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# Correlation Study for Assessment of Water Quality and its Parameters of Kushiyara River, Sylhet, Bangladesh

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*Abstract*—**This research aims to analyze correlation between surface water quality parameters of River Kushiyara, Sylhet Division, Bangladesh on the basis of physico-chemical parameters such as Temperature, $P^H$, DO (Dissolved Oxygen), BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), TS (Total Solids), TDS (Total Dissolved Solids) and SS (Suspended Solids). Pearson's correlation coefficient (r) is determined using correlation matrix to identify the highly correlated and interrelated water quality parameters. To test the significance of the pair of parameters p-value is carried out. There is a relationship between variables which shows that one variable actually causes change in another variable. In rainy season the highest significant correlation is found between COD & TS, TS & TDS, BOD & COD and BOD & SS. In winter season the highest significant correlation is found between TS & TDS, TS & SS, TDS & SS and Temperature & $P^H$. The DO showed negative correlation with most of the parameters and in winter season the DO show negative correlation with all other parameter more or less, which reveals that when other water quality parameters increase the DO value decreases.**

*Index Terms*— **Kushiyara River, Water Quality Parameters, Rainy Season, Winter Season, Correlation Coefficient.**

## I. Introduction

Rivers play a major rule to the growth of a country's economy. The utility from rivers are not limited to the supply of water; they also serve other purposes such as recreation and sport, navigation, irrigation, fishing, generation of hydropower, transportation, waste disposal, and even sand mining. Water quality is a worldwide problem which disturbs human beings lives profoundly. A lot of researchers studies on assessment of water quality parameters around the world ([4]-[6],[8], [9],[14], [20],[22]-[24],[32], and [37]).Water scarceness is strengthened in result of quality deterioration. A river is a system comprising both main course and tributaries, carrying the one-way flow of a significant load of matter in dissolved and particulate phases from both natural and anthropogenic sources. Both organic and inorganic waste effluents adversely interact with the river system and deteriorating the water quality of the rivers. For this reason, water causes the adverse effect on surrounding land and aquatic ecosystem as well as subsequent impact on the livelihood of the local community ([2], and [26]). On the other hand, rivers play a major role in assimilation or transporting municipal and industrial wastewater and runoff from agricultural land. Municipal and industrial wastewater discharge constitutes a constant polluting source, whereas surface runoff is a seasonal phenomenon, largely affected by climate of the basin [15]. Many researchers (The degree of association that exists on two variables is measured by the correlation coefficient (r) where one take as dependent variable and is the mutual relationship between two variables. When increase or decrease to the value of one parameter is associated with a corresponding increase or decrease to the value of other parameter than direct correlation exists between this two variables [13]. The study of water quality is necessary to prevent serious water quality deteriorations in future. The present study take an attempt to assess water quality of Kushiyara River in Sylhet Division, Bangladesh.

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## II. Material and Method

### A. Description of Study Area

Kushiyara River one of the trans-boundary rivers of Bangladesh. The Kushiyara River is situated in the north eastern region of Bangladesh which has got a multipart river system that supports a diversity of uses, comprising irrigation systems in agricultural lands, drinking water and industries wastewater. The effluents from all these sources are directly discharged into the river. The Barak River enters Bangladesh along 24°53' north latitudes and 92°32' east longitudes. The Barak splits into two branches at Amalshid in the northeast border of Zakiganj Upozila of Sylhet district. The northwest part is the Surma and the southwestern part is the Kushiyara. At Amalshid, the bed of the Surma has to a large extent dried up and as a result, about 85 percent flow of the Barak runs through the Kushiyara. The total length of the Kushiyara River is about 161 km and the average width of the river is 250m. In the rainy season the mean depth of the Kushiyara reaches up to 10m. The river carries an enormous amount of water with sediments from Karimganj of Assam and the hilly areas of Hill Tripura. The river passes over Zakiganj, Golabganj, Fenchuganj, Balaganj, Rajnagar, Maulvibazar and Nabiganj. The Fenchuganj Fertilizer Factory stands on the bank of the Kushiyara [16].The study area is shown figure 1.

### B. Sampling and Analysis

The water quality parameters were grouped in two different periods (rainy and winter season). Water samples were collected from the first 20-30 cm of the water column along the Kushiyara River from upstream to downstream during two seasons- namely rainy season (June-July) and winter season (November-December) at each site using a

pre-sterilized two liter plastic bottle, repeatedly washed with water from those sites and tested for some physical and chemical water quality parameters which are required for this study. Water samples were collected for the years 2010, 2011, 2012 and 2013 respectively along the rivers for both seasons. For correlation analysis the average data is used and the data for the years 2005-2009 and 2014, is collected from DoE, BWDB and CEE department's previous research works.

