Qualitative assessment of treated wastewater for Irrigation Purpose in Al-Hindiyah district / Karbala City / Iraq

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Abstract

Reuse wastewater for irrigation purposes can be a realistic solution to the problem of water scarcity in Iraq. This paper was conducted to study the specifications of influent and effluent wastewater of two treatment plants, Muharram Easha and Al-Menfhan which is located in Iraq/Karbala city/ Al-Hindiyah district to evaluate the efficiency of the two plants and to assess the possibility of re-use the effluent water for irrigation purpose. The variables that have been examined in this paper are Biological oxygen demand (BOD) , chemical oxygen demand (COD), total suspended solids (TSS), degree of alkalinity(pH), nitrate (NO_3-N),(fat, oil and grease) (FOG), total dissolved solids(TDS), chloride(Cl^{-1}), and sulfate(SO_4^{-2}). The results showed that the mean values of removal efficiency of (BOD) and (COD) for Muharram Easha plant were between 88% and 84% respectively while the mean values for these parameters for Al-Menfhan plant were between 87% and 79% respectively. The mean values of removal efficiency of TSS and FOG for Muharram Easha plant were between 79% and 71% respectively and the mean values of these parameters for Menfhan plant were between 74% and 75% respectively. The results illustrated that according to Jordanian standards for wastewater reuse in irrigation JS 893/2006, the effluent wastewater for Al-Menfhan wastewater treatment plant can be reuse for irrigation purpose.
Keywords: Irrigation, Jordanian standards, Removal efficiency, Wastewater reuse.

التقييم النوعي لمعالجة مياه الصرف الصحي لغرض الري في قضاء الهندية/ مدينة كربلاء/ العراق

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الخلاصة

إن إعادة استخدام مياه الصرف الصحي لأغراض الري يمكن أن يمثل احد الحلول الواقعية لمشكلة شحة المياه في العراق. أجري هذا البحث لدراسة مواصفات مياه الصرف الصحي الداخلة والخارجة من محطتي محرم عيشة و المنفهان الواقعتين في محافظة كربلاء ضمن الحدود الإدارية لقضاء الهندية لغرض تقييمها وتحديد إمكانية إعادة استخدامها لغرض الري. المتغيرات التي تم فحصها في هذه الدراسة لمياه الصرف الصحي هي المتطلب الحيوي للأوكسجين BOD، المتطلب الكيميائي للأوكسجينCOD ، ومجموعة المواد الصلبة العالقةTSS، ودرجة القلويةpH و النتراتNO_3-N والدهون والزيوتFOG والمواد الصلبة الذائبةTDS و الكلوريدCl^{-1} والكبريتات SO_4^{-2}. أظهرت النتائج أن متوسط قيم كفاءة إزالةBOD و COD لمحطة محرم عيشة كانت بين 88٪ و 84٪

على التوالي، بينما كان متوسط القيم لهذه المتغيرات لمحطة المنفهان بين 87٪ و 79٪ على التوالي . وتوضح من النتائج بان القيم المتوسطة لكفاءة إزالة TSSوFOG لمحطة محرم عيشة كانت بين 79٪ و 71٪ على التوالي، بينما كانت القيم المتوسطة لهذه المتغيرات لمحطة المنفهان بين 74٪ و 75٪ على التوالي. استنادا إلى المواصفة الأردنية لإعادة استخدام مياه الصرف الصحي في الري والمرقمة JS 893/2006 والنتائج التي تم الحصول عليها ،تبين انه من الممكن استخدام مياه الصرف الصحي الخارجة من محطة المنفهان لغرض الري .
كلمات البحث: الري، المواصفة الاردنية، وكفاءة الإزالة، اعادة استخدام مياه الصرف الصحي.

1-Introduction

The problem of water scarcity has increased dramatically over the last few decades, particularly in the arid and semi-arid areas. There is concern that the world is heading towards the water crisis. Lack of water and deterioration of its quality hinder the economic development in many developing countries. Throughout the world, the agriculture sector is the largest consumer of water. Agriculture sector consumes approximately 67% of the total water withdrawal and accounts for 86% of total consumption in 2000 (1). By 2025, an irrigation water requirement is expected to increase by 1.2 times (2). More efficient use of agricultural water through wastewater reuse is essential for sustainable water management (3).

It is important to look for other sources of water or reuse safely for various purposes, especially in the field of agricultural. There has been an increasing interest in the re-use of wastewater to irrigate various crops over the past few decades because of increased demand for fresh water. Population growth, increased use of water per capita, and the requirements of the industry and the agricultural sector contributed to the increasing pressure on water resources (4).There-use of wastewater in agriculture has potential for both positive and negative environmental impacts (5); with careful planning and management the use of wastewater in agriculture can be beneficial to the environment. (6).Irrigation by using wastewater can increase the available water supply or release better quality supplies for alternative uses. In addition to these direct economic benefits that conserve natural resources, the fertilizer value of many wastewaters is important (7).

FAO estimated that typical wastewater effluent from domestic sources could supply all of the nitrogen and much of the phosphorus and potassium that are normally required for agricultural crop production (8). However, the wastewater may contain unwanted chemical composition unwanted pathogens that constitute negative environmental and health impacts (9). At the same time, a number of risk factors have been identified in wastewater reuse, some of them are short term (e.g., microbial pathogens) whereas others have longer-term impacts that increase with the continued use of recycled water (e.g., salinity effects on soil). So, many guidelines have been developed to give a wastewater quality criteria and guidance on how treated wastewater should be reused for irrigation purposes (10, 5).

The amount of waste water that is collected and treatment has increased substantially with population growth and rapid urbanization, and improving the coverage of health services (11, 12). Hence, the use of treated wastewater in agriculture is one of the strategies adopted for increasing water supply in arid and semi-arid areas (13).

Wastewater also has been used in agriculture for decades in many countries like India , United State , Australia, Spain , South Africa [(14)].Under the conditions of increased freshwater scarcity at Arabian countries like Saudi-Arabia [(15,16)], Kuwait [(17)],and Jordan [(18,19)] the reuse of wastewater in agriculture is receiving great attention and increased recognition as a potential water source.

Historically, Iraq has an abundance of fresh surface water resources, which contains the Euphrates and Tigris rivers and their tributaries [(20)]. Most of the fresh water from these rivers comes from Turkey (71%) followed by Iran (6.9%) and Syria (4%). The reminder is from internal sources [(21)]. In 1977, the Turkish government set up a project referred to as Southeastern Anatolia Project (GAP) that include 22 dams and 19 hydraulic power plants which are supposed to irrigate 17,000 km^2 of land. Syria built three major dams with a total storage capacity of 16.1 km^3. When GAP project is completed, 80% of the Euphrates water will be controlled by Turkey [(21)].

The flow of the Tigris and the Euphrates is expected to decrease further by 2025, with the Euphrates declining by more than 50 percent and the Tigris by more than 25 percent [(22)].

Iraq now faces water shortages especially during the hot summer months of June, July and August [(20)].The gap between supply and demand is increasing [(21)].However, in Iraq such usage of treated or untreated wastewater has not been widely investigated and evaluated [(6)].

Karbala is one of the major Iraqi cities, which also suffers from water scarcity and this city receives its water requirements from the Euphrates river. In addition to all that the city is one of the religious cities receives millions of visitors annually, which constitutes an additional stress on water requirements.

Al-Hindiyah region is one of the districts of Karbala city. This district has two new wastewater treatment plants are the Muharram Easha and Al-Menfhan which were constructed in 2010.This paper aims to evaluate the efficiency of the two wastewater treatment plants and to assess the possibility of re-use the effluent water for the purpose of irrigation as non-conventional water resources.

