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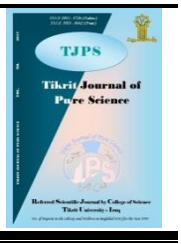

Performance Evaluation of Al-Khadraa' Wastewater Treatment Plant, Mosul-Iraq

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Abstract

The study aims to evaluate the operational efficiency of Al-Khadraa' wastewater treatment plant and the compatibility of the quality of treated water with the Iraqi standards for disposal into rivers and valleys. The study showed that there are large variations in the quantities and quality of the influent to the plant which sometimes lead to stop operational units of the plant and this has an adverse effect upon the plant function. The results showed that the strength of the influent is classified as weak to medium. The average BOD_5/COD ratio is equals to 0.6. Also it seemed that the efficiency of the treatment was weak and the quality of the effluent is out of the Iraqi standards for disposal into rivers and valleys. The percentage removal of BOD, COD, TSS, PO_4, NH_3 were 83.15%, 79%, 69.7%,56.15%,41.88% respectively. The sequence of removal efficiency was in the order of: NH_3<PO_4< TSS< COD< BOD.

Introduction

Water pollution is the most serious environmental issue. Surface water bodies in developing countries are under serious threat as a result of indiscriminate discharge of polluted effluents from industrial, agricultural, and domestic/sewage activities [1].

The wastewater treatment plant is defined as all facilities constructed in certain location to oxidize organic matter existing in wastewater and to separate solid impurities from water which can be discharged in a safe manner without causing any damage to public health. The objectives of wastewater treatment commonly include protecting water sources from pollution, preventing prevalence of diseases, limiting sediments to the bottoms of surface water and removing detriment and troubles due to bad odors associated with sewage wastewater. Sewage treatment plants are designed and operated in order to stimulate the natural treatment processes to reduce pollutant loads to a level that nature can handle. In this regard, special attention is necessary to assess the environmental impacts of existing sewage treatment facilities [2]. The general yardstick of evaluating the performance of a sewage treatment plant is the degree of BOD_5 or COD and suspended solids reduction, which constitute organic pollution [3]. Al-Khadraa' wastewater treatment plant lies at the left side of Mosul city, to the east of Tigris river, the function of the plant is to treat domestic wastewater of Al-Khadraa' residential flats and discharge the treated effluents to Al-Danfeelee valley which ends into Tigris river. The plant is designed to operate as an extended aeration activated sludge system. Extended aeration system had higher removal efficiencies for ammonia, TSS, COD and BOD and produced good quality final effluents for ultimate disposal in accordance with the discharge standard [4]. The study aims to evaluate the performance efficiency of AlKhadraa wastewater treatment plant, one of the other plants existing in Mosul city through evaluating influent and effluent flow and to compare water quality characteristics of effluent flow with disposal standards into receiving water bodies. The study also aims to discuss operational problems which the plant is suffering from and try to solve them or suggest other alternatives.

Data collection and analysis

The samples were collected during the period from March 2013 to December 2013. 4years ago The samples locations include influent wastewater, treated effluent and aeration tank. In addition, some data

were used from the laboratory of quality control in the sewage department in Mosul. The measurements (parameters) that had carried out are BOD, COD, TSS, NO_3, PO_4, NH_3, Cl, pH on influent and effluent wastewater in addition to temperature and Dissolved oxygen DO in aeration tank and effluent wastewater as showen in tables (3) and (4).

Results and discussion

The efficiency of plants is generally measured in terms of removal of organic matter removal [5]. The biological treatment can be illustrated through the amount of BOD, TSS removals and the pH value after treatment [6].

1) Characteristics of influent wastewater

Table (1) shows the characteristics of raw influent wastewater flow, the average monthly, maximum and minimum concentrations of BOD_5, COD, TSS, NO_3, PO_4, pH, Cl, and NH_3 during study period. The BOD_5, COD, TSS, ranged from (119.5 – 205) mg/l, (206.4 – 332.2) mg/l, (108 – 263.33) mg/l respectively with an average 162.92 mg/l, 272.74 mg/l, 183.92 mg/l respectively. BOD removal is indicative of the efficiency of biological treatment processes [7]. The data explain that the influent to the plant can be considered of medium to week strength according to classification conducted by [8] table (2). The highest value of BOD_5 (205 mg/l), COD (332.26mg/l), TSS (263.33 mg/l) were noticed on Jun. is attributed to heavy organic and inorganic load with less liquid content (Table 1). The DO was "nil" at inlet, stimulated by oxidation of sewage ammonia to nitrates, septic condition, heavy organic loadings.

