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RESEARCH ARTICLE

CHARACTERIZATION AND PERFORMANCE OF HAMDAN WASTEWATER TREATMENT PLANT IN BASRAH, IRAQ

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ABSTRACT

Wastewater characterization is a constitutional part of treatment and schemes for city effluent. The aims of this research are to show the characterization and removal efficiencies of Hamadan wastewater treatment plant which is located in the south of Iraq. This study was carried between 2009 and 2010. Hamadan wastewater treatment plant was designed in 1979 and firstly operated on 2005. The assessment of wastewater treatment plant was aspired to demonstrate the characteristics of the influent wastewater to the treatment plant, the quality of the effluent from the treatment plant and the efficiency of the treatment units. The qualities of the treated effluent were ranged as follows: pH values across all study period ranged between 7.1 and 7.8. The concentrations of biological oxygen demand (BOD) and chemical oxygen demand (COD) varied from 100 to 242 mg/L and 225 to 936 mg/L, respectively. Total suspended solids (TSS) of the months during the study period were in the range of 176-924 mg/L. Oil and grease concentration in this study varied from 70 to 658 mg/L The results mostly show a negative impact of discharging treated effluent on the receiving lands. Results of primary treatment of Hamdan wastewater treatment suggested that the primary treatment alone was not adequate to reduce pollutant loads significantly. Hence, biological treatment was demanded to meet local effluent quality standards.

INTRODUCTION

During the late 19th Century, a population of many cities grew larger because of the industrial expansion; sewer system and network were established to transport domestic wastewater and industrial wastewater to surface water or rivers for disposal with small or no treatment. Debris and settleable solids can be removed by primary wastewater treatment that usually used sedimentation tank only. The main purpose of wastewater treatment is to remove the soluble and suspended organic component that is measured as chemical oxygen demand (COD). The COD for the wastewater is the amount of oxygen that is required to absolutely degrade or break down the wastewater into form of carbon-dioxide and water. The COD of the wastewater also provides an estimate associated with the energetics corresponding with the wastewater treatment process. The majority of organic material was not removed by the primary wastewater treatment due to its slow settling because this organic material is either dissolved or its density is low. Secondary wastewater treatment was thereafter utilized to biologically remove that organic material to facilitate this problem.

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The Biological wastewater treatment plants have already been employed around the world for the wastewater treatment that is certainly municipal wastewater. Inspite of the known fact that it really is efficient in removing organics, large amounts of excess sludge that are tend to be produced. The sludge that is excess can be categorized into primary sludge and secondary sludge (Metcalf and Eddy, 2003). Primary sludge is the sludge that consists of settleable solids that removed from raw wastewater in primary (main) settler tank. Secondary sludge may be the sludge created by the biological process such activated-sludge process. Generally speaking, the biodegradability of primary sludge is high and therefore it will be quite difficult to improve its degradation during the pretreatment technologies. In comparison, the biodegradability features of secondary sludge are low (Carrere *et al*., 2010). Therefore, lots of technologies are developed to reduce the secondary sludge production. Many Municipal Wastewater Treatment Plant has primary treatment which achieves physical removal of both floatable and settleable solids and the plant have also secondary treatment process such as the biological treatment that used for the removal of dissolved solids (Meglei *et al*. 2006; Dima *et al*. 2006; Huertas *et al*. 2008; Vaiopoulou *et al*. 2007; Matamoros *et al*. 2009). One of the most commonly wastewater treatment process that used in

pollution control process is the activated biological wastewater treatment process. This process usually used where land requirements are relatively small and when the treated effluent needed with a very high quality. Because of the complexness of this type of wastewater treatment process, it demands careful monitoring and operating. This study was conducted to describe the sources and quality of wastewater in Basrah city, and to study the structure and characteristics of wastewater. The main aim of the current study was to demonstrate the characterization of raw wastewater in Basrah and to evaluate the performance of the Hamdan wastewater treatment plant. The other potential objective of this research is to show the unsuitability of discharging effluent from wastewater treatment plant to land without further treatment.

MATERIALS AND METHODS

Study Area

The Hamdan wastewater treatment plant is located in Basrah, south of Iraq. It was designed in 1979 and it did not operate till 2005 because of the wars that happened in that period. The Hamdan wastewater treatment plant has been operated since 2005 by sewerage directorate in Basrah governorate and was designed in five stages. Currently, only the fourth and fifth stages are under construction, while now the other stages that under operation require maintenance works for its units. The final treated effluent is discharging into land.

