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Characterisation of Raw Sewage and Performance Evaluation of Al-Diwaniyah Sewage Treatment Work, Iraq

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Abstract

These days, water and wastewater treatment are one of the most important issues regarding to the human health. Wastewaters are one of the most environmental pollutants and a wide range of adverse effects linked to the effect of untreated wastewaters or wastewaters that treat improperly. The aim of this present study was to evaluate performance of the wastewater treatment plant at Al-Diwaniyah City according to the national standards. Therefore, data of the most common parameters (PH, BOD_5, COD, TSS, PO_4, NO_3, Cl, and Oil and Grease) were collected from the wastewater treatment plant. The study revealed that the wastewater treatment plant was receiving medium to strong influent with a BOD_5/COD ratio of between (0.4 - 0.7). Regression analysis was achieved to approximate the influent of BOD5 and TSS. While the effluent quality was exceeded the Iraq standards for disposing treated wastewater to the water bodies with a fluctuation in the ratio of $BOD_5$to COD as a consequence of the operational problems. Therefore, these results would be of help to planners and policy makers in the City to combat such this problem and to take the necessary actions to reduce the impact of these pollutants.

Keywords

Biochemical Oxygen Demand, Total Suspended Solids, Al-Diwaniyah, Sewage Treatment Works, Activated Sludge Process

1. Introduction

Simply, wastewater defends that water has been used. However, one of the most common definitions of wastewaters is a combination of the liquid or water carried wastes removed from residences, institutions and commer-

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cial and industrial establishments together with such ground water, agriculture runoff and storm water, encompassing a wide range of potential contaminants and concentrations [1]. The characterization of wastewater in terms of quantity and quality is principally a function of the wastewater origin, which means the composition of wastewater varies widely depending on the type of activity producing the wastewater. As civilization developed, domestic sewage and industrial waste are eventually discharged into sewers, and the entire contents empty into the nearest watercourse [2].

Therefore, the primary objective of wastewater treatment is to allow human and industrial effluents to be disposed of without threat to human health or unacceptable damage to the natural environment. Basic wastewater treatment evolved from 1900 to 1970. Treatment systems focused on removal of suspended and floatable materials, treatment of biodegradable organics, and elimination of pathogenic organisms [3]. Then standards were raised and treatment using nitrogen and phosphorous was introduced, mainly to protect lakes and inland streams. Later on, more attention was given to public health and treatments using toxic chemicals and trace compounds that might have long-term health consequences [4]. Treatment technology included physical, biological, and chemical methods. Activated sludge processes, as a biological treatment, were commonly used as efficient means of wastewater treatment. Residual matters, removed or created by treatment processes, must be dealt with and reused or disposed of in a safe way. The purified water was discharged to surface water.

Around the world, many researchers have studied and evaluated the performance of the wastewater treatment plants in different places with different types of treatment and technologies to remove metal, inorganic, and organic constituents. In the USA, many studies have documented the removal efficiencies of physicochemical parameters (such as COD, TSS, and BOD), metals, and inorganics from wastewater treatment works [5] [6]. In Iraq, there are a wide range of studies about the performance of different types of wastewater treatment plants with different kinds of sources such as in Baghdad [7], Basra [8], and for different source of wastewater such as [9]. There are several national and international guidelines relating to the quality of the treated effluent to the water bodies and that come from lifestyle, climate and weather and population awareness, which make it difficult to have a unique international guideline.

The main purpose of the current study is to evaluate the final effluent of Al-Diwaniyah wastewater treatment plant and how it is compliance with the national guideline.

