Assessment of Performance of Wastewater Treatment Plants in Jordan

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ABSTRACT

Jordan is a small country facing limited water supplies and increasing population size due to natural growth and migrations due political instability in the region. Water shortage is affecting water and wastewater treatment systems operations.

We will analyze the present state of WWTP's in Jordan. The assessment will consider inflow and outflow rates, outflow quality, and treatment efficiency. The analysis is important to identify needs for future development.

Keywords- Wastewater, treatment plants, water reuse, wastewater characteristics, wastewater treatment, Jordan.

1. INTRODUCTION

Jordan has faced the problem of water scarcity for many years. Jordan is experiencing a surge in population growth mainly due to political instability in the region.

In the year of 2000, the demand of water was estimated to be about 1100 millions m^3 (MCM), while the available water from all sources (surface and ground water) was less than 850 MCM, indicating a shortage of water of 250 MCM.

The shortage of water has affected the individual consumption. For example the water consumption in the year of 1998 was about 160 m^3 /capita/yr and is expected to fall to 90 m^3/capita/yr in 2020, which is very low in comparison to the international per capita consumption level of 1000 m^3/yr (Al-Zboon, 2002).

Population growth caused an increase in water use and wastewater production and as a result high demand for wastewater treatment capacity. Natural population growth in Jordan is increasing steadily. In addition, the size of forced immigration is increasing due to continual political instability in the region.

Table1. Summary of Jordan's population and Refugees Estimate for the years from 2010 to 2013.

	2010	**2011**	**2012**	**2013**
Total Population	6,046,000[a]	6,181,000[a]	6,318,000[a]	6,459,000[a]
Number of Refugees at the end of the year	450,900[b]	451,009[b]	302,700[b]	641,900[b]

a: Government Estimates, b: UNHCIR estimates

The wastewater treatment sector needs development even without considering population growth which puts more pressure on the existing treatment capacity. According to Jordan's Water Strategy for 2008-2022, there are about 40 % of the population are not served by sewer systems. The annual production of sewerage systems is about 100 Million Cubic Meter (MCM) of effluent that is utilized primarily in agriculture in Jordan valley.

This increase in water demand combined with the limited water resources adds high value to the use of reclaimed wastewater. The interest in wastewater reuse in various parts of the world has promoted the development of wastewater and secondary effluent treatment technologies (Consolated Consultants, 2012).

In Jordan reclaimed wastewater is utilized in agriculture. The agricultural demand of water is estimated to be 73% of the total water consumption, while 22% of water is used for domestic needs and only 5% is used for industrial sector (WAJ, 2006). Reclaimed wastewater is applied on soil, on cultivated as well as marginal areas in various facilities, in irrigation, industry, and for recharge of ground water.

The reuse of reclaimed wastewater should be controlled by comprehensive environmental plan, which will take into consideration safety actions relative to quality standard of released reclaimed wastewater, this requires examination of physical-chemical and environmental properties of applications on soil, plants, and construction processes (MWI, 2002, and MWI/JVA/GTZ, 2002). The level of treatment is determined by the designated beneficial uses of the receiving water bodies (Hammer, 1996).

The current quality standards of reclaimed wastewater are obtained from the Standard number 893 of year 2002 which are shown in Table 2.

Table2. Summary of Selected Wastewater Quality Properties limits according to Jordan Standards.

Property	Unit	Release to Streams	Groundwater Recharge	Restricted Irrigation
PH		6 to 9	6 to 9	6 to 9
BOD5	mg/L	60	15	30
COD	mg/L	150	50	100
DO	mg/L	> 1	> 2	> 2
TSS	mg/l	60	50	50
NO3-N	mg/l	45	30	30
E coli	CFU/ 100 ml	1,000	< 2.2	100

In Jordan there are twenty three municipal treatment plants, which cover most of the major cities and towns.

These plants serve about 56% of the population. The total inflow to these plants is around 216,412 m3/d, of which 186223 m3/d inflow to Asamra wastewater treatment plant (ASTP) (Bataineh et al., 2002). Jordanian standards for reclaimed wastewater (JS893/1995) try to regulate both water reuse and environmental discharges.

Jordanian standards allow discharging treated wastewater to valleys and streams when it meets the specific criteria for many parameters such as BOD, COD, TSS, and Escherichia coli bacteria.

