Pak. J. Biotechnol. Vol. 15 (2) 423-427 (2018) ISSN Print: 1812-1837
www.pjbt.org ISSN Online: 2312-7791

CORRELATION BETWEEN BOD_5 AND COD FOR AL- DIWANIYAH WASTEWATER TREATMENT PLANTS TO OBTAIN THE BIODIGRABILITY INDICES

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Article received 18.4.2018, Revised 30.5.2018, Accepted 9.6.2018

ABSTRACT

The present study aims to establish an empirical correlation between biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD) of the sewage flowing in Al-Diwaniyah wastewater treatment plant. The strength of the wastewater entering the plant varied from medium to high. High concentrations of BOD_5 and COD in the effluent were obtained due to the poor performance of the plant. This was observed from the BOD_5 /COD ratios that did not confirm with the typical ratios for the treated sewage. Regression equations for BOD_5 and COD removal percentages were suggested which can be used to evaluate rapid effluent assessment after the treatment processes or optimal process control to improve the performance of wastewater treatment plants. The average Biodegradability indices (B.I) of Al-Diwaniyah wastewater plants was found to be 0.69. The equations relating the percentage removal of BOD_5(y) with influent BOD_5(x), y= 0.044x + 80.66 and the percentage removal of COD (y) with influent COD (x), y= 0.045x + 55.15 were found with high correlation R^2 =0.72 and 0.86 respectively.

Keywords: BOD_5, COD, BOD_5/COD ratio, Biodegradability indices, BOD_5 and COD correlations

INTRODUCTION:

The levels of biochemical oxygen demand (BOD_5), and chemical oxygen demand (COD) of wastewaters could pose potential pollution to water bodies in which they are discharged to Typical values for the ratio of BOD_5/COD for untreated municipal wastewater are in the approximate range 0.3 to 0.8 as shown in Table 1. If the ratio is equal or greater than 0.5 the wastewater is considered to be easily treatable by biological treatment. If the ratio is below 0.3, either the wastewater may have some toxic components or acclimated microorganisms may be required for degradation. This ratio decreases to 0.11 – 0.31 for the treated sewage [Alsaqqar *et al*., 2017 and Metcalf and Eddy, 2003].

Table 1 Comparison of ratios of various parameters to characterize wastewater (1)

Type of raw wastewater	*BOD_5/COD*	*BOD_5/TOC*
Untreated wastewater	*0.29 – 0.79*	*1.20 – 2.00*
Primary Sedimentation	*0.41 – 0.59*	*0.78 – 1.20*
Final Effluent wastewater	*0.11– 0.31*	*0.20– 0.51*

(7) Metcalf and Eddy (2003)

Several researchers studied the performance of wastewater treatment plants through the removal efficiency considering the parameters pH, Turbidity, TSS, COD and BOD, etc. and the operation and maintenance problems resulting there from. These plants are designed with hydraulic and organic loading rates to achieve effluents that meet the local or global specifications. Poor design, operating maintenance of these plants create major environmental problems, when such wastewater is discharged to surface water or on land [Attioghe *et al*., 1999, Dissanayake *et al*., 2007 and Metcalf and Eddy, 2003].

Attioghe *et al*., (1999) studied the effluents of several industrial wastes in Ghana that are large in volume and discharged into public drainage systems or to near streams. Analysis of the effluents BOD_5 and COD were used to establish a correlation between BOD_5 and COD. The results obtained a tool for monitoring and evaluation of effluents also it will facilitate fast effluent quality assessment or process control. The BOD_5/COD ratios for the selected industries ranged 0.31 (GGL), 0.49 (Coca-Cola) and 0.62(GBL). The linear regression performed on the data were highly correlated, 0.93, 0.81 and 0.83 respectively.