2. Methodology

2.1. Site Description

The city of Al-Diwaniyah is located in the south-mid part of Iraq; it is located on the Al-Diwaniyah River which is a brunch of Euphrates River as shown in **Figure 1**, with a population of around 400,000 inhabitants and several small industries. Although only about 30% of the city is served, however, municipal and industrial wastewaters of the served area are connected to a wastewater treatment plant through sewer. The basic wastewater treatment process in Al-Diwaniyah Sewage treatment plant is activated sludge processes. The plant capacity is 4DWF is the design capacity of the plant and amount of about (0.925 m^3/s) enters the plant. Four screw pumps channels were constructed, only two screw pumps were installed, working on (Duty-standby) system, and each one has 3366 m^3/hr. The project consists of two streamlines, each one includes screen with a maximum screen chamber of (2DWF) to protect the rest of the wastewater treatment plant units. These screens are cleaned mechanically. Then followed by the detritor which where grit are removed via the big change in the channel flow section which lead to decrease the flow velocity, the detritor contains a circular scraper to remove the settled grit. The return sludge coming from the secondary sedimentation tanks are mixed with the wastewater that leaving the detritor in the distribution tank in order to have a well mixing before entering the aeration tanks. An activated sludge process (ASP) represents the secondary treatment of the plant. Two aeration tanks (16,500 m^3) were constructed, each one has six vertical aerators with (44 Kw each) which were organic matters are degraded. The effluent from the aeration tanks are received via a mixing chamber and then be distributed to the two circular sedimentation tanks, each one has a 36m diameter. Before the final effluent from the secondary sedimentation tanks is discharged to the river, it passes into the chlorination tank in order to be disinfected. The wasted sludge from the secondary sedimentation tanks is collected in a holding tank where the settled sludge is pumped to the thickener tank and drying beds while the supernatant is pumped back to the distribution chamber [10]. **Figure 2** show the general layout of Al-Diwaniyah wastewater treatment plant. The plant was planned to make the final effluent of 60 mg/L suspended solids and 40 mg/L BOD_5.

Figure 1. Map of the Al-Diwaniyah City with the wastewater treatment plant (Google earth).

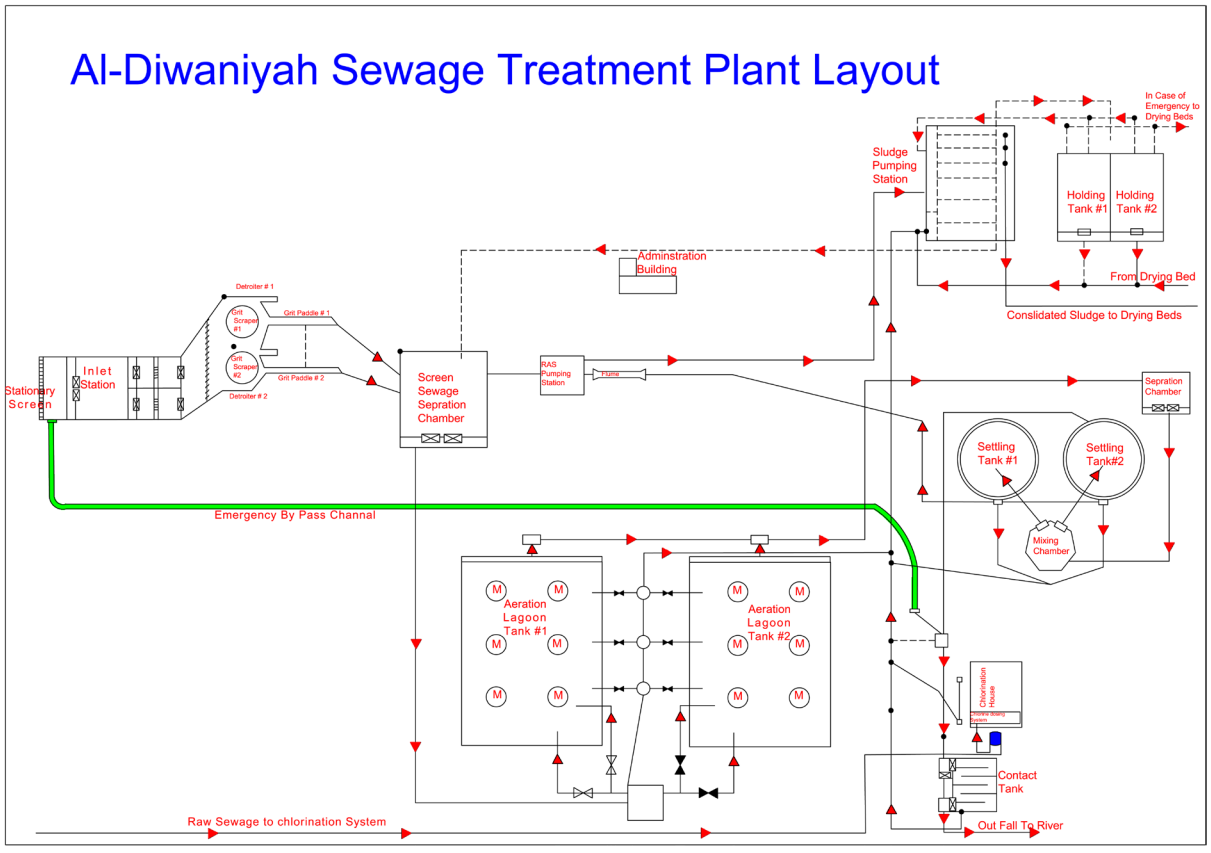

Figure 2. Al-Diwaniyah wastewater treatment plant layout.

