

Correlating BOD₅ and COD of Sewage in Wastewater Treatment Plants; Case study Al- Diwaniyah WWTP in Iraq

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ABSTRACT

This study aims to establish an empirical correlation between biochemical oxygen demand (BOD₅) 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 BOD₅ and COD in the effluent were obtained due to the poor performance of the plant. This was observed from the BOD₅ /COD ratios that did not confirm with the typical ratios for the treated sewage. To improve the performance of this plant, regression equations for BOD₅ and COD removal percentages were suggested which can be used to facilitate rapid effluent assessment or optimal process control. The equations relating the percentage removal of BOD₅(y) with influent BOD₅(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.

Key words: Sewage treatment, BOD₅, COD, BOD₅/COD ratio, BOD₅&COD correlations

1.Introduction

The levels of BOD₅ (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) of wastewaters indicate the potential pollution to water bodies in which they are discharged to. Typical values for the ratio of BOD₅/COD for untreated municipal wastewater are in the range 0.3 to 0.8 as shown in Table 1. If the ratio is 0.5 and greater the waste is considered to be easily treatable by biological means. If the ratio is below 0.3, either the waste may have some toxic components or acclimated microorganisms may be required for degradation. This ratio decreases to 0.1 – 0.3 for the treated sewage, [3].

Attighe et al., 1999 studied the effluents of several industrial wastes in Ghanathat that are large in volume and discharged into public drainage systems or to near streams. Analysis of the effluents BOD₅ and COD were used to establish a correlation them.

Table 1 Ratios of various parameters used to characterize wastewater [3]

Type of wastewater	BOD ₅ /COD	BOD ₅ /TOC
Untreated	0.3 – 0.8	1.2 – 2.0
After Primary Settling	0.4 – 0.6	0.8 – 1.2
Final Effluent	0.1 – 0.3	0.2 – 0.5

The results obtained are useful tools for monitoring and evaluating the effluents, also it facilitates speedy effluent quality assessment or process control. The BOD₅/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 [1].

Olive, 2007 established a correlation between BOD₅ and COD for wastewater from Alfenas, where this

waste is mixed with natural spring water. The correlation was very high $R^2=0.96$. From the regression curve, it is found that BOD_5 could be calculated from COD by applying a factor of 0.6 to the COD value [4].

Dissanayake et al., 2007 tested wastewater used for irrigation in Sri Lanka. They stated that wastewaters 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 [2].

2.OBJECTIVES OF THE STUDY

This study aims to establish an empirical correlation between BOD_5 and COD of the sewage flowing in Al-Diwaniyah Wastewater treatment plant (WWTP). This correlation could be used to facilitate effluent quality assessment or optimal process control of the treatment plant.

3.AL-DIWANIYAH WWTP

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 m³/day. The plant consists of two identical stream lines to treat the sewage in two stages, Primary and Secondary treatment processes, [5].

The primary stage consists of a rack screen and the Detritors 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 from the secondary sedimentation tanks flows into the chlorine tank for disinfection before it is discharged to the river. The wasted sludge from the secondary sedimentation tanks 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.

4.DATA ANALYSIS

This study analyzes the quality of the influent and effluent of Al-Diwaniyah wastewater treatment plant. The data of the sewage quality were recorded for the period between 2005 until 2008 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 2005 to 2008. High strength COD was recorded in 2007.

Table 2 Strength classification of Untreated Sewage

Parameter	Strength [3]		
	Low	Medium	High
BOD_5 mg/L	110	190	350
COD mg/L	250	430	800
TOC mg/L	80	140	260
Parameter	Strength [6]		
	Low	Medium	High
BOD_5 mg/L	100	200	400
COD mg/L	175	300	600
TOC mg/L	100	200	400