Wastewater Samples

Wastewater sampling was carried over a period of 14 months from April, 2009 to June, 2010. This sampling period was sufficient to take into consideration all possible variations in the production processes. Wastewater samples were collected from the wastewater treatment plant on a monthly basis for the study period except in September 2009, because there was a maintenance work in that month. The wastewater samples were collected from different points in the wastewater treatment plants in each month. These collected points are as follows: influent (raw wastewater) , primary settling tank (primary treated wastewater) , and effluent (finally treated wastewater). Measured values for each month of the studied period were constructed by analyzing samples for pH, BOD, COD, TSS, and (oil and grease) parameters. All analyses were performed according to the standard method of test water and wastewater (APHA *et al*. 1998).

RESULTS AND DISCUSSION

The Statistical Parameters of wastewater samples in the Hamadan wastewater treatment plant during the period of study are summarized in Tables 1-3.

Influent (raw wastewater) characteristics

Raw wastewater characterization is essential for the selection of suitable treatment technology and efficient design of treatment facilities. Characterization of wastewater is also required for evaluating the performance of separate unit operations and processes. The characteristics of raw wastewater are shown graphically in Figures (1-5). The pH ranged from 6.82 to 7.79 with a mean value of 7.52. From the available data it was found that biological oxygen demand (BOD) ranged from 208 to 700 mg/L, with a mean value of 320.3 mg/L. The corresponding chemical oxygen demand (COD) ranged between 338 and 1666 mg/L, with a mean value of 778.6 mg/L. The total suspended solids (TSS) ranged from 233 to 2400 mg/L, with a mean value of 1060 mg/L. The concentration of oil and grease in this study were ranged from 94 to 4306 mg/L, with a mean value of 1167.3 mg/L. It was found that the average value of BOD5/COD ratio was 0.47 and 0.51 for 2009-2010 raw wastewater, respectively. The BOD5/COD ratio shows the treatability of wastewater. It is noticed that if the BOD5/COD ratio is above 0.5, that is mean that the wastewater is reflected to be highly biodegradable (Cossu *et al*, 2012). Therefore, the biodegradability of Basrah wastewater has been believed to be good.

Table 1. Minimum, maximum, average, and standard deviation (SD) of raw wastewater samples in the Hamdan Wastewater Treatment plant

S.No.	Parameter	Min.	Max.	Average	SD
1	pH	6.82	7.79	7.52	0.23
2	BOD5 (mg/L)	208	700	320.29	132.75
3	COD (mg/L)	338	1666	778.57	424.96
4	TSS (mg/L)	233	2400	1060.00	628.97
5	Oil and Grease (mg/L)	94	4306	1167.31	1273.77

Primary effluent characteristics

The Biological treatment processes tend to be used to degrade the organics (COD) in the wastewater prior to discharged it. In activated sludge, the majority typical biological process for wastewater treatment, the microbes tend to be suspended with the wastewater, in the reactor. The characteristics of effluent (primary treated wastewater) are presented in Figures (1-5). The pH ranged between 7.2 and 7.98 with a mean value of 7.55. The residual BOD ranged from 150 to 300 mg/L, with a mean value of 216.6 mg/L. The corresponding residual COD ranged between 288 and 1040 mg/L, with a mean value of 556.9 mg/L. The residual TSS in the primary effluent was ranged between 204 and 2000 mg/L, with a mean value of 791.2 mg/L. The concentration of residual oil and grease ranged from 75 to 1082 mg/L, with a mean value of 463.1 mg/L. The Biological treatment processes tend to be used to degrade the organics (COD) in the wastewater prior to discharged it. In activated sludge, the majority typical biological process for wastewater treatment, the microbes tend to be suspended with the wastewater, in the reactor. The characteristics of effluent (primary treated wastewater) are presented in Figures (1-5). The pH ranged between 7.2 and 7.98 with a mean value of 7.55. The residual BOD ranged from 150 to 300 mg/L, with a mean value of 216.6 mg/L. The corresponding residual COD ranged between 288 and 1040 mg/L, with a mean value of 556.9 mg/L. The residual TSS in the primary effluent was ranged between 204 and 2000 mg/L, with a mean value of 791.2 mg/L. The concentration of residual oil and grease ranged from 75 to 1082 mg/L, with a mean value of 463.1 mg/L.