2.2. Sampling Regime

For period from January 2011 to July 2012, samples were collected and tested directly at the laboratory of the wastewater treatment plant at Al-Diwaniyah sewerage Authority. Samples were taken from the inlet of the

wastewater treatment plant (after the grit chamber unit) and the effluent samples were collected at the final stage (after disinfection stage). The methods were used for the determination of the concentration of the parameters were followed that of standards methods [1].

Data were tabulated and analysed using simple descriptive statistics. Independent (unpaired) T-test for two means and analysis of variance for multiple means were used. $P \leq 0.05$ were considered significant throughout data analysis.

3. Results and Discussion

The results will present the concentrations of the main parameters in the influent, effluent, and the performance of the wastewater treatment plant.

3.1. Characteristics of Influent Wastewater

Table 1 shows the concentrations of some of the influent wastewater parameters for about 16 month between January 2011 and July 2012. The compositions of typical municipal wastewater were used to determine strength of parameters were tabulated in **Table 2** [11]. High concentrated wastewater represents cases with low water consumption and/or infiltration while diluted wastewater (low) represents high water consumption and/or infiltration. To characterize the quality of waste water averages, standard deviations as well as maximum and minimum values were calculated for the main parameters from the data.

According to the information in tables (1and 2), the raw wastewater showed a characteristic pH of 7.78 ± 0.11, it can be seen that the BOD_5 concentration for the influent wastewater was in the medium range (328.6 ± 61.3 mg/L) ranging from (158.8 - 367.7 mg/l). One of the most important parameters for wastewater characteristics is Biochemical Oxygen Demand (BOD), since in employ the type of the biological treatment. It is interested to notice that the concentration of BOD_5, COD were increased significantly during the years of this study compared with the previous study achieved [12]. This is meaning that the biological loading was increased due to either a difference in the type of exerted matter or due to the low consumption of the water used leads to high concentration of BOD. Consequently, it is important to examine carefully the concentration levels of influent and effluent BOD to establish potential water quality impacts in order to regulate these discharges. The COD concentration at Al-Diwaniyah wastewater treatment plant (STW) was determined in the medium range also (429 ± 109.4 mg/L). In addition, the total suspended solids for the influent sewage (228.7 ± 30.4 mg/L) with 288.0 mg/l and 190.8 mg/l for a maximum and minimum respectively and therefore it considered as a medium classification. For the sulphate, the average concentration for the influent was (604.7 ± 202.4 mg/L) ranging from (1063.5 - 452.3) mg/l and thus it can be classified as a high strength according to typical wastewater classification [11]. Moreover, Chloride was also categorised as a high strength due to the fact the average concentration is (362.5 ± 19.9 mg/l) with 329.8 mg/l and 407.0 mg/l for the minimum and maximum concentrations.

Figure 3 shows the influent concentrations of the BOD, COD, and TSS for the wastewater treatment plant. It can be seen that the TSS and BOD were very consistence with a constant trend for the influent wastewater, however, it also important to note that COD was higher and fluctuated especially in cold weather which might be due the fact of the low activity of microbes in cold weather.

In order to establish a constant relationship between deferent measures, regression analysis was used. Therefore, the variation of influent BOD with the influent TSS was determined, due to the fact that TSS test can be conducted much faster than BOD_5, which will take5 days. Once the correlation has been established, TSS measurement can be used to good advantage for treatment plant control and operation. **Figure 4** displays the regression equation between the influent BOD_5 and influent TSS.