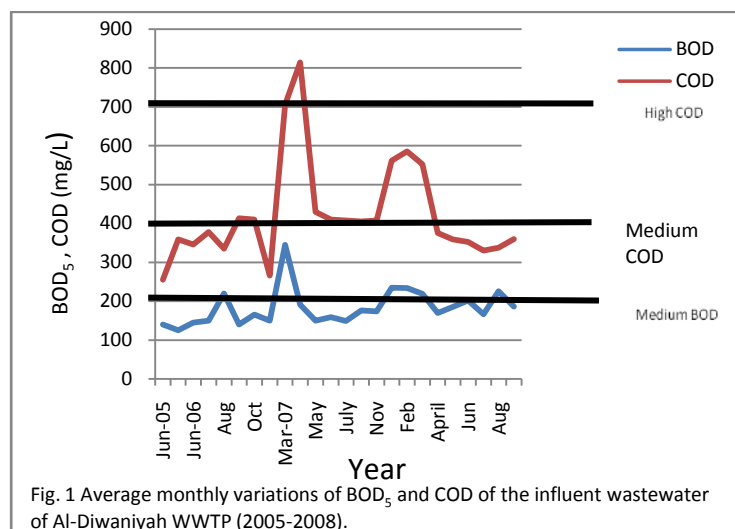
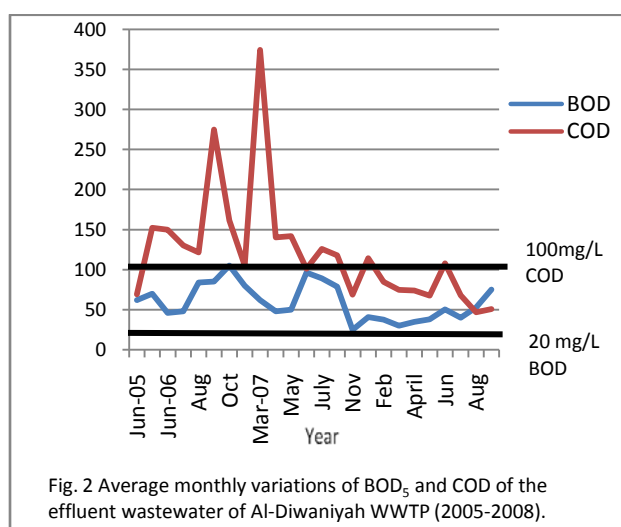


Fig. 1 Average monthly variations of BOD_5 and COD of the influent wastewater of Al-Diwaniyah WWTP (2005-2008).

4.Results and Discussion

The quality of the effluent from the plant has been found to be higher than the Iraqi effluent standards for disposal to water bodies (BOD₅ 20 mg/L and COD 100 mg/L), indicating poor treatment. High BOD₅ and COD could constitute potential pollution problems to the water bodies since it contains organic compounds that require large amounts of oxygen for degradation. Figure 2 shows the average monthly variation of BOD₅ and COD for the treated sewage from the plant. The BOD₅ exceeded the 20 mg/L for disposal limitations over the whole period, where COD reached the 100 mg/L limitations in year 2008.



The detained BOD₅/COD ratio from the data is found to be between 0.23 and 0.69 as shown in Table 3 for the untreated sewage which can be considered as a normal case according to Table 1. Hence this waste is considered to be easily degradable by the biological processes. As for the effluent (treated sewage) the ratio varied over a wide range 0.17 to 0.95, reaching to 1.09 and 1.48 in 2008. This indicates problems in the treatment process. Attioghe et al., (1999) found in their study that the BOD₅/COD ratio for the wastewater (untreated) from the selected 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. The correlation equations can be used to estimate the BOD₅ or COD for reporting and process control. The regression analysis for the present study showed very

low correlation between BOD₅ and COD, $R^2 = 0.26$, these results are not significant to be used in the analysis.

The regression for BOD₅ and COD of the influent for the first four months in year 2004 had good correlation as shown in Table 4. The BOD₅/COD ratios could be approximated to the gradient of their respective fitted equations as they are near to the calculated ratios.

Another regression was performed in this study for removal percentages of BOD₅ and COD with the influent quality. The removal percentages of BOD₅ and COD in this plant are shown in Table 5. The removal percentages for BOD₅ were low as 36.36% (in 2006) and reached 86.19% (in 2008) but 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 2008 to 100 mg/L. Low correlation were obtained from the regression analysis for BOD₅ and COD, indicating the poor performance of the treatment plant.

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 BOD₅ and 0.86 for COD as shown in Figures 3 and 4 respectively. The treatment process in this plant has to be functioned to the regression equations, $y = 0.044x + 80.66$ for BOD₅ and $y = 0.045x + 55.15$ for COD. More quality data are required for the flowing influent through the plant to improve the treatment process and make full use of the regression analysis.