Total ten years seasonal data is used for statistical analysis. Water sample from various point in Kushiyara River was collected and routine laboratory analysis made for physical and chemical qualities according to the standard method [3].

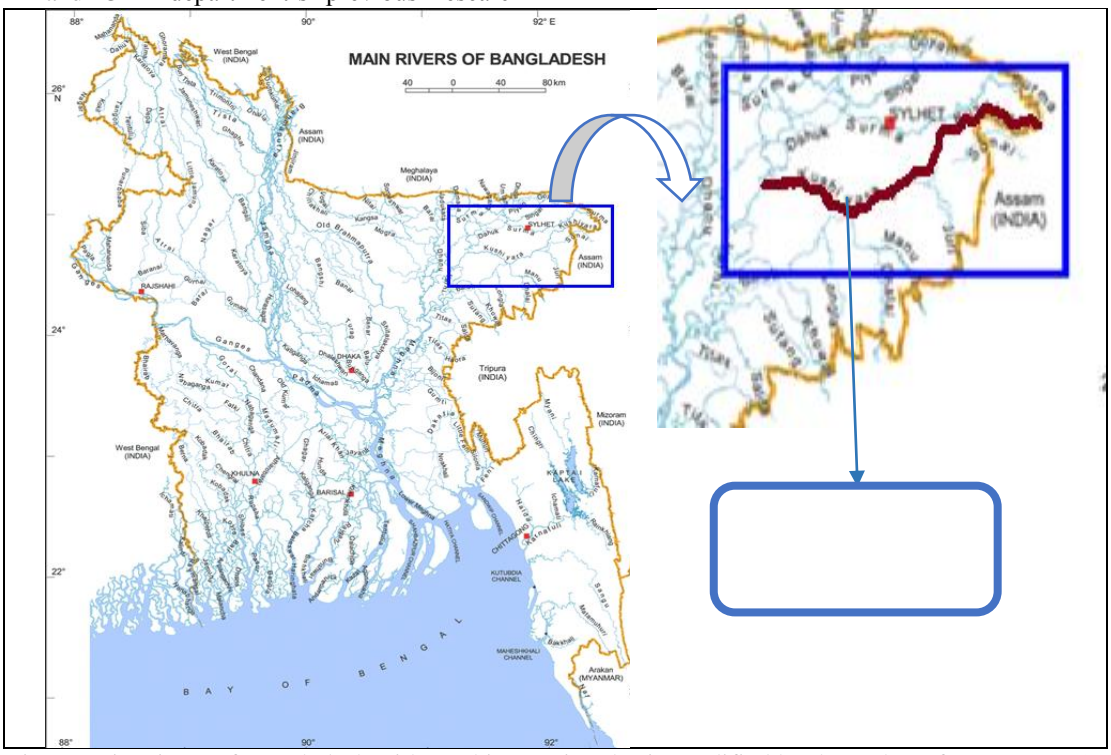


Fig. 1 Main Rivers of Bangladesh with Kushiyara River basin modified by the author after source [18].

### C. *General information of Water Quality Parameters*

Temperature is an important water quality and environmental parameter because it manages the kinds and types of aquatic life, controls the maximum dissolved oxygen concentration of the water, and effects the rate of chemical and biological reactions [28]. $P^H$ is a very significant factor that must be considered to determine for water quality. The $P^H$ of any water body surface is defined as a magnitude of Hydrogen ion concentration. In other words, $P^H$ is a measure of the alkalinity or acidity of water soluble substances [1].Dissolved Oxygen (DO) is defined as the amount of oxygen dissolved in a water body and measures the health of the water and its ability to maintain a balance aquatic ecosystem ([10] and[11]). The DO seems as microscopic bubbles of gaseous oxygen which are mixed in water and available to aquatic organisms for respiration ([10] and[36]). BOD (Biochemical Oxygen Demand) is defined as the amount of oxygen required by aerobic microorganisms to dissolve organic matter in a sample of water. It is one of the most essential and widely used parameters for the most essential and widely used parameters for measuring pollutants and biodegradable organic compounds in water ([7], [10], and[27]). Low the BOD, higher the desirability of using for human use, like drinking & domestic purposes. For drinking water, BOD should be nil. The COD is the amount of specified oxidant that reacts with a sample of water under controlled conditions and is expressed in terms of oxygen equivalence [10]. COD is observed as a useful measure of water quality because its application determines the quantity of organic pollutants present in surface water or wastewater [35]. Total solids comprises both total suspended solids, the portion of total solids retained by a filter and total dissolved solids, the portion that passes through a filter [31]. The total amount of all dissolved solutes and silica present in a water body is recognized as the total dissolved solids (TDS). TDS are mainly the inorganic minerals and sometimes some organic matter. It can be determined gravimetrically by evaporating a known volume of water and measuring the mass of the residue left[30]. Suspended solid (SS) are the solid matter suspended in water, comprising of organic and inorganic materials, such as plankton, silt and industrial waste ([10] and[20]).