In the present time, the reclaimed wastewater is used for restricted agriculture either near the plants or downstream after mixing with natural surface water (Bataineh et al., 2002). More than 70 million m3/year of reclaimed water, around 10% of the total national water supply, is used either directly or mostly indirectly in Jordan and will increases to a share of more than 15% within the next 30 years (Ammary, 2007, and Bataineh et al., 2002).

In this study, characteristics of wastewater for the four seven largest wastewater treatment plants, which are Al-Samra (ASTP), Baqa, Wadi Al-arab, Irbid (ITP), Aqaba, and Salt were determined. Characterization of wastewater was evaluated in terms of measuring chemical oxygen demand (COD), biological oxygen demand (BOD), total suspended solids (TSS), total dissolved solids (TDS), and dissolved oxygen (DO) for the influent and effluent from the selected plants. The performance of the major wastewater treatment plants (WWTPs) was evaluated and the quality of the reclaimed wastewater was compared with Jordanian standards to determine its suitability for reuse. The agriculture demands are mainly directed towards the Jordan Valley, where the majorly of Jordan's agricultural is located.

The majority of these treatment plants are stressed. The treated wastewater is considered an integral part of Jordan's sustainable water resources system. About 70% of the population living in urban areas is serviced with sewer collection system. The annual treated wastewater effluent form theses serviced areas is about 80 MCM.

The two largest wastewater treatment plants in Jordan are the As-Samra and Irbid (Wadi AL-Arab) WWTP. The design capacity of the As-Samra WWTP is 68,000 m3/day and Irbid (Wadi Al-Arab) WWTP design capacity is 21,000 m3/day (Mohsen, 2008).

2. MATERIALS AND METHODS

The impact of population growth is shown as the increase in annual inflow of WWTP's. Data sets for the WWTP's are collected from ministry, government agencies, and visits to the plants. The data sets include inflow and outflow rates, water quality measurements.

Some plants with small capacity have gaps in their data collection, however, the major WWTPs have sufficient data for analysis. In the following analysis we select the plants with largest capacities. The selected plants treat about 90% of the domestic wastewater in Jordan and serve more than 2 million inhabitants (Bataineh et al.,2002).

The largest plant is As samra wastewater treatment plant (ASTP) in Jordan and treat more than 76% of collected municipal wastewater, most of the environmental studies concentrate on the performance of this plant and the possible actions to enhance its efficiency. ASTP utilizes stabilization ponds as the treatment process as shown in Table 2. ASTP has an area of 181 hectare and three units (Asa'ad, 2006). There are two aerobic ponds, four facultative ponds, and four maturation ponds in each unit.

The effluent from the ASTP to the Zarqa River represents more than 80% of the total flow in the river during dry weather. River 's water contains high concentrations of organic matter, inorganic minerals, salts, and heavy metals (Al-Zboon, 2002).

3. RESULTS AND DISCUSSION

The change of inflow over 5 year period from 2007 to 2012 is selected as an indictor of population growth effect. The geographic locations with significant increase in inflow rate are the locations with biggest population growth. The table indicates that there is a surge in wastewater inflow in several parts of Jordan. This surge in wastewater inflow is due to population growth and expansion of sewer system network.

Table2. Wastewater Treatment Plants in Jordan showing inflow levels for years 2007 and 2012.

Plant	Annual Influent per year m3/yr			
	2007	2012	% fraction	% change (2012-17)
AS-SAMRA WSP + mech.	83399699	88028510	72.5	5.6
Baqa'a	4275580	4275354.5	3.5	0.0
Wadi Arab	3906017	3898711	3.2	-0.2
Irbid	2322738	3179405.5	2.6	36.9
AQABA MCHIC+P. ST	2785011	3106515	2.6	11.5
AQABA WSP	2013310	2635300	2.2	30.9
Salt	1635808	2387100	2.0	45.9
MADABA	1719606	1919754	1.6	11.6
WADI ESSIR	1136245	1479272	1.2	30.2
Ramtha	1238293	1478213.5	1.2	19.4
Jerash	1238050	1216618	1.0	-1.7
AL- AKADEER	1350074	1070326	0.9	-20.7
Kufranja	1434633	962724	0.8	-32.9
Wadi Mousa & P.ST	724251	925786	0.8	27.8
Abu - Nuseir	860518	876219	0.7	1.8
Ma'an	882023	860597	0.7	-2.4
FUHEIS	653928	841325	0.7	28.7
Karak	565933	676053	0.6	19.5
Mafraq	726654	590643	0.5	-18.7
Tafila	431095	575021	0.5	33.4
AL-LAJJOUN	189070	268165.5	0.2	41.8
TALL- ALMANTAH	105953	133225	0.1	25.7