2. Study Area

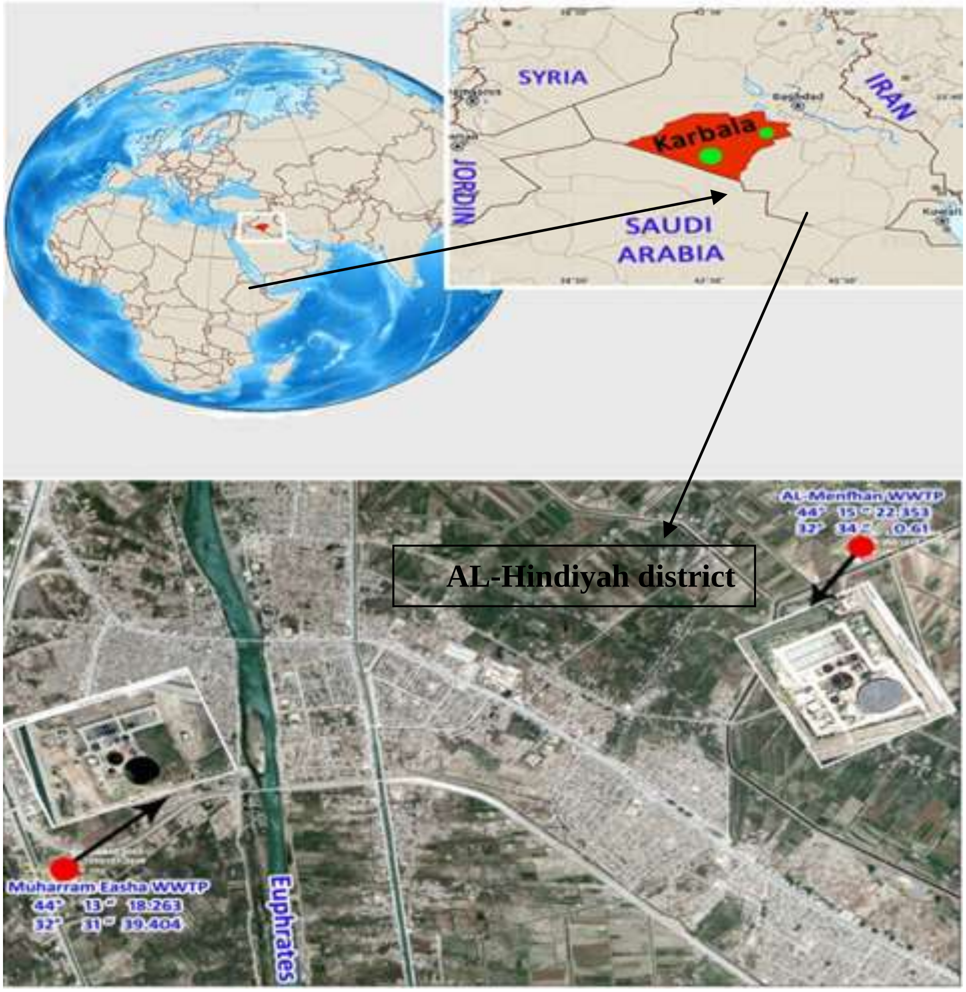
The present paper studied two wastewater treatment plants located in Al-Hindiyah district -Iraq with design capacities ranging from (6000-12000) m^3/day. Al-Hindiyah district falls within the scope of Karbala Governorate at the site of (32° 32′ 36″ North latitude) and (44° 13′ 21″ East longitude), approximately 100 km south of Baghdad and about 25 km southeast of Karbala city center. This region is characterized by arid to semi-arid climate with dry hot summers and cold winters. The temperature during summer is usually over 43°C during July and August and drops down to 16°C and 2°C during the day and night respectively in winter time. The mean annual rainfall is about 2.5 mm .More characteristic of the study area is the density of palm groves and citrus trees and fruits cultivated there. In addition, wheat, barley and rice are grown in abundance in this region. Soil texture was analyzed and was found to be sandy clay. The estimated wastewater production in this region will be 35000 m^3/day. Shatt al-Hindiyah is a branch of the Euphrates River and it represents the main source of the water requirement for the study area for different uses as drinking, irrigation, and other purposes. It has a discharge approximately 100 m^3/sec. This river divides Al-Hindiyah district into two parts, right part that called Al-Soub al –Segeer and left part that called Al-Soub al-Kabeeras shown in Fig.(1).

2.1 Muharram Easha wastewater treatment plant

Muharram Easha wastewater treatment plant MEWTP lies in (Al-soub al al-Kabeer) at coordinates of (32° 31′ 39.404″ North latitude) and (44° 13′ 18.263″ East longitude) as shown in Fig.(1). This plant is designed to serve about 50,000 people, with the design effluent discharge of 12000 m^3/day, while the actual discharge about 8000 m^3/day.

2.2 Al-Menfhan wastewater treatment plant

Al-Menfhan wastewater treatment plant AMWTP lies in (Al-Soub al -Sageer) at coordinates of (32° 34′ 0.61″ North latitude) and (44° 15′ 22.353″ East longitude) as shown in Fig.(1). This plant is designed to serve about 20,000 people, with the design effluent discharge of 6000m^3/day while the actual discharge about 4000 m^3/day.



Figure(1).AL-Hindiyah district and locations of Muharram Esaha and AL-Menfhan WWTPs.

3. Sampling and Analysis

Wastewater samples were collected on-site from influent and effluent wastewater for the two plants at a rate of twice per month during August 2011 to May 2012 in 3 L stopper fitted polyethylene bottles that prewashed with dilute hydrochloric acid and then rinsed several times with the same sample water quality to be examined before filling them to the required capacity. These samples were stored in a refrigerator at temperature below 4C° prior to analyze at the central laboratory of the sewerage directorate of Karbala / Division of Laboratory and the environment / Ministry of Municipalities and Public Works -Iraq.

The samples were analyzed Biochemical parameters which were biochemical oxygen demand and chemical oxygen demand and physicochemical parameters which were include total suspended solids, degree of alkalinity, nitrate, fat, oil and grease, total dissolved solids, chloride, and sulfate. The parameters were measured according to standard methods for the examination of water and wastewater [APHA–AWWA–WEF, 1998] [23] as described in Table (1).

Table (1).Water quality parameters, units, and standard methods techniques.

Parameters	Abbreviation	Standard Method Techniques
Biological oxygen demand	BOD_5 (mg/l)	APHA: AWWA:WEF, (1998) section 5210B
Chemical Oxygen Demand	COD (mg/l)	APHA : AWWA:WEF, (1998) section 5220 C
Total Suspended Solids	TSS (mg/l)	APHA : AWWA:WEF, (1998) section 2540D
Alkalinity	pH	APHA : AWWA:WEF,(1998) section 4500-H+/ B
Nitrate -nitrogen	NO_3-N (mg/l)	APHA: AWWA:WEF, (1998) section 4500-NO_3 B
Fat , Oil & Grease	FOG (mg/l)	APHA: AWWA:WEF, (1998) section 5520B
Total Dissolved Solids	TDS (mg/l)	APHA : AWWA:WEF, (1998) section 2540C
Chloride	CL^{-1} (mg/l)	APHA: AWWA:WEF, (1998) section 4500-Cl B
Sulfate	SO_4^{-2} (mg/l)	APHA : AWWA:WEF, (1998) section 4110 B

4. Treatment method

MEWTP and AMWTP use secondary treatment with activated sludge of wastewater. Appendix A shows the phases of raw wastewater treatment in the two plants. The treatment process in the two plants can be explained as follows:

1. The incoming raw wastewater to the treatment plant (influent) are collected in the inlet tank and then pumped to passing through a bar screens to remove all large objects like cans, rags, sticks, plastic packets etc. carried in the sewage stream. The material removed is transported to landfills. Generally this stage reduces and /or prevents damage or clogs the pumps and pipes and other equipment in the remaining treatment stages.
2. The wastewater passes through the channel contain; Shredder machine that shred large materials into small pieces, and Ultrasonic meter to measure the discharge of wastewater entering the treatment plant.
3. The wastewater send to the grit removal tank , where the air is pumped from the bottom of the basin and this accelerates the removed and collected of grit into grit collector , while skimming the floating fat from the top of the tank.
4. The wastewater transferred to the aeration tank, where oxygen is pumped into the bottom of the basin, in order to activate the bacteria found in sewage and thus gets biological treatment process, which is converted dissolved organic materials to inorganic materials that can be separated and removed.
5. The wastewater moved from the aeration tanks to a final settling tank where the biomass settles to the bottom of the tank and is concentrated as activated sludge.

6. The waste activated sludge (WAS) is pumped from the bottom of final settling tank to return and waste sludge tank (R.S&W.S Tank).Some of the activated sludge is pumped back to the aeration tank influent; as “seed” to stimulate the activated sludge process, and is called return activated sludge (RAS).
7. The reminder of (WAS) pumped to the thickening tank which allows to the sludge to collect, settle and separate from the water for up to 24 hours. The water is then sent back to the head of the plant to the inlet tank.
8. The sludge pumped from the bottom of thickening tank to drying beds, where the water is withdrawn from its bottom by a network of perforated pipes and then pumped to the inlet tank. Sludge produced at each plant is land applied as fertilizer in neighboring farm fields.
9. The treated wastewater (effluent) discharge from the top of final settling tank flows to the chlorine contact chambers for disinfection by killing the bacteria that cause the disease before discharge to Euphrates river.

5. Results and Discussion

In this paper EXCEL is used to described statistics (median, standard deviation, minimum and maximum) of the biochemical and physiochemical parameters concentrations in the influent and effluent samples of wastewater for MEWTP and AMWTP as shown in Tables (2 and 3).The experimental results for all biochemical and physiochemical parameters concentrations for the two plants are listed in Appendix B.

5.1 Biochemical Parameters

The Biochemical parameters include Biological oxygen demand BOD_5 and Chemical oxygen demand COD. The two parameters BOD_5 and COD represent the most important biochemical parameters commonly used to examine wastewater quality since they reflect the organic load in wastewater [24, 25].

5-1-1 BOD_5 parameter

Fig. (2) shows the measured BOD_5values of influent and effluent wastewater for MEWTP and AMWTP. The values of BOD_5 for the influent wastewater of MEWTP vary between (20- 235) *mg/l* during May-2012 and April-2012 respectively. The values of this parameter for AMWTP vary between (80-250) *mg/l* during Oct.-2011and Feb.2012 respectively. In addition, the values of BOD_5 for the effluent of MEWTP varies between (4-30) *mg /l* during May- 2012 and (Sep. - 2011 & Mar.-2012) respectively. The values of this parameter for AMWTP vary between (6 - 40) *mg /l* during Dec.-2011and Nov.-2011respectively.

Table (2). Summary of basic statistics for water quality parameters for MEWTP and AMWTP-INFLUENT.