3.2. Characteristics of Final Effluent Wastewater

The concentrations of some parameters for effluent wastewater samples for the period between January 2011 and July 2012 are tabulated in **Table 3**. It can be noticed that the concentration of the most parameters were exceeded the maximum allowable limits that for disposing the treated wastewater to the river and water bodies. **Figure 5** show the effluent of BOD and TSS comparing with the Iraqi standards for exposing treated wastewaters.

Typical values for the ratio of BOD_5/COD for untreated municipal wastewater are in the range from (0.3 to 0.8) and for the final effluent in the range from (0.1 to 0.3) [13].

Table 1. Monthly average concentrations of the main characteristics for the influent wastewater.

Parameter / Month-Year	PH	BOD_5 mg/l	COD mg/l	TSS mg/l	SO_4 mg/l	PO_4 mg/l	NO_3 mg/l	Cl mg/l	Oil & Grease mg/l
Jan-11	7.81	201.2	275.2	209.1	483.7	3.0	20.5	356.3	130.0
Feb-11	7.81	201.3	494.6	223.2	569.0	1.7	14.4	407.0	138.0
Jun-11	7.82	203.8	332.6	228.0	452.3	4.2	26.8	329.8	149.3
Jul-11	7.86	212.3	297.9	197.1	482.0	5.6	39.3	341.0	162.0
Aug-11	7.63	210.6	503.9	190.8	531.3	3.7	45.5	346.8	154.5
Sep-11	7.71	252.5	490.8	217.9	457.8	4.9	36.3	376.8	157.7
Oct-11	7.86	232.9	491.2	194.4	513.6	1.5	41.5	346.7	240.0
Nov-11	7.82	281.6	549.3	237.0	477.7	2.9	29.5	362.0	225.7
Dec-11	7.97	299.3	402.3	248.0	513.0	2.6	26.0	395.0	146.0
Jan-12	7.82	367.7	625.8	264.1	577.3	3.7	11.5	375.0	127.3
Feb-12	7.79	332.9	466.0	281.2	565.8	3.5	19.0	359.5	42.8
Mar-12	7.87	305.4	572.0	288.0	580.3	3.5	18.5	373.0	60.6
Apr-12	7.84	191.7	374.6	207.3	488.8	3.6	24.8	362.6	38.9
May-12	7.76	169.9	289.0	206.6	857.2	4.7	26.3	368.3	30.9
Jun-12	7.72	158.8	371.8	252.3	1063.5	4.4	11.7	348.8	79.4
Jul-12	7.47	196.7	327.8	213.6	1062.8	5.5	32.5	351.0	58.6
Average	7.78	238.6	429.0	228.7	604.7	3.7	26.5	362.5	240.0
STD	0.11	61.3	109.4	30.4	202.4	1.2	10.5	19.9	30.9
Maximum	7.97	367.7	625.8	288.0	1063.5	5.6	45.5	407.0	121.4
Minimum	7.47	158.8	275.2	190.8	452.3	1.5	11.5	329.8	63.9
Classification		Medium	Medium	Medium	High			High	High

Table 2. Typical municipal wastewater characterization [11].

Constituents	Unit	Concentration		
		High	Medium	Low
COD	mg/l	800	430	250
BOD	mg/l	350	190	110
Nitrogen (Total)	mg/l	70	40	20
TOC	mg/l	260	140	80
Phosphorus (Total)	mg/l	12	7	4
TSS	mg/l	400	210	120
Cl	mg/l	90	50	30
SO_4	mg/l	50	30	20
Oil and Grease	mg/l	100	90	50

Table 3. Monthly average concentrations of the main characteristics for the effluent wastewater.

