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Performance Evaluation of the Organic Matter Removal Efficiency inWastewater Treatment Plants; Case study Al- Diwaniyah WWTP in Iraq

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Abstract: ***This study aims to assess the removal efficiency andestablish the BOD_5 and COD statisticalcorrelation of the sewage flowing in Al-Diwaniyah wastewater treatment plant in Iraq during the study period (2005-2016). The strength of the influent wastewater entering the plant varied from medium to high in strength. 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. To improve the performance of this plant, regression equations for BOD_5 and COD removal percentages were suggested which can be used to facilitate evaluation of liquid waste and optimal control process. 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: wastewater treatment, BOD_5, COD, BOD_5/COD ratio, BOD_5 and COD correlations, removal efficiency

1. Introduction

The wastewater treatment plant design, construction and management aimed to remove the pollutants before the effluent dispose to water bodies. Several researchers studied the performance of wastewater treatment plants through the removal efficiency considering the parameters pH, Turbidity, TSS, TDS, COD and BOD, etc. and the operation and maintenance problems resulting therefrom. These plants are designed with hydraulic and organic loading rates to achieve effluentsthatmeet the local or global specifications.Poor design, operation and/or maintenance of these plants create major environmental problems, when suchwaste water is discharged to surface water or on land[1, 2, and 3].

The levels of Biochemical Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD)of wastewaters indicate the effluent pollution to water resources. The untreated municipal wastewater has a typical range values for BOD_5/COD ratio from 0.3 to 0.8 as shown in **Table 1**. Sewage can be considered easy treatable using biological methods if the ratioif the ratio is 0.5 and greater, while microorganisms and some toxic compounds in wastewater may be required for degradation if the ratio is below 0.3. This ratio decreases to 0.1 – 0.3 for the treated sewage [4].

Attioghe et al., 1999 [5]studied the effluents of several industrial wastes in Ghanathat that are large in volume and discharged into public drainage systems or to near streams. TheBOD_5/COD ratios for the selected industries were 0.31 (GGL), 0.49 (Coca-Cola) and 0.62(GBL). They found in their study, found the untreated wastewater BOD_5/COD ratio for the selected industries would be fitted equations approximately. The linear regression performed on the data were highly correlated, 0.93, 0.81 and 0.83 respectively and can be used to estimate the BOD_5 or COD values. The results obtained are useful tools for monitoring and assessment of the quality effluent.

Olive, 2007,[6]established a correlation between BOD_5 and COD for wastewater from Alfenas, where this waste is mixed with natural spring water. The correlation was very high R^2=0.96., it was found from the regression curve that BOD_5 could be determined by applying COD value to a factor of 0.6.

Dissanayake et al., 2007, [7] 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 from 0.25 to 0.5.

This study aims to assess the removal efficiency and establish an empirical correlation between BOD_5 and COD for the sewage flowing in Al-Diwaniyah Wastewater treatment plant (WWTP) that could be used to facilitate effluent quality assessment of the treatment plant.

2. Material and Methods

2.1 Al-Diwaniyah STP, Case Study Description

This plant location is on road 8 in the south of Al-Diwaniyah Governorate on Shut Al-Diwaniyah, a branch of the Euphrates River, southern part of Iraq Fig. 1. 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[8].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 secondary sedimentation tank effluents flow to the chlorine contact tank for disinfection before it is discharged to the river.

Theholding tank receives the sludge waste from secondary clarifiers where the supernatant is pumped back to the WWTP' s head and the settled sludge is pumped to the drying beds. The plant is designed to yield an effluent of 20mg/L BOD_5 and 30mg/L suspended solids.

Figure 1: Al-Diwaniyah WWTP site location

2.2 Data Collection and Analysis

This study analyzes the quality of the raw and treatedwastewater of Al-Diwaniyah treatment plant.The collection and experimental data used in this paper were provided from Ministry of Health and the Environment, Ministry of Construction and Housing and Public municipalitiesand Al-Diwaniyah WWTP'officefor the period between 2005 until 2016. The data represented the average daily and monthly values of the mainly parameters of the influent and effluent, as biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), dissolved oxygen (DO), and nitrate (NO_3).