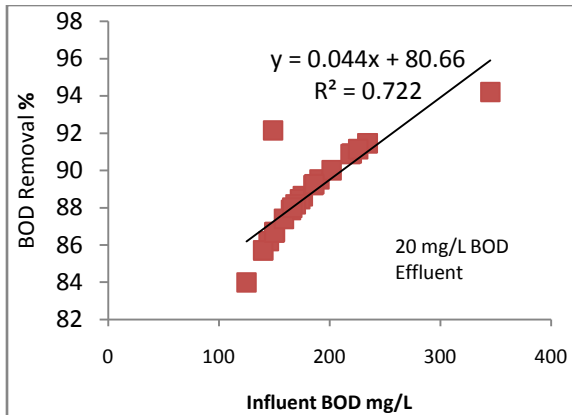


Fig. 3: Regression Analysis for Standard Effluent and BOD Removal %

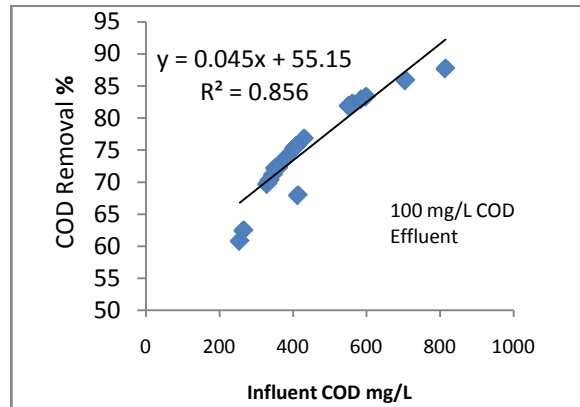


Fig. 4 Regression Analysis for Standard Effluent and COD Removal %

Table 3 BOD₅/COD Ratios for the wastewater of Al-Diwaniyah WWTP (2005-2008).

Year Month	2005		2006		2007		2008	
	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		
Average	0.45	0.68	0.47	0.56	0.38	0.51	0.49	0.47

Table 4 Regression Analysis for BOD₅ and COD of the Influent in Year 2008.

Month	Regression Equation	R ²	BOD ₅ /COD (from eqs)	BOD ₅ /COD
Jan.	$y = 0.352x + 13.74$	0.926	0.35	0.42
Feb.	$y = 0.382x + 0.083$	0.979	0.38	0.4
March	$y = 0.206x + 103.1$	0.905	0.21	0.4
April	$y = 0.255 + 77.18$	0.779	0.26	0.45

Table 5 Removal Percentages of BOD₅ and COD.

Year Month	2005		2006		2007		2008	
	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		
Average	49.86	65.20	53.42	57.13	63.32	65.93	77.72	81.54

5.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 20 mg/L and COD 100 mg/L), indicating poor treatment. These values of BOD_5 and COD could constitute potential pollution problems to the water bodies since it contains organic compounds that require large amounts of oxygen for degradation.

2-The BOD_5 /COD ratio ranged 0.23 to 0.69 for the untreated sewage which can be considered normal 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 2008.

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 2008 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, $y = 0.044x + 80.66$ for BOD_5 and $y = 0.045x + 55.15$ for COD removal to reach the effluent standards.

REFERENCES

- [1] Attioghe, F.K., Amengor, M.G. and Nyadziehe K.T. (1999) 'Correlating Biochemical and Chemical Oxygen Demands of Effluents. A Case Study of Selected Industries in Kumasi, Ghana'.
- [2] Dissanayake, P., Amin, M. Amerasinghe P. and Clemett, A. (2007) 'Baseline Water Quality Survey for Rajshahi, Bangladesh' WASPA Asia, Project Report 7.
- [3] Metcalf and Eddy (2003)'Wastewater Engineering, Treatment and Reuse' 4th edition, McGraw Hill Com. Inc. New York.
- [4] Olive,N. (2007) 'Design of a Chemically Enhanced Primary Treatment Plant for the City of Alfenas, Minas,
- [5] Palmer, S.J. (2004)'Process Description' Bechtel International Systems Inc.Project no.24910-602.
- [6] Steel, E. W. and McGhee, T. J. (1979)'Water Supply and Sewerage' 4th edition, McGraw Hill.