ASSESSMENT OF BOD AND COD RELATIONSHIPS IN DIFFERENT WASTEWATER

Md. Kamruzzaman Khan[1*] Md- Kamrul Hasan[1], Dr. Md. Saiful Islam[2]

[1] Workshop Super (Civil), Rajshahi Polytechnic Institute, Bangladesh,
e-mail: kamrul2k7@gmail.com
[1] *Executive Engineer (Civil), Bangladesh Water Development Board (BWDB), Bangladesh,*
e-mail: kamrulhasance07@gmail.com
[2] *Professor, Khulna University of Engineering & Technology (KUET), Bangladesh,*
e-mail: saiful@ce.kuet.ac.bd

***Corresponding Author**

ABSTRACT

Chemical Oxygen Demand (COD) measures the total amount of organic molecules dissolved in wastewater, whereas Biochemical Oxygen Demand (BOD) is the most often used metric to assess the discharge quality of wastewater.These concepts were introduced while people start through the wastewater into the water bodies. The organic matter in municipal and industrial trash that contains substances harmful to living things is also measured using these assays. COD and BOD_5 can be correlated for a variety of wastewater types. Because the COD may be measured in three hours as opposed to five days for the BOD_5, this can be highly helpful. COD measurements may be utilized to good effect for treatment plant control and operation after the correlation has been established (Metcaff & Eddy, 1996). The ratio of BOD_5 and COD ranges from 0 to 1. The higher value indicates easily biodegradable wastewater. The final BOD and the five-day BOD do not generally correlate. In a similar vein, BOD_5 and COD do not generally correlate. Such correlations can be established for certain waste pollutants in particular wastewater streams. This is due to the fact that every wastewater stream has a unique composition. In this study several BOD_5 and COD tests are done with different wastewaters by standard method. Ultimate BOD and BOD rate constants are determined by Least Square, Fujimoto and Thomas Graphical Method. 0.607, 0.373 and 0.139 are the BOD_5/COD ratio values of Domestic, Municipal and Industrial wastewater. Several relationships are developed of BOD5 – COD, BOD_5 – BODU for three wastewater types. More tests should be conducted to improve the accuracy of the correlation. The ratio of COD to BOD can be shown using a straightforward expression. This ratio can take on a broad range of values for various substrates, according to a study of data published in the literature. The impact of a particular alteration in the environmental conditions on the ratio of BOD to COD has been assessed experimentally in the bacterial system. Since BOD is dependent on the quantity of biodegradable organics in a particular waste, there is no consistent connection between COD and BOD that can be applied to all wastewaters. COD and BOD can be measured a few times, and the COD/BOD ratio may be calculated from the average readings. As the test time lengthens, the BOD value for biodegradable chemicals tends to approach COD. However, because some of the biodegraded chemical is not oxidized because it is needed for cell development, the final BOD will be lower than COD.

Keywords: *Wastewater, BOD, COD, Biological Life, Bacteria*

1. INTRODUCTION

Water-borne bacteria are fed by natural organic detritus and organic waste from wastewater treatment facilities, collapsing septic systems, and agricultural and urban runoff. Reducing the BOD in the effluent released into natural waterways is the primary goal of wastewater treatment facilities. Wastewater treatment facilities are intended to serve as bacterial farms, providing organic waste and oxygen to the bacteria. The extra bacteria that have formed in the system are eliminated as sludge, and this "solid" waste is then dumped on land. The quantity of oxygen that organisms in a wastewater sample utilize to consume organic materials is known as BOD. By monitoring the BOD5 of the input and outflow, a wastewater treatment plant's performance may be evaluated. Numerous variables, including the incubation temperature, dilution rate, nitrification, poisonous chemicals, kind of bacterial seed, and presence of anaerobic organisms, might affect this test. All natural wastewater contains nutrients and bacteria; practically any waste product added to such rivers will start biochemical processes. The biochemical oxygen demand (BOD), which is evaluated in the lab, is produced by these metabolic processes. Strong oxidizing agents can also break down such molecules, resulting in chemical processes that produce what is known as the Chemical Oxygen Demand (COD) in the lab. The relative oxygen-depletion impact of a waste pollutant is measured by both the BOD and COD tests. Both are commonly used as indicators of the impact of pollution. BOD appears to vary linearly with a given waste's COD value. Because BOD and COD have a strong association, BOD may be computed from the less time-consuming COD. The 5-day BOD is nearly commonly used as a measure of relative pollution effect since the ultimate BOD is so time-consuming. There are benefits to measuring BOD_U from BOD_5 values thanks to the BOD_5, BODu relationship. The final BOD and the 5-day BOD do not generally correlate. In a similar vein, BOD and COD do not generally correlate. Such correlations can be created for certain waste pollutants in a particular wastewater stream, but they cannot be applied to other waste contaminants or wastewater streams. This is due to the fact that every wastewater stream has a unique composition. For instance, an effluent from a candy factory that contains a solution of simple sugars is likely to have organic components that break down fast. In this scenario, there would be very little organic material remaining after five days, making the five-day BOD and the final BOD relatively comparable. This study focuses on evaluating the relationship between BOD and COD for assessing wastewater biodegradability and comparing different methods for determining ultimate BOD and reaction rate constants in treatment plant operations.