3. Results and Discussion

Table 1 shows the influent and effluent sewage statistical descriptive concentrations. The influent wastewatercan be evaluated the strength from medium to high according to the classifications in Table 2. Figure 2 shows the average monthly variation of BOD_5 and COD of the influent through the study period. The quality of the effluent from the plant has been found to be higher than the Iraqi effluent standards for disposal to water bodies ($BOD_5$40 mg/L and COD 100 mg/L) as shown in Table 3, indicating poor treatment process. High BOD_5 and COD could be regarded as pollution problems to the water bodies since, the organic compounds degradation is required a large oxygen amounts. Figure 3 shows the average monthly variation of $BOD_5$and COD for the treated sewage from the plant. The BOD_5 exceeded the disposal limitations over the whole period, where COD reached the limitations.

The BOD_5/COD ratio from the data was found to be between 0.55and 0.71 with an average value of 0.63for the untreated sewage as shown in Table 3, this sewage is considered to be easily degradable by biological processes (Table 4). For the effluent (treated sewage) the average value of this ratio was 0.55, this indicates problems in the treatment process which represented partially degradable or non-biodegradable organic matter in the effluent.

Table 5, shows the overall efficiency of the Al-Diwaniyah sewage treatment plantfor BOD_5, COD, TSS, and NO_3, reduction was 62.1%, 68.2%, 61.8%, and 53.2%, respectively during the study period.The efficiency removals were not enough to treat the flowing sewage according to the Iraqi standards for disposal, which indicates the weakness of the treatment process within the primary and secondary stages.Low correlation was obtained from the regression analysis for BOD_5 and COD, indicating the poor performance of the treatment plant.

The regression for BOD_5 and COD of the influent for the first four months during the study period had good correlation as shown in Table 6.The BOD_5/COD ratios could be approximated to the fitted equations as they are near to the calculated ratios. To make use of this analysis the removal percentages were calculated according to the Iraqi effluent standards. The regression analysis here showed good correlation, R^2 =0.72 for BOD_5 and 0.86 for COD asshown in Figures 4 and 5 respectively. 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.

4. Conclusions

1) The quality of the effluent from the plant has been found to be higher than the Iraqi effluent standards for disposal to water bodies ($BOD_5$40 mg/L and COD 100 mg/L), indicating poor treatment process.
2) The BOD_5/COD ratio for the untreated sewage can be considered normal and thesewage is easily degradable by the biological processes, while for the effluent (treated sewage) according to this ratio indicatednon-biodegradableor partially degradable effluent disposal and poor performance process of the treatment plant.
3) The removal percentages for BOD_5 were not enough to treat the flowing sewage according to Iraqi standards.
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 removal to reach the effluent standards for disposals.

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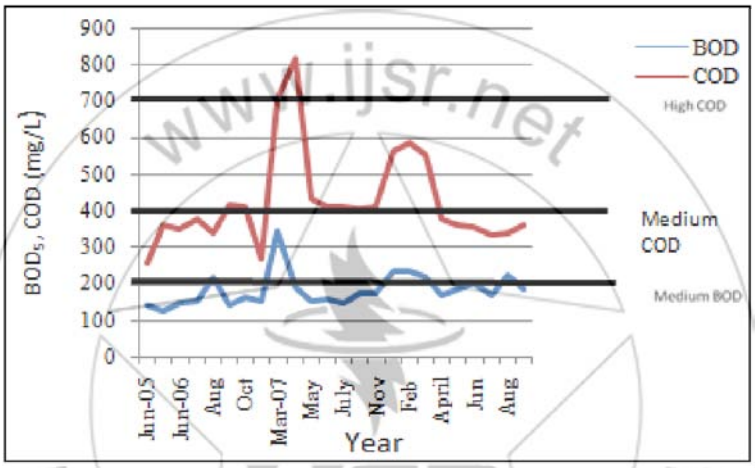

Figure 2: Average monthly variations of BOD_5 and COD of the influent wastewater of Al-Diwaniyah WWTP (2005-2016)

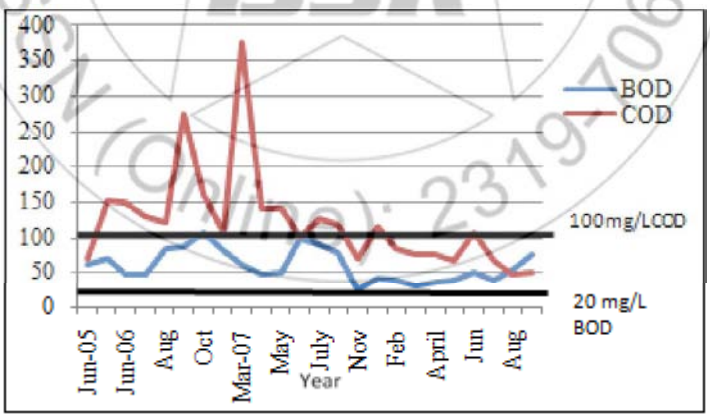

Figure 3: Average monthly variations of BOD_5 and COD of the effluent sewage of Al-Diwaniyah WWTP (2005-2016).