Parameter / Month-Year	PH	BOD_5 mg/l	COD mg/l	TSS mg/l	SO_4 mg/l	PO_4 mg/l	NO_3 mg/l	Cl mg/l	Oil & Grease mg/l
Jan-11	8.03	53.0	80.7	73.4	515.0	4.6	10.0	373.5	139.0
Feb-11	7.93	122.9	178.6	142.1	601.0	2.4	23.2	406.0	108.7
Jun-11	7.85	95.9	143.5	98.7	469.3	3.7	29.6	332.0	71.0
Jul-11	7.84	130.7	110.0	110.8	565.5	4.5	10.2	337.7	66.7
Aug-11	7.64	125.3	126.1	112.6	577.0	1.8	16.5	317.4	68.0
Sep-11	7.53	165.8	209.8	119.8	513.8	0.4	52.8	354.8	77.7
Oct-11	7.92	170.7	373.5	130.3	538.2	1.2	36.8	342.7	252.0
Nov-11	7.85	199.2	409.0	132.8	553.3	2.0	26.0	362.0	217.0
Dec-11	7.84	157.5	277.7	126.6	534.0	1.7	18.0	375.0	154.0
Jan-12	7.99	180.5	264.8	150.4	562.3	2.3	12.0	375.0	201.0
Feb-12	7.97	186.7	241.3	147.4	584.0	2.7	17.0	353.0	105.7
Mar-12	7.99	131.3	247.9	143.7	561.7	2.2	22.5	361.0	79.3
Apr-12	8.05	98.7	206.9	124.9	502.8	2.4	43.5	351.0	95.3
May-12	7.85	82.7	186.6	125.8	861.2	2.7	27.0	340.5	59.3
Jun-12	7.82	75.0	216.8	111.9	1131.8	2.6	19.2	336.0	134.7
Jul-12	7.99	76.7	172.0	121.3	1159.3	2.5	23.5	303.3	63.7
Average	7.88	128.3	215.3	123.3	639.4	2.5	24.2	351.3	118.3
STD	0.14	45.1	88.4	19.6	215.3	1.1	11.9	24.9	60.2
Maximum	8.05	199.2	409.0	150.4	1159.3	4.6	52.8	406.0	252.0
Minimum	7.53	53.0	80.7	73.4	469.3	0.4	10.0	303.3	59.3
IQ Standards	6-9.5	40	100	60	-	3	50	-	-

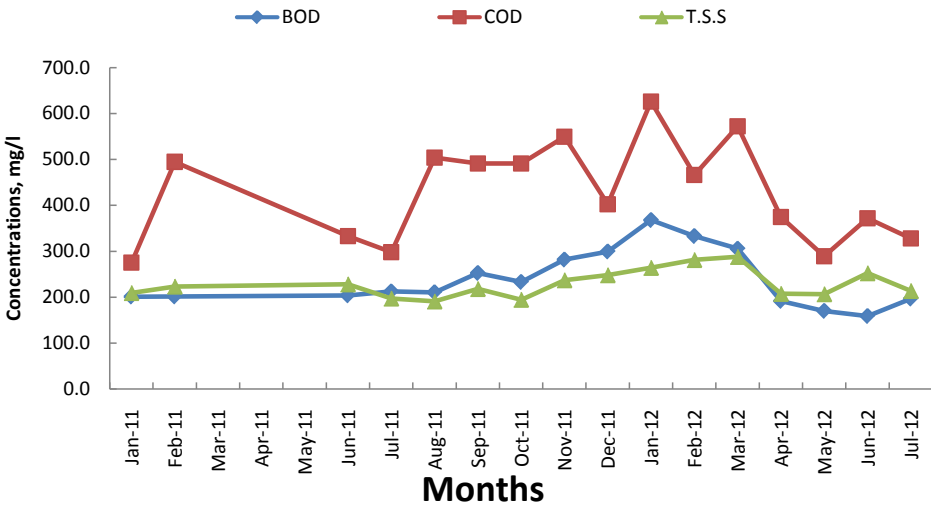

Figure 3. BOD_5, COD, and TSS for the influent wastewater.

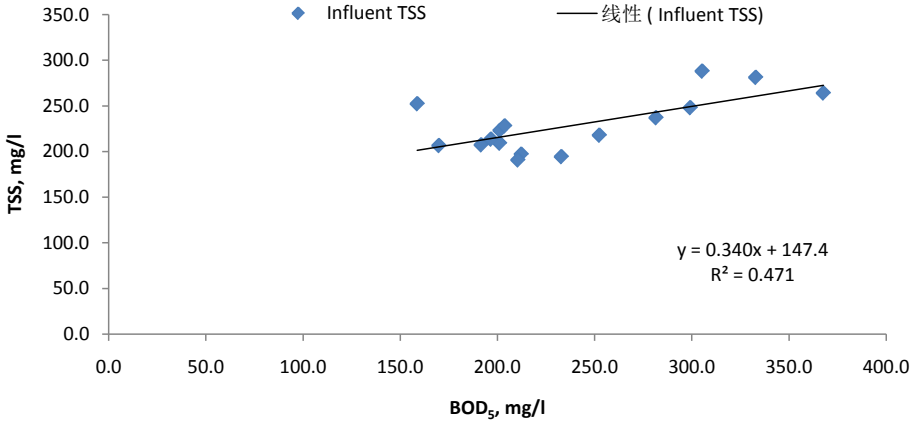

Figure 4. BOD_5, and TSS regression for the influent wastewater.