Olive (2002) established a correlation between BOD_5 and COD for wastewater from Alfenas, Furnas 2 project, where this wastewater is mixed with natural spring water. The correlation was very high R^2=0.96. From the regression curve, the curve is found that BOD_5 could be calculated from COD by multiplying a factor of 0.6 to the COD value. Dissanayake, (2007) tested waste water used for irrigation in Sri Lanka. They stated that waste waters high in organic content may clog soil pores especially at BOD_5 levels exceeding 500 mg/l. Also, wastewaters with BOD_5 between 110 -400 mg/l can increase crop productivity and condition the soil if it is used for irrigation. The BOD_5/COD ratio of this irrigation water ranged 0.25-0.5. On the other hand, COD analysis estimates the amount of organic matter in waste water in only (3~4) hours, rather than the BOD_5 test for the five days required by use and can be used as an alternative. COD results are typically greater than BOD_5 values, and the ratio between them will vary depending on the characteristics of the raw wastewater. This ratio has been commonly used as an indicator for biodegradation capacity. It is called Biodegradability index (B.I.). It is generally considered the cut-off point between biodegradable and non- biodegradable waste [Metcalf and Eddy, 2003; Turak, 2004].

Once an average B.I. has been established for the plant wastewater stream, COD test can be used to predict BOD_5. The BOD_5 /COD ratio is typically 0.5:1 for raw domestic wastewater and may drop to be as low as 0.1:1 for a well-stabilized secondary effluent. There is no limited value for biodegradability index for different types of wastewater [Papadopoulous, 2001; Turak, 2004].

However, biodegradability index value varies from 0.4 to 0.8, for municipal raw wastewater. The ratio can exceed 10 for industrial wastewater. Raw wastewater BOD_5 and COD are obviously correlated, and the correlation is a linear positive [Khaled and Gina, 2014].

This study aims at establishing and determining ranges and mean values of biodegradability indices in an attempt to make a kind of zoning for the BOD_5/COD ratio (biodegradability index) of the sewage flowing in Al-Diwaniyah Wastewater Treatment Plant (WWTP). This correlation could be used to simple effluent quality assessment or optimal process control for the treatment plant.

Al-Diwaniyah wastewater treatment plant location and description: This plant is located on road 8 in the southern part of Al-Diwaniyah city on Shut Al-Diwaniyah (a branch of the Euphrates River, southern part of Iraq. The design capacity of this plant is 4DWF (dry weather flow) which is 80000 m^3/day. The plant consists of two identical stream lines to treat the sewage in two stages, Primary and Secondary treatment processes [Palmer, 2004].

The primary stage consists of a rack screen and the Detroiters for the sedimentation of inorganic suspended solids. The secondary treatment is an activated sludge process for the biological degradation of the organic content. The effluent from the primary treatment enters a distribution chamber that receives the return sludge from the secondary sedimentation tank. The mixture from this chamber is distributed to the aeration tanks of the two streams. The final effluent wastewater from the secondary settling tank flows into the chlorine tank for disinfection before it is discharged to the river. The wasted sludge from the sedimentation tank is collected in a holding tank where the supernatant is pumped back to the distribution chamber and the settled sludge is pumped to the drying beds. The plant is designed to yield an effluent of 20 mg/L BOD_5 and 30 mg/L suspended solids.

Data analysis: This study analyzes the quality of the influent and effluent of Al-Diwaniyah WWTP. The data of the sewage quality were recorded for the period between 2013 until 2016 for BOD_5 and COD. From these data, the influent reaching the plant is considered of a medium strength according to the classifications in Table 2. According to the COD values the strength varied from medium to high. Figure 1 shows the average monthly variation of BOD_5 and COD of the influent through 2013 to 2016.High strength COD was recorded in 2014 [Metcalf and Eddy, 2003].

