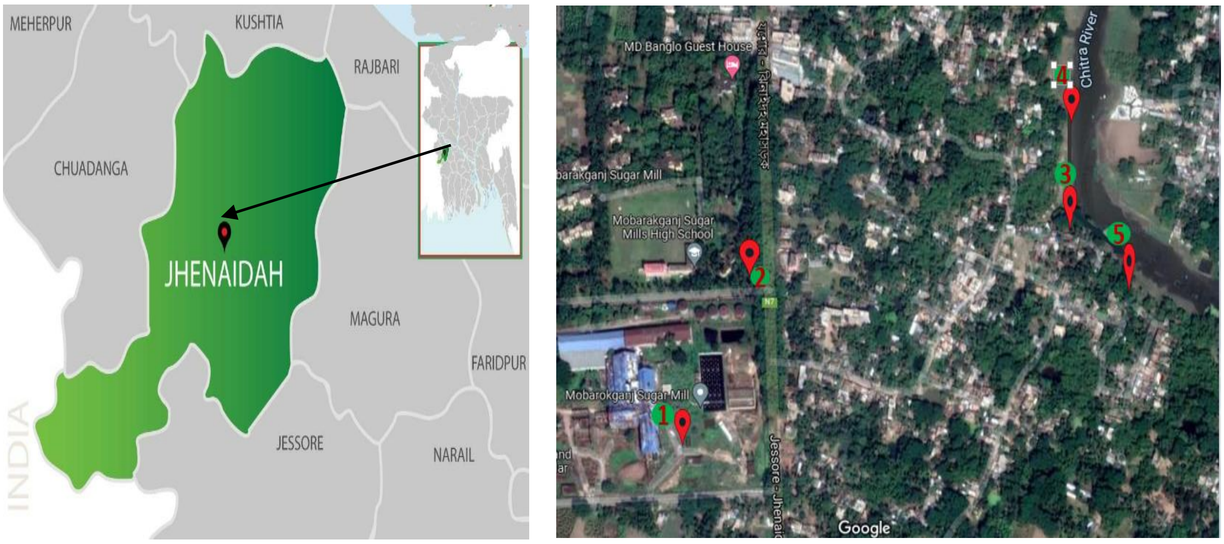

Fig. 1 Sampling stations (S1 to S5); map of Chitra River in Jhenaidah, Southwest Bangladesh

2.2 Sampling, preservation and preparation of water sample

Prior to the selection of sampling stations a well researched reconnaissance survey was carried out. Samples were collected from 5 sampling stations based on the characteristic features of the locations along the industrial area and the Chitra River. Samples were taken at the month of October according to standard method guidelines. Water was contained in high-density plastic containers with a capacity of 1 L. All samples were refrigerated prior to transport to laboratory for examination. The samples are then carefully transported to the laboratory and tested immediately.

2.3 Analysis of various water quality parameter

Temperature, electric conductivity, PH, chloride content, alkalinity, Hardness, turbidity, total solid, total dissolved solid, suspended solid, dissolved oxygen, BOD, COD, TC, FC are some of the physical, chemical, and biological characteristics that have been measured and evaluated. In addition, the concentrations of As, Fe, Mn, and Na^+ in industrial effluent and surface water are determined. Physicochemical variables including as pH, EC, and TDS were measured directly. The American Public Health Association recommended that biochemical oxygen demand, chemical oxygen demand, total hardness, chloride, sodium,and nitrate be measured (APHA 2005).

Heavy metals testing was done on water samples. The amounts of heavy metals including iron and manganese were measured using an atomic absorption spectrophotometer.

2.4 Statistical Analysis

2.4.1 Water quality index

The water quality index is a mathematical approach for computing a single value from a sequence of test results. The index result indicates the water quality in a particular water basin, such as stream, lake, or river.

To detect changes in the water's ecology, it's necessary to track water quality over time. This water quality index can be applied to track and assess changes in the watershed over time, as well as provide an indicator of the watershed's health at different times in time. A variety of physicochemical factors can be applied to compute WQI. For calculating WQI, 8 significant physicochemical variables that are most likely to influence Chitra river water quality were chosen and applied in the following equation (Harkins 1974; Mohanta and Patra 2000; Kesharwani *et al.*2004):

$$WQI = \sum_{i=1}^{n} WiQi$$

$$Qi = 100 * \frac{Va - Vi}{Vs - Vi} \qquad (1)$$

Where *Va* denotes the actual value in a water sample, *Vi* denotes the ideal value (0 for all variables except DO and pH, which are 14.6 mg/L and 7.0, respectively), and Vs denotes the standard value.
According to Jindal and Sharma (2011): The WQI of water is classified as excellent (0–24), good (25–49), poor (50–174), very poor (75–99), and unfit for human consumption (≥100).

