Performance Evaluation of Al-RustamiyaWastewater Treatment Plant

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ABSTRACT

Al-Rustamiya sewage treatment plant (WWTP) serves the east side of Baghdad city (Rusafa) and is considered one of the largest projects.It consists of three parts (old project F0, first extension F1, and second extension F2) that treat wastewater and the effluent is discharged into Diyala river and thus into the Tigris River. These plants are designed and constructed with an aim to manage wastewater to reachIraqi effluent standard for BOD_5, COD, TSS and chloride concentrations of 40, 100, 60 and 600 mg/L respectively. The data recordedfrom March till December 2011 provided from Al-RustamiyaWWTP, were considered in this study to evaluate the performance of the plant. The results indicated that the strength of the wastewater entering the plant varied from medium to high. The average concentrations of the effluent of BOD_5, COD, TSS and chloride were within Iraqi effluent standards. The overall efficiency removalswere:
For BOD_5: 92.1, 90.31, and 92.96% for F0, F1, and F2 respectively
COD: 88.23, 87.9, and 87.95% for F0, F1, and F2 respectively
TSS: 86.98, 80.72, and 89% for F0, F1, and F2 respectively
Chloride: 14.79, 15.37, and 15.31% for F0, F1, and F2
The mean value of BOD_5/COD ratio of the raw wastewater was 0.67 as for typical untreated domestic wastes. The mean BOD/COD ratios of the treated sewage from F0 was 0.48, from F1 0.50 and from F2 0.38. These ratios did not confirm with the typical ratios indicating that the wastewaterneeds more treatment.

KEYWORDS: Al-RustamiyaWWTP, domestic wastewater characteristics, chemical oxygen demand,biochemical oxygen demand, total suspended solids, pH, chloride.

تقييم اداء محطة الرستمية لمعالجة مياه الصرف الصحي

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الخلاصة

تخدم محطة معالجة مياه الصرف بالرستمية الجانب الشرقي لمدينة بغداد الرصافة ويعتبر واحد من اكبر المشاريع ويتالف من ثلاثة اجزاء (المشروع القديم F0والتوسعة الاولىF1 والتوسعة الثانية F2) ويقوم المشروع بمعالجة مياه الصرف الصحي ورمي المياه بعد المعالجة الى نهر ديالى وهكذا الى نهر دجلة بعد المرور بمجموعة من العمليات. وهذه المحطة مصممة لمعالجة مياه الصرف الصحي يموجب المواصفة العراقية 40لتراكير BOD_5,CODوالمواد العلقة والكلوريد

المساوية الى 40 و100و60و 600 ملغم/لتر على التوالي.القراءات اليومية للفترةمن بداية شهر اذار ولغاية نهاية كانون الاول عام 2011 لقياسات خصائص مياه الصرف الصحي في مداخل ومخارج المحطة زودت من ادارة محطة معالجة الرستميةلتقييم اداء المحطة.النتائج اظهرت ان قوة مياه الصرف الصحي تتفاوت من الوسط الى المستوى العالي وان المياه المعالجة ذات تراكيز لل BOD_5 و COD والمواد العالقة والكلوريدكانت ضمن المواصفة العراقية لرمي المياه المعالجة الى المصادر المائية. والاداء العام لمحطة الرستمية بمراحله المشار لها يكون جيد .وكانت كفاءة الازالة العامة هي:

1-قيم ال $BOD_5$92.1 و 90.31 و 92.96% على التوالي للرستمية F_oوF_1 و F_2

2-قيم الCOD87.23 و 87.9و 87.95 %على التوالي للرستمية F_oوF_1 و F_2

3-قيم ال SS 86.98 و 80.72و 89%على التوالي للرستمية F_oوF_1 و F_2

4-قيم الكلورايد 14.79 و 15.37و 15.31% على التوالي للرستمية F_oوF_1 و F_2.