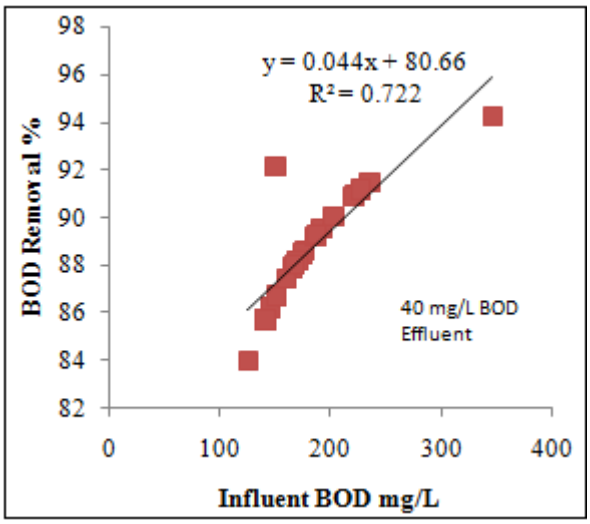

Figure 4: Regression Analysis for Standard Effluent and BOD Removal %

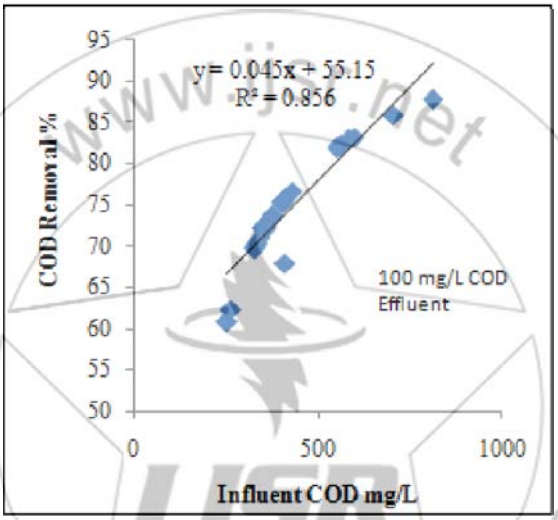

Figure 5: Regression Analysis for Standard Effluent and COD Removal %

Table 1: Influent and effluent sewagestatistical descriptive concentration for the period (2005-2016)

Parameter	Influent(mg/L)				Effluent(mg/L)			
	Min	Max	Average	STDEV	Min	Max	Average	STDEV
TSS	202.6	365.2	251.5	65.5	49.9	131.7	81.5	38.7
COD	326.1	498.7	415.6	75.9	76.6	225.7	129.2	70.4
BOD	169.1	265.8	211.8	36.5	23.7	135.1	82.2	50.7
DO	2.3	17	6.6	7	2.3	9.7	4.4	3.5
NO_3	25.7	40.3	32.7	6.9	11.4	21	15.7	4.1

Table 2: Strength classification of the Untreated Sewage

Parameter	Strength [4]			Strength [9]		
	Low	Medium	High	Low	Medium	High
BOD_5 mg/L	110	190	350	100	200	400
COD mg/L	250	430	800	175	300	600
TOC mg/L	80	140	260	100	200	400

Table 3: BOD_5/COD Ratios for the sewage of Al-Diwaniyah WWTP (2005-2016)

Sewage	Min	Max	Avg	STDEV	Kurtosis	Skewness	Cv
Untreated	0.55	0.71	0.63	0.09	0.93	0.50	0.18
Treated	0.53	0.57	0.55	0.02	0.16	0.34	0.23

Table 4: Ratios of various parameters used to characterize wastewater [4]

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

Table 5: Overall Removal efficiency of Al-Diwaniyah STP (2005-2016)

Parameter	Min	Max	Average	STDEV
TSS	42.5	84.4	61.8	18
COD	50.1	82.1	68.2	15.1
BOD	39.9	85.8	62.7	18.9
NO_3	44.8	62.9	53.2	6.7

Table 6: Regression Analysis for BOD_5 and COD of the Influent

Month	Regression Equation	R^2	BOD_5/COD (from eqs)	BOD_5/COD (recorded)
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