Plant	Param.	Mean	Median	St. Deviation	Range	Min.	Max.
Muharram Easha	BOD_5	162.3	182.5	68.9	215	20	235
	COD	357	335.5	123.1	380	196	576
	TSS	190.4	205.3	71.5	218.5	49	267.5
	PH	6.6	6.7	0.57	1.65	5.65	7.3
	NO_3-N	20.8	12	17.2	45	5	50
	FOG	15.4	14.7	7.1	26.4	5.4	31.8
	TDS	1274.9	1264.5	141.8	437	1020	1457
	CL^{-1}	249.1	252	45.5	133	186	319
	SO_4^{-2}	621.1	584.5	168.6	539	405	944
Al-menfhan	BOD_5	185.5	210	60.0	170	80	250
	COD	381.8	383.5	160.5	580	170	750
	TSS	140.2	118	71.0	242	65	307
	PH	6.5	6.75	0.85	2.1	5.2	7.3
	NO_3-N	8.6	8.5	3.1	9	4	13
	FOG	14.1	12.5	7.2	25.7	7.8	33.5
	TDS	1079.2	1127	144.7	402	822	1224
	CL^{-1}	233.4	222	100.4	300	84	384
	SO_4^{-2}	457.4	303	507.6	1698	190	1888

Table.(3) Summary of basic statistics for different water quality parameters for MEWTP and AMWTP-EFFLUENT.

Station	Param.	Mean	Median	St. Deviation	Range	Min.	Max.
Muharram Easha	BOD_5	15.6	13.75	8.78	26	4	30
	COD	55.85	59.5	31.59	89	8	97
	TSS	40.75	36.75	18.15	67	13	80
	pH	7.51	7.6	0.26	0.7	7.1	7.8
	NO_3-N	40.15	43	14.46	52	8	60
	FOG	4.36	3.1	3.08	10.1	1.8	11.9
	TDS	1100.6	1126	202.3	761	589	1350
	CL^{-1}	225	224	37.96	121	178	299
	SO_4^{-2}	575.4	572	100.0	360	445	805
Al-menfhan	BOD_5	20.7	19	9.6	34	6	40
	COD	76.6	76	41.9	136	20	156
	TSS	34.6	42.5	18.2	54	6	60
	pH	7.34	7.5	0.48	1.7	6.2	7.9
	NO_3-N	51.5	48.5	27.9	106	9	115
	FOG	3.36	3.25	1.28	3.9	1.8	5.7
	TDS	1018.5	1016	108.9	414	846	1260
	CL^{-1}	224.3	237.5	82.9	296	19	315
	SO_4^{-2}	453.1	387.5	344.98	1237	141	1378

5-1-2 COD parameter

Fig. (3) shows the measured COD values of influent and effluent wastewater for the two plants. The values of COD of the influent wastewater for MEWTP ranged between (196-576) *mg/l* during Nov-2011 and Dec.-2011respectively. The values of COD of the influent for AMWTP vary between (170-750) *mg/l* during May-2012 and Nov.-2011 respectively. The values of COD in the effluent of MEWTP ranged between (8-97) *mg/l* during may- 2012and April- 2012 respectively. For AMWTP these values ranged from (20-156) *mg/l* during Mar. -2012 and Feb. -2012 respectively.

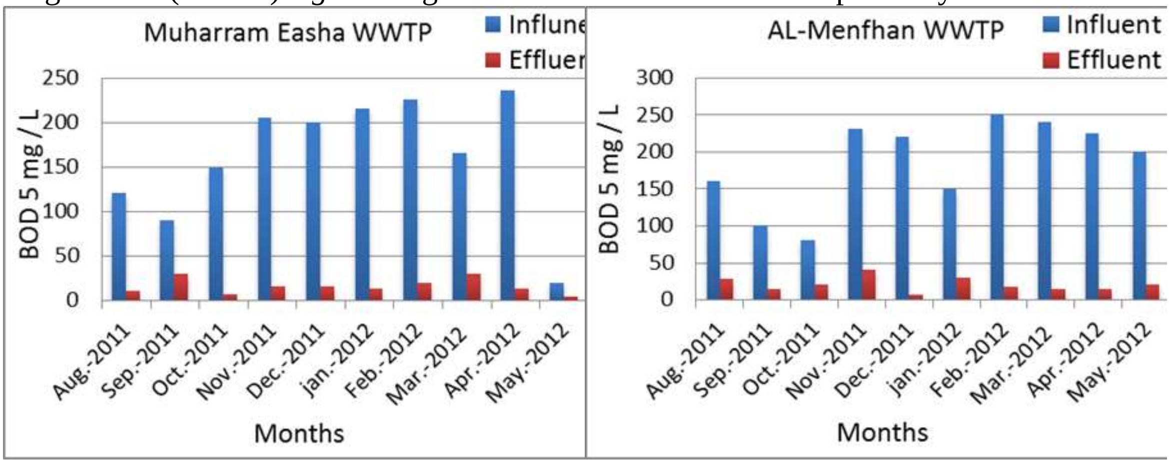


Figure (2). Variation of BOD_5 of influent and effluent wastewater.

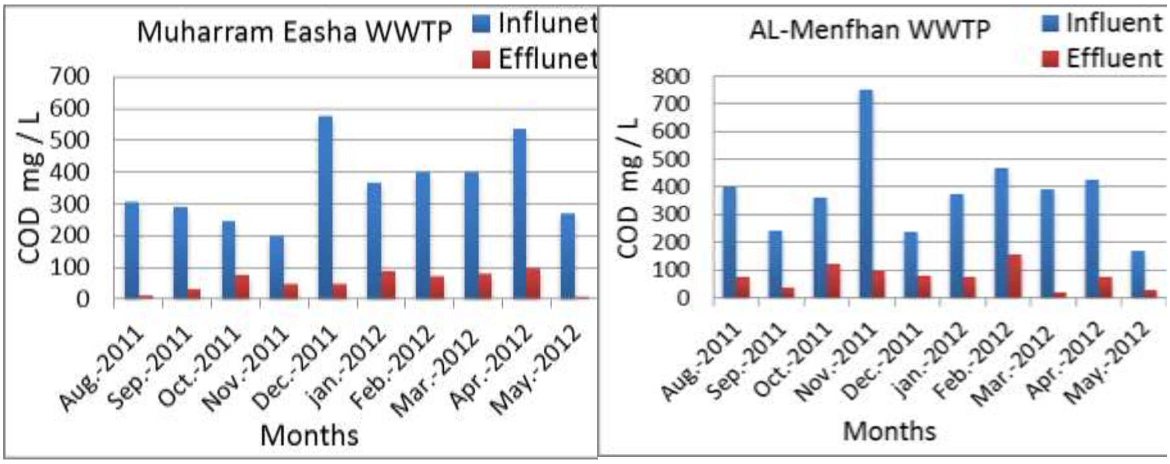


Figure (3). Variation of COD of influent and effluent wastewater.

5-1-3 Removal Efficiency of Biochemical Parameters:

The values of removal efficiency *RE* for all measured parameters in this paper were calculated using the following formula:

$$RE = \frac{P_{inf.} - P_{eff.}}{P_{inf.}} x100 \qquad \text{.............(1)}$$

where *P* is the measured parameter, *inf.* stands for influent wastewater, and *eff.* stands for the effluent wastewater. Figures (2 and 3) seem clear the amount of significant decline in BOD and COD concentrations for the two plants. This refers to the large amount of the removal of the two parameters. Table (4) shows the calculated *RE* values of BOD_5 and COD for the two plants. The values of *RE* for BOD_5 for MEWTP were between 67% and 95%with a mean value 88% .The values of *RE* for BOD_5 for AMWTP were between 75% and 97% with a mean value 87%.Thevalues of RE for COD for MEWTP were between 69% and 97% with a mean value 84%, while these values for AMWTP were between 66% and 95% with a mean value 79%. This result agrees with the results of Zimmo R.O.et al., 2006 [26].

Table (4). Removal efficiency for biochemical parameters.

Plants	Parameter	Removal Efficiency %									
		Aug.	Sep.	Oct.	Nov	Dec.	Jan.	Feb.	Mar	April	May
Muharram Easha WWTP	BOD_5	92	67	95	93	93	94	91	82	95	80
	COD	96	90	69	76	92	76	82	80	82	97
Al-Menfhan WWTP	BOD_5	83	85	75	83	97	80	93	94	93	90
	COD	81	85	67	87	66	80	67	95	82	84

5-2 physiochemical parameters

The laboratory work carried out to examine the physiochemical parameters that include TSS, pH, NO_3-N, FOG, TDS, CL^{-1}, and $SO4^{-2}$.The following subsections present a discussion on concentration of each parameter and its removal efficiency.

5-2-1 TSS parameter

Fig. (4) shows the measured TSS values of influent and effluent wastewater for the two plants. The TSS values of influent for MEWTP recorded a wide range were between 49 and 267.5 *mg / l* , while for AMWTP these values were between 65 and 307 *mg/l*.

Results of TSS of effluent wastewater for MEWTP ranged between 13 and 80 *mg /l*, while TSS values of effluent for AMWTP ranged between 6 and 60 *mg /l*. The results of the two plants for this variable are somewhat close.