2. METHODOLOGY

BOD test is a long process and not so much easy. It takes 3 or 5 days whereas COD test is a short process and so much easy. It takes only 3 hrs in a day. If someone prefers to forecast BOD by measuring the COD of a specific sample for regular monitoring purposes, they can use statistical procedures to build a Correlation Regression equation by evaluating both tests around 20 times. It is same for developing BOD_5 and BODU correlation. To make the study fruitful, firstly literature review have been done accordingly several samples have been collected from different sources like domestic wastewater, municipal wastewater and industrial wastewater and measured their BOD and COD at several time interval upto 7 days.

3. LABORATORY INVESTIGATIONS

3.1 INTRODUCTION

In this study domestic, municipal and industrial wastewater are selected for COD & BOD test. For domestic wastewater Khan Jahan Ali Hall and Khanabari water is collected. For industrial wastewater, Khalishpur Card Board Mill industry effluent is collected and for municipal wastewater, Daulatpur and Religate drain water is collected. Several BOD_5 & corresponding COD values are tested in laboratory for these samples. The BOD_5 & corresponding COD value are then plotted in plain graph. From the plot BOD_5, COD equation is developed for these three samples. And the error is then compared by RSQ values for each equation. On the other hand BOD_5, COD ratio is also calculated from the previous values.

Table 1: BOD_5/COD ratios for different sewage.

Wastewater type	Domestic	Municipal	Industrial
BOD_5/COD	0.60	0.48	0.25

(Henry & Heinke, 1978)

Table 1 shows the BOD_5/COD ratio for different wastewaters. The smaller ratio means the waste samples are not easy to biodegrade and higher COD values and for higher ratio, vice versa. For ultimate BOD and COD relation and BOD rate constant determination municipal wastewater and Industrial wastewater is selected. 7 days BOD values are measured for ultimate BOD determination. BOD rate constant is also determined by those values. BOD rate constant is determined by least square method. For test results, 0.01 dilution factor is used for BOD test and 0.5 for COD.

3.2 SAMPLING

A crucial factor in accurately classifying wastewater is sampling. The ability of a wastewater to consistently undergo biological changes may be impacted by ongoing variations in flow rate and wastewater quality. Gathering a composite sample across three to four hours is a suitable sampling technique. This will minimize the sample holding time and yield data that may be regarded as indicative of typical wastewater properties throughout the day. 500 ml bottles are used to collect sample from the wastewater stream. The wastewaters are collected at the maximum flow time of a day.

3.3 SERIAL BOD AND COD TESTING

For BOD_5 measurements 3 BOD bottle is placed in incubator for 5^{th} day DO measurement. Serial BOD measurements were taken for the first seven days of the produced samples that were incubated at 20°C in order to estimate the BOD kinetics parameters. In other words, BOD_1, BOD_2,..., and BOD7 were assessed for the relevant sample. 24 BOD bottles were used in the experiment for facilitating daily DO measurement. The sample was diluted using a dilution factor of around 1/100. The diluting water was aerated distilled water. The remaining bottles were incubated in a BOD incubator at 20°C for seven days while three bottles were examined for initial DO. Using the BOD measuring method, three of the incubated bottles were removed each day and evaluated for DO. The following formulas were used to determine the sample's BOD:

$BOD_t \text{ at } 20^oC = (DO_i - DO_f)/DF$ -- (1)

Where,

BOD_t = BOD exerted in't' days of incubation.