2.4.2 OIP INDEX

In relation to the highest permissible limit, the pollution index was utilized to calculate the increase in heavy metal concentration in wastewater released into the environment. The pollution index was used to calculate a rise in the amounts of heavy metals in wastewater discharged into inland surface water compared to the highest allowable limit**.**
Several of the study conclusions have used this comprehensive pollution index to classify water quality (Zhao *et al*. 2012). It is estimated using the following equations:

P_i = *(measured concentration of individual parameter) ÷ (standard permissible concentration of parameter)*

$$OIP = \sum_{i=1}^{n} \mathrm{Pi} \qquad (2)$$

Where P_i= Pollution index for the i^{th} parameters and n=numbers of parameters.
Sargaonkar and Deshpande (2003) classified the water pollution into 5 classes on the basis of the OIP.

Water quality status	CLASS	OIP INDEX
Excellent	C1	1
Acceptable	C2	2
Slightly polluted	C3	4
Polluted	C4	8

3. RESULTS AND DISCUSSION

3.1 Physicochemical variables of Industrial Wastewater and Chitra River water

The analytical results of physicochemical variables, metal ions were summarized and transformed into expressive statistical parameters. The pH level of water sample indicates whether it is alkaline or acidic. pH level in the study area ranged from 8.62 to 8.9. The value of pH ranged between 6.5 to 8.5 , which is considered normal (ECR 1999).The salinity of river water as well as any salts, minerals, metals, anions or cations dissolved in it are measured in TDS and EC (singh et al. 2008). The EC values were in the range of 499 to 1200 s/cm. TDS concentrations ranged from 250 to 650 mg/l. Turbidity in the studied region ranged from 98 to 242 NTU, above the allowed limit. The BOD value ranges from 3.8 to 11 and the COD value ranges from 100 to 199, all of which are within the acceptable range. The Cl^- content recorded at different places ranged from 28 to 63, which is well within the allowed limit. Chloride levels in the river rose as a result of the addition of sewage and domestic garbage. SO_4^2 and are NO^{3-} important surface water indicators that represent the level of pollution and anthropogenic load in river water (suthar et al. 2010). They are found within the allowable range.

The graphical representations of the summarized results from laboratory test of all samples are shown in below:

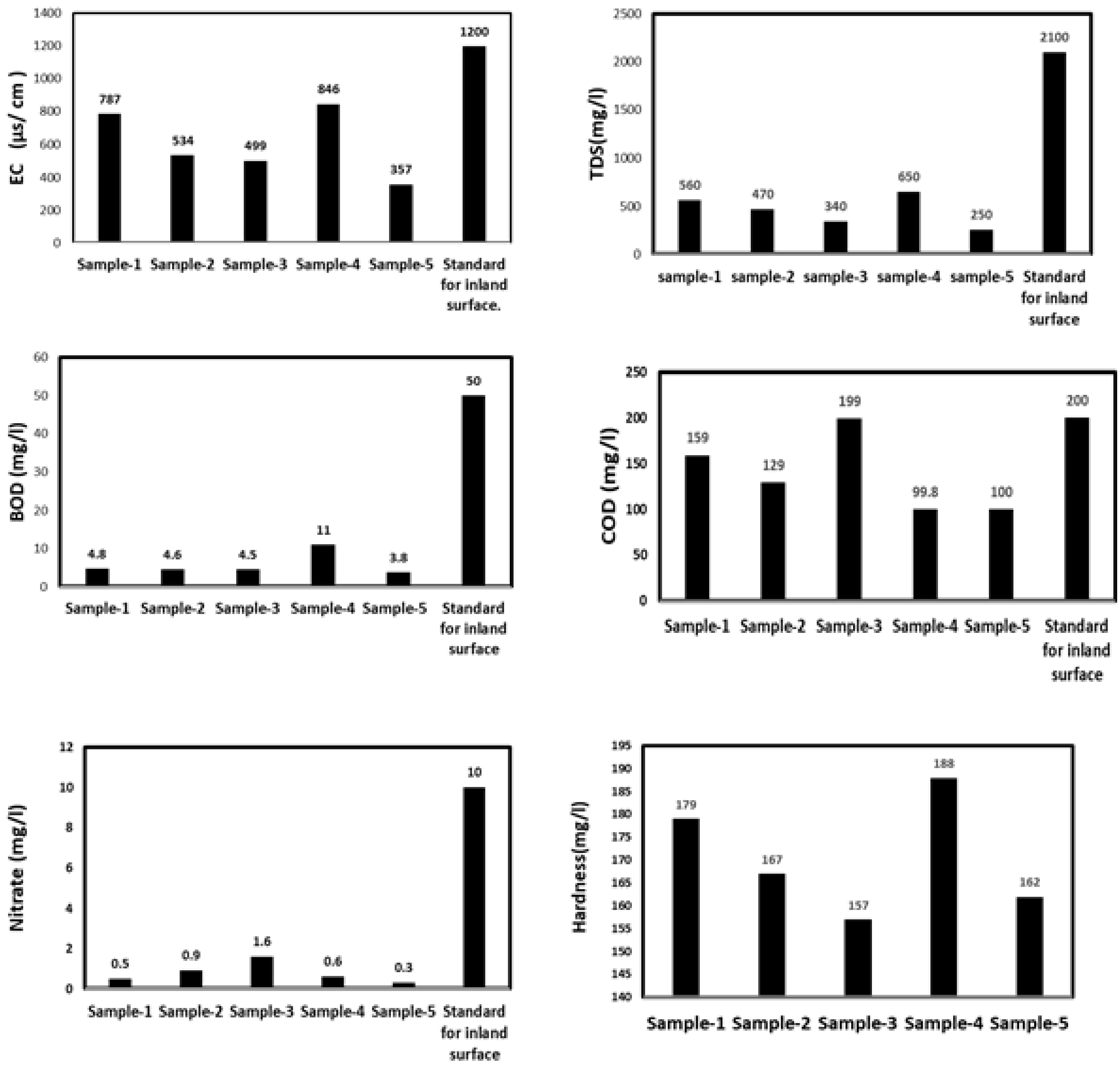

Figure 2: Comparison of EC, TDS, BOD, COD, Nitrate and Hardness with ECR’97 standard

Water samples from industry wastewater and Chitra River was examined quantitatively for the concentrations of metals such as Fe, Mn and As by using atomic absorption spectrophotometer and the values are found within the allowable range. Fe is a crucial metal for humans and other living organisms. Mn is involved in a number of physiological activities in humans. Mn may cause discomfort and lend a peculiar metallic taste and colouring to water used in household activities if it is present in excessive concentrations (Postawa *et al*. 2013).