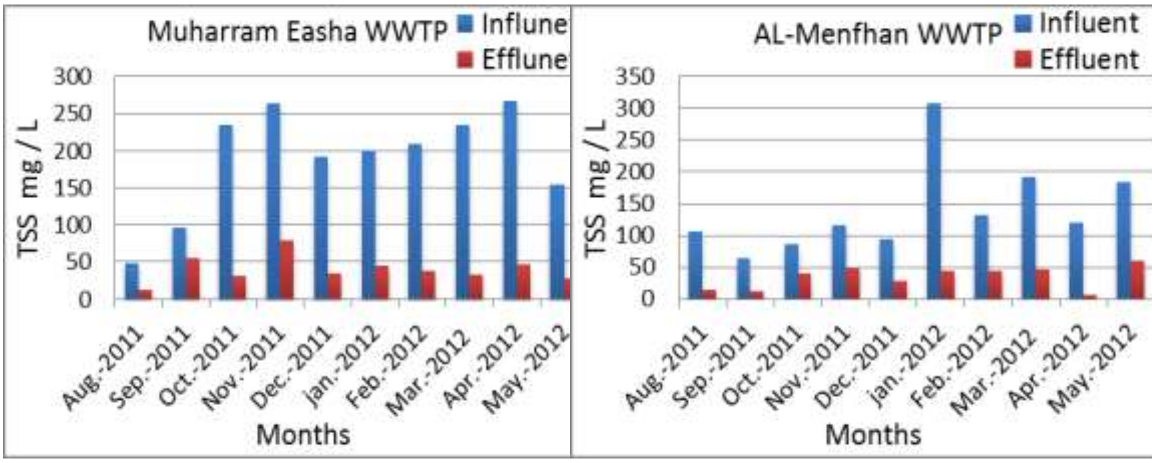


Figure (4).Variation of TSS of influent and effluent wastewater.

5-2-2 pH parameter

The value of pH for the influent wastewater for the two plants various from 5.2 to 7.3 during all the months of the study period as shown in Fig. (5). The values of this parameter are almost to be close in both plants. The values of pH for effluents wastewater of MEWTP ranged between (7.1-7.8) and between 6.2 and 7.9 for AMWTP. It turns out that the values of this parameter close to a large extent between the two plants.

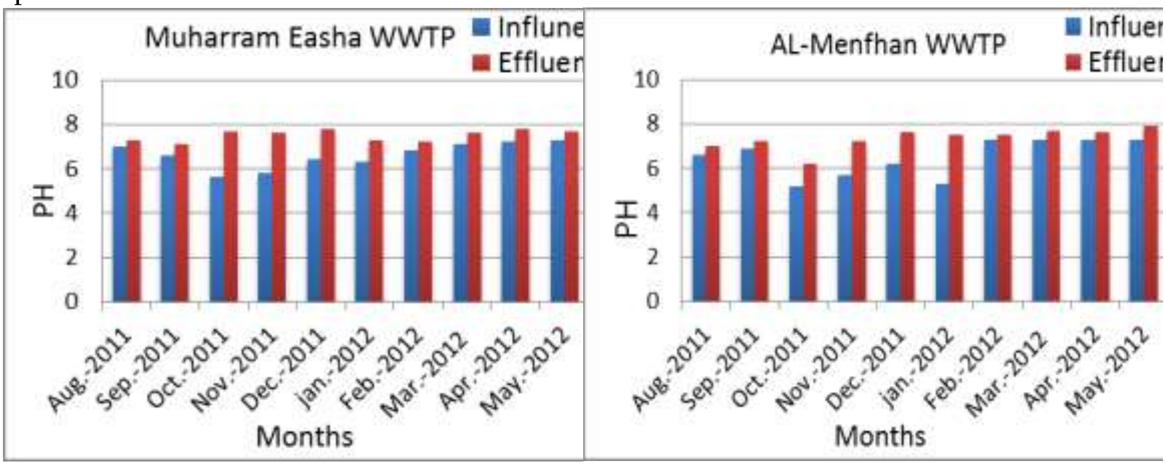


Figure (5).Variation of pH of influent and effluent wastewater.

5-2-3 NO_3-N parameter

The nitrate values of influent wastewater are presented in Fig. (6). For MEWTP the nitrate recorded wide range between (5-50) *mg / l*, while for AMWTP those values tend to stability and convergence in most months has ranged between (4-13) *mg / l*. Generally, during the study period nitrate concentration values for influent for MEWTP are less than that of AMWTP. The concentrations of nitrate for the effluent of MEWTP varies between (8-60) *mg/ l* and the values of this parameter for the effluent of AMWTP were varies from (9-115) *mg / l.*

The raw influent wastewater contained amount of ammonia-nitrogen and through Secondary Biological Treatment, with extended aeration (continuous feeding of oxygen), so that the ammonia-nitrogen can be converted to nitrate-nitrogen, this process called nitrification [27]. As a result of the process of extended aeration followed in two WWTPS in the current study, so necessary to reverse the nitrification conditions (de-nitrification; converted nitrate to nitrogen gas) are not available, which led to increase the concentration of nitrates in the effluent of two plants. The two plants in the current study are not designed to deal with nitrogen compounds removal [28]. It should be mentioned that the increase in nitrates significantly could lead to devastating damage of agricultural crop [29].

5-2-4 FOG parameter

The values of FOG in the influent of MEWTP ranged between (5.4-31.8)*mg/l* as shown in Fig. (7), while the concentrations of this parameter for AMWTP are ranged between (7.8-33.5) *mg/l* . The FOG concentration values in effluent wastewater for MEWTP has ranged between (1.8-11.9) *mg/l* , while for AMWTP ranged between (1.8-5.7) *mg/l* .

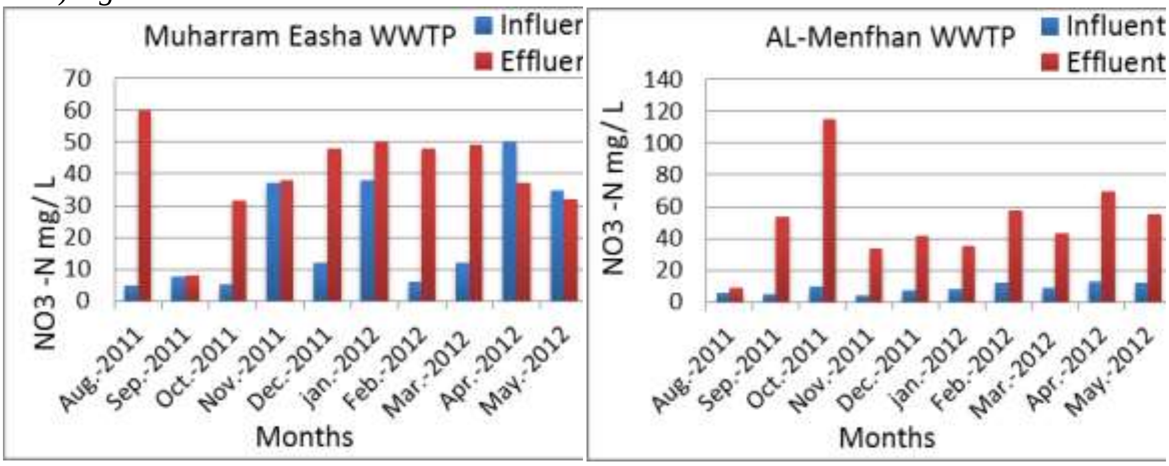


Figure (6). Variation of NO_3-N of influent and effluent wastewater.

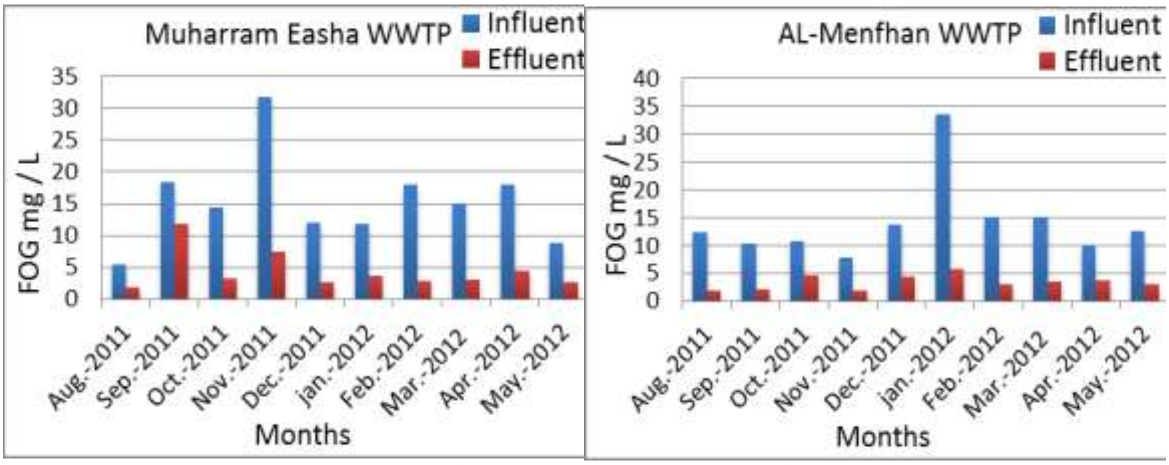


Figure (7). Variation of FOG of influent and effluent wastewater.

5-2-5 TDS parameter

The TDS concentrations of the influent for MEWTP were recorded varying values ranged between (1020-1457) *mg/l* ; see Fig. (8).With regard to the AMWTP these values ranged between (822-1224) *mg/ l* . The TDS concentrations in the effluent of the MEWTP recorded values from (589-1350) *mg/l*. This variable in the effluent of the AMWTP ranged between (846 -1260) *mg/l*.

5-2-6 Cl^{-1} parameter

It seems clear from Fig. (9), the consternations of chloride Cl^{-1} in raw influent of MEWTP ranged between (186-319) *mg/l*. The values of these parameters for AMWTP ranged between (84-384) *mg/l*. We can observe from Fig. (8) that the chloride for the effluent of MEWTP recorded values between (178-299) *mg / l*. The chloride concentration in effluent of AMWTP ranged between (19-315) *mg / l*.