Final effluent characteristics

In order for the biological treatment technique to work effectively in treatment of wastewater, the biomass have to separate from the water and this is achieved by gravity settling in a final clarifier. Final effluent characteristics o Hamdan wastewater treatment plant are illustrated graphically in Figures (1-5). The pH mean value of 7.55 was founded. The

mean value of residual BOD was 157.7 mg/L, while the corresponding residual mean value of COD was 443.4 mg/L. The mean value of residual TSS was 517.9 mg/L. The concentration of residual oil and grease was 270.1 mg/L.In order for the biological treatment technique to work effectively in treatment of wastewater, the biomass have to separate from the water and this is achieved by gravity settling in a final clarifier.

Final effluent characteristics of Hamdan wastewater treatment plant are illustrated graphically in Figures (1-5). The pH mean value of 7.55 was founded. The mean value of residual BOD was 157.7 mg/L, while the corresponding residual mean value of COD was 443.4 mg/L. The mean value of residual TSS was 517.9 mg/L. The concentration of residual oil and grease was 270.1 mg/L.

Table 2. Minimum, maximum, average, and standard deviation (SD) of primary effluentwastewater samples in the Hamdan Wastewater Treatment plant

S.No.	Parameter	Min.	Max.	Average	SD
1	pH	7.2	7.98	7.55	0.22
2	BOD5 (mg/L)	150	300	216.64	40.49
3	COD (mg/L)	288	1040	556.86	236.36
4	TSS (mg/L)	204	2000	791.21	521.98
5	Oil and Grease (mg/L)	75	1082	463.08	334.94

Table 3. Minimum, maximum, average, and standard deviation (SD) of final effluentwastewater samples in the Hamdan Wastewater Treatment plant

S.No.	Parameter	Min.	Max.	Average	SD
1	pH	7.1	7.89	7.55	0.25
2	BOD5 (mg/L)	100	242	157.07	45.40
3	COD (mg/L)	225	936	443.36	172.51
4	TSS (mg/L)	176	924	517.93	276.59
5	Oil and Grease (mg/L)	70	658	270.08	188.03

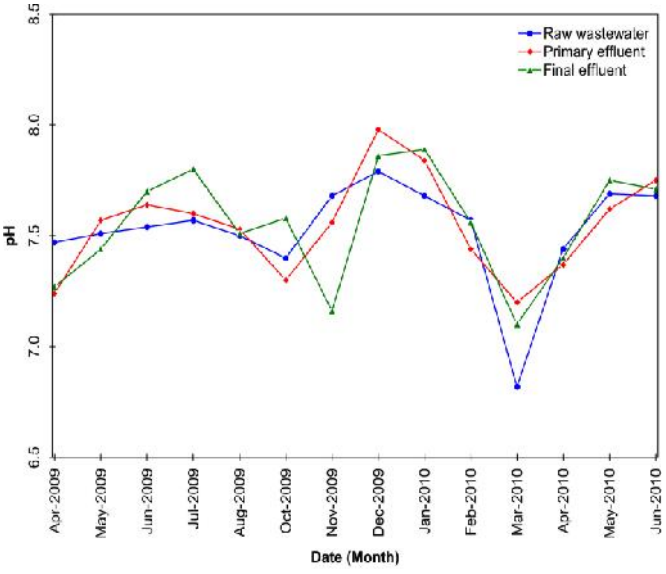

Figure 1. Variation in pH illustrating the characteristics of raw wastewater, primary effluent and final effluent at Hamdan Wastewater Treatment Plant

