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# ASSESMENT OF WATER QUALITY IN AN URBAN RIVER USING POLLUTANT LOAD CONCEPT

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## ABSTRACT

The present study attempts to examine the water quality of Moyur river at Khulna in Bangladesh, using the concept of pollutant load and comparing the results with water quality index. Six points were selected along the river and particular collections were carried out at a specified point. Nitrate, dissolved oxygen (DO), biochemical oxygen demand ($BOD_5$), total dissolved solids (TDS), turbidity, fecal coliform, pH were measured at six selected stations along the river using standard methods. The results showed that the water quality index score ranges between 21.59 to 32.62. The water classification, therefore, ranges from very bad to bad. Flow measurement were also carried out which enabled the calculation of the polluting load. The pollutant load value were calculated with respect to some parameters like $BOD_{5,}$ TDS and Nitrate. The estimated pollutant load value for $BOD_5$ likely ranges between 2.63 kg/hr to 32.07 kg/hr. Also the pollutant load value for TDS and Nitrate ranges between 0.078 kg/hr to 1.13 kg/hr and 0.31 kg/hr to 16.47 kg/hr,respectively.The calculation of the pollutant load showed a constant disposal of contaminats into the river, which indicates that the quality of the river is continuously decressing. This information could not be found by only analysing the water quality index. The use of the calculation of pollutant load for Moyur river is, therefore, a tool for assessment of pollution that can provide more appropriate information for the water resources management.

***Keywords:*** *Flow, Pollutant load, Urban river, Water quality index.*

## 1. INTRODUCTION

Water is an essential requirement of human and industrial developments and it is one the most delicate part of the environment (Das and Acharya, 2003). But the quality of water is very important for both human and industrial development. With the passage of time, development of communities, and increased use of water resources, pressures upon controlling water resources and detection of abnormal changes in water quality conditions have increased (Sánchez *et al.*, 2007). Population growth, environmental pollution from discharge of urban and industrial sewage, and run-off have increased pollution and limited available water resources (Simeonov*et al.*, 2003; Sánchez *et al.*, 2007). As the quality of water is a major concern of now-a days, water quality monitoring of the water resources are absolutely necessary regularly to assess the quality of water for health, ecosystem, industrial use, agricultural use and domestic use.

Water quality index (WQI) is one of the most effective tools to communicate information about the quality of water to the concerned citizens. WQI is defined as a rating reflecting the composite influence of different water quality parameters. This index was developed from a mathematical relationship that transforms the result of various analysis of physical, chemical and microbiological parameters into a single number. This simplifies the quality evaluation of the fresh waters (Maane*et al.*, 2010). To ensure water quality the use of the WQI has been widely accepted over a very long period. WQI is calculated from the point of view of the suitability of surface water for human consumption (Atulegwu and Njoku, 2004). Although the water quality index is widely used to determine water quality but there is a question which can be raised so easily if flow measurement has any significance to evaluate water quality? In this respect, an alternative way to evaluate the effects of pollution in rivers is the use of the concept of pollutants load. The volumetric organic load, for example, is a fundamental parameter for the design of biological reactors for treating sewage and industrial effluents (Metcalf and Eddy, 2013). For the monitoring of water resources, the use of more widespread pollutant load is related to the calculation of the mass of suspended solids transported by water. This measure is an important indicator of soil loss and also the basis for the design and control of dams (Richards, 1998). According to this author, the knowledge of a load of suspended solids has a greater significance when compared to the concentration of these species. Many researchers have addressed this issue in a similar manner. The pollutant load concept has been considered by many authors as a tool for evaluating the impact of pollution in rivers. A study about the pollution of Lake Taihu in China using parameters such as chemical oxygen demand (COD), ammonia, total nitrogen and total phosphorus were evaluated in terms of the pollutant load. (Zhang*et al*., 2012). The concept load used to evaluate the runoff of pollutants due to various land uses and occupation in Chongqing in China. The application of the concept of the load was used to check which activity has more intensely influenced the pollution of waters in that locality. (Wang *et al.*, 2013). Recently a study had occurred to prioritize investments in pollution control on the Great Barrier Reef in Australia. The authors used the concept of load to evaluate which watersheds had the greatest influence on the pollution of reefs and used it to improve the effectiveness of programs for environmental protection. (Brodie*et al*., 2016). Finally, an application of the pollutant load concept had occured to study benzene series in an urban environment. (Li *et al*., 2019). Based on these studies, we can observe that the pollutant load concept has been considered by many authors as a tool for evaluating the impact of pollution in rivers.