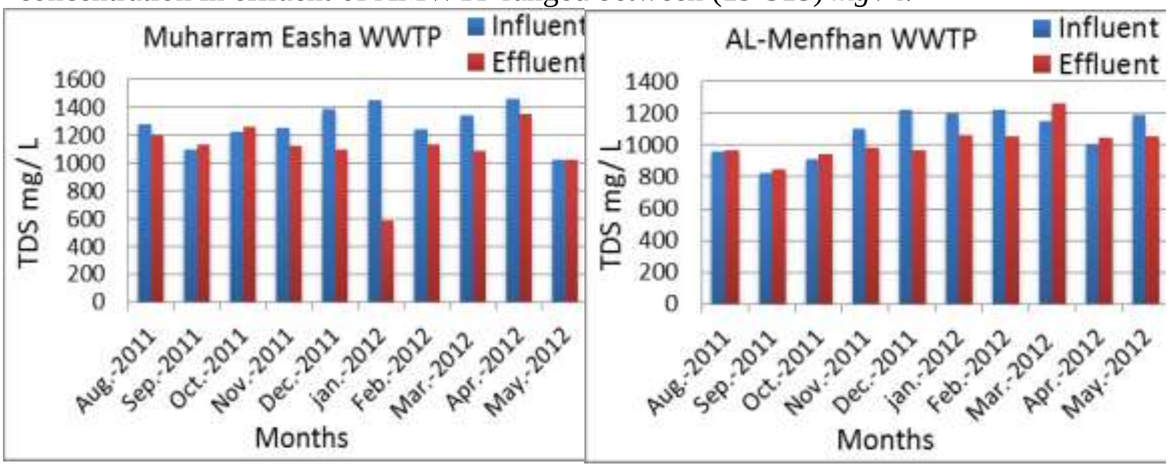


Figure (8). Variation of TDS of influent and effluent wastewater.

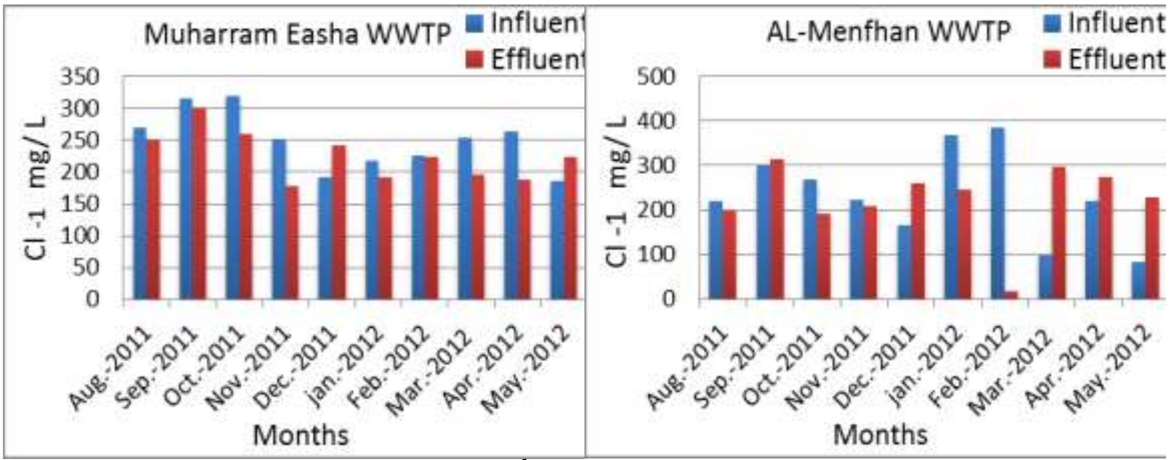


Figure (9). Variation of Cl^{-1} of influent and effluent wastewater.

5-2-7 SO_4^{-2} parameter

It's noted from fig. (10), that sulfate (SO_4^{-2}) concentrations values for the influent of MEWTP were between (405-944) *mg/l*. These values for AMWTP ranged between (190-1888) *mg /l*. Sulfate (SO_4^{-2}) concentrations values of treated effluent from MEWTP were between (445-805) *mg/l* , while these values for AMWTP ranged between (141-1378) *mg /l*.

5.2.8 Removal Efficiency of Physiochemical Parameters:

Table (5) shows the calculated *RE* values for TSS and FOG parameters for the two plants using Eq. (1). The removal efficiency values of TSS for MEWTP ranged between 42% and 92%, with a mean value reached to 79%, while for AMWTP these values were ranged between 52% and 95%, with a mean value reached to74%.There is a clear closer between the mean values of removal efficiency for TSS for both plants. The results for two plants have a good agreement with the result of study produced from Hamoda et al., 2004[30]. Another studies ; Healy et al. (2006) [31] and Al-Jlil (2009)[32] found that the sand filter was able to remove 97% of wastewaters TSS . The MEWTP can remove the FOG with efficiency ranged between (35-84) %. The mean value of this efficiency reached to 71 %. The removal efficiency of FOG for AMWTP ranged between (57-85) %, with a mean value reached 75 %. It is important here to note that FOG can be forms a surface film on the river can coat plants and animals reducing oxygenation from the atmosphere above [33].

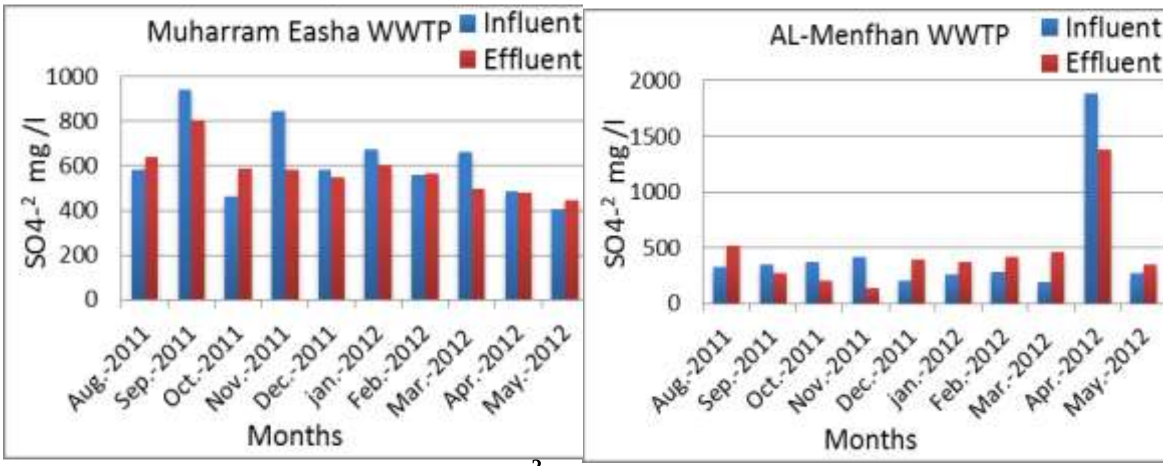


Figure (10). Variation of SO_4^{-2} of influent and effluent wastewater.

Table (5). Removal efficiency for physiochemical parameters.

Plant	Parameter	Removal Efficiency %									
		Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May
Muharram Easha WWTP	TSS	73	42	87	92	82	77	82	86	82	82
	FOG	67	35	78	76	78	69	84	80	75	70
Al-menfhan WWTP	TSS	87	80	52	59	70	86	66	76	95	67
	FOG	85	81	57	76	69	83	80	77	62	76

5.3 Evaluation of using effluent wastewater for irrigation purpose

5.3.1 Standards for Treated Wastewater Reuse

Previous studies have shown that there are many standards and guidelines for the reuse of treated wastewater (effluents) for irrigation purposes in many countries in the Arab homeland region such as Lebanon [29] , Jordan [29,34] , Bahrain, Tunisia, Yemen, Kuwait, Oman, and Saudi Arabia [34] , while there is no specific guideline in Iraq for reuse wastewater in irrigation. Because of the large water scarcity in Jordan, it represents one of the neighboring countries interested in subject of wastewater re-use for different purposes. Therefore, the present study has been accomplished using the current and further Jordanian standards for wastewater reuse in irrigation and discharge to wadis /streams *JS 893/2006* [29] , as shown in Table (6) to assess the validity of the effluent of MEWTP and AMWTP for irrigation purpose.

Table 6. Current Jordanian standards for wastewater reuse in irrigation and discharge to wadis/streams JS 893/2006 (after JISM, 2006) [29].