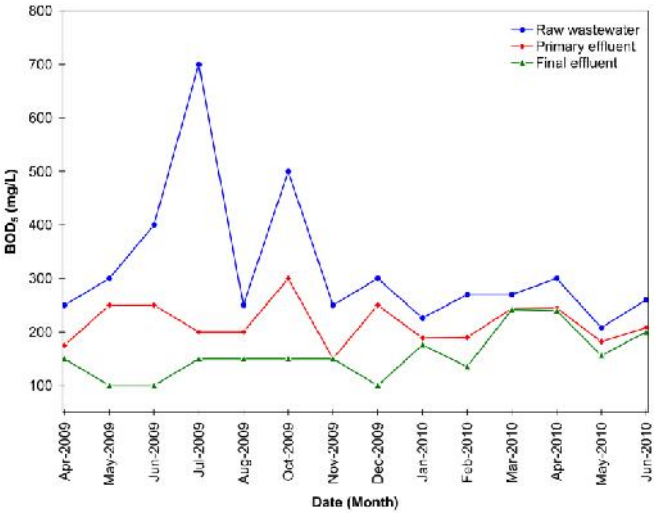

Figure 2. Variation in BOD5 illustrating the characteristics of raw wastewater, primary effluent and final effluent at Hamdan Wastewater Treatment Plant

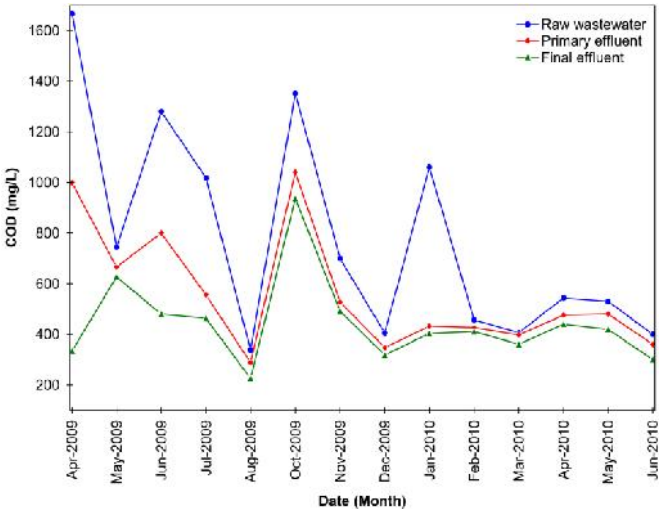

Figure 3. Variation in COD illustrating the characteristics of raw wastewater, primary effluent and final effluent at Hamdan Wastewater Treatment Plant

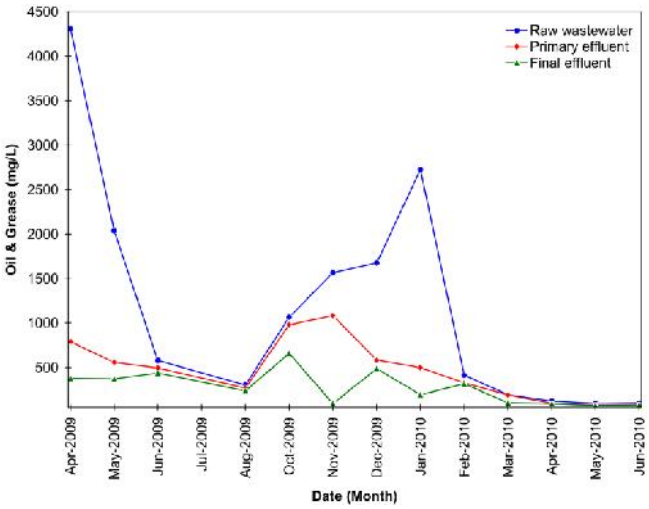

Figure 4. Variation in oil and grease illustrating the characteristics of raw wastewater, primary effluent and final effluent at Hamdan Wastewater Treatment Plant

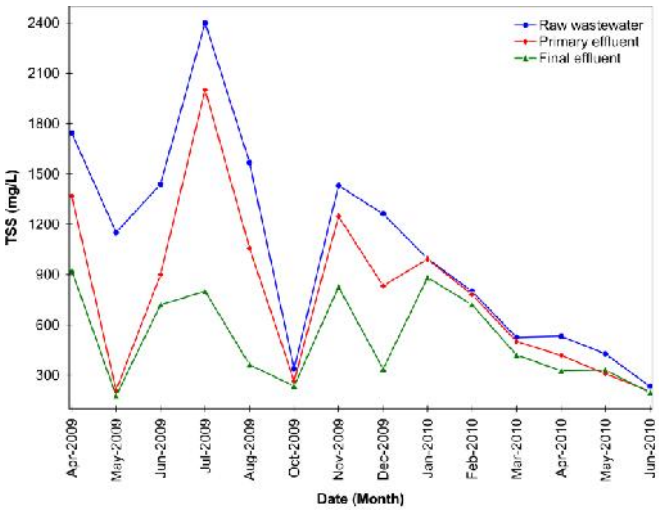

Figure 5. Variation in TSS illustrating the characteristics of raw wastewater, primary effluent and final effluent at Hamdan Wastewater Treatment Plant

