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Establishing relationships between water quality parameters for the Buriganga River using BOD_5 and pH as a common parameter

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Abstract

Reaffirming the need for the proper utilization of water resources while ascertaining the importance of this resource in the context of Bangladesh, we have tried to outline a procedure whereby the degree of pollution of the river Buriganga can be estimated by collecting the values of a few selected water quality parameters hence outweigh the necessity to perform multiple tests in order to fulfill the same goal. Situated just beside its capital Dhaka is the river Buriganga, which plays a very important role in the water treatment, sewage disposal and water distribution to the capital. While realizing the importance of performing tests for different water quality parameters such as BOD_5, pH, EC, NH_3N, TDS, and Cr we have also understood the effort that has to be undertaken for such procedures hence we have derived relationships to minimize such effort by performing only tests for BOD_5, pH.

INTRODUCTION

Bangladesh is a river irrigated country. The capital city Dhaka is surrounded by a peripheral river system comprising of rivers Buriganga, Dhaleswari, Shitalakhya, Balu, Turag and Tongi canal. Much demand of water supply of Dhaka is fulfilled by treated water from Buriganga. Over the decades much of the wastewater of the capital was also deposited into it. This deteriorated the quality of water. Since Buriganga plays the most important role in the livelihoods of city dwellers and is also the most polluted among the peripheral rivers so it is considered as the study area.

The objective of this study was to derive some relationships among the various water quality parameters hence minimize the cost, time required, equipment and physical effort consumed in performing the multiple tests on water. We have tried to establish some equations whereby only values of BOD_5 and pH are sufficient to project the values of EC, TDS, NH_3-N, and Cr. Since pH values can easily be obtained using pH meter and the BOD_5 is a commonly carried out laboratory test hence they serve as an appropriate common parameter.

MATERIALS AND METHODS

A. Selection of test fish species

To perform our study we have used previously obtained sample data of Water Quality Parameters from thesis paper titled "*A Study on the Water Quality Parameters of the River Buriganga*"[2] from 7 randomly selected stations within the time span of February to April 2012. Water samples were tested in BUET Environmental Engineering Laboratory. Equations were derived from these data such that BOD_5 and pH are sufficient to obtain all other parameters notably EC, TDS, NH_3-N, Cr. The data collected are shown in Table 1.

Table 1: Collected set of data of BOD_5-COD, BOD_5- EC and BOD_5-NH_3N.

BOD_5 (mg/L)	COD (mg/L)	BOD_5 (mg/L)	EC (µS/cm)	BOD_5 (mg/L)	NH_3N (mg/L)
28	115	35	650	35	7.5
28	155	37	720	38	6
35	88	40	750	40	10.5
32	135	48	910	48	11
45	70	43	1010	54	11.1
54	178	60	1050	63	10
67	113	70	1055	70	12

Water Samples were completely random and fulfilled the criteria of Statistical Sample. Furthermore the values of parameters are observed to be symmetric about a mean value. Thus the conditions for normal distribution are fulfilled and its application in our study is validated. Hence utilization of this hypothesis test is also validated.

For testing the hypothesis that a correlation coefficient is zero:

Product Moment Correlation Co-efficient (R) = $\sqrt{R^2}$

Ho: $\rho = 0$, there is zero correlation between the readings.

H1: $\rho \neq 0$(two-tailed), there is either a positive or a negative correlation.

Table 2: Critical Values for Correlation Coefficient [1]

Product-moment Coefficient			
Level			Sample Size
0.10	0.05	0.025	
0.6084	0.7293	0.8114	6
0.5509	0.6694	0.7545	7
0.5067	0.6215	0.7067	8

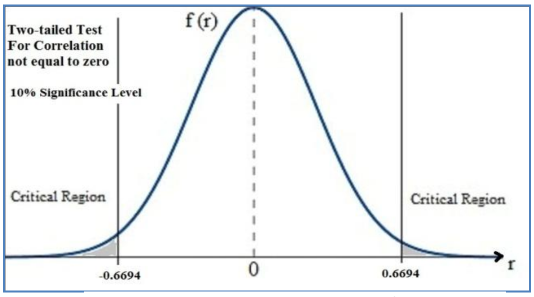

Fig. 1. Graph showing the critical regions for two-tailed hypothesis test at 10% significance level.

From Table 2, we will get the critical value for R which will tell us if the result is significant or not at 10% significance level.

From these relations we have calculated the values of multiple water quality parameters and compared them with another set of data collected from Buriganga by Bangladesh Water Development Board (BWDB). The software Microsoft Excel was used to derive equations from collected values and compute correlation coefficient values.

RESULTS

A. The correlation and Hypothesis test between BOD_5 and COD are shown in Figure 2:

From COD vs. BOD_5 curve, R=$\sqrt{(0.0001)}$ =0.0316

The result is not significant at the 10% level. We accept Ho. So, there is zero correlation between the readings.