Parameter	(A) Cooked Vegetables, Parks, Playgrounds and Sides of Roads within city limits	(B) Fruit Trees, Sides of Roads outside city limits, and landscape	(C) Field Crops, Industrial Crops and Forest Trees	(D) Discharge to wadis or streams
BOD (mg/L)	30	200	300	60
COD (mg/L)	100	500	500	150(300 WSP*)
TSS (mg/L)	50	200	300	60 (120 WSP*)
pH	6-9	6-9	6-9	6-9
NO_3-N (mg/L)	30	45	70	80 (100 WSP*)
FOG (mg/L)	8	8	8	8
TDS(mg/L)	1500	1500	1500	1500
Cl^{-1}(mg/L)	400	400	400	350
SO_4^{-2}(mg/L)	500	500	500	300

* WSP; (wastewater stabilization ponds)

The Jordanian standards *JS 893/2006* for wastewater reuse are based on reuse categories depending on crops/ areas to be irrigated. The standard prohibits using reclaimed water for irrigating vegetables that are eaten uncooked (raw). Further, it is prohibited to use sprinkler irrigation except for irrigating golf courses. In the latter case, irrigation should take place at night and sprinklers must be movable and not accessible for day use. When using reclaimed water for irrigating fruit trees, irrigation must be stopped two weeks prior to fruits harvesting and any falling fruits in contact with the soil must be removed [35, 29].This standard contain four groups (categories) for using wastewater, three of which include the use it for the purpose of irrigation and the fourth includes the discharge it into wadis and streams. In this study it will be referred to the symbols A, B, C, and D to represent the possibility of using wastewater according to the columns of 2 to 5 respectively, as shown Table 6.

5.3.2 Evaluation of MEWTP and AMWTP

The two plants MEWTP and AMWTP have been evaluated, depending on the values of the concentration mean of the tested parameters for effluents wastewater according to Jordanian standards for wastewater reuse in irrigation and discharge to wadis/streams *JS 893/2006* as mentioned previous in Table (6). Table (7) illustrates the evaluation of the two plants according to the Jordanian standards and identifies the possibility of using the effluent wastewater for each plant as well as set the parameters need to be treatment to improve water quality. Parameter evaluation of effluent wastewater for MEWTP illustrates that the concentration values of BOD_5, COD,TSS, pH, FOG, TDS, and CL^{-1} falls within the limits of groups A,B,C, and D mentioned previous in Table (6) as in Table (7). The nitrate value falls within the limits of all groups unless group A. The sulfate exceeded the limits of all groups. Overall evaluation for MEWTP shows that its effluent is unsuitable for irrigation for three groups A, B, and C as well as unsuitable for group D to discharge it to surface water sources.

Table (7) shows that for evaluating the performance of the AMWTP, the concentration of all the biochemical and physiochemical parameters within the limits of the values of the Jordanian standards except nitrate and sulfate.

The nitrate values fall within the limits of the Jordanian standards for groups C and D only, while exceed the standards for groups A and B. The sulfate values fall within the limits of the Jordanian standards for groups A, B, and C while exceed the standards for group D. This means that the effluent wastewater for the AMWTP can be used without water treatment for a group C only. Where group C allow re-using the effluent wastewater to irrigate field crops, industrial crops and forest trees.

5.3.3 Effluent wastewater treatment

The results of this study showed that the increasing concentrations of the nitrate and sulfate in the effluent wastewater for the two plants prevented its use for all selected groups for Jordanian standards. Therefore, in order to make the water suitable for use for all groups A, B, C, and D, it requires treatment processes to reduce the concentrations of the two parameters nitrate and sulfate.

WHO recommended that the problem of increasing wastewater nitrate can be solved by mixing the effluent water with river water [29, 36]. The treated wastewater can be mixed with the river water by a ratio 1:4 to become within the permissible limits for all groups for the Jordanian standard [37]. It is worth noting that the advanced treatments are necessary in order to reduce the nitrate values to the guidelines [38, 18]. One of the treatment system used for denitrifying wastewater effluent is the denitrifying filter [39].

The second problem in the effluent wastewater is the increase in sulfate concentration.

This requires a reduction in the concentrations of sulfate in treated wastewater effluents either by mixing with river water or by advanced treatment [37, 40, and 41]. Membrane removal of sulfate one of the choosing of an advanced treatment and have a three possible methods; reverse osmosis, electrical dialysis and filtration [42].It should be noted that many industrial processes, including the food and fermentation industries, generate wastewaters containing high levels of organic matter and sulfate [41]. According to recommendation produced from WHO in 2006, So that it can be overcome the problem of increasing the sulfate in treated wastewater effluents by the locally pre-treatment in the industrial factories or separate the industrial wastewater and not to allowed to entry into the treatment plants in the study area, because this water is characterized by an increase in the concentrations of sulfate [29].

Table (7). Evaluation of MEWTP and AMWTP effluents according to Jordanian standards for wastewater reuse in irrigation and discharge to wadis/ streams *JS 893/2006*

Plant	Parameter	*Mean	**Reuse option	Reuse type without treatment	Reuse type after further treatment
Muharram Easha	BOD_5	15.6	A,B,C,D	It cannot be used for all groups	Use for all groups after treatment NO_3-N and SO_4^{-2}
	COD	55.85	A,B,C,D		
	TSS	40.75	A,B,C,D		
	PH	7.51	A,B,C,D		
	NO_3-N	40.15	B,C,D		
	FOG	4.36	A,B,C,D		
	TDS	1100.6	A,B,C,D		
	CL^{-1}	225	A,B,C,D		
	SO_4	575.4	Out of the limit of all groups		
Al-mnfhean	BOD_5	20.7	A,B,C,D	Use for C group	Use for all groups after treatment NO_3-N and SO_4^{-2}
	COD	76.6	A,B,C,D		
	TSS	34.6	A,B,C,D		
	PH	7.34	A,B,C,D		
	NO_3-N	51.5	C,D		
	FOG	3.36	A,B,C,D		
	TDS	1018.5	A,B,C,D		
	CL^{-1}	224.3	A,B,C,D		
	SO_4	453.1	A,B,C		

*Mean value of concentration for each parameter, **Possibility of re-use for the purposes described in Table (6).

7. Conclusions

In this paper, the biochemical and physiochemical parameters concentrations of an influent and an effluent wastewater of MEWTP and AMWTP were examined to study the performance of two plants and the possibility of reuse of their effluents in irrigation purpose depending on the Jordanian standards JS 893/2006. According to the results of the laboratory, the following conclusions were found:

1. The values of BOD_5 for the effluent of MEWTP vary between (4-30) mg /l and the values of this parameter for AMWTP vary between (6 - 40)mg /l.
2. The values of COD in the effluent of MEWTP ranged between (8-97) mg/l. For AMWTP these values ranged from (20-156) mg/l.

3. The mean values of removal efficiency of BOD_5 for EMWTP and AMWTP were 88% and 87% respectively. While
4. The mean values of removal efficiency of COD for EMWTP and AMWTP were 84% and 79% respectively.
5. TSS values of effluent wastewater for MEWTP ranged between 13 and 80 *mg /l*, while these values for AMWTP ranged between 6 and 60 *mg /l*.
6. The values of pH for effluents wastewater of MEWTP ranged between 7.1 and 7.8, while these values for AMWTP ranged between6.2 and 7.9.
7. The concentrations of nitrate for the effluent of MEWTP vary between 8 and 60 mg / l, while values for this parameter of the effluent for AMWTP were varies from 9 to115 mg/ l.
8. The FOG concentration values in effluent wastewater for MEWTP has ranged between (1.8-11.9) mg / l, while for AMWTP ranged between (1.8-5.7) mg / l.
9. The TDS concentrations in the effluent of the MEWTP recorded values from (589-1350) mg / l. This variable in the effluent of the AMWTP ranged between (846 - 1260) mg / l.
10. The chloride for the effluent of MEWTP recorded values between (178-299) mg / l. The chloride concentration in effluent of AMWTP ranged between (19-315) mg / l.
11. Sulfate ($SO4^{-2}$) concentrations values of treated effluent from MEWTP were between (445-805) mg/l, while these values for AMWTP ranged between (141-1378) mg /l.
12. The removal efficiency of TSS for MEWTP ranged between 42% and 92%, with a mean value reached to 79%, while for AMWTP these values were ranged between 52% and 95%, with a mean value reached to 74%.
13. The removal efficiency of FOG for MEWTP ranged between 35% and 84%.The removal efficiency of FOG for AMWTP ranged between 57% and 85%.
14. According to Jordanian standards for wastewater reuse in irrigation and discharge to wadis/streams *JS 893/2006*, the effluent wastewater for MEWTP cannot be used for irrigation purpose neither discharges to wadis or streams.
15. According to Jordanian standards for wastewater reuse in irrigation and discharge to wadis/streams JS 893/2006, the effluent wastewater for AMWTP can be reuse to irrigate field crops، industrial crops and forest trees.
16. The effluent wastewater for the two plants can be used for irrigation or discharged in wadis or streams after advanced treatment to decrease the concentrations of nitrate and sulfate to allowable extent.

References

(1) UNESCO; United Nations Educational Scientific and Cultural Organization " *Water Use in the World: Present Situation / Future Needs* " , 2000. [online] Available from http://www.unesco.org

(2) Igor A. Shiklomanov, *"World Water Resources And their Use"*, UNESCO'S Intergovernmental scientific programme in water resources/International Hydrological programme, 1999. [online] Available from _http:webworld .unesco.org/water/ihp/db/ Shiklomanov/index.shtml

(3) UNEP- GEC ; United Nation Environment Program and Global Environment Centre Foundation , *" Water and Wastewater Reuse- An Environmentally Sound Approach for Sustainable Urban Water Management "* , UNEP Division of Technology, Industry and Economics, 2005 , http :// www.unep.or.ip / letc / Publications / water sanitation / wastewater reuse / Booklet –Wastewater reuse.

(4) Blumenthal, UJ, A Peasey, G Ruiz-Palacio and DD Mara *" Guidelines for wastewater reuse in agriculture and aquaculture :recommended revisions based on new research evidence"*, WELL Study No.(68) part (1) , London School of Hygiene& Tropical Medicine , UK. WEDC , loughborough University , UK , June 2000.Available at: http://www.lboro.ac.uk/well/resources/well-studies/full-reports-pdf/task0068i.pdf

(5) WHO, "*Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture*", World health organization, Report of a WHO Scientific Group, Geneva, 2006 .

