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$_3$N, 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>
<thead>
<tr>
<th>BOD$_5$ (mg/L)</th>
<th>COD (mg/L)</th>
<th>BOD$_5$ (mg/L)</th>
<th>EC (µS/cm)</th>
<th>BOD$_5$ (mg/L)</th>
<th>NH$_3$N (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>115</td>
<td>28</td>
<td>72</td>
<td>35</td>
<td>7,5</td>
</tr>
<tr>
<td>28</td>
<td>155</td>
<td>35</td>
<td>72</td>
<td>38</td>
<td>6</td>
</tr>
<tr>
<td>35</td>
<td>88</td>
<td>72</td>
<td>750</td>
<td>40</td>
<td>10,5</td>
</tr>
<tr>
<td>32</td>
<td>135</td>
<td>40</td>
<td>910</td>
<td>48</td>
<td>11</td>
</tr>
<tr>
<td>45</td>
<td>70</td>
<td>43</td>
<td>1010</td>
<td>54</td>
<td>11,1</td>
</tr>
<tr>
<td>54</td>
<td>178</td>
<td>60</td>
<td>1050</td>
<td>63</td>
<td>10</td>
</tr>
<tr>
<td>67</td>
<td>113</td>
<td>70</td>
<td>1055</td>
<td>70</td>
<td>12</td>
</tr>
</tbody>
</table>

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) = |R|$

H_0$: $\rho = 0$, there is zero correlation between the readings.

H$_1$: $\rho \neq 0$(two-tailed), there is either a positive or a negative correlation.

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.

Table 1: Collected set of data of BOD$_5$, COD, EC and BOD$_5$-NH$_3$N.

Table 2: Critical Values for Correlation Coefficient [1]

| Product-moment Coefficient | Sample Size | $

<table>
<thead>
<tr>
<th>0.10</th>
<th>0.05</th>
<th>0.025</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6084</td>
<td>0.7293</td>
<td>0.8114</td>
</tr>
<tr>
<td>0.5509</td>
<td>0.6694</td>
<td>0.7545</td>
</tr>
<tr>
<td>0.3067</td>
<td>0.6215</td>
<td>0.7067</td>
</tr>
</tbody>
</table>

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

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, $R = \sqrt{(0.667)} = 0.8167$
The result is significant at the 10% level. We reject $H_0$ and accept $H_1$. So, there is evidence to suggest that the correlation is not zero.

![Graphical presentation of the correlation between EC and BOD$_5$](image)

C. The correlation and hypothesis test between BOD$_5$ and NH$_3$N are shown in Figure 4:
From NH$_3$N vs. BOD$_5$ curve, $R = \sqrt{(0.5022)} = 0.7087$
The result is significant at the 10% level. We reject $H_0$ and accept $H_1$. So, there is evidence to suggest that the correlation is not zero.

![Graphical presentation of the correlation between NH$_3$N and BOD$_5$](image)

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>
<thead>
<tr>
<th>BOD$_5$ (mg/L)</th>
<th>Cr (mg/L)</th>
<th>BOD$_5$ (mg/L)</th>
<th>pH</th>
<th>BOD$_5$ (mg/L)</th>
<th>TDS (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.42</td>
<td>0.002</td>
<td>37.8</td>
<td>7.13</td>
<td>10.305</td>
<td>400</td>
</tr>
<tr>
<td>18.06</td>
<td>0.003</td>
<td>45.555</td>
<td>7.28</td>
<td>17.355</td>
<td>500</td>
</tr>
<tr>
<td>27.93</td>
<td>0.02</td>
<td>31.455</td>
<td>7.3</td>
<td>17.7075</td>
<td>505</td>
</tr>
<tr>
<td>19.47</td>
<td>0.023</td>
<td>43.44</td>
<td>7.48</td>
<td>19.1175</td>
<td>525</td>
</tr>
<tr>
<td>24.405</td>
<td>0.028</td>
<td>23.7</td>
<td>7.49</td>
<td>22.995</td>
<td>580</td>
</tr>
<tr>
<td>27.93</td>
<td>0.04</td>
<td>47.67</td>
<td>7.58</td>
<td>23.3475</td>
<td>585</td>
</tr>
<tr>
<td>29.34</td>
<td>0.145</td>
<td>49.08</td>
<td>7.61</td>
<td>23.7</td>
<td>590</td>
</tr>
</tbody>
</table>

D. The correlation and hypothesis test between BOD$_5$ and Cr are shown in Figure 5:
From Cr vs. BOD$_5$ curve, $R = \sqrt{(0.4006)} = 0.633$
The result is not significant at the 10% level. We accept $H_0$. So, there is zero correlation between the readings.

![Graphical presentation of the correlation between Cr and BOD$_5$](image)

E. The correlation and hypothesis test between BOD$_5$ and pH are shown in Figure 6:
From pH vs. BOD$_5$ curve, $R = \sqrt{(0.0845)} = 0.291$
The result is not significant at the 10% level. We accept $H_0$. So, there is zero correlation between the readings.

![Graphical presentation of the correlation between pH and BOD$_5$](image)

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, $R = \sqrt{(0.4733)} = 0.691$
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.

![Graphical presentation of the correlation between Cr and pH](image)

H. The correlation and hypothesis test between TDS and pH are shown in Figure 9:
From TDS vs. pH curve, $R = \sqrt{(0.8981)} = 0.948$
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.
The result is significant at the 10% level. We reject Ho and accept H1. So, there is evidence to suggest that the correlation is positive.

From TDS vs. pH curve, R = $\sqrt{0.8981}$ = 0.948

The result is significant at the 10% level. We reject Ho and accept H1. 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>
<thead>
<tr>
<th>BOD5</th>
<th>EC</th>
<th>BOD5</th>
<th>NHN</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>510</td>
<td>56</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td>Calculated</td>
<td>487.96</td>
<td>Calculated</td>
</tr>
<tr>
<td>7.54</td>
<td>0.123</td>
<td>7.2</td>
<td>378</td>
</tr>
<tr>
<td></td>
<td>Collected from Mill Barrack (2007)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calculated</td>
<td>0.022</td>
<td>Calculated</td>
</tr>
</tbody>
</table>

Upon observation we discover that the calculated and obtained values are quite close to each other except for the projected values of NH:N from pH where such formulations appear inappropriate once we compare the values. However when BOD5 is used to compute NH:N, calculated values is comparable to experimental as long as they are above magnitude 1. For obtaining TDS from BOD5, 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 BOD5 and pH only. We can get projections for TDS, EC, Cr and NH:N. 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 BOD5: y = 10.961x + 356.43; $R^2 = 0.6997$

NH:N and BOD5: y = 0.1157x + 3.976; $R^2 = 0.5022$

TDS and BOD5: 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 = 326.74x - 2161.5; $R^2 = 0.8981$

And also there are no correlations between 

COD and BOD5; COD and pH; 

pH and BOD5; Cr and BOD5

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 BOD5 did. Furthermore we have established relationship between ionic parameters such as Cr, NH:N with the common parameters. Dissolved oxygen can be measured more easily using a probe but we have relied upon BOD5 tests as it is more widely used and frequently tested in laboratories.

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REFERENCES