DO_i = DO of the diluted sample immediately after preparation, mg/l.

DO_f = DO of the diluted sample at particular day of incubation, mg/l.

DF = Dilution factor. (Peavy et al., 1985)

For determination of COD values the following standard method is executed. Here dilution factor is taken 1/2. COD value is calculated by equation (Hammer et al., 2003).

$COD = (A-B)*M*8000/\text{ml of sample}$ -------------------- (2)

Where,

A= ml of FAS (Ferrous Ammonium Sulfate) need to titrate distilled water
B= ml of FAS (Ferrous Ammonium Sulfate) need to titrate wastewater
M= Molarities of FAS
FAS= molarities of Ferrous Ammonium Sulfate

Ultimate BOD and BOD rate constant determined by Least Square method and Fujimoto method which is stated before. Sample calculation is shown below,

3.4 SAMPLE CALCULATION FOR LEAST SQUARE METHOD

The kinetic parameters of the different wastewater effluent were estimated as follows:

3.4.1 Determination of Kinematic Parameters for Khan Jahan Ali Hall Water Sample (Using Least Square Method)

Table 2: Determination of Kinematic Parameters for Khan Jahan Ali Hall water sample (Using Least Square Method)

Time(day)	y_t(mg/l)	dy/dt= $(y_{t+1}-y_{t-1})/2\Delta t$	y_t^2	y_t.dy/dt
1	7	38	49	266
2	76	53.5	5776	4066
3	114	27.5	12996	3135
4	131	14.5	17161	1899.5
5	143	11	20449	1573
6	153	9.5	23409	1453.5
7	162*			
sums	624	154	79840	12393

3.4.2 Determination of Kinematic Parameters for Khana Bari Water Sample (Using Least Square Method)

The kinetic parameters of the Khana Bari effluent were estimated as follows:

Table 3: Determination of Kinematic Parameters for Khana Bari water sample (Using Least Square Method)

Time(day)	y_t(mg/l)	dy/dt= $(y_{t+1}-y_{t-1})/2\Delta t$	y_t^2	y_t.dy/dt
1	13	44.5	169	578.5
2	89	55	7921	4895
3	123	26	15129	3198
4	141	18	19881	2538
5	159	11	25281	1749
6	163	6	26569	978
7	171*			
sums	688	160.5	94950	13936.5

3.4.3 Determination of Kinematic Parameters for Daulatpur Water Sample (Using Least Square Method): The kinetic parameters of the Daulatpur effluent were estimated as follows:

Table 4: Determination of Kinematic Parameters for Daulatpur water sample

(Using Least Square Method)

Time(day)	y_t(mg/l)	dy/dt= $(y_{t+1}-y_{t-1})/2\Delta t$	y_t^2	y_t.dy/dt
1	191	124	36481	23684
2	248	62	61504	15376
3	315	70.5	99225	22207.5
4	389	75	151321	29175
5	465	68	216225	31620
6	525	35	275625	18375
7	535*			
sums	2133	434.5	840381	140437.5

3.4.4 Determination of Kinematic Parameters for Raligate Water Sample (Using Least SquareMethod) The kinetic parameters of the Religate effluent were estimated as follows:

Table 5: Determination of Kinematic Parameters for Raligate water sample (Using Least Square Method)

Time(day)	y_t(mg/l)	dy/dt= $(y_{t+1}-y_{t-1})/2\Delta t$	y_t^2	y_t.dy/dt
1	253	192.5	64009	48702.5
2	385	103	148225	39655
3	459	62.5	210681	28687.5
4	510	85.5	260100	43605
5	630	72.5	396900	45675
6	655	27.5	429025	18012.5
7	685*			
sums	2892	543.5	1508940	224337.5

* Value not included in total and n = 6 is used and the sample is collected in 24 May.