(6) Abdul Hameed M. Jawad Alobadiy , Mukheled A.Al-Sameraiy ,Abass J.Kadhem, Athmar Abdul Majeed *"Evaluation of Treated Municipal wastewater* Quality for irrigation " Journal of Environmental Protection vol. 1, pp. 216-255 , 2010 .

(7) D.W. Westcot , *" Quality Control of Wastewater for Irrigation Crop Production "* (Water Reports-10), FAO, Rome, 1997, ISSN 1020-1203, M-56, ISBN 92-5-103994-1, http // www. fao.org. /docrep / W5367 E / w 5367 e00.htm.

(8) M. B. Pescod, *"Wastewater Treatment and Use in Agriculture"* FAO Irrigation and Drainage Paper No. (47), FAO, Rome, 125p, 1992 .

(9) I. Papadopoulos, *"Wastewater Management for Agriculture Protection in the Near East Region"* , Technical Bulletin FAO, Regional Office for the Near East, Cairo , Egypt, 1995 .

(10) EPA, *"Guidelines for Water Reuse"* EPA625-R-04/018, US Environmental Protection Agency, Cincinnati, 2004.

(11) W. K .Al-Zubari , *" Towards the Establishment of a Total Water Cycle Management and Re-Use Program in the GCC countries"*, Desalination , Vol. (120) , No. (1-2) , pp. (3-14), 1998 .

(12) M. Qadir, D. Wichelns, I. Raschid-Sally, P. G. McCornik, P. Drechsel, A. Bahri and P. S. Minhas, "*The Challenges of Wastewater Irrigation in Developing Countries"* Agricultural Water Management, Vol. (97), No. (4) , pp. (561-568) , 2009 .

(13) G. Hussain and A. J. A1-Saati, *"Wastewater Quality and its Reuse in Agriculture in Saudi Arabia"* Desalination, Vol. (123), No. (2-3), pp. (241-251) , 1999.

(14) Vinod Tare, Purnendu Bose, Subrata Hait, Ligy Philip and A A Kazmi, *"Review of Wastewater Reuse Projects Worldwide: Collation of Selected International Case Studies and Experiences "* GRB EMP : Ganga River Basin Environment Management Plan by Indian Institutes of Technology , 2011 . Report Code: 012_GBP_IIT_EQP_SOA_01_Ver 1_Dec 2011.

(15) FAO/NERO and WHO/EMRO ; Food and Agriculture Organization of the United Nation- Near East Regional Office& World Health Organization-Eastern Mediterranean Regional Office, *" Proceeding Consultation for launching the Regional Network on Wastewater Re-use in the Near East "*, Cairo, Egypt , 2003 . www.fao.org/3/a-y5186e

(16) Ahmad I.Al-Turki, *"Assessment of Effluent of Tertiary Wastewater Treatment Plant at Buraidah City and Its Reused in Irrigation "* Journal of Applied Sciences vol. (10), No. (16), pp. (1723-1731), 2010. ISSN 1812-5654 © 2010 Asian Network for Scientific Information.

(17) S.B. Al-Shammiri and A. M. Shahalam, *,"Effluent from and Advanced Wastewater Treatment Plant –An Alternate Source of Non-Potable Water for Kuwait "* Desalination ,Vol. (196) , NO. (1-3), PP. (215-220), 2006.

(18) Suleaman Mohammed said,*" Application of Reuse of Wastewater for Irrigation in Middle East Countries , Particularly in Jordan "* Master Thesis Department of Land and Water Resources Engineering Royal Institute of Technology (KTH) SE-10044 STOCHOLIM,Sweden,2009,ISSN1651-064XLWR-EX-09-30Advisor:ElzbietaPlazaBengt,*www2.lwr.kth.se/Publikationer/.../LWR_EX_09_30.pdf*

(19) B.Y Ammary,*" Wastewater Reuse in Jordan : Present Status and Future Plans "* Desalination , Vol. (211), No. (1-3) , pp. (164-176), 2007

(20) Abdul-Fattah. M. Ali, *" Reuse of Domestic Wastewater for Irrigation: Conceptual and Basic Design Elements "* Iraqi Journal of Chemical and Petroleum Engineering Vol. (12) , No. (1), pp.(43 – 52) , 2011 , ISSN: 1997-4884

(21) Nadhir A. Al-Ansari, *" Management of Water Resources in Iraq: Perspectives and Prognoses"* Engineering, vol. (5), pp. (667-684) , 2013 .

(22) UN / Iraq ,*" Water in Iraq Factsheet "* , Inter-Agency Information and Analysis Unit (IAU) , Report from UN country Team in Iraq , 2013. http://reliefweb.int/report/iraq/water-iraq-factsheet-march-2013

(23) APHA: AWWA: WEF (1998) , *"Standard Method for the Examination of Water and Wastewater"* , 20th ed. , Published by American Public Health Association , Washington , DC 20005-2605, 1998.

(24) Uz , G.,F. Turak and H. Afsar ,*" Research of BOD and COD values of Wastewater that Contain Certain Organic Materials"* Adnan Menderes University , 4th AACD Congress , 29 Sept. – 3Oct. , Kupadasy'-AYDIN, Turkey Proceeding Book 177.DOC, 2004.

(25) Huertasa, E., M. Salgota, J. Hollenderb, S. Weberb and W. Dottb et al., " *Key Objectives for Water Reuse concepts.*" Desalination, Vol. (218) , pp. (120-131), 2008.

(26) Zimmo O.R., Abu-sara I.H , Abu-Hamdeh S.K and Hujaij S.D , *" Evaluation of Treatment Performance of the Extended Aeration System at Al-Bireh –Palestine "* , EMWater Project Regional Conference, (30/10-01/11) , Amman – Jordan P.18, 2006. www.Abstracts book26-10-06.cdr - Hispagua - Cedex
(27) Pa. DEP ; Pennsylvania Department of Environmental Protection," *Introduction to Wastewater "* Wastewater Operator Training, Training Module 1, Pennsylvania State Harrisburg Environmental Training Center, 2014. file:///C:/Users/dell/Downloads/ww01_intro_to_ww_treatment_wb.pdf
(28) Ahmed Ali Ulimat ,*" Wastewater Production, Treatment, and Use in Jordan "* Ministry of Water & Irrigation Water Authority of Jordan, Second Regional Workshop ' Safe Use of Wastewater in Agriculture ' , (16-18 May) , New Delhi , India,2012.http://www.ais.unwater.org/ais/pluginfile.php/356/mod_page/content/111/Jordan_ULIMAT_ICID_AHMA_2012-1.pd
(29) Armin Margane and D Anke Steinle ,*" Proposed of National Standard for Treated Domestic Wastewater Reuse for Irrigation"*, German-Lebanese Technical Cooperation Project Protection of Jeita Spring , project-No.2008.2162.9 ,Special reportNo.4,Ballouneh,Lebanon,2011. http://www.bgr.bund.de/EN/Themen/Wasser/Projekte/abgeschlossen/TZ/Libanon.
(30) Hamoda, M.F., I. Al-Ghusain and N.Z. Al-Mutairi, *"Sand Filtration of Wastewater for Tertiary Treatment And Water Reuse "* Desalination ,Vol. (164) , pp.(203-211) , 2004 .
(31) Healy, M.G., M. Rodgers and J. Mulqueen,*" Performance of a Stratified Sand Filter in Removal Chemical Oxygen Demand , Total Suspended Solids and Ammonia nitrogen from High-Strength Wastewater"* Journal of Environmental Management, Vol. (83), pp.(409- 415) , 2007.
(32) Al-Jlil, S.A., (2009), *"COD and BOD reduction of Domestic Wastewater Using Activated Sludge, Sand Filters And Activated Carbon in Saudi Arabia "* Biotechnology Journal, ISSN 1682-296X, Vol. (8), pp. (473-477), 2009, Asian Net.
(33) Ram S. Lokhande , Pravin U. Singere and Deepali S.Pimple , " *Study on Physico-Chemical Parameters of Wastewater Effluents from Taloja Industrial Area of Area of Mumbai, India*" International Journal Of Ecosystem, Vol. (1), No.(1), pp.(1-9),2011.
(34) WHO, *"A Compendium of Standards for Wastewater Reuse in the Eastern Mediterranean Region"*, World Health Organization, Regional Office for the Eastern Mediterranean- Regional Centre for Environmental Health Activities, WHO-EM/CEH/142/E, 2006. http://applications.emro.who.int/dsaf/dsa1184.pdf
(35) Annika Kramer and Julika Post," *Guidelines and standards for Wastewater Reuse "*, Efficient Management of Wastewater (EMWATER)-E-Learning Course, Lesson D1: Policy Guidelines, Adelphi Resarch ,(Berlin), Project funded by The European Union, http://cgi.tu-harburg.de/~awwweb/wbt/emwater/documents/lesson_d1.pdf
(36) M. R. Massoudinejad, M. Manshouri, A.R. Yazdanbakhsh,*" Study on the Reuse of Zamyad Factory Wastewater Treatment Plant Effluent in Irrigation"* Iranian

Journal of Environmental Health Science & Engineering , Vol. (3), No. (4) , pp.(285-288) , 2006 http://www.bioline.org.br/request?se06039