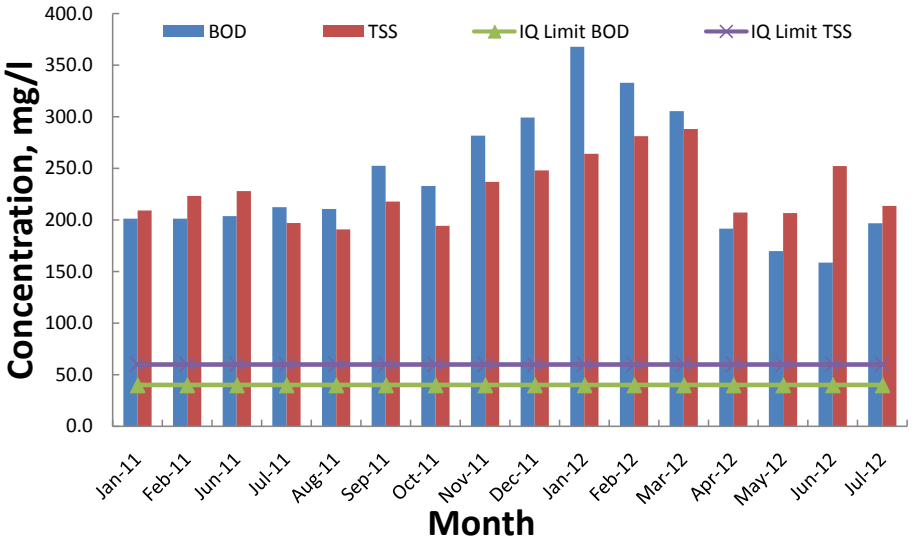

Figure 5. BOD_5 and TSS for the effluent sewage with the Iraqi standards for treated wastewater effluent.

The value of BOD_5/COD ratio for untreated wastewater for the Al-Diwaniyah wastewater treatment plant is in the range from (0.4 - 0.7) with an average of 0.6 ± 0.1as shown in **Figure 6**, while the ratio of BOD_5 to COD for the final effluent is in the range of (0.3 - 1.2) with an average of (0.6 ± 0.2). If the BOD/COD ratio for untreated wastewater is 0.5 or greater, the waste is considered to be easily treatable by biological means. If the ratio is below about 0.3, either the waste may have some toxic components or acclimated microorganisms may be required in its stabilization [14].

3.3. Wastewater Treatment Performance

From **Table 4**, the summary of Al-Diwaniyah sewage treatment plant performance, the results shows that there are removals for some main parameters had happened. Although the results of T-Test show that there is a significant difference between the influent and effluent concentrations of PH, BOD_5, COD, TSS and PO_4, however, these percentages of removal were very low compared to the design criteria of the sewage treatment work. In addition, there was no significant difference between the influent and effluent of SO_4, Cl and oil and grease content. Therefore, it is clear that the wastewater treatment is not working properly and that due many different reasons which is either the quality of the return activated Sludge (RAS) or insufficient aeration that unable the microorganisms to biodegrade the organic matters. In addition, the secondary sedimentation tank may be suffered from insufficient time to make sludge settled. In fact, it is difficult to specify the exact problem because