3.4.5 Determination of Kinematic Parameters for Khalishpur Card Board Mill Water Sample (Using Least Square Method).

Table 6: Determination of Kinematic Parameters for Khalishpur Card Board Mill water sample (Using Least Square Method)

Time(day)	y_t(mg/l)	dy/dt= $(y_{t+1}-y_{t-1})/2\Delta t$	y_t^2	y_t.dy/dt
1	495	292.5	245025	144787.5
2	585	80	342225	46800
3	655	72.5	429025	47487.5
4	730	67.5	532900	49275
5	790	41.5	624100	32785
6	813	14.5	660969	11788.5
7	819*			
sums	4068	568.5	2834244	332923.5

* Value not included in total and n = 6 is used the sample is collected in 2 January.

3.5 Sample calculation for Fujimoto Method

The following estimates were made for the river Khan Jahan Ali Hall effluent's kinetic parameters:
Using the following table, an arithmetic plot of BODt+1 vs BODt was created:

Table 7: Determination of Kinematic Parameters for Khan Jahan Ali Hall water sample (Using Fujimoto Method)

Sr. No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
BOD_t(mg/l)	7	76	114	131	143	153	162
BOD_{t+1}	76	114	131	143	153	162	-

3.6 Sample calculation for Thomas Graphical Method

The kinetic parameters of the Khan Jahan Ali Hall sample effluent were estimated as follows:

Prepared and arithmetic plot of BOD_t versus $(\frac{t}{BODt})^{1/3}$ using the following table:

Table 8: Determination of Kinematic Parameters for Khan Jahan Ali Hall sample (Using Thomas Graphical Method)

Time,t(days)	1	2	3	4	5	6	7
BOD_t(mg/l)	7	76	114	131	143	153	162
$(\frac{t}{BODt})^{1/3}$	0.52	0.297	0.297	0.313	0.327	0.340	0.351

3.7 Domestic wastewater

The liquid portion of waste that is extracted from homes, businesses, and institutions is known as domestic wastewater. Before it is used, water is essentially regarded as drinking or potable water; after it has been used and disposed of, it becomes wastewater. Material disposed of via washing machines, sinks, toilets, bathtubs, and showers is typically considered domestic wastewater. Domestic wastewater must be treated and disposed of in a manner that reduces potential for damaging human health, as well as limits the impact on the environment. Table 9 shows BOD corresponding COD values and their ratio for domestic waste.

Table 9: BOD, COD values and ratio for domestic wastewater.

Sample no	BOD(mg/l)	COD(mg/l)	BOD/COD	Avg. BOD/COD
1	176	320	0.55	0.607
2	284	480	0.59	
3	326	480	0.68	
4	348	640	0.54	
5	386	640	0.60	
6	364	480	0.76	
7	338	640	0.53	

3.8 Municipal wastewater

Municipal wastewater is one type of wastewater which contains domestic sewage and some variety of small industries effluent. The composition of waste is quite different than domestic and industrial wastewater. Table 10 shows BOD corresponding COD values and their ratio for Municipal waste.

Table 10: BOD, COD values and ratio for municipal wastewater**.**

Sample no	BOD(mg/l)	COD(mg/l)	BOD/COD	Avg. BOD/COD
1	356	640	0.56	0.373
2	312	960	0.33	
3	385	960	0.40	
4	458	1280	0.36	
5	523	1600	0.33	
6	512	1920	0.27	
7	568	1600	0.36	

3.9 Industrial wastewater

Many different types of pollutants are produced by industrial operations. Pollutant levels and properties differ greatly between industries. Conventional pollutants, non-conventional pollutants, and priority pollutants are the three categories into which the environmental protection agency has divided the pollutants. Pollutants include BOD (biochemical oxygen demand), suspended particles, nutrients, heavy metals, oils and greases, and other hazardous organic and inorganic substances can be found in wastewater produced by industrial processes. These contaminants have the potential to seriously affect the ecosystem if they are not handled. BOD is the conventional pollutant, and COD is the non-conventional pollutant of industrial wastewater. Table 11 shows BOD corresponding COD values and their ratio for industrial waste.

Table 11 shows BOD corresponding COD values and their ratio for Industrial waste.