3.1 Inflow Trends

The wastewater inflow for the largest five wastewater treatment plants shows variable increase in inflows. The various levels of increase reflect the impact of variables other than population growth. The wastewater collection network is undergoing significant expansion and many urban centers are still using septic systems which do not reflect directly on wastewater inflow. However, urban centers where population numbers have increased show significant rise in wastewater inflows like Irbid and Salt.

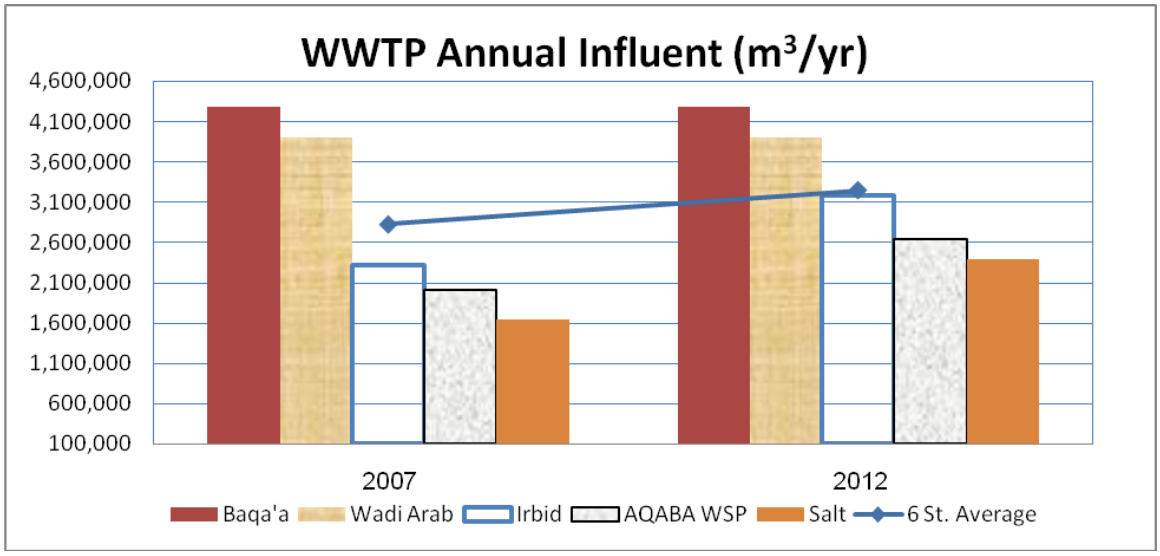

Figure3.The increase in inflow from 2007 to 2012 for five WWTPs

3.2 Water Quality Trends

The available data contain measurements of essential water quality parameters like pH, TSS, BOD, COD, ammonia, and DO. The TSS for the large WWTP are summarized in Figure 1. The inflow and outflow annual average indicate high loading level for wadi arab than other plants. This is due to the diversity of inflow from storm and urban runoff and storage in the dam. The outflow show TSS levels exceeding limit of 60 mg/l for Irbid, Wadi arab, and Aqaba.