Table 2 Strength classification of Untreated Sewage

Parameter (mg/L)	*Strength [1]*			*Strength [6]*		
	Low level	*Medium level*	*High level*	*Low level*	*Medium level*	*High level*
BOD_5	*107*	*192*	*354*	*100*	*200*	*400*
COD	*255*	*428*	*796*	*175*	*300*	*600*
TOC	*82*	*138*	*265*	*100*	*200*	*400*

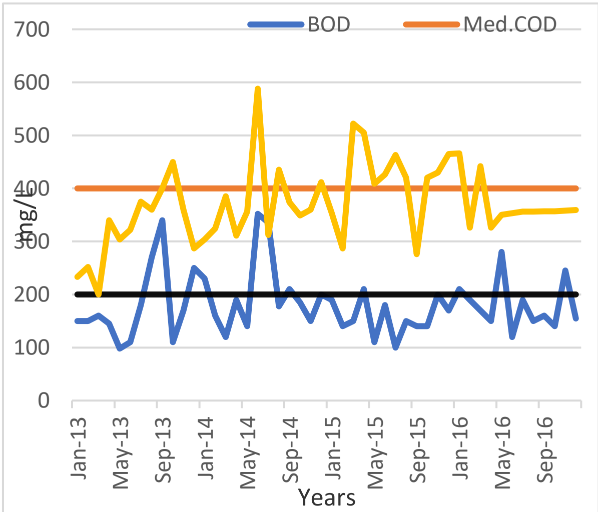

Figure 1: Average monthly variations of BOD_5 and COD of the influent sewage of Al-Diwaniyah WWTP (2013-2016)

3. RESULTS AND DISCUSSION

The quality of the effluent from the plant has been found to be higher than expected from the Iraqi effluent standards for disposal to water bodies (BOD_5 20 mg/l and COD 100 mg/l), indicating poor treatment. High level of BOD_5 and COD could constitute potential pollution problems to the water bodies because it contains organic materials that require large amounts of oxygen demand for degradation. Figure 2 shows the average monthly variation of BOD_5 and COD for the treated sewage from the plant. The BOD_5 exceeded the 20 mg/l limit for disposal limitation over the whole period, where decreasing values of COD reaching the 100 mg/l limitations were obtained in years 2015 and 2016.

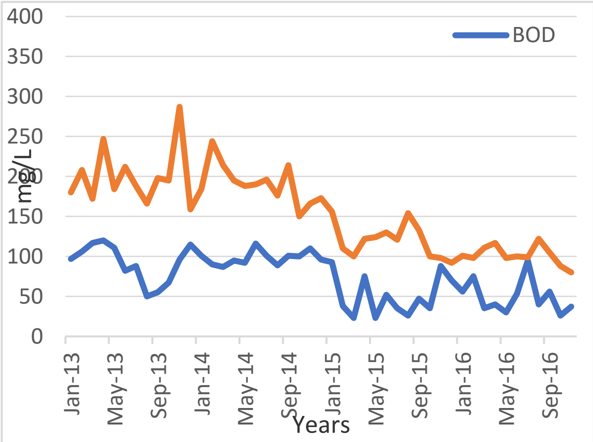

Figure 2: Average monthly variations of BOD5 and COD of the effluent sewage (2013-2016)

The BOD_5/COD ratio ranged 0.23 to 0.69 as shown in Table 3 for the untreated sewage which is a normal case as indicated in Table 1 and this waste is easily degradable by the biological processes. As for the effluent (treated sewage) the ratio varied over a wide range as low as 0.17 to 0.95, reaching to 1.09 and 1.48 in 2016. These values are very large than those shown in Table 1.for the treated sewage which may also indicate problems in the treatment process. Attioghe *et al* (1999)., found in their study that the BOD_5/COD ratio for the wastewater (untreated) from the limited industries could be approximated to the gradient of their respective fitted equations, i.e. 0.66, 0.35, and 0.23 for GBL, Coca-Coal and GGL respectively