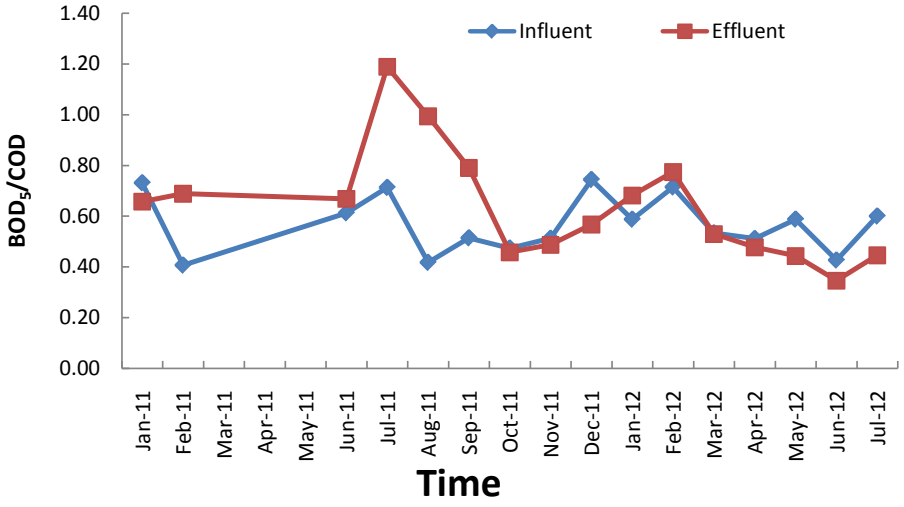

Figure 6. BOD_5/COD ratio for the influent and effluent sewage.

Table 4. Summary of results: influent and final effluent average parameters concentrations, percentage removal efficiencies and classification of parameters for Al-Diwaniyah wastewater treatment plant.

Parameter	Influent (mg/l)	Classification	Effluent (mg/l)	Removal Efficiency %	T-Test
BOD_5	328.6 ± 61.3	Medium	128.3 ± 45.1	46.7	2.41E−06
COD	429 ± 109.4	Medium	215.3 ± 88.4	49.9	1.12E−06
TSS	228.7 ± 30.4	Medium	123.3 ± 19.6	45.8	1.12E−12
SO_4	604.7 ± 202.4	High	639.4 ± 215.3	-	0.642609
PO_4	3.7 ± 1.2	High	2.5 ± 1.1	27.3	0.005307
Cl	362.5 ± 19.9	High	351.3 ± 24.9	3.1	0.171306
Oil & Grease	240.0 ± 30.9	High	118.3 ± 60.2	-	0.890743

there was measurement were taken from different location after each individual unit. Consequently, the sewage treatment work is in need of design and/or operational improvement.

One of the important elements to the growth of algae and other biological organisms is Phosphorus. However, the amount of phosphorus compounds present in wastewater discharge has to be controlled in order to avoid noxious algal blooms occurred in surface water [14]. Because a human excreta, mainly urine, domestic wastewater is a rich source of chlorides. It does not present a major pollution threat. But, Chloride ion concentration is an important factor to be considered if treated effluent is used for irrigation [14] [15].

In general, it can be say that, surface water bodies are under serious risk as a result of indiscriminate discharge of polluted effluents from the inefficient treatment and from industrial and/or agricultural, and/or domestic/sewage activities.

4. Conclusions and Recommendations

The aim of this study is to assess the quality of influent wastewater and evaluate the performance of Al-Diwaniyah wastewater treatment plant in Al-Diwaniyah City. The results obtained show that:

1) According to typical composition of wastewater, the influent of Al-Diwaniyah sewage treatment plant is considered medium to high in strength.

2) The wastewater can be treated by biological treatment due to the fact that the BOD_5/COD ratio for untreated wastewater ranges 0.4 to 0.70 which can be treated by biological treatment processes.

3) The final effluents are exceeded the limit of disposal as regulated by Iraq.

4) BOD_5/COD exceeds the limit and the maximum ratios value is of the treated sewage varied from 0.35 to

1.19 demonstrating weak performance for the wastewater treatment units.

5) The wastewater treatment plant is not enough able to treat the sewage to be within disposal limitations, hence the average removal percentages for BOD_5, COD, TSS and PO_4 are 46.7%, 49.9%, 45.8% and 27.3% respectively.

6) For the influent BOD_5 with the influent TSS, regression analysis is carried out in order to calculate the anticipated influent BOD_5 with R squared of 0.47.

Consequently there some recommendations should be considered:

1) Take the necessary actions to reduce the impact of effluent on the water bodies. It is also important to study the feasibility to treat the constituents that are responsible for the eutrophication phenomena in the water bodies.

2) Undertake another study to assess each unit within the sewage treatment plant and to find the solution to solve this issue especially with the aeration tank.

3) The development of environmental awareness and the creation of basic environmental knowledge in order to develop a positive environmental behaviour as a basic requirement that the citizen can effectively play its role in protecting the environment.

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