The Moyur River in Khulna is one of the important channels of the Bhairab-Rupsa River system located in the south-west part of Bangladesh. This river has been increasingly polluted due to the disposal of municipal wastewater as well as various organic and inorganic waste materials from nearby market areas. Many research works had been carried out addressing the gradual degradation of water quality in Moyur River. However, the variation of pollutant load with river flow regime is yet to be addressed. In this context, the current study had been undertaken to compare the water quality index with the concept of pollutant load in Moyur River and evaluate the methodologies for more substantial information.

## 2. METHODOLOGY

### 2.1 Sample Collection Location

The Moyur River is one of the important channels of the Bhairab-Rupsa River system located in the south-west part of Bangladesh and in the downstream of the well-known Ganges delta (Rahman, Das, Roy and Akbar, 2013). The length of the Moyur River is nearly 100 km north of the coast line of the Bay of Bengal. The Moyur River is located at 22°47′ to 22°50′ N latitudes and 89°31′ to 89°34′ E longitudes in the north-south direction, geographically. The river originates from the Beel Dakatia (a large wetland) and meets with the Rupsha River. The total length of the river is 11.42 km and it has a basin area of 40 km2 with more or less a flat elevation varying from 2.7 m to 3.9 m (Roy, Datta, Adhikari, Chowdhury and Roy, 2005), The surface study of the basin area is classified as deltaic deposits which are composed of tidal deltaic deposits, deltaic silt deposits and mangrove muddy deposits with soils of sand, silty clay and clay in texture. The sub-surface studies are also characterized by a varied mixture of sand, silt and clay.


Figure 1: Location map of the water sampling spots in the Moyur River

### 2.2 National Sanitation Foundation Water Quality Index

As per NSFQWI, nine parameters have been used for calculating the water quality index which include dissolved oxygen (DO, mg/ L), biochemical oxygen demand ($BOD_5$, mg /L), nitrate ($NO^{3-}$, mg/ L), phosphate ($PO^{4-}$, mg/ L), fecal coliform bacteria (CFU/100 mL), turbidity (NTU), total solids (TS, mg /L), temperature change from 1 mile upstream (˚C), and pH. Following the guidelines of NSFQWI, weighting factor of each parameter had been used. For weighting factor determination, scientists were asked to graph the level of water quality ranging from 0 (the worst) to 100 (the best) from the raw data, (e.g. pH values 2–12), first. The curves drawn had been averaged to get the weighting curve for each parameter. Results of the nine parameters had been compared to the curves and a numerical value "Q-value," is obtained. The Q-value was then multiplied by a "weighting factor," based on the importance of that water quality with regards to the hydro-geological setup of the study area. The nine resulting values were then aggregated to obtain an overall WQI.

The NSFWQI ranges are divided by five quality classes (Table 1). Each of the NSFWQI parameters has its own weighting factor (Wi) which describes the importance of the effect of each parameter in the calculation. The weighting factor for each parameter has been described below:

Dissolved oxygen (DO) 0.17, Turbidity 0.08, Fecal coliform (FC) 0.15, Suspended solids (SS) 0.08, pH 0.12, Temperature 0.1, Total phosphates (TP) 0.1, Biochemical oxygen demand ($BOD_5$) 0.1, Ammonia nitrogen (NH3-N) 0.1.