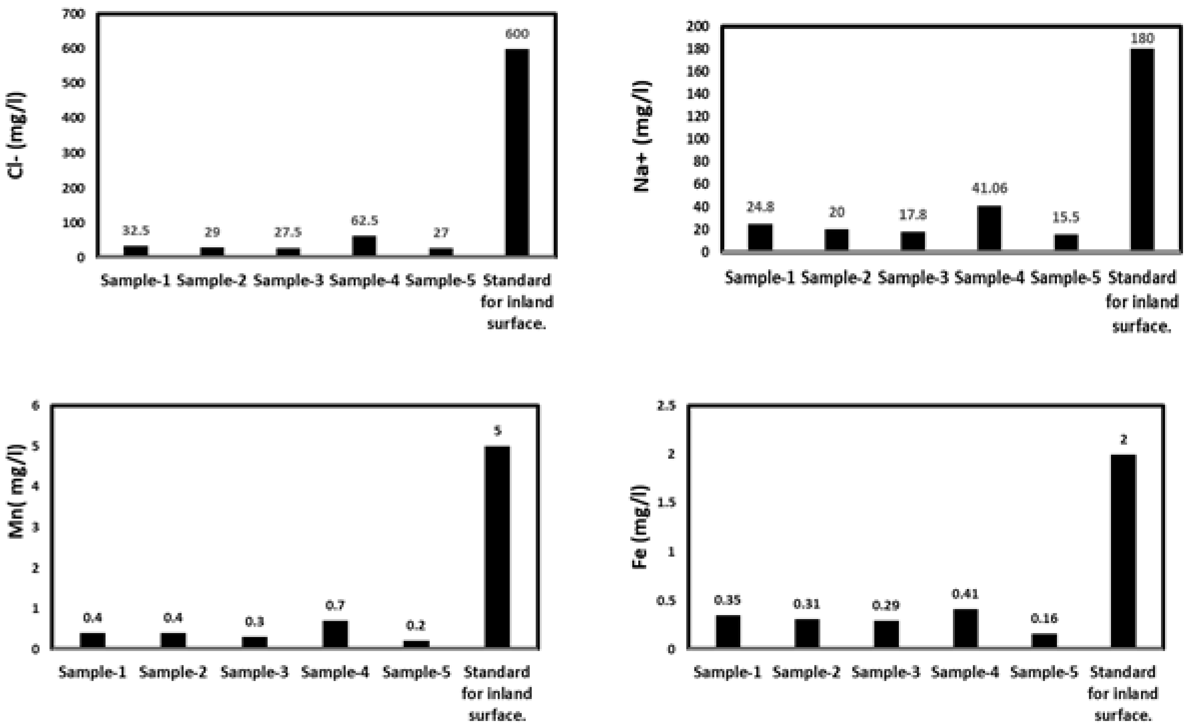

Figure 3: Comparison of Na^+, Cl^-, Fe and Mn with ECR'97 standard

The laboratory test results of wastewater from Sugar mill area and Chitra River water samples are shown in Table 2-

All the five samples are collected and a number of Physical and chemical properties were tested for characterization of wastewater and assessment the water quality of alongside Chitra River. This table revealed that the parameters used for determination of suitability of indirect reuse of wastewater were in the permissible limit. So, this wastewater can also be used indirectly for irrigation purposes.

Table 2: Tested results of physicochemical variables, units, and standards for inland Surface (ECR 1997)

Parameters	Sample no- 01	Sample no-02	Sample no- 03	Sample no-04	Sample no-05	Standard value for inland surface (ECR 1997)
pH	8.9	8.88	8.85	8.62	8.72	6.5-9
EC (µS/cm)	787	787	499	846	357	1200
TDS (mg/l)	560	470	340	650	250	2100
TSS (mg/l)	130	110	90	1160	5	150
TURBIDITY (NTU)	179	143	143	242	98	10
COLOR (Pt-co)	897	523	366	1490	128	-
DO (mg/l)	6.2	6.0	6.0	5.5	5.5	4.5-8
BOD (mg/l)	4.8	4.6	4.5	11	3.8	50
COD (mg/l)	159	138	129	199	100	200
NITRATE (mg/l)	0.5	0.9	1.6	0.6	0.3	10
HARDNESS (mg/l)	179	167	157	188	162	-
Na^+ (mg/l)	24.8	20	17.8	41.06	15.5	<180
Cl^- (mg/l)	33	29	28	63	27.0	600
Fe (mg/l)	0.35	0.31	0.29	0.41	0.16	2.0
Mn (mg/l)	0.4	0.4	0.3	0.7	0.2	5.0
As (mg/l)	0	0	0	0	0	0.2
TC (N/100ml)	42	46	51	60	90	-
FC (N/100 ml)	20	22	30	32	62	-

3.2 WQI INDEX

In this study physicochemical parameter such as pH, EC, TDS, BOD, COD, Turbidity, Hardness, NO^{3-}, Cl^- were chosen for WQI calculation. This set of values indicate that WQI was very poor at Sampling station-1 and Sampling station-2 due to a lack of wastewater treatment. The water quality of the Chitra River at Sampling station 3 and Sampling station-5 was determined to be "poor" while samples from Sampling station-4 were found to be Unfit for human consumption as a lot of waste is dumped at this point.," which could be due to a lack of effluent treatment.

The summary of WQI calculation is given below in a tabular form.

Table 3: WQI INDEX

Sampling Stations	WQI SCORE	Water Quality Status
Sample No-01	99.6	Very poor
Sample No-02	92.6	Very poor
Sample No-03	74.46	Poor
Sample No-04	131	Unfit for human consumption
Sample No-05	63.7	Poor

3.3 OIP INDEX

In this study, OIP index revealed the pollution status of Chitra River. The water quality of the Chitra River at Sampling station-3 and Sampling station-5 was determined to be in the acceptable limit, while samples from sampling station-4 were found to be polluted. The summary of OIP values of water samples from five different sampling sites was shown in Table-4.

Table 4: OIP INDEX

Sampling Stations	OIP SCORE	CLASS	Pollution Status
Sample No-01	3.5	C3	Slightly polluted
Sample No-02	3.0	C3	Slightly polluted
Sample No-03	2.75	C2	Acceptable
Sample No-04	4.5	C3	Polluted
Sample No-05	2.05	C2	Acceptable

4. CONCLUSIONS

In this present study, two wastewater sample from industry area and three water samples from Chitra River are collected and tested to characterize sugar industry effluent and to analysis the impact after being contaminated with surface water. Maximum physicochemical parameter of the water samples both from industry and Chitra River was observed to be in the permissible range. Only turbidity, colour and COD value at some sampling stations exceeds the permissible range.

