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Wastewater Production, Treatment, and Use in Jordan

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By

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Abstract:

Jordan has very limited renewable water resources of only 145 cubic meter per capita per year which is basically at the survival level and is considered as one of the most water scarce countries in the world. This number is below the widely recognized "water poverty line" of 1000 cubic meter per capita per year,(Water Strategy 2008-2022). As a result, existing water resources are being seriously over exploited. The growing population and the increase in the per capita consumption of water constitute a challenge for decision makers as the gap between the limited available and the demand of the different sectors is widening. Reclaimed water as a non-conventional water resource is one of the most important measures that have been considered to meet the increasing water demand of the growing population and industrialization. Over 64% of the Jordanian population is connected to sewerage system and raw wastewater is discharged to 26 wastewater treatment plants to be treated for minimum discharge standards and reuse requirements stated in the JS 893/2006. With the current emphasis on environmental health and water pollution issues, there is an increasing awareness of the need to dispose wastewater safely and beneficially. In Jordan, appropriate standards and guidelines for water reuse are an important requirement to rely on reclaimed water as a resource, therefore; the previous water reuse standards JS 893/2002 were reviewed, and issued in 2006. The revised standards allow for a wide range of water reuse activities including, where economic conditions allow, highly treated reclaimed water for landscapes, cut flowers and high-value crops, and for lower cost smaller-scale treatment and reuse activities with restricted cropping patterns. Reclaimed water use in Jordan will result in the conservation of higher quality water and its use for purposes other than irrigation. Properly planned use of municipal wastewater alleviates ground and surface water pollution problems and not only conserves valuable water resources but also takes advantage of the nutrients contained in sewage to grow crops.

Key Words: Reclaimed water, Reuse, Domestic wastewater, Sustainable