Table 1: Water quality rating as per NSFWQI

| **WQI Value** | **Rating of Water Quality** |
|---|---|
| 91-100 | Excellent water quality |
| 71-90 | Good water quality |
| 51-70 | Medium water quality |
| 26-50 | Bad water quality |
| 0-25 | Very bad water quality |

**2.3 Flow Measurement and Calculation of Load**

With regard to the flow measurement a current meter (Model 802 electromagnetic current meter) was used at sampling point one to six. First, the water velocity and depth was measured at many points along the margins. The water velocity data is collected from the current meter using a software called CDU Express. Then, the water flow was determined by multiplying the average velocity of the channel by the cross-sectional area of flow.

Figure 2: Experimental set up for Model 802 Water Flow Meter

Finally, after the determination of the concentration and flow data, it was possible to perform the calculation of pollutant load F according to Equation 1.

$$F = Q * C \tag{1}$$

Where, F is the load (g/ h or Kg/ h)
Q is the flow rate (L/ h)
C is the concentration (g/ L or Kg/ L)

## 3. RESULTS AND DISCUSSION

**3.1 Water Quality Index (WQI)**

Biochemical Oxygen Demand ($BOD_5$) is an important indicator of the water quality and the extent of pollution in the watershed areas. At every sampling points from 1 to 6 the value of BOD is extensively high (Table 2). It means that the disposal of municipal domestic waste or other toxic wastes are too high in the watersheds. As the value of $BOD_5$ is too high the natural oxygen that had been replenished by the plankton was inadequate with regards to microbial oxidation of biodegradable organic matters and thus the value of Dissolved Oxygen got less at every sampling points (Table 2). The pH at most of the points in the stream was found to be in the range of 6.6 to 7.36. The point with the highest pH was point 6 having a pH of 7.36. The other point with slightly higher pH values are 3, 4, and 5 with pH values of 7.19, 7.10 and 7.20, respectively. The rest of the points of pH values are less than ranges of seven.

As the value of Fecal coliform (FC) are also too high that means the amount of waste present in the river water is too much contaminated with faecal sludge and that's why there is a lot of pathogenic bacteria present in water which is found in human and animal excreta. Nevertheless, nitrate ion in water is undesirable. High nitrate levels were found at points 1, 3 and 4 with values of 1mg/L, 1.3 mg/L and 1.9 mg/L, respectively. The results of other points do not exceed 1 mg/L but it is also harmful for natural water. Total dissolved solids had concentration range between 600 and 3600 mg/L. The observed high concentration of dissolved solids in the surface water is an indicator to the fact that there are anthropogenic activities and the run- off includes high suspended material. The turbidity is linked to suspended solids in that the higher the turbidity the higher the suspended solids. The points with higher turbidity values are 4 (22.0 NTU), 5 (20.4 NTU) and 1(20.7 NTU), while the rest of the points had a turbidity less than 20 NTU but it's also higher and harmful for in total environment of any natural resources.

The results of the WQI showed that water quality at point 1 is classified as "very bad" and at points 2 to 6 as "bad" (Table 1). The score of WQI ranges between 0 to 40. Overall, the scores were below 40, which indicate that the land use and occupation on this watershed likely affect the water quality.

Table 2: Measurement results for parameters

| **Parameter** | **Sampling points** | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| $BOD_5$ (mg/ L ) | 240 | 198 | 228 | 222 | 196 | 264 |
| DO (mg/ L) | 2.58 | 2.80 | 2.86 | 3.13 | 2.87 | 3.10 |
| pH | 6.6 | 6.98 | 7.19 | 7.10 | 7.20 | 7.36 |
| FC | 400 | 600 | 900 | 800 | 500 | 600 |
| Nitrate (mg/ L) | 1.0 | 0.9 | 1.3 | 1.9 | 0.8 | 0.5 |
| TDS (mg/ L) | 900 | 3600 | 600 | 800 | 1400 | 1300 |
| Turbidity (NTU) | 20.7 | 17.1 | 19.1 | 22.0 | 20.4 | 18.7 |

Note: DO=Dissolved oxygen $BOD_5$=Biochemical oxygen demand FC=Fecal coliform TDS=Total dissolved solids.