ان متوسط قيمة نسبة (BOD_5/COD) لمياه الصرف الخام كانت 0.67 وكما هي لمياه الصرف المنزلية غير المعالجة. واماللمياه الصرف المعالجة فان معدل نسبة BOD_5/COD في الرستمية القديم F0هي 0.48 وبالنسبة للتوسع الاولFفكانت0.50 والبالنسبة للتوسع الثاني Fكانت النسبة 0.38 . وهذه النسب من (BOD_5/COD) لم تكن مطابقة للنسب المثالية للمياه المعالجة.و هذه المياه تحتاج الى معالجة اكثر.

الكلمات الرئيسة: الرستمية(محطة معالجة مياه الصرف)، خصائص مياه الصرف المنزلية، الحاجة الكيميائية للاوكسجين، الحاجة البايوكيميائية للاوكسجين، المواد العالقة الكلية ، الدالة الحامضية PH، الكلورايد.

INTRODUCTION

Sewage is created by residences, institutions, commercial and industrial establishments. It can be treated close to where it is created (in septic tanks, onsite package plants or other aerobic treatment systems), or collected and transported via a network of pipes and pumping stations to a treatment plant. Industrial sources of wastewater often require specialized treatment processes. Wastewater treatment is the process of removing the contaminants from itby physical, chemical and biological processes. Its objective is to produce a treated effluent and a solid waste or sludge suitable for discharge. This sludge may also be reused. The sludge is often inadvertently contaminated with toxic organic and inorganic compounds. Typically, sewage treatment involves three stages, called primary, secondary and tertiary treatment.

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 (Kambole, 2003). Water pollution is the most serious environmental issue due to the disposal of solid and liquid waste on land and into surface water. Among them the most significant are domestic wastewater, industrial effluent and agriculture residues and chemicals (Poudyal, 2000). Moreover continued discharge of domestic and industrial wastewater directly into the rivers is one of the main cause'sriver pollution.

Wastewater treatment plantsare designed and operated 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 wastewater treatment facilities (Jamrah,1999). As such urban drainage system should also be considered as an important infrastructure in removing both wastewater and rainwater from the city to prevent unhygienic conditions and to avoid damage from flooding (Karrman, 2001 and Erbe*et al*., 2002).

The reduction of BOD_5 and COD in different treatment units of a plant can be used to measure the efficiency of each unit in wastewater treatment. The ratio of BOD_5/COD indicates the biodegradability of wastewater and the higher the ratio thehigher biodegradability of the wastewater (Metcalf and Eddy, 2003).

Ratio values depend on the nature of the wastewater namely; whether it is municipal or industrial oriented andvaryconsiderably with the degree of treatment the wastewater has undergone (Metcalf and Eddy, 2003). The COD/BOD_5 ratio value for municipal raw wastewater is in the range of 1.25 to 2.5, whereas for industrial wastewater up to 10 or more (Markantonatos,1990).Therefore, municipal wastewater is able to be biologically degraded more than industrial wastewater. COD/BOD_5 ratios in the range from 3 to 7, indicates that the wastewater is moderately biodegradable. However, there is no official COD/BOD_5 ratio index for different types of wastewater. In the case of extremely low biodegradable wastewater, ($COD/BOD_5>10$), a treatment process that will reduce the chemically oxidized organic part is required so the ratio will reach the 'biodegradable' range ($COD/BOD_5<3$). Such a significant change in COD/BOD_5improves the efficiency of subsequent biological treatment (Pak and Wonseok, 1999, Hsieh et al., 2000).

Several researches studied the performance of Al-Rustamiya wastewater treatment plant.

Palmer, (2004)carried out a description field study on the performance of the Al-Rustamiya plant, 3rd extension for the benefit of the American International Development Agency (USIDA) and CPA (Coalition Provisional Authority). The study was done in order to carry out a rehabilitation work on the plant which was later executed. The aim of the rehabilitation program was to achieve a secondary (biological) treatment compatible with thedesign aim as stated previously by Haist and Parteners in 1981. His study presented a description for the treatment process (physical, biological and chemical) and an assessment of the quality of effluents as stated by the original designer Haist and Partners in1981. The effluent quality which was employed by the designer was based on the Iraqi standards of effluent discharges into receiving waters.