From the finding of the WQI index, the quality of the effluent from sugar industry was very poor and two sampling points of Chitra river where industrial wastewater along with urban waste dump are found bad water quality. OIP index revealed that effluent from sugar industry can be classified into C3 (slightly polluted) category as they are found polluted and the river water can be categorized into C2 (acceptable) category as they are found in acceptable limit.

ACKNOWLEDGEMENTS

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

REFERENCES

APHA, AWWA, WEF. (2012).The standard method for the examination of water and wastewater (22 Ed.) Washington, DC. ISBN 978-087553-013-0.

Ali, M. M., Ali, M. L., Islam, M. S., & Rahman, M. Z. (2016). Preliminary assessment of heavy metals in water and sediment of Karnaphuli River, Bangladesh. *Environmental Nanotechnology, Monitoring & Management*, *5*, 27-35.

Banerjee, U. S., & Gupta, S. (2013). Impact of industrial waste effluents on river Damodar adjacent to Durgapur industrial complex, West Bengal, India. *Environmental monitoring and assessment*, *185*(3), 2083-2094.

Dore, M. H. (2015). *Global drinking water management and conservation*. Springer International Publishing, Basel, Switzerland. https://doi. org/10.1007/978-3-319-11032-5.

Divahar, R., Raj, P. A., Sangeetha, S. P., & Mohanakavitha, T. (2019). Impact of industrial wastewater disposal on surface water bodies in Kalingarayan canal, Erode district. *Indian Journal of Ecology*, *46*(4), 823-827.

de Melo Gurgel, P., Navoni, J. A., de Morais Ferreira, D., & do Amaral, V. S. (2016). Ecotoxicological water assessment of an estuarine river from the Brazilian Northeast, potentially affected by industrial wastewater discharge. *Science of the Total Environment*, *572*, 324-332

Galvis, A., Jaramillo, M. F., Van der Steen, P., & Gijzen, H. J. (2018). Financial aspects of reclaimed wastewater irrigation in three sugarcane production areas in the Upper Cauca River Basin, Colombia. *Agricultural Water Management*, *209*, 102-110.

Islam, M. S., Ahmed, M. K., Raknuzzaman, M., Habibullah-Al-Mamun, M., & Islam, M. K. (2015). Heavy metal pollution in surface water and sediment: a preliminary assessment of an urban river in a developing country. *Ecological indicators*, *48*, 282-291.

Jindal, R., & Sharma, C. (2011). Studies on water quality of Sutlej River around Ludhiana with reference to physicochemical parameters. *Environmental Monitoring and Assessment*, *174*(1–4), 417–425.

Kamboj, n., & kamboj, v. (2019). Water quality assessment using overall index of pollution in riverbed-mining area of ganga-river haridwar, India. *Water science*, *33*(1), 65-74.

Kumar, S., & Singh, G. R. (2010). Kali Nadi water quality status in Muzaffarnagar district of Uttar Pradesh, India. *Asian Science*, *5*(2), 102-106.

Kumar, R., Rani, M., Gupta, H., & Gupta, B. (2014). Trace metal fractionation in water and sediments of an urban river stretch. *Chemical Speciation & Bioavailability*, 26(4), 200–209.

Mokarram, M., Saber, A., & Sheykhi, V. (2020). Effects of heavy metal contamination on river water quality due to release of industrial effluents. *Journal of Cleaner Production*, *277*, 123380.

Mulk, S., Azizullah, A., Korai, A. L., & Khattak, M. N. K. (2015). Impact of marble industry effluents on water and sediment quality of Barandu River in Buner District, Pakistan. *Environmental monitoring and assessment*, *187*(2), 1-23.

Patel, sahadev & Bhatia, R.K. (2020). Effect of sugar industry liquid waste on ground water and river water in gadarwara. *International Journal for Research Trends and Innovation (IJRTI*), 5.

Singh, G., Patel, N., Jindal, T., Srivastava, P., & Bhowmik, A. (2020). Assessment of spatial and temporal variations in water quality by the application of multivariate statistical methods in the Kali River, Uttar Pradesh, India. *Environmental Monitoring and Assessment*, *192*, 1-26