The ratio of BOD_5/COD table (3) for the influent wastewater was in the range of (0.45-0.79) with an average of 0.6 indicates that the wastewater is moderately biodegradable and consequently can be submitted to biological treatment [8] table (3).

The pH values of influent wastewater were in the range of (6.62 – 7.4) with an average of 6.98. These values are within the common range of (6.5-8.5) for operating aeration system. The process is to be optimal when the pH value of influent wastewater is within common range[9]. The ammonia concentrations in the influent wastewater are varied from 21.27 to 75.26 mg/l, some values are relatively higher than the values proposed by EPA for raw wastewater (25-30) mg/l. The chloride concentrations ranged from (30.7-87.15) mg/l with an average of 57.96 mg/l. This value is within the proposed range given by EPA (50 – 60) mg/l for raw wastewater.

The concentrations of influent nutrients (NO_3 and PO_4) in wastewater were (1.28 – 6.5) mg/l and (3 – 9.33) mg/l respectively with an average value of 3.43 mg/l and 7.55 mg/l respectively.

Table (1): Influent wastewater characteristic of Al-Khadraa' WWTP

Parameter / Month	BOD_5 mg/l	COD mg/l	TSS mg/l	NO_3 mg/l	PO_4 mg/l	NH_3 mg/l	Cl mg/l	pH Unit	BOD_5/COD	DO (mg/l)
Mar.	125	231.7	254.66	6.25	3	52.8	61.15	7.07	0.54	Nil
Apr.	185	313.5	175.5	3.77	8.56	75.26	82.5	7.17	0.59	Nil
May.	150	245.5	136.75	1.46	8.07	61.3	70	7.17	0.61	Nil
Jun.	205	332.26	263.33	2.3	9.33	51.2	30.7	6.93	0.61	Nil
Jul.	185	327.33	143	1.73	9	61.7	87.15	6.62	0.56	Nil
Aug.	163.33	206.4	108	Nil	8.35	28	23.9	6.83	0.79	Nil
Sept.	136.25	273	213.5	1.285	8.8	37.3	43.5	6.75	0.5	Nil
Oct.	119.62	266.5	171	1.43	7.65	41.4	46.2	6.65	0.45	Nil
Nov.	165	286.85	212	6.18	7.7	24.95	75	7.4	0.57	Nil
Dec.	195	245.35	161.5	6.5	5.05	21.27	59.5	7.27	0.79	Nil
Min	119.62	206.4	108	1.285	3	21.27	30.7	6.62	0.45	Nil
Max	205	332.26	263.33	6.5	9.33	75.26	87.15	7.4	0.79	Nil
Average	162.92	272.74	183.92	3.43	7.55	45.5	57.96	6.98	0.6	Nil

Table (2): Strength classification of untreated sewage, (Metcalf and Eddy2003)

(Parameter (mg/l)	Weak	Medium	Strong
Total dissolved solids	270	500	860
Total suspended solids	120	210	400
BOD5	110	190	350
COD	250	430	800
TOC	80	140	260
Total N	20	40	70
Total P	4	7	12
Chloride	30	50	90
Sulfate	20	30	50

Table (3): Ratios of various parameters used to characterize wastewater, (Metcalf and Eddy, 2003)

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	0.1-0.5

2) Characteristics of effluent wastewater

Table (4) shows the characteristics of effluent wastewater coupled with Iraqi standards for disposal into rivers and valleys. The average pH value of effluent was 6.97. It is within Iraqi standards for disposal, whereas the average concentration for each of BOD_5, COD and TSS were (26.05, 56.28 and 54.18) mg/l respectively, the TSS reaches permissible limits for disposal compared with Iraqi standards for disposal. Improper settlement in secondary settling tank for removal of microbial mass may be due to some problems in the aeration basin including excessive turbulence, anaerobic conditions and toxic shock load [10].