Sample no	BOD(mg/l)	COD(mg/l)	BOD/COD	Avg. BOD/COD
1	564	4160	0.14	0.139
2	510	4480	0.11	
3	458	3520	0.13	
4	487	3520	0.14	
5	568	3840	0.15	
6	504	3520	0.14	
7	576	3520	0.16	

3.10 Ultimate BOD and BOD rate constant, k

For ultimate BOD, BOD rate constant determination, 7 days BOD data is calculated by least square method and Fujimoto method. The table 12 below shows various values of BODu and BOD rate constant.

Table 12: Ultimate BOD, BOD rate constants for different WASTEWATER.

Sample type		Least Square Method	Fujimoto Method
Domestic wastewater	BOD_u(mg/l)	210.5	178

	k(day^{-1})	0.26	0.29
Municipal wastewater	BOD_u(mg/l)	779	694.53
	k(day^{-1})	0.17	0.19
Industrial wastewater	BODu(mg/l)	816	811.32
	k(day^{-1})	0.68	0.72

4. RESULTS AND DISCUSSION

4.1 Results and Discussion

BOD and COD value of Domestic wastewater sample, Municipal wastewater sample and Industrial wastewater sample is being plotted in plain graph. The correlation of BOD and COD is obtained from the graph. The trend line implies the relationship pattern. For each plot developed equation and RSQ values are shown.

Table 13: BOD-COD relationship of different wastewater

	Domestic wastewater	Municipal wastewater	Industrial wastewater
BOD, COD relation	COD=(-) 0.001BOD^2 + 2.234BOD-29.07	COD=0.001BOD^2+ 2.779BOD - 266	COD=(-)0.125BOD^2 +133.3BOD - 31325
RSQ value	0.678	0.754	0.268
BOD/COD ratio	0.607	0.373	0.139
Reported value BOD/COD ratio	0.6	0.48	0.25

(Henry & Heinke, 1978)

From Table 13, the ratio of BOD/COD is less deviated from the reported values. And the RSQ values are tends to 1. That means the correlation developed is a good relation. From the BOD/COD ratio it seems that the lowest value is for Industrial wastewater and the highest value for domestic wastewater. It means Industrial wastewater is less biodegradable than Municipal and Domestic wastewater.

Table 14: BOD kinetic parameters of different wastewater

Sample No.	Domestic Wastewater			Municipal Wastewater			Industrial Wastewater		
	BOD_5 (mg/l)	BOD_u (mg/l)	k (day^1)	BOD_5 (mg/l)	BOD_u (mg/l)	k (day^{-1})	BOD_5 (mg/l)	BOD_u (mg/l)	k (day^1)
1	143	210	0.242	465	779.32	0.171	790	816.62	0.689
2	159	211	0.278	500	759.18	0.327	680	925.81	0.526
3	181	219.32	0.235	545	718.25	0.254	654	1003.36	0.485
4	176	217.5	0.231	586	758.48	0.287	688	952.97	0.587

Table 14, shows the BOD_5, Ultimate BOD and kinematic parameter k values for Domestic wastewater, Municipal wastewater and Industrial wastewater. These values are plotted in graph for BOD_u and BOD_5 relation development.

Figure 13 & figure 14 shows the BOD_5 vs. BOD_u graph for Domestic wastewater, Municipal wastewater and Industrial wastewater.