Table 3 *The ratios for the Influent (Untreated) and Effluent (Treated) Sewage*

Year / Month	2013		2014		2015		2016	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
Jan.							0.42	0.36
Feb.							0.40	0.44
March					0.49	0.17	0.40	0.41
April					0.23	0.34	0.45	0.47
May					0.35	0.35	0.52	0.57
June	0.55	0.90			0.39	0.95	0.57	0.47
July			0.40	0.37	0.37	0.71	0.50	0.59
August	0.35	0.46	0.66	0.69	0.43	0.67	0.67	1.09
Sept.			0.34	0.31			0.52	1.48
Oct.			0.40	0.65				
Nov.			0.56	0.76	0.43	0.36		
Dec.								
Average	0.45	0.68	0.47	0.56	0.38	0.51	0.49	0.47

To make use of this analysis the removal percentages were calculated according to the Iraqi effluent standards. The regression analysis here showed high correlation, R^2 =0.72 for BOD_5 and 0.86 for COD from Figures 3. The treatment process in this plant has to be functioned to the regression equations, y= 0.044 x + 80.66 for BOD_5. More quality data are required for the following flow through the plant to improve the treatment process and make full use of the regression analysis.

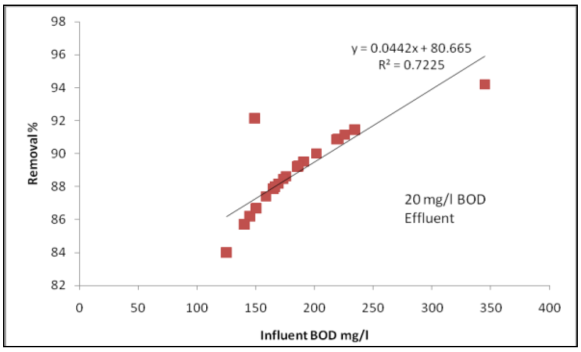

Figure 3: Regression analysis for standard effluent for BOD and removal %

The regression for BOD_5 and COD of the influent for the first four months in year 2016 had good correlation, as shown in Table 4. The BOD_5/COD ratios could be approximated to the gradient of their respective suitable equations as they are near to the calculated ratios.

Table 4 Regression Analysis for BOD_5 and COD of the Influent

Month	Regression Equation	R^2	BOD_5/COD (from equations)	BOD_5/COD (recorded)
Jan.	y=0.352x +13.74	0.926	0.35	0.40
Feb.	y=0.382x +0.083	0.979	0.38	0.39
March	y=0.206x +103.1	0.905	0.21	0.41
April	y=0.255x +77.18	0.779	0.26	0.46

Another regression analysis was performed in this study for removal percentages of BOD_5 and COD with the influent quality. The removal percentages of BOD_5, COD in this plant are shown in Table 5. The removal percentages for BOD_5 in 2013 were low as 36.36% and reached 86.19% in 2016 that were not enough to treat the flowing sewage to 20 mg/l. As for COD they ranged from 21.05 to 86.44%, which decreased the COD in 2016 to 100 mg/l. Low correlation were obtained from the regression analysis for BOD_5 and COD as shown in Figures 4, indicating the poor performance of the treatment plant.