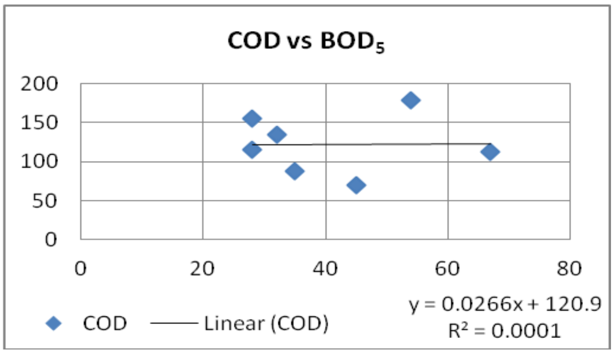

Fig. 2. Graphical presentation of the correlation between COD and BOD_5

B. The correlation and hypothesis test between BOD_5 and EC are shown in Figure 3:

From EC vs. BOD_5 curve, R = √ (0.667) =0.8167

The result is significant at the 10% level. We reject Ho and accept H_1. So, there is evidence to suggest that the correlation is not zero.

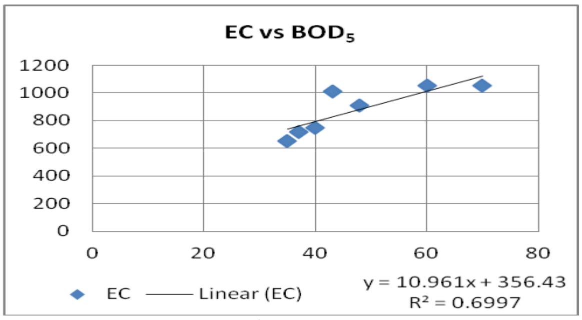

Fig. 3. Graphical presentation of the correlation between EC and BOD_5

C. The correlation and hypothesis test between BOD_5 and NH_3N are shown in Figure 4:

From NH_3-N vs. BOD_5 curve, R =√ (0.5022) =0.7087

The result is significant at the 10% level. We reject Ho and accept H_1. So, there is evidence to suggest that the correlation is not zero.

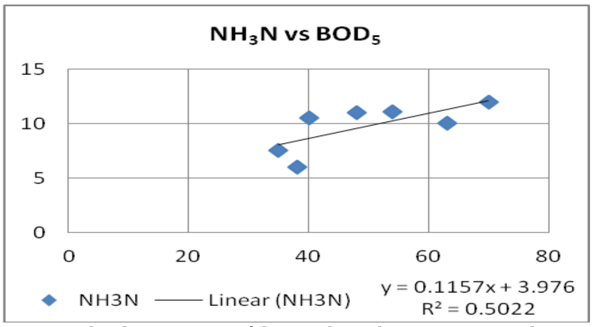

Fig. 4. Graphical presentation of the correlation between NH_3N and BOD_5

We have computed values of BOD_5-Cr from different set of collected data of BOD_5-EC and EC-Cr using proportionality. BOD_5-TDS is also computed in the same way using EC values. BOD_5-pH values are directly collected. They are tabulated below:

Table 3: Obtained set of data of BOD_5-Cr, BOD_5- pH and BOD_5–TDS

BOD_5 (mg/L)	Cr (mg/L)	BOD_5 (mg/L)	pH	BOD_5 (mg/L)	TDS (mg/L)
12.42	0.002	37.8	7.13	10.305	400
18.06	0.003	45.555	7.28	17.355	500
27.93	0.02	31.455	7.3	17.7075	505
19.47	0.023	43.44	7.48	19.1175	525
24.405	0.025	23.7	7.49	22.995	580
27.93	0.04	47.67	7.58	23.3475	585
29.34	0.145	49.08	7.61	23.7	590

D. The correlation and hypothesis test between BOD_5 and Cr are shown in Figure 5:

From Cr vs. BOD_5 curve, R = √ (0.4006) =0.633

The result is not significant at the 10% level. We accept Ho. So, there is zero correlation between the readings.

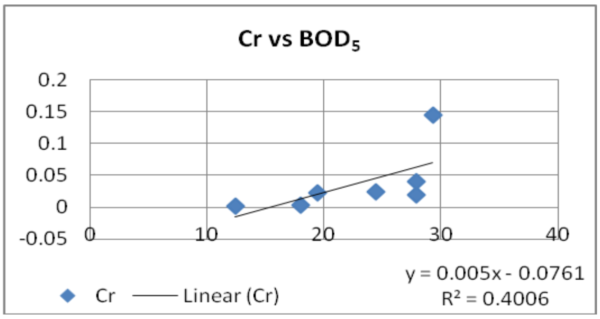

Fig. 5. Graphical presentation of the correlation between Cr and BOD_5

E. The correlation and hypothesis test between BOD_5 and pH are shown in Figure 6:

From pH vs. BOD_5 curve, R = √ (0.0845) =0.291

The result is not significant at the 10% level. We accept Ho. So, there is zero correlation between the readings.