The ammonia concentration in effluent was 26.19 mg/l exceeding the Iraqi standards by 260 times, whereas effluent nutrient concentrations for NO_3 and PO_4 were (4.68 and 3.05) mg/l respectively. These concentrations exceeded Iraqi permissible limits for disposal by 4.7 and 3 times respectively.

High concentrations of nutrients (NO_3 and PO_4) in the effluent discharge lead to immoderately growth of an algae and hydrophytes which is known as eutrophication, [11]. Other factors that affect up on the efficiency are temperature, flow of wastewater, pH and presence of different components of toxic matter [12].

The average concentration of effluent chloride was 57.33 mg/l and of dissolved oxygen in disposal wastewater was 5.67mg/l, these concentrations are within Iraqi standards for disposal, and this may be attributed to long flow distance and high flow velocity.

The range of BOD_5/COD ratio of effluent wastewater was (0.35 – 0.5), It is a high ratio compared with the ratio of (0.1- 0.3) table (3) for treated wastewater. The variation between BOD_5 and COD concentrations for effluent wastewater refer to the presence of non-biodegradable organic compounds and this refers to the fact that the effluent needs additional treatment [13]. Mixed liquor suspended solids (MLSS) concentrations was in the range of (1116-2536) mg/l versus (3000-6000) mg/l as designing value for extended aeration process [8], This is attributable to the scarcity of recycling the sludge from the settling basin to the aeration tank, the ratio was 67.92% compared with the design value of 100% and even more during optimal operation for extended aeration system.

Table (4): Effluent (treated) wastewater characteristic of Al-Khadraa' WWTP

Parameter / Month	BOD_5 mg/l	COD mg/l	TSS mg/l	NO_3 mg/l	PO_4 mg/l	NH_3 mg/l	Cl mg/l	pH Unit	Temp. °C	DO mg/l	BOD_5/ COD
Mar.	36.25	67.1	51	5.35	2.61	34.5	53.92	7.1			0.54
Apr.	21.5	61.4	34	4.71	4.07	49.87	57.22	6.72			0.35
May	23.33	61.05	53	5.15	3.07	42.97	64	7.4			0.38
Jun.	23	60.53	106.66	4.66	2.86	22.16	61.23	7.26			0.38
Jul.	23	59.4	61	4.95	2.6	27.47	61.65	6.85			0.38
Aug.	21.66	48	38.66	4.2	3	9.1	58.9	6.76			0.45
Sept.	26.5	52.85	49	3.03	4.63	20.9	54.75	6.67			0.5
Oct.	27.5	49.5	45.5	4.6	2.42	17.95	54.35	6.65	25.1	4.15	0.55
Nov.	35	60.1	51	5.04	2.67	20.55	55.45	7.05	18	6.33	0.58
Dec.	22.75	42.9	52	5.17	2.6	16.45	51.84	7.25	12	6.55	0.53
Min	21.5	42.9	34	3.03	2.42	9.1	51.84	6.65	12	4.15	0.35
Max	36.25	67.1	106.66	5.35	4.63	49.87	64	7.4	25.1	6.55	0.58
Average	26.05	56.28	54.18	4.68	3.05	26.19	57.33	6.97	18.36	5.67	0.42
Disposal limits[14]	< 40	100	30	< 1	< 1	< 0.1	250	6.5-8.5	13-30	5	0.1-0.3

The range of removal of TSS was (57.34 – 80.62)% with an average value of 69.7%. This range is considered too low compared with the range (85-95)% table(5). This gives an indication that the plant performance in removing suspended solids is weak. The removal ratio of BOD_5 and COD ranged from (71 – 88.78)% and (71 – 82.51)% respectively with an average of 83.15% and 79% respectively, and this removal ratio is less than the recommended range for extended aeration treatment plants (85 – 95)%. This reveals that the plant is suffering in removing from wastewater.