Final Efficiency of treatment processes

The maximum BOD5 removal efficiency at final effluent in the study area was 78.6% (Table 4), while the maximum removal efficiency for the same parameter (BOD5) for the primary effluent was 71.4% . It was observed from table 1, that the maximum removal efficiency for COD was 59.2 % at the primary effluent, while the maximum removal efficiency for the final effluent was 84.7%. The maximum removal efficiency for TSS was observed from the table as 81.7% for the primary effluent, while the maximum removal efficiency was 84.7% for the final effluent. The highest removal efficiencies were obtained in oil and grease that was found to be 81.7% and 94% for primary effluent and final effluent, respectively.

Table 4. Correlation Coefficients for the primary treated wastewater samples in Hamdan Wastewater Treatment plant

Wastewater	Maximum Removal Efficiency (%)			
	BOD5	COD	TSS	Oil and Grease
Primary effluent	71.4	59.2	81.7	81.7
Final effluent	78.6	80.0	84.7	94.0

Correlation between Parameters

The correlations between studied parameters were performed using Pearson's correlation. A correlation analysis is a bivariate method applied to explain the degree of relation between wastewater parameters. Related the variable representing with correlation coefficient is r, and the multiple correlations, which represent the percentage of variance in the dependent variable, is defined collectively by all the independent variables. A correlation coefficient that is higher, which is near 1 or -1, indicate simplies a good strong relationship between the two parameters, and a correlation coefficient around of around zero indicates implies that there is no relationship between the two parameters, at a significance level of 0.05. Much more specifically it may bestated that parameters showing r > 0.7 are believed to be strongly correlated, while when r has actuallya value between 0.5 and 0.7, a moderate correlation is revealedis believed to occur (Helena *et al*. 2000, Kim *et al*. 2002; Shammas and Jacks, 2007). Positive values of r suggest a relationship that is positive, whereas negative values suggest an inverse relationship. The correlation coefficient of the studied parameters is shown in Tables5 and 6. In the present study, COD is good correlated with (oil and grease) during the study area for raw wastewater samples, and a similar case of result was observed during the study period for the primary treated wastewater.

Table 5. Correlation Coefficients for raw wastewater samples in Hamdan Wastewater Treatment plant

Parameter	pH	BOD5	COD	TSS	Oil and Grease
pH	1.00	-0.06	0.01	0.20	0.17
BOD5	-0.06	1.00	0.38	0.44	-0.25
COD	0.01	0.38	1.00	0.36	0.61
TSS	0.20	0.44	0.36	1.00	0.31
Oil and Grease	0.17	-0.25	0.61	0.31	1.00

Table 6. Maximum Removal efficiency for selected parameters in primary treated wastewater and final effluent at Hamdan Wastewater Treatment plant

Parameter	pH	BOD5	COD	TSS	Oil and Grease
pH	1.00	-0.13	-0.46	0.07	-0.10
BOD5	-0.13	1.00	0.30	-0.51	0.04
COD	-0.46	0.30	1.00	0.05	0.59
TSS	0.07	-0.51	0.05	1.00	0.13
Oil and Grease	-0.10	0.04	0.59	0.13	1.00

Conclusions

Based on this study, the following conclusions can be drawn.

- The maximum removal efficiency of BOD5 for Hamdan wastewater treatment plant was found to be 78.6 % at the final treated wastewater .
- The maximum COD removal efficiency of Hamdan wastewater treatment plant was found to be 80 %.
- The maximum removal efficiency of TSS for Hamdan wastewater treatment plant was found to be 84.7 % at the final treated wastewater, while the maximum removal efficiency for oil and grease was 94 %.
- The current final result suggests that the treated effluent is not complying with the standard values and cannot be used for irrigation along the study period.
- Due to the high values of BOD5 and COD in treated effluent that exceeds the Standards of 100 mg/l and 250 mg/l, Hence it is recommended to operate the other stages of the treatment plant to achieve better performance, also based on results we can conclude that the primary and secondary treatment processes is not efficient to remove BOD5 and COD and hence it is to be redesigned.

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