AL-Samawi, H., (2008) studied the efficiency performance of Al-Rustamiyah WWTP before and after rehabilitation, to check the efficiency of the rehabilitated work. Data from the different treatment units within the plant for year 2006 were statistically analyzed and compared with the original design parameters and the Iraq standards of effluent discharges into the receiving water. The results indicated that the effluent discharged from Al-RustamiyaWWTPinto DiyalaRiver was not in complete agreement with the Iraqi effluent standards. However, the results of the biological processes;aeration tanks and final clarifiers showed that there was a clear chronic biological upset. The results indicated clearly that the rehabilitated program had no significant effect on improving its state of dereliction.

Alzuhary, (2008) evaluated the efficiency of the sewage treatment plants at Al-Risafa and Al-Karkh sides of Baghdad city. The calculations were executed according to the average and peak capacity of each plant depending on three values of population growth rates in Baghdad for the period 2005-2025. The study reveals that the deficit ratio in treatment efficiency will reach 273% at 2025 in Al-Rustamiyah WWTP. The situation will be more critical at Al-Karkh sewage treatment plant where the deficit in efficiency will approach 700%.

Knowledge of mean concentrations, ratios and variation range of chemical parameters used to describe wastewater quality is crucial for ensuring suited design and sizing of treatment facilities. This paper describes the performance of Al-Rustamiya wastewater treatment (WWTP), in Baghdad, in terms of wastewater characterization of the influent and effluent.The performance evaluation is to derive a comparative account between the pollution load before and after the treatment processes, besides, discerning their efficiency. The main objective of the study is to study the concentrations; ratios and variation range of wastewatercharacterized by BOD_5, COD, TSS, pH and chloride as well toexamine the BOD_5/COD ratio fluctuation based on BOD_5 and COD variations.

MATERIAL AND METHODS:

Study Area Description

Baghdad city is about 900 km^2 and the approximation number of population for the year 2010 was 7.6 million people. It is a very largecity and almost flat divided by the Tigris River to two main parts: the east side (Rusafa) and the western side (Karkh). The city includes 457 sectors where about 82% of the sectors are served by sewerage systems.

Baghdad city has three projects for wastewater treatment. These projects are Al-RustamiyaSouth Station,Al-Rustamiya North Station and Al-Karkh.These stations suffer in the recent years of weakness in the arrival of spare parts and a deficit in the maintenance of mechanical and electrical equipment. Karkh sewage treatment project serves the western side of Baghdad (Karkh) at a design capacity of205,000m^3/day, while the current incoming flow is 625,000 m^3/day.

Al-Rustamiya wastewater treatment plant serves the eastern side of Baghdad (Rusafa) it is considered one of the largest projects that treats wastewater.The effluent is discharged into Diyala river and thus into the Tigris River. Al-Rustamiya wastewater treatment plants are illustrated in Fig. (1).

Al-Rustamiya (WWTP) is the oldest project in Iraq,it consists of:

a) The old project, Al-RustamiyaSouth station working since1963and consists of threeintegratedprojects which are zero (F0)andexpansionI(F1), with a designed capacity of175,000m^3/daywhere theactual flow reaches300,000m^3/day.This plant serves 1,500,000 inhabitants on the eastern side of Baghdad.

b) Al-RustamiyaNorth station,Expansion II (F2) working since 1984with a design capacity of 300,000m^3/dayandtheactual influent 450,000 m^3/day from1.5 millionpeopleserved in theeasternside of Baghdad. Thefinal disposalof the plantis into the Diyala River.

DATA COLLECTION AND ANALYSIS

The collection and experimental data used in this paper were provided by Al-Rustamiya STP's office-Mayoralty of Baghdad.

The data collected were biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), pH and chloride of the influent and effluent of the Al-RustamiyaWWTPthrough the study period from March till December 2011 and represented as daily and monthly average values for each parameter.

RESULTS AND DISCUSSION

One of the commonly found environmental problems in developing countries is water pollution caused by direct disposal of untreated wastewater. In Iraq, most of the wastewater treatment plants are not functioning due to high cost of spare parts, chemical additives, utility bills and lack off trained human resources. These financial and managerial problems are common in every developing country.