### 3.2 Pollutant Load

The pollutant load values were calculated with respect to some parameters such as $BOD_5$, TDS, and nitrate. The concept of pollutant load involves the mass of a pollutant that is discharged into the water for a period of time (Metcalf and Eddy, 2013). The measurements of concentrations previously considered for WQI scores computing and the flow measurements were used to obtain the pollutant load values. As can be seen in figure 3, the highest value of flow is 2.41 cubic meter per second which is at sampling point 4 and the lowest value of flow is 0.166 cubic meter per second which at point 6. These flow measurements were done on the sunny day. If the measurement were taken at a rainy day may be then there will be some variation in results. These measurements of water flow allowed us to compute the pollutant load transported by the river. With regard to the figure 4 the average pollutant load for $BOD_5$ranges between 2.63 kg/hr. to 32.07 kg/hr. From this pollutant load value of $BOD_5$ we can say that there are a lot of existences of biodegradable waste in the water which is harmful for total environment of river water and its ecosystem. As the value of $BOD_5$ is too much that means a lot of industrial waste, municipal waste that generated in the city is released into the Moyur River. Similarly, analysing the pollutant load for total dissolved solids in figure 5 ranges between 0.078 kg/hr.to 1.13 kg/hr. which represents the availability of too much salts, some organic materials and a wide range of other things from nutrients to toxic materials that may cause death of many aquatic life forms. Again the pollutant load for nitrate in figure 6 ranges between 0.31 kg/hr. to 16.47 kg/hr. The presences of excess nitrogen can be harmful to ecosystem. It also happened for the contamination of sewage and industrial waste.