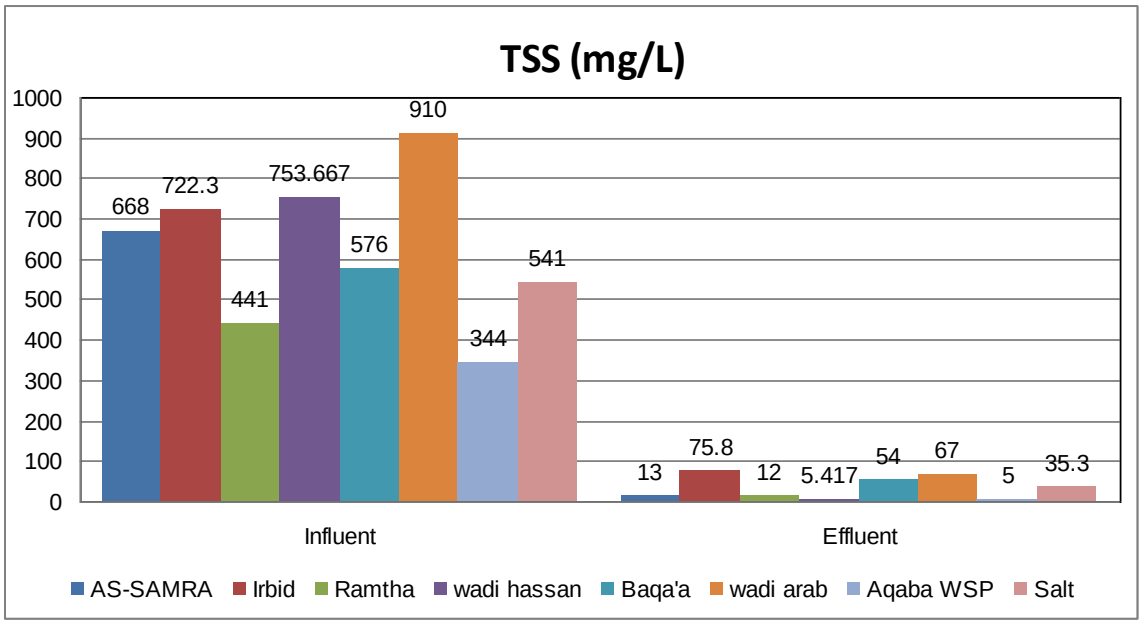

Figure 4. Total Suspended Solids (TSS) Inflow and Outflow of major WWTPs in Jordan

The COD level is an indicator of inflow pollution level and treatment efficiency. As samra, Aqaba, and Irbid WWTPs show high levels of COD exceeding standard of 150 mg/L for outflow.

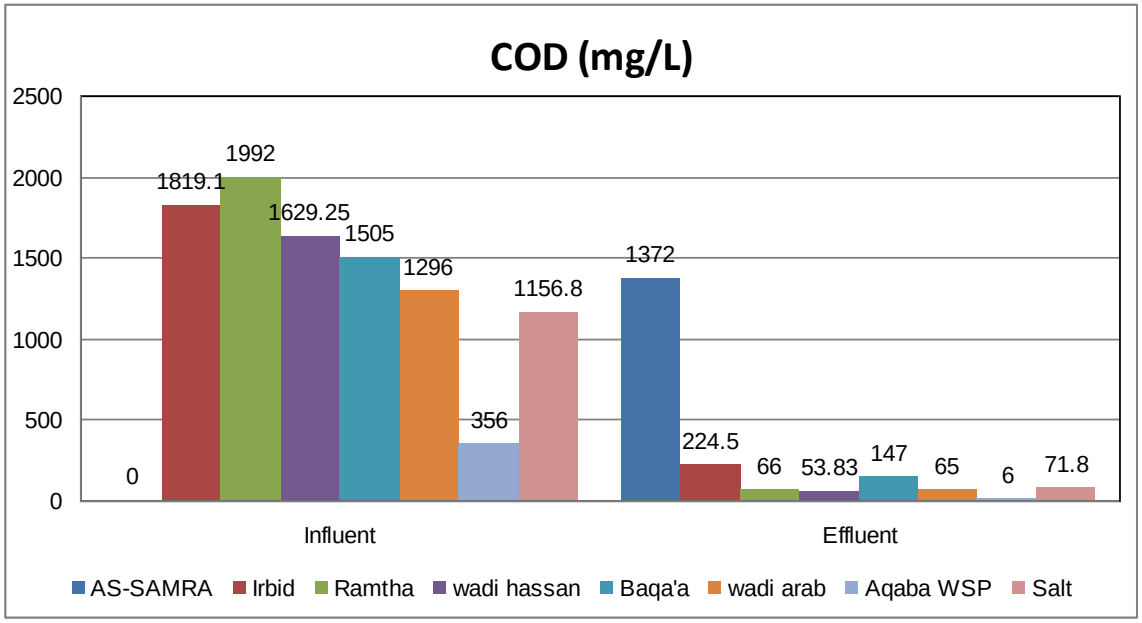

Figure2. COD levels for Inflow and Outflow of major WWTPs in Jordan.