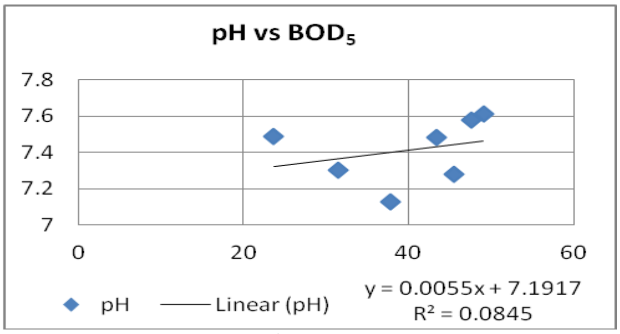

Fig. 6. Graphical presentation of the correlation between pH and BOD_5

F. The correlation and hypothesis test between TDS and BOD_5 are shown in Figure 7:

From TDS vs. BOD_5 curve, R = √ (0.8253)=0.908

The result is significant at the 10% level. We reject Ho and accept H_1. So, there is evidence to suggest that the correlation is not zero.

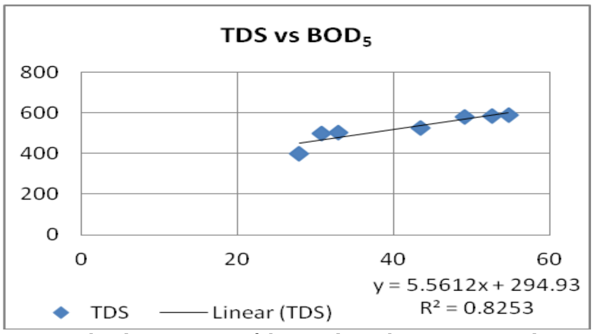

Fig. 7. Graphical presentation of the correlation between TDS and BOD_5

The test for COD vs. BOD_5, Cr vs. BOD_5, pH vs. BOD_5 is not significant. Hence we have derived some more relationships for the unsatisfied parameters using pH as a common parameter using same data.

G. The correlation and hypothesis test between Cr and pH are shown in Figure 8:

From Cr vs. pH curve, R = √ (0.4733) =0.691

The result is significant at the 10% level. We reject Ho and accept H_1. So, there is evidence to suggest that the correlation is not zero.

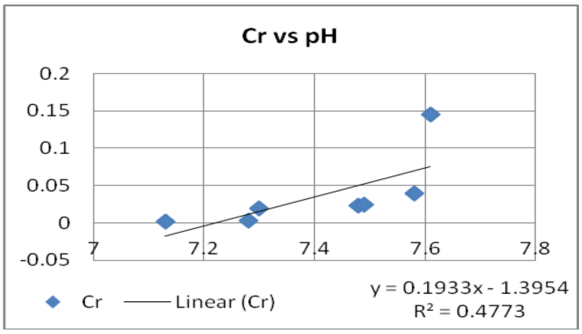

Fig. 8. Graphical presentation of the correlation between Cr and pH

H. The correlation and hypothesis test between TDS and pH are shown in Figure 9:

From TDS vs. pH curve, R = √ (0. .8981) =0.948

The result is significant at the 10% level. We reject Ho and accept H_1. So, there is evidence to suggest that the correlation is not zero.

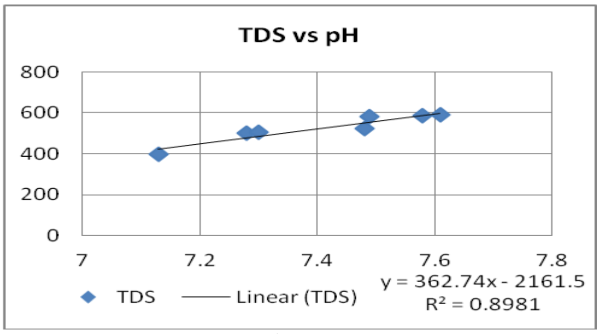

Fig. 9. Graphical presentation of the correlation between TDS and pH

I. The correlation and hypothesis test between COD and pH are shown in Figure 10:

From COD vs. pH curve, R = √ (0. 022) =0.148

The result is not significant at the 10% level. We accept Ho. So, there is zero correlation between the readings.