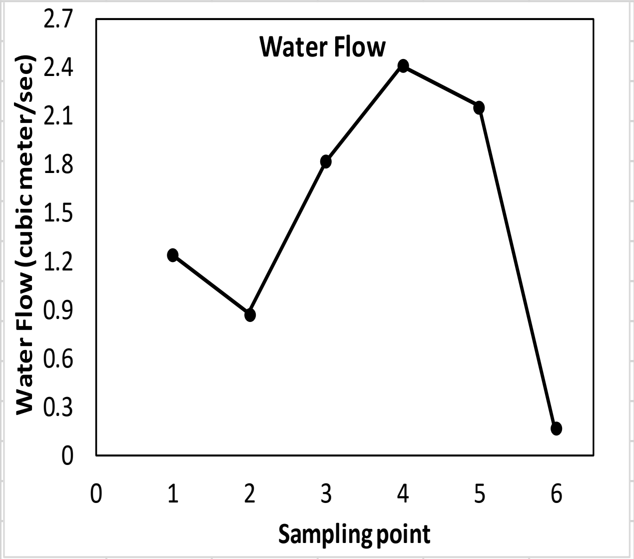


Figure 3: Flow Measurement

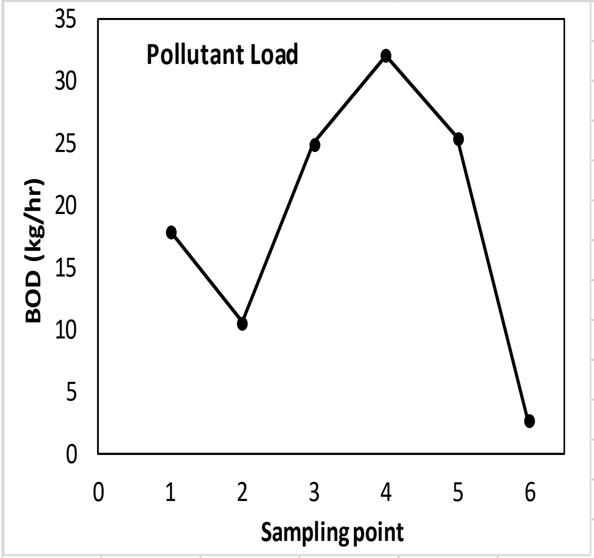


Figure 4: Pollutant load for BOD

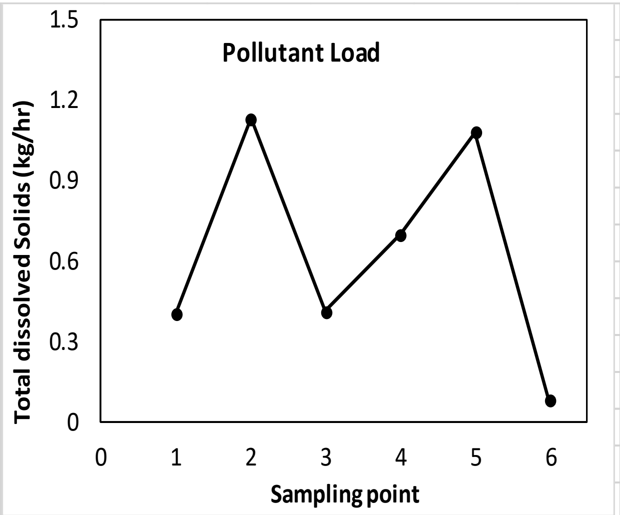


Figure 5: Pollutant load for TDS

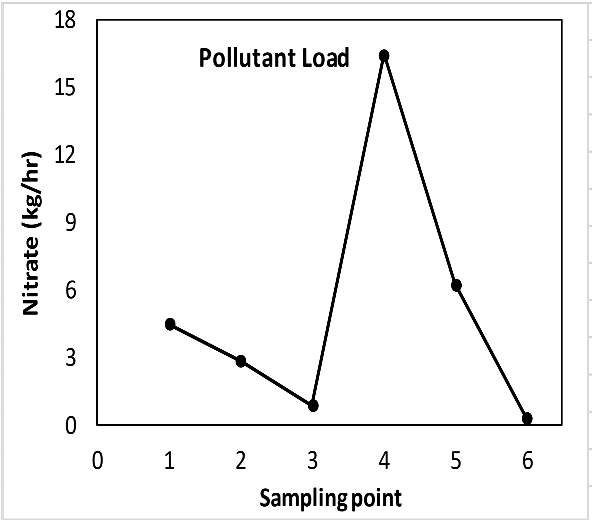


Figure 6: Pollutant load for Nitrate

Overall, it can be concluded that there is high value of pollutant load at some sampling points while it is less in other points. In some cases, the value of WQI and the value of Pollutant load did not match up at the same sampling points which mean that sometimes the WQI value cannot be able to show the exact information for the water bodies. That's why the calculation for pollutant load is needed for appropriate information for any water bodies.

## 4. CONCLUSIONS

The results obtained in this study showed that the monitoring of Moyur River by pollutant load concept is more representative of the environmental impacts. The river is increasingly polluted by various types of wastes which comes from various sources and deposited in the river basin, which could be detected by the pollutant load values. The highest pollutant load value of biodegradable organic matters had been found 32.07 kg/hr as biochemical oxygen demand ($BOD_5$), 1.13 kg/hr as total dissolved solids (TDS) and 16.47 kg/hr as nitrate, respectively which is highly threatening for ecosystem by reducing the dissolved oxygen levels significantly. On the other hand, the water quality index seemed to be not so effective to express the progressive contamination in the watershed. Sometimes the water quality index value and the value of pollutant load did not match up. That means very often the water quality index value is not enough to express the quality of water to provide the outmost situation of inland water bodies. The WQI value provide information about surface water quality and the pollutant load concept provide the information about suspended load which is transported by water at a specific time. As a whole, the use of the calculation of load for Moyur River is, therefore, a tool for assessment of pollution that can provide more appropriate information for the management of this water resource.

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