1. Characteristics of the influent Wastewater

The average monthly concentrations of BOD_5, COD, TSS, pH and chloride in the influent ranged from 221.43 to 252.11 mg/L with an average of 235.39 mg/L for BOD_5.As for COD it ranged from 258 to 443 mg/L with an average of 361.09 mg/L.The TSS ranged from 203.59 to 355.3 mg/L with an average of 245.16 mg/L and 288.55 to 342.21 mg/L with an average of 324.25 mg/L for chloride. The pH varied from 7.07 to 7.39 with an average value of 7.18 as shown in Table 1. The strength of the wastewater entering the plant varied from medium to high according to Table 2.

2. Characteristics of the effluent Wastewater

The average monthly concentrations of BOD_5, COD, TSS, pH and chloride of the effluentare shown in Table 1, from F0,F1 and F2 in Al-RustamiyaWWTP.The effluent concentrations of BOD_5, COD, TSS and chloride were within Iraqi effluent standards of 40, 100, 60 and 600 mg/L respectively. Considering the effluent of F1 in November, the BOD (44.3mg/L) and TSS (162.19mg/L) concentrations exceeded the effluent standards also the COD value was high regarding the overall effluent characteristics over the period of the study. This may be due to operational problems in the biological treatment of F1.

3. Overall Efficiency of Al-Rustamiya Treatment Plant

The overall efficiency of the Al-RustamiyaWWTPis shown in Table 3. The average BOD_5reduction at F0, F1and F2 was 92.1%, 90.31%, and 92.96% respectively. The average reduction of COD was88.23%, 87.95%, and 87.95% in F0, F1 and F2 respectively. As for the average reduction at F0, F1 and F2 for TSS was 86.98%, 80.72%, and 89% respectively.

As for F1 the lowest percentages removal for BOD, COD and TSS were observed in November. Low chloride reductionswere observed at F0,F1 and F2 that reached 14.79%, 15.73%, and 15.31% respectively as this plant is designed for the biological treatment of the organic matter represented by BOD or COD reduction and not for dissolved matter.

4. BOD_5/COD RATIO

Typical values ofBOD_5/COD ratio for untreated municipal wastewater are in the range of 0.3 to 0.8 as shown in Table 4. 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.For the influent raw sewage the BOD_5/COD ratios,shown in Table 5 ranged from a minimum of 0.54 to a maximum value of 0.89 with an average of 0.67, these values confirm with the typical ratios for the untreated sewage.For the effluent sewage from F0, the BOD_5/COD ratios range from a minimum value of 0.28 and maximum of 1.12 with an average of 0.48.The effluent from thefirst extension F1 had BOD_5/COD ratios ranging from 0.32 to 0.82 with an average of 0.50. As for the second extension F2the BOD_5/COD ratios ranged from 0.24 to 0.54 with an average value of 0.38. The high concentrations of BOD_5 and COD in the effluent gave highBOD_5 /COD ratios that did not confirm with the typical values for the treated sewage (Table 5). These results indicate that the wastewaterneeds more treatment.

The BOD_5/CODratio remains practically constant, after the wastewater has been treated anaerobically. This type of treatment plays a very important role in the performance of the whole treatment system, since it efficiently removes chemical and biological material maintaining.There is usually no correlation between BOD_5 and COD in wastewater with slowly biodegradable organic suspended solids and in complex waste effluents containing refractory substances (Eckenfelder, 1989). Hence, treated effluents may exert virtually no BOD_5 and yet exhibit a substantial COD. Since, the COD represents virtually all organic matter, either partially degradable or non-biodegradable where BOD_5represents the biodegradable matter only.