## III. Statistical Analysis

Statistical analysis was conducted by using Statistical Packages for Social Science (SPSS Version 23),[33]. The physico-chemical parameters for all the study were explored by calculating Pearson's correlation coefficient (r) value in order to assess the relationship between water quality variables. With the purpose of calculation of correlation coefficients, correlation matrix was constructed by calculating the coefficients of different pairs of parameters. A correlation coefficient near -1 or 1 means a strongest negative or positive relationship between them [21]. After that correlation for significance was tested by applying p value ([12] and [25]). The variations are significant if $p<0.05$, $p<0.01$, and non-significant if $p>0.05$. The significance is

considered at the level of 0.01 and 0.05 (2-tailed analysis). The physico-chemical parameters for all the study were analyzed by calculating Pearson's correlation coefficient (r) value. Correlation is a bivariate analysis that measures the strengths of association between two variables and the direction of the relationship ([19] and[34]). In terms of the strength of relationship, the value of the correlation coefficient varies between +1 and -1. When the value of the correlation coefficient lies around ± 1, then it is said to be a perfect degree of association between the two variables. As the correlation coefficient value goes towards 0, the relationship between the two variables will be weaker. The direction of the relationship is simply the + (indicating a positive relationship between the variables) or - (indicating a negative relationship between the variables) sign of the correlation. The degree of association that exists between two variables is measured by the correlation coefficient (r) where one taken as dependent variable and is the mutual relationship between two variables. When increase or decrease in the value of one parameter is associated with a corresponding increase or decrease in the value of other parameter than direct correlation exists between this two variables [13]. Usually, in statistics, there are four types of correlations: Pearson correlation, Kendall rank correlation, Spearman correlation, and the Point-Biserial correlation. Among them Pearson r correlation is the most widely used correlation statistic to measure the degree of the relationship between linearly related variables. The following formula is used to calculate the Pearson r correlation:

$$r = \frac{N\sum xy - \sum x \sum y}{\sqrt{[N\sum x^2 - (\sum x)^2]\ [N\sum y^2 - (\sum y)^2]}}$$

Where,

r = Pearson r correlation coefficient
N = number of value in each data set
∑xy = sum of the products of paired scores
∑x = sum of x scores
∑y = sum of y scores
∑x2= sum of squared x scores
∑y2= sum of squared y scores

Assumptions for the Pearson r correlation, both variables should be normally distributed (normally distributed variables have a bell-shaped curve). Other assumptions include linearity and homoscedasticity. Linearity assumes a straight line relationship between each of the variables in the analysis and homoscedasticity assumes that data is normally distributed about the regression line. In order to calculate correlation coefficients, correlation matrix was constructed by calculating the coefficients of different pairs of parameters and correlation for significance was further tested by applying p value ([12], and [25]). The variations are significant if $p<0.05$, $p<0.01$, and non-significant if $p>0.05$. The significance is considered at the level of 0.01 and 0.05 (2-tailed analysis).

## IV. Result and Discussion

The statistical result with respect to minimum, maximum, mean, Standard Deviation (SD) and Standard Error (SE) values for surface water quality parameters of rainy season and winter season are summarized in Table 1 and 2. The statistical results for various physico chemical parameters were revealed in Table 3 and 4 for surface water with correlation matrix for rainy and winter season respectively.