Dissolved oxygen is an indicator of healthiness of treated wastewater. There are gaps in DO measurement for WWTPs. However, the annual averages are consistent with the treated wastewater standard of 1 mg/L.

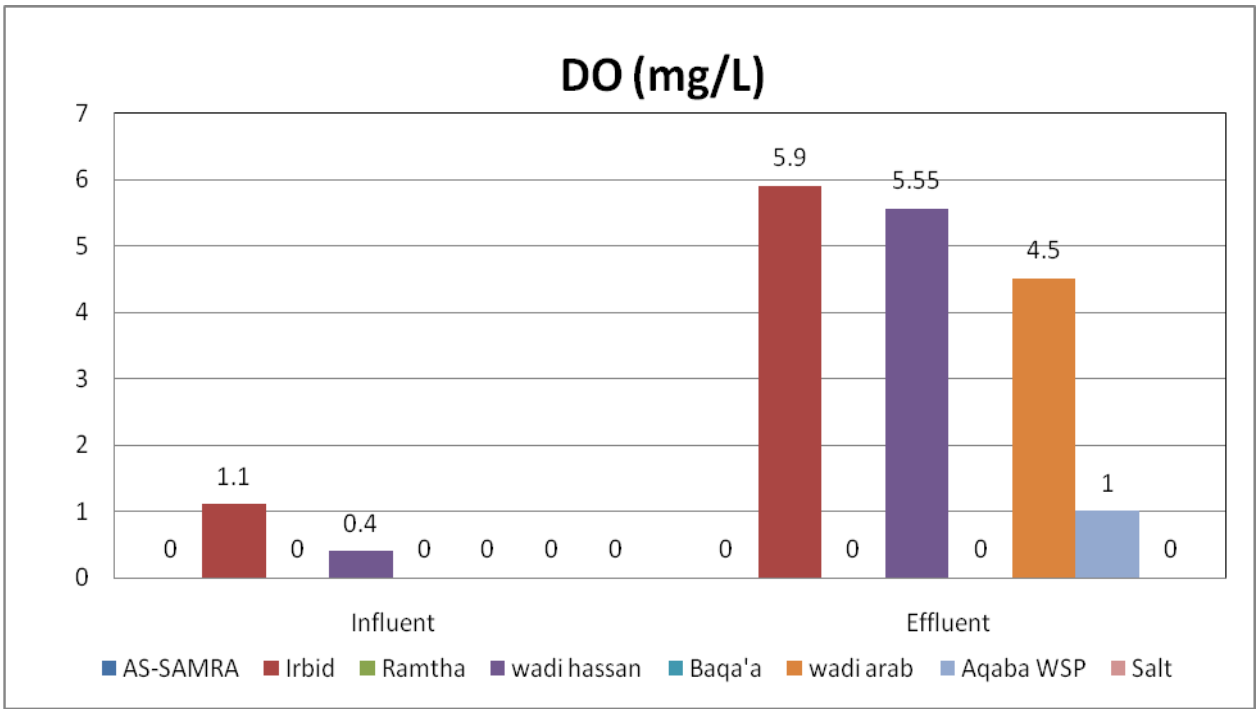

Figure3. COD levels for Inflow and Outflow of major WWTPs in Jordan.

4. DISCUSSION

There are several challenges facing the water sector in Jordan. These challenges include increasing population due to normal growth rates and incoming migrations due to regional conflict. The elevated loadings degraded surface and groundwater qualities and put more stress on WWTP's.

Jordan's population projections for the year 2020 is about 9.9 million with 65% of the populations will be served with sewer service. The projected sewerage generation is about 237 MCM, which is about three times the sewerage generation from the current population estimates (Abu-Taleb, 2000).

The regulation on industrial discharge to the public sewer collection lines is loosely enforced in Jordan. Therefore, industrial effluent from various types of industries with varying industrial wastewater strengths are currently being discharged into public sewers collection lines and eventually treated by municipal WWTP using standard technologies that is used to treat domestic sewerage. As result, when released, the treated effluent from the municipal WWTP is less desirable for agricultural purposes.

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