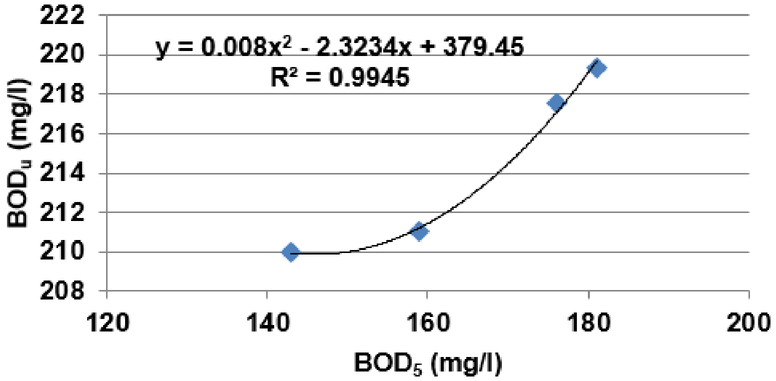

Figure 1: BOD_5 Vs. BOD_u for Domestic Wastewater

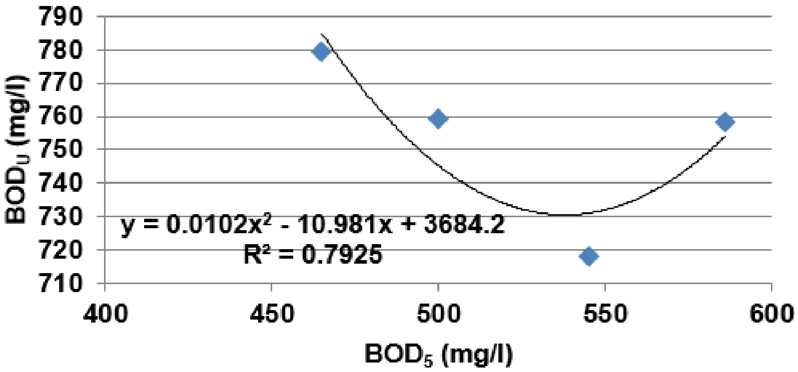

Figure 2: BOD_5 Vs. BOD_u for Municipal Wastewater

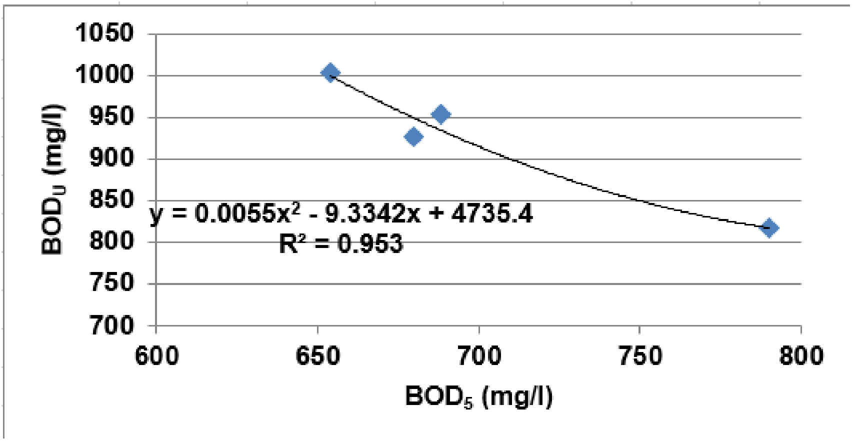

Figure 3: BOD_5 Vs. BOD_u for Industrial Wastewater

The figure 1, 2 and 3 shows the BOD_5, BOD_u relation of three wastewater samples. The relationships are: The RSQ value of Municipal wastewater is quite low. More tests will increase the RSQ value of the correlation. But the RSQ values of rest two samples have satisfactory values .That means these two samples BOD_u and BOD_5 correlation is good.

	Domestic Wastewater	Municipal Wastewater	Industrial Wastewater
BOD,COD relation	$BOD_u = 0.008BOD_5^2 - 0.323\ BOD_5 + 0.379.4$	$BOD_u = 0.010BOD_5^2 - 10.98BOD_5 + 3684$	$BOD_u = 0.005BOD_5^2 - 9.334BOD_5 + 4735$
RSQ value	0.994	0.792	0.953

5. CONCLUSIONS

Techniques for determining the concentration of organic matter are highly precise and require very little effort. However, they are unable to distinguish between organic materials that are biodegradable and those that are not. Moreover, volatile organic matter and organic matter containing nitrogen bases cannot be reliably estimated by COD. BOD is favored over COD for various reasons. The correlation of BOD_5, COD can be used for determining the waste loading carrying that wastewater. For treatment plant operation it is important to know the waste loading of the effluent. BOD/COD is often measured as a rapid indicator of organic pollutant in water. Measuring waste loadings to treatment facilities and assessing the effectiveness of such treatment systems are its most common uses. The test results imply that BOD/COD value of domestic water is more than the industrial waste. It means industrial waste is less biodegradable than domestic waste. The ratio should increase by treatment for disposal. Ultimate BOD and BOD rate constant is determined by Least squares method and Fujimoto method, because these methods are widely used. The comparison of Least squares method and Fujimoto method sows that, Least Square method gives greater result of BOD_u than Fujimoto method but quite similar to each other.

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