The water temperature not showed significant correlation with other water quality parameters in rainy season but it showed positive correlation with $P^H$ (r = 0.392), COD (r = 0.60), TS ( r = o.317) and TDS ( r = 0.450), negative correlation with DO (r = -0.214), BOD (r = -0.116) and SS (r = -0.72), but temperature not showed any significant correlation. In winter season water temperature showed positive correlation with $P^H$ (r = 0.748, $p < 0.05$), BOD (r = 0.231), COD (r = 0.707, $p < 0.05$), TS (r = 0.508), TDS (r = 0.584) and SS (r = 0.236). Temperature showed negative correlation only with DO (r = -0.595) in winter season. Temperature showed significant positive correlation with $P^H$ and DO in winter season but it showed negative correlation with DO in both season, revealed that when water temperature increases the metabolic rate of microorganisms also increases and the amount of DO in water is decreases. $P^H$ showed positive correlation with BOD (r = 0.410), COD (r = 0.302), TS (r = 0.478), TDS (r = 0.411) and SS (r = 0.396) in rainy season and in winter season $P^H$ showed positive correlation with BOD (r = 0.202), COD (r = 0.403), TS (r = 0.068) and TDS (r = 0.148). It is remarkable that $P^H$ showed negative correlation with DO (r = -0.214) in rainy season and DO (r = -0.595) in winter season. $P^H$ also showed negative correlation with SS (r = -0.163) in winter season but not showed significant correlation with other water quality parameter in both season. Dissolved Oxygen (DO) showed negative correlation with Temperature, $P^H$, BOD (r = -0.141), COD (r = -0.232), TS (r = -0.401) and TDS (r = -0.0.558) in rainy season. In winter season temperature showed negative correlation with all other parameters as Temperature, $P^H$, BOD (r = -0.562), COD (r = -0.433), TS (r = -0.482), TDS (r = -0.0.559) and SS (r = -0.172). DO showed positive correlation only with SS (r = 0.015) in rainy season. The DO not showed significant correlation with other water quality parameter in both season. The BOD showed positive correlation with $P^H$, COD (r = 0.898, $p < 0.01$), TS (r = 0.791, $p < 0.01$), TDS (r = 0.566) and SS (r = 0.834, $p < 0.01$) in rainy season. It showed negative correlation with temperature and DO in rainy season. In winter season BOD not showed significant correlation with other water quality parameter but it showed positive correlation with temperature, $P^H$, COD (r = 0.123), TS (r = 0.550), TDS (r = 0.529) and SS (r = 0.540). It showed negative correlation with DO in winter season.

**Table 1**. Descriptive statistics of water quality parameter of Kushiyara River in rainy season

| Water quality parameter(Unit) | Minimum | Maximum | Mean | Std. Error | Std. Deviation |
|---|---|---|---|---|---|
| Temperature(° C) | 26.04 | 27.44 | 26.54 | 0.14 | 0.45 |
| $P^H$ | 6.27 | 6.92 | 6.68 | 0.06 | 0.20 |
| DO(mg/l) | 5.50 | 10.93 | 7.65 | 0.45 | 1.41 |
| BOD(mg/l) | 3.21 | 5.92 | 4.67 | 0.31 | 0.98 |
| COD(mg/l) | 5.89 | 7.24 | 6.55 | 0.12 | 0.39 |
| TS(mg/l) | 165.23 | 287.00 | 214.79 | 10.54 | 33.34 |
| TDS(mg/l) | 106.32 | 200.44 | 134.74 | 8.06 | 25.48 |
| SS(mg/l) | 58.91 | 99.35 | 79.91 | 4.51 | 14.25 |

**Table 2.** Descriptive statistics of water quality parameter of Kushiyara River in winter season

| Water quality parameter(Unit) | Minimum | Maximum | Mean | Std. Error | Std. Deviation |
|---|---|---|---|---|---|
| Temperature(° C) | 23.98 | 26.31 | 24.90 | 0.22 | 0.69 |
| $P^H$ | 6.18 | 6.74 | 6.50 | 0.06 | 0.17 |
| DO(mg/l) | 4.90 | 7.36 | 6.33 | 0.27 | 0.85 |
| BOD(mg/l) | 3.40 | 5.32 | 4.23 | 0.19 | 0.60 |
| COD(mg/l) | 6.05 | 6.97 | 6.31 | 0.09 | 0.28 |
| TS(mg/l) | 142.36 | 250.22 | 195.85 | 11.20 | 35.41 |
| TDS(mg/l) | 66.93 | 163.67 | 109.09 | 9.48 | 29.99 |
| SS(mg/l) | 75.43 | 96.70 | 87.43 | 2.50 | 7.90 |

**Table 3.** Correlation among different parameter of Kushiyara River in rainy season

| **Correlations** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature | $P^H$ | DO | BOD | COD | TS | TDS | SS |
| Temperature | 1 | .392 | -.214 | -.116 | .060 | .317 | .450 | -.072 |
| $P^H$ | | 1 | -.472 | .410 | .302 | .478 | .411 | .396 |
| DO | | | 1 | -.141 | -.232 | -.401 | -.558 | .015 |
| BOD | | | | 1 | .898** | .791** | .566 | .834** |
| COD | | | | | 1 | .927** | .773** | .784** |
| TS | | | | | . | 1 | .917** | .704* |
| TDS | | | | | | | 1 | .362 |
| SS | | | | | | | | 1 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | | | |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | | | |

The COD showed positive correlation with temperature, $P^H$, BOD, TS ($r = 0.927$, $p < 0.01$), TDS ($r = 0.773$, $p < 0.01$) and SS ($r = 0.784$, $p < 0.01$) in rainy season. In winter season COD showed positive correlation with temperature, $P^H$, BOD, TS ($r = 0.174$) and TS ($r = 0.274$). It showed negative correlation with temperature and DO in rainy season. In winter season COD showed negative correlation with DO and SS. The TS showed positive correlation with temperature, $P^H$, BOD, COD, TDS ($r = 0.917$, $p < 0.01$) and SS($r = 0.704$, $p < 0.05$) in rainy season. In winter season TS showed positive correlation with temperature, $P^H$, BOD, COD, TDS ($r = 0.986$, $p < 0.01$) and SS ($r = 0.873$, $p < 0.01$).

It showed negative correlation with DO in both season with (r = -0.401) and (r = -0.482) respectively. The TDS showed positive correlation with temperature, $P^H$, BOD, COD, TS and SS (r = 0.362) in rainy season. In winter season TDS showed positive correlation with temperature, $P^H$, BOD, COD, TS and SS (r = 0.783, p < 0.01). It showed negative correlation with DO in both season with (r = -0.558) and (r = -0.559) respectively. The SS showed positive correlation with $P^H$, DO, BOD, COD, TS and TDS in rainy season. In winter season SS showed positive correlation with temperature, BOD, TS and TDS. It showed negative correlation with temperature in rainy season and with $P^H$, DO and COD in winter season. [25] found that significant positive correlation holds between Temp with BOD GH1 (r= 0.99, p<0.01), EC with chloride GH6 (r=0.877, p<0.01), EC with TDS GH6 (r=0.836, p<0.01); and TA with DO GH1(r=0.842, p<0.01), PH with Mg GH6 (r=-0.79, p<0.01), EC with Nitrate GH6 (r=0.846, p<0.01). A significant negative correlation was found for DO with BOD GH3 (r=-0.943, p<0.01), DO with TDS GH6 (r=-0.838, p<0.01), and TA with TDS GH6 (r=-0.88, p<0.01) for Ganga River, Kanpur, Uttar Pradesh, India. [17] found the relationship between COD with BOD, DO with BOD, DO with COD and TS with alkalinity is established which give correlation coefficient (r = 0.8657, p<0.01), (r = -0.8795, p<0.01), (r = -0.8897, p<0.01) and (r = 0.8328, p<0.01) respectively, showing a very good correlation for the River Kosi, India.

**Table 4.** Correlation among different parameter of Kushiyara River in winter season

| Correlations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature | $P^H$ | DO | BOD | COD | TS | TDS | SS |
| Temperature | 1 | .748* | -.595 | .231 | .707* | .508 | .584 | .236 |
| $P^H$ | | 1 | -.426 | .202 | .403 | .068 | .148 | -.163 |
| DO | | | 1 | -.562 | -.433 | -.482 | -.559 | -.172 |
| BOD | | | | 1 | .123 | .550 | .529 | .540 |
| COD | | | | | 1 | .174 | .274 | -.067 |
| TS | | | | | | 1 | .986** | .873** |
| TDS | | | | | | | 1 | .783** |
| SS | | | | | | | | 1 |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | | | |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | | | |

## V. Conclusion

The statistical correlation analysis has been found to be a very suitable technique and finding correlation between numerous physico-chemical parameters can be recognized as a unique step ahead towards the surface water quality management. The results of the present investigation conclude that from correlation analysis, the COD showed maximum positive correlation with TS (r = 0.927, p < 0.01) in rainy season and TS showed maximum positive correlation with TDS (r = 0.986, p < 0.01) in winter season. Though there is no negative significant correlation found but the

DO showed negative correlation all other parameters in both season except SS of Rainy season. From this it can be concluded that the high organic pollution from industrial and anthropogenic activities in the river basin is occurring. Thus the method of Pearson's correlation has been found to a significant approach to get fairly accurate clue of quality of the surface water by determining a few important parameters experimentally.

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