CONCLUSION

This study aimed to evaluate the BOD_5, COD, TSS and chloride removal efficiencies as well as itexamined the BOD_5/CODratio fluctuation inAl-Rastumiya municipal wastewater treatment plant comprising of its three stages.
The strength of the wastewater entering the plant varied from medium to high.
The concentrations of BOD_5, COD, TSS and chloride in the effluent were within the Iraqi effluent standards of 40, 100, 60 and 600 mg/L respectively.
The mean BOD_5/CODratio of the influent raw sewage to Al-RustamiyaWWTP was 0.67. andthe waste is considered to be easily treatable by biological means.
The mean BOD_5/CODratios of the effluent from Al-RustamiyaWWTP were, for F0 0.48, F1 0.5 and F2 0.38. The BOD_5/COD ratios varied considerably with the degree Of treatment the wastewater had undergone.

The performance ofAl-Rustamiya WWTP is determined fromthe overall efficiency removal in:

1. $BOD_5$was 92.1, 90.31, and 92.96% for F0, F1, andF2 respectively.
2. COD was 88.23, 87.9, and 87.95% for F0, F1, and F2 respectively.
3. SS was 86.98, 80.72, and 89% for F0, F1, and F2 respectively.
4. Chloride was 14.79, 15.37, and 15.31% for F0, F1, and F2 respectively.

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Fig(1) Al-Rustamiya wastewater treatment plant.

Table 1 Average monthly variation of BOD_5, COD, TSS, pH and chloride of Al-Rustamiya WWTP

Month	BOD ppm				COD ppm				TSS ppm				pH				Chloride ppm			
	Influent	F0	F1	F2	Influent	F0	F1	F2	Influent	F0	F1	F2	Influent	F0	F1	F2	Influent	F0	F1	F2
Effluent Standard		40				100				60				6.5 - 8.5				600		
Mar.	228.64	37.33	22.36	11.73	258.00	33.33	27.33	43.86	233.36	46.91	38.68	23.27	7.22	7.27	7.35	7.33	337.59	289.18	290.45	286.09
Apr.	241.58	11.53	16.95	16.26	397.00	41.67	41.00	54.50	355.30	24.35	28.55	23.80	7.07	7.33	7.33	7.35	334.45	283.45	288.85	289.75
May.	234.55	20.41	16.36	16.23	432.67	54.00	51.33	54.83	279.00	25.41	26.82	21.23	7.12	7.33	7.35	7.31	334.00	286.64	279.68	275.50
Jun.	242.38	17.05	18.19	19.67	443.00	39.38	39.38	42.38	235.86	21.29	26.48	20.19	7.07	7.25	7.25	7.26	325.33	281.33	274.10	277.71
Jul.	252.11	22.42	20.39	19.50	342.83	46.00	37.33	44.17	214.32	23.00	26.79	29.53	7.07	7.27	7.28	7.26	342.21	286.74	293.05	294.63
Aug.	240.50	18.55	20.30	18.30	341.70	40.00	38.40	33.90	203.59	28.45	28.95	22.59	7.15	7.32	7.34	7.30	318.77	278.32	273.91	274.00
Sep.	221.43	12.86	14.00	15.90	343.38	26.13	26.13	33.63	220.18	23.27	23.86	21.55	7.39	7.54	7.51	7.51	288.55	243.95	234.36	242.82
Oct.	226.09	18.48	15.04	13.17	331.21	38.21	38.50	38.75	235.92	29.96	24.42	21.79	7.28	7.43	7.44	7.45	317.29	267.13	267.71	264.67
Nov.	226.00	17.30	44.30	15.30	398.31	42.19	77.81	36.19	228.63	34.63	162.19	32.19	7.24	7.45	7.48	7.43	324.00	271.25	272.50	270.13
Dec.	240.59	14.76	21.82	11.65	322.76	49.00	51.32	48.47	245.45	22.55	29.90	20.60	7.22	7.43	7.47	7.46	320.30	264.75	262.60	262.30
Average	235.39	19.07	20.97	15.77	361.09	40.99	42.85	43.07	245.16	27.98	41.66	23.67	7.18	7.36	7.38	7.37	324.25	275.27	273.72	273.76
STDEV	9.64	7.21	8.67	2.91	56.29	7.83	14.80	7.74	43.67	7.80	42.55	4.00	0.11	0.09	0.09	0.09	15.16	13.91	17.09	15.08
MIN.	221.43	11.53	14.00	11.65	258.00	26.13	26.13	33.63	203.59	21.29	23.86	20.19	7.07	7.25	7.25	7.26	288.55	243.95	234.36	242.82
MAX.	252.11	37.33	44.30	19.67	443.00	54.00	77.81	54.83	355.30	46.91	162.19	32.19	7.39	7.54	7.51	7.51	342.21	289.18	293.05	294.63

Table 2 Strength classification of Untreated Sewage (Metcalf and Eddy, 2003).