The decrease in plant efficiency in removing BOD, COD and TSS is attributed to the recycling of old sludge that contain fewer microorganisms, in addition to the lack of MLSS for aerobic digestion of the organic matter. The average concentration of dissolved oxygen in aeration tank was 0.73mg/l, whereas the dissolved oxygen concentration in the aeration tank should not be less than (1-3) mg/l [15]. Dissolved oxygen is essential element for

microorganisms respiration and providing them with required energy to complete decomposition and oxidation in the aeration tank, The activated sludge process depends on the activity of aerobic microorganisms, consequently the accurate control and ensuring the remaining dissolved oxygen concentration in the aeration tank over than 2 mg/l is necessary and vital for the stability of the process [16].The weakness in aeration process is due to the inefficient aeration system because of deterioration of the air compressors [15].

Table (5): Average monthly overall removal of BOD_5, COD, TSS, PO_4 and NH_3 in Al-Khadraa' WWTP

Parameter / Month	BOD_5 %	COD %	TSS %	PO_4 %	NH_3 %
Mar.	71	71.04	80	13	34.65
Apr.	88.37	80.41	80.62	52.45	33.73
May.	84.44	75.13	61.24	61.95	29.9
Jun.	88.78	81.78	59.49	69.34	56.71
Jul.	87.56	81.85	57.34	71.11	55.47
Aug.	86.73	76.74	64.2	64.07	67.5
Sept.	80.55	80.64	77.05	47.38	43.96
Oct.	77	81.42	73.39	68.36	56.64
Nov.	78.78	79.05	75.94	65.32	17.63
Dec.	88.33	82.51	67.8	48.5	22.66
Min	71	71.04	57.34	13	17.63
Max	88.78	82.51	80.62	71.11	67.5
Average	83.15	79	69.7	56.15	41.88

Conclusions

According to what is mentioned above the problems of Al-Khadraa treatment plant can be abridged in the following points:-

1-Inefficiency in aeration tank performance which is the major part of treatment because of the lack in air diffusors performance which leads to inefficiency in dissolved oxygen concentration necessary for oxidation and microorganisms duration into tank

2-Stopping aeration for long periods leads to microorganisms debilitation and retardance into aeration tank operation in spite of sludge recirculation from the bottom of secondary settling tank into aeration tank (Omer, et al, 2010).

3-The effluent quality exceeds the Iraqi standards for disposal into water bodies, especially for the parameters of TSS, NO_3, PO_4 and NH_3

4-Irregular plant operation due to the availability and variation in the influent have an adverse effect up on the quality of the effluent from the plant.

5-Lack of specialized technicians in the field of treatment.

6- The plant is out of service now.

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تقييم أداء محطة الخضراء لمعالجة مياه الصرف الصحي، الموصل– العراق.

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الملخص

تهدف هذه الدراسة إلى تقييم الكفاءة التشغيلية لمحطة معالجة الخضراء ومدى توافق نوعية المياه المعالجة مع المحددات العراقية للطرح في الأنهار والمجاري المائية. تبين من خلال الدراسة أن هنالك تغاير كبير في كميات ونوعية المياه الداخلة إلى المحطة ما يؤدي ذلك إلى إيقاف تشغيل المحطة في بعض الاحيان وانعكاس ذلك سلبا على أداء المعالجة في المحطة. بينت النتائج أن شدة تركيز المياه الداخلة الى المحطة يمكن تصنيفها متوسطة– ضعيفة وان نسبة BOD_5/COD تساوي 0.6 , كما أظهرت النتائج أن كفاءة المعالجة في المحطة ضعيفة وأن نوعية المياه المعالجة لا تتطابق مع المحددات العراقية للطرح في الأنهار والمجاري المائية إذ بلغت نسب الإزالة لكل من BOD، COD، TSS، PO_4 ، NH_3 (83.15%، 79% و69.7%، 56.15%، 41.88%)على التوالي وكفاءة الإزالة كانت على الترتيب BOD>COD>TSS>PO_4>NH_3.

الكلمات الدالة: تقييم محطة معالجة مياه الفضلات، المعالجة البايولوجية، خصائص مياه الفضلات، BOD_5 ، COD ، TSS ، NO_3 ، نسبة BOD_5/COD. مدينة الموصل.