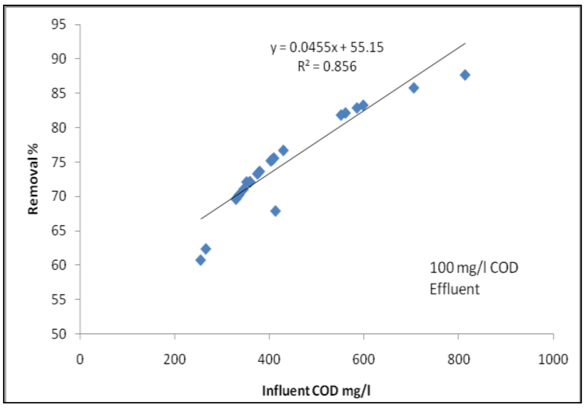

Figure 4: *Regression analysis for standard effluent for COD and removal %*

Table 5 Removal Percentages of BOD_5 and COD

Year Month	2013		2014		2015		2016	
	BOD_5 %	COD %	BOD_5 %	COD %	BOD_5 %	COD %	BOD_5 %	COD %
Jan.				56.65		21.05	82.55	79.61
Feb.							83.89	85.53
March					81.20	46.93	86.19	86.44
April					74.85	82.79	79.42	80.23
May				58.26	66.67	67.00	79.32	81.22
June	55.71	72.92	68.28		39.37	75.30	75.04	69.39
July			68.11	65.45	40.27	69.09	75.86	79.39
August	44.00	57.46	61.82	63.83	55.28	70.88	77.55	86.13
Sept.			39.29	33.43		77.26	59.73	85.88
Oct.			36.36	60.57				
Nov.			46.67	60.45	85.58	83.08		
Dec.				58.40				
Average	49.86	65.20	53.42	57.13	63.32	65.93	77.72	81.54

Assessment of biodegradability index values periodically and comparing it to the mean B.I. for the particular wastewater treatment plant can assist in monitoring the presence of toxic and non-biodegradable substances; and hence in applying the appropriate preventive actions. It is important to know the biodegradability index of the raw influent wastewater inside the treatment plant, before choosing the biological wastewater treatment plant technology, thus this would affect the quality of treated effluent [Khaled and Gina, 2014]. If BOD_5/COD ratio is greater than 0.6, then the wastewater is treated biologically because of it is fairly biodegradable. If BOD_5/COD ratio is between 0.3 and 0.6, then seeding is required to treat it biologically, the acclimatization of the microorganisms that help in the degradation process takes time, as the process of biodegradation will be relatively slow. If BOD_5/COD is less than 0.3, biodegradation will not proceed, because of the effluent wastewater generated from these activities inhibits the metabolic activity of bacterial seed due to their refractory properties and toxicity, thus it cannot be treated biologically.

The relation between BOD_5 and COD for WWTPs in diwaniya, as shown in Table 4. Thus, it can be used as a check parameter to evaluate performance of these WWTPS for quick action and may also assist in monitoring the presence of toxic and non-biodegradable substances**.**

4. Conclusions

1. The quality of the effluent from the plant has been found to be higher than expected from the Iraqi effluent standards for disposal to water bodies (BOD_5 is 20mg/L and COD is 100mg/L), indicating poor treatment. The potential pollution problems for the water bodies because of these values of BOD_5 and COD, being a contain organic materials that require large amounts of oxygen for degradation.

2. Biodegradability Index (B.I.) for the investigated WWTPs varied from 0.23 up to 0.69, which indicate the variability in the value of B.I. Thus, a constant ratio for B.I. cannot be assumed unless under identical environmental conditions, as for the effluent (treated sewage) the ratio varied over a wide range as low as 0.17 to 0.95, reaching to 1.09 and 1.48 in 2016.

3. The removal percentages for BOD_5 were low as 36.36% and reached 86.19% that were not enough to treat the flowing sewage to 20 mg/l. As for COD they ranged from 21.05 to 86.44%, which decreased the COD in 2016 to 100 mg/l.

4. Regression analysis was performed for removal percentages of BOD_5 and COD with the influent quality. High correlation, R^2 =0.72 for BOD_5 and 0.86 for COD was obtained. The treatment process in this plant has to be functioned to the regression equations, $y= 0.044 x + 80.66$ for BOD_5 and $y=0.045 x + 55.15$ for COD to reach the effluent standards.

5. All investigated influent wastewater for WWPT indicated the average B.I. was 0.69.

6. The BOD_5 to COD ratio of a particular waste water will remain constant forever, through the observation demonstrate of the BOD_5 to COD levels in the same wastewater. Therefore, the correlation should be periodically rechecked due to probable seasonal variations in climatic conditions, water availability, population size, and the presence of industrial wastes, etc.

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