Parameter	Strength		
	Low	Medium	High
BOD_5 mg/L	100	200	400
COD mg/L	175	300	600
TOC mg/L	100	200	400

Table 3 Average monthly overall of BOD, COD, TSS and chloride removal in Al-Rustamiya WWTP

Month	BOD_5 Removal%			COD Removal%			TSS Removal%			Chloride Removal%		
	F0	F1	F2	F0	F1	F2	F0	F1	F2	F0	F1	F2
Mar.	88.87	89.88	94.52	86.82	89.22	85.87	78.46	80.32	88.34	13.87	13.75	15.07
Apr.	94.98	92.80	92.64	89.56	89.52	86.27	92.04	91.04	92.16	14.97	13.45	13.19
May.	90.71	92.40	92.86	86.84	87.81	86.90	89.72	89.20	91.40	13.95	16.22	17.17
Jun.	92.72	92.41	91.39	90.33	90.07	90.03	89.34	87.87	90.39	12.91	15.16	13.98
Jul.	91.05	92.22	92.64	86.34	89.03	87.19	87.86	85.80	84.43	16.10	14.05	13.76
Aug.	92.01	91.26	92.19	87.86	88.41	89.59	84.44	83.89	87.97	12.05	13.52	13.29
Sep.	93.55	93.23	91.89	92.27	92.13	89.47	88.04	87.88	89.09	15.51	18.53	15.93
Oct.	91.48	93.02	93.81	87.84	88.24	87.90	85.85	88.71	90.13	15.72	15.70	16.62
Nov.	91.80	75.80	92.64	89.23	80.49	90.86	84.05	25.77	84.86	15.83	15.72	16.51
Dec.	93.83	90.06	95.03	85.17	84.11	85.46	90.01	86.70	91.20	16.99	17.60	17.61
Average	92.10	90.31	92.96	88.23	87.90	87.95	86.98	80.72	89.00	14.79	15.37	15.31
STDEV	1.75	5.23	1.15	2.13	3.30	1.91	3.93	19.54	2.65	1.55	1.75	1.67
MIN.	88.87	75.80	91.39	85.17	80.49	85.46	78.46	25.77	84.43	12.05	13.45	13.19
MAX.	94.98	93.23	95.03	92.27	92.13	90.86	92.04	91.04	92.16	16.99	18.53	17.61

Table 4 Comparison of ratios of various parameters used to characterize wastewater.

Type of wastewater	BOD_5/COD	BOD_5/TOC
Untreated	0.3-0.8	1.2-2.0
After primary settlement	0.4-0.6	0.8-1.2
Final effluent	0.1-0.3	0.2-0.5

Table 5 Average monthly values of BOD_5/COD ratio of Al-RastumiyaSTP.

Month	BOD_5-COD RATIO			
	C	F0	F1	F2
Mar.	0.89	1.12	0.82	0.27
Apr.	0.61	0.28	0.41	0.30
May.	0.54	0.38	0.32	0.30
Jun.	0.55	0.43	0.46	0.46
Jul.	0.74	0.49	0.55	0.44
Aug.	0.70	0.46	0.53	0.54
Sep.	0.64	0.49	0.54	0.47
Oct.	0.68	0.48	0.39	0.34
Nov.	0.57	0.41	0.57	0.42
Dec.	0.75	0.30	0.43	0.24
Average	0.67	0.48	0.50	0.38
STDEV	0.11	0.24	0.14	0.10
MIN.	0.54	0.28	0.32	0.24
MAX.	0.89	1.12	0.82	0.54