(37) Eng. Rana Ardah, Eng. Tharwa Qotaish, *"Mixing Ratio Study ; Towards Piloting and strengthening Adaptation Capacity to Water Scarcity in the Jordan Valley"*, Knowledge Cluster Energy, Water and Environment Sector. Royal Scientific Society Amman, Jordan, 2009. http://en.envirocitiesmag.com/articles/pdf/waste_management_eng_art9.pdf

(38) Mohamed. A. Baghapour, Simin Nasseri and Babak Djahed , (2013),"*Evaluation of shiraz Wastewater Treatment Plant Effluent Quality for Agriculture Irrigation by Canadian Water Quality Index (CWQI)"*, Iranian journal of Environmental Health Sciences & Engineering ,Vol.(10), pp.(27), 2013. doi:10.1186/1735-2746-10-27

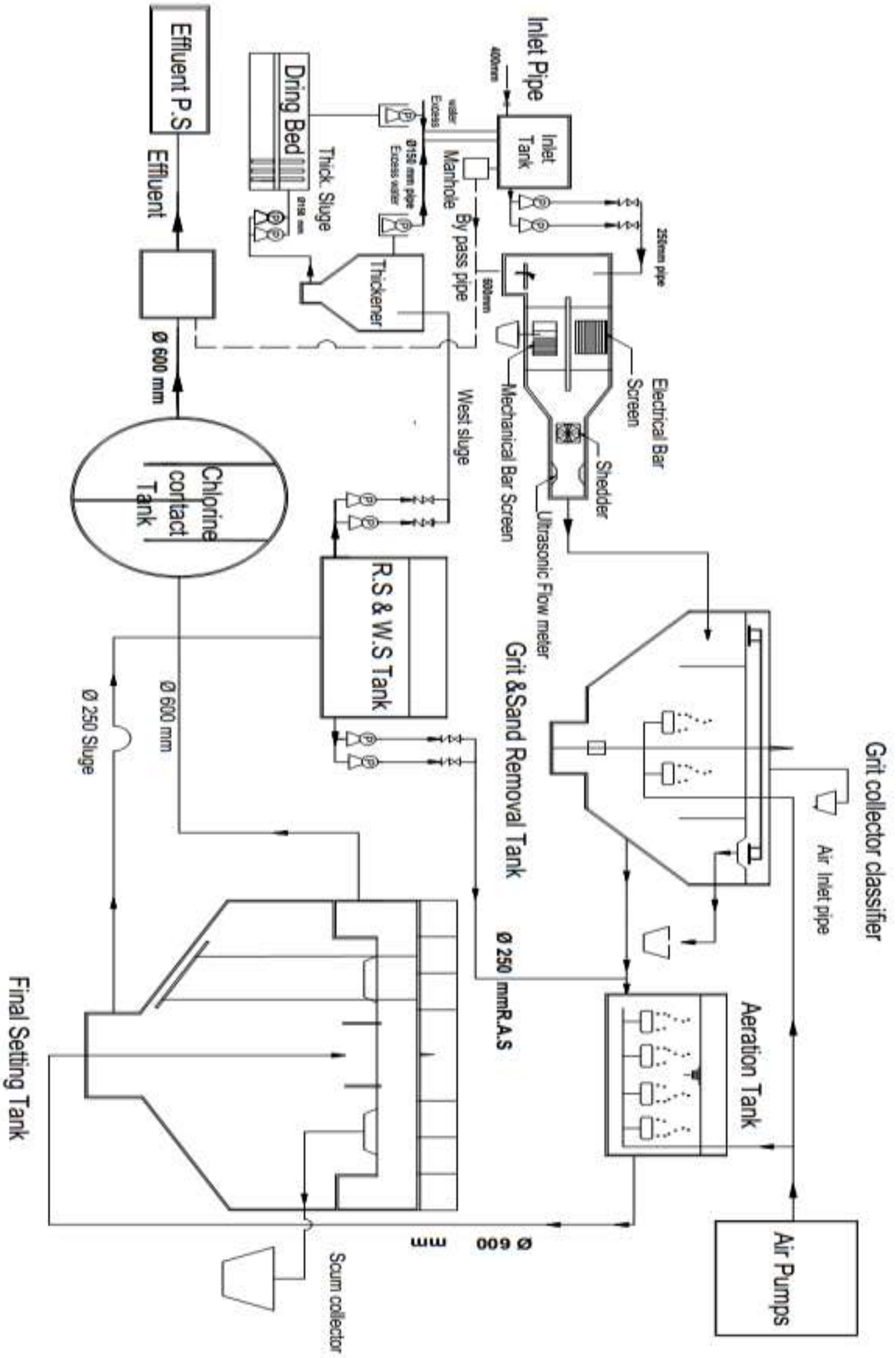
(39) US-EPA, *"Wastewater Management Factsheet Denitrifying Filters "* , United State Environmental Protection Agency , EPA 832-F-07-014 Office of Water , September 2007. http://www.methanol.org/environment/resources/environment/epa-denit-fact-sheet.aspx

(40) P. Kousi, E. Remoudaki, A. Hatzikioseyian & M. Tsezos ," *A study of the operating parameters of a sulphate-reducing fixed-bed reactor for the treatment of metal-bearing wastewater"* National Technical University of Athens, School of Mining and Metallurgical Engineering, Laboratory of Environmental Science and Engineering Heroon Polytechniou 9, 15780 Athens, Greece IBS , 2007. http://www.metal.ntua.gr/uploads/2748/302/IBS_2007_NTUA_poster.pdf

(41) S.zub, T. kurissoo , A. Menert and V. Blonskaja , *" Combined Biological Treatment of High- Sulphate Wastewater from Yeast Production"* Water and Environment Journal , ISSN 1747-6585 , Vol.(22) , pp. (274–286),2008 . doi:10.1111/j.1747-6593.2007.00097.x, http://www.seit.ee/failid/594.pdf

(42) R.J Bowell, *" A review of Sulfate Removal Options for Mine Waters "* International Mine Water Association (IMWA) Proceedings, 2004 . http://www.imwa.info/docs/imwa_2004/IMWA2004_43_Bowell.pdf

Appendix A: Flow –Diagram for MuharaamEsaha and Al-Menfhan WWTPS



APPENDIX B: Water quality parameters used in this study.

Plant	Parameter	Waste water	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	April	*May*
Muharram Easha WWTP	BOD_5	Influent	120	90	148	205	200	215	225	165	235	20
		Effluent	10	30	7	15	15	12.5	20	30	12.5	4
	COD	Influent	304	288	246	196	576	367	398	400	534	270
		Effluent	12	30	76	48	48	88.5	71	80	97	8
	TSS	Influent	49	96	235	264	193	200.5	210	235	267.5	154
		Effluent	13	56	31	80	35.5	45.5	38	33	47.5	28
	PH	Influent	7	6.6	5.65	5.8	6.4	6.3	6.8	7.1	7.2	7.3
		Effluent	7.3	7.1	7.7	7.6	7.8	7.3	7.2	7.6	7.8	7.7
	NO_3-N	Influent	5	7.5	5.35	37	12	38	6	12	50	35
		Effluent	60	8	31.5	38	48	50	48	49	37	32
	FOG	Influent	5.4	18.4	14.4	31.8	12	11.8	18	15	18	8.9
		Effluent	1.8	11.9	3.2	7.5	2.6	3.6	2.8	3	4.5	2.7
	TDS	Influent	1278	1100	1224	1251	1385	1451	1240	1343	1457	1020
		Effluent	1201	1133	1264	1122	1100	589	1130	1089	1350	1028
	CL^{-1}	Influent	269	315	319	251	192	218	225	253	263	186
		Effluent	249	299	259	178	241	192	224	196	188	224
	SO_4^{-2}	Influent	584	944	462	845	585	676	560	664	486	405
		Effluent	640	805	589	581	550	600	563	499	482	445
Al-mnfhean WWTP	BOD_5	Influent	160	100	80	230	220	150	250	240	225	200
		Effluent	28	15	20	40	6	30	18	15	15	20
	COD	Influent	399	240	360	750	238	375	470	392	424	170
		Effluent	76	37	120	98	80	75	156	20	76	28
	TSS	Influent	106	65	86	116	94	307	132	192	120	184
		Effluent	14	13	41	48	28	44	45	47	6	60
	PH	Influent	6.6	6.9	5.2	5.7	6.2	5.3	7.3	7.3	7.3	7.3
		Effluent	7	7.2	6.2	7.2	7.6	7.5	7.5	7.7	7.6	7.9
	NO_3-N	Influent	6	5	10	4	7	8	12	9	13	12
		Effluent	9	54	115	34	42	35	58	43	70	55
	FOG	Influent	12.3	10.3	10.8	7.8	13.8	33.5	15	15	10	12.7
		Effluent	1.8	2	4.6	1.9	4.3	5.7	3	3.5	3.8	3
	TDS	Influent	956	822	914	1106	1224	1200	1222	1148	1006	1194
		Effluent	964	846	943	984	964	1064	1056	1260	1048	1056
	CL^{-1}	Influent	220	299	268	223	167	367	384	101	221	84
		Effluent	200	315	193	209	261	247	19	297	274	228
	SO_4^{-2}	Influent	324	351	378	414	207	263	282	190	1888	277
		Effluent	523	274	204	141	398	377	422	458	1378	356

Note: The units for all parameters are in (mg / L) except (pH) which has no units.