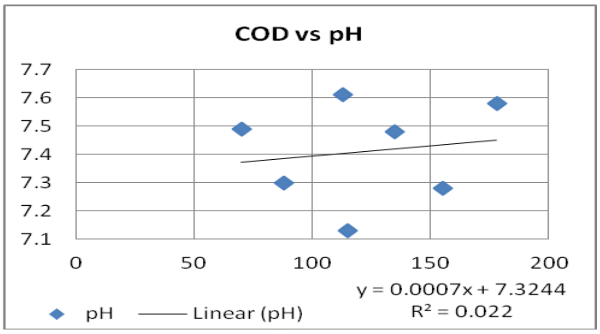

Fig. 10. Graphical presentation of the correlation between COD and pH

Testing the hypothesis that a correlation coefficient is positive:

Product Moment Correlation Co-efficient (R) = $\sqrt{R^2}$

Ho: $\rho = 0$, there is zero correlation between the readings.

H1: $\rho > 0$(one-tailed), there is a positive correlation.

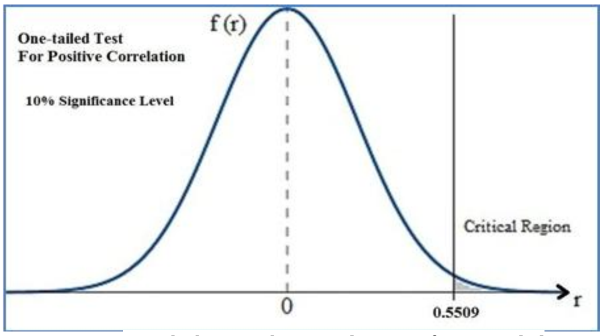

Fig. 11. Graph showing the critical regions for one-tailed hypothesis test at 10% significance level

From table 2 we will get the critical value for R which will tell us if the result is significant or not at 10% significance level.

Hypothesis test (one tailed): when BOD_5 is common parameter:

From EC vs. BOD_5 curve, R = √ (0.667)=0.8167

The result is significant at the 10% level. We reject Ho and accept H_1. So, there is evidence to suggest that the correlation is positive.

From NH_3-N vs. BOD_5 curve, R =√ (0.5022)=0.7087

The result is significant at the 10% level. We reject Ho and accept H_1. So, there is evidence to suggest that the correlation is positive.

From TDS vs. BOD_5 curve, R = √ (0.8253)=0.908

The result is significant at the 10% level. We reject Ho and accept H_1. So, there is evidence to suggest that the correlation is positive.

Hypothesis test (one tailed): when pH is common parameter:

From Cr vs. pH curve, R = √ (0.4733) =0.691

The result is significant at the 10% level. We reject Ho and accept H_1. So, there is evidence to suggest that the correlation is positive.

From TDS vs. pH curve, R = √ (0 .8981) =0.948

The result is significant at the 10% level. We reject Ho and accept H_1. So, there is evidence to suggest that the correlation is positive. Using these correlations we got another set of data shown in Table 4:

Table 4: Water quality parameters value collected by BWDB at Buriganga River and the projected values using derived equations

BOD_5	EC		BOD_5	NH_3N	
12	Collected from Kamrangir Char (2004)	510	56	Collected from Kamrangir Char (2010)	11.3
	Calculated	487.96		Calculated	10.46
pH	Cr		pH	TDS	
7.54	Collected from Pagla (2008)	0.0123	7.2	Collected from Mill Barrack (2007)	378
	Calculated	0.022		Calculated	450.23

Upon observation we discover that the calculated and obtained values are quite close to each other except for the projected values of NH_3N from pH where such formulations appear inappropriate once we compare the values. However when BOD_5 is used to compute NH_3N, calculated values is comparable to experimental as long as they are above magnitude 1. For obtaining TDS from BOD_5, such conclusions could not be reached due to absence of field data.

CONCLUSION

In our study we have collected field data and tried to develop relationships between water quality parameters in order to provide projections of other values from BOD_5 and pH only. We can get projections for TDS, EC, Cr and NH_3N. Such relationships have been verified using hypothesis tests and cross-checked using another set of field data. We have summarized our findings below.

From our experiment we got that there are positive correlation between

EC and BOD_5: $y = 10.961x + 356.43$: $R^2 = 0.6997$

NH_3N and BOD_5: $y = 0.1157x + 3.976$:$R^2 = 0.5022$

TDS and BOD_5: $y = 5.5612x + 294.93$:$R^2 = 0.8253$

pH and Cr : $y = 0.1933x - 1.3954$:$R^2 = 0.4773$

pH and TDS : $y = 362.74x - 2161.5$:$R^2 = 0.8981$

And also there are no correlations between

COD and BOD_5; COD and pH;

pH and BOD_5 ; Cr and BOD_5

In our study conventional parameters such as pH, alkalinity, EC, turbidity provided a valid relationship. Organic parameter such as COD did not have a reliable relationship with any common parameter whereas BOD_5 did. Furthermore we have established relationship between ionic parameters such as Cr, NH_3N with the common parameters. Dissolved oxygen can be measured more easily using a probe but we have relied upon BOD_5 tests as it is more widely used and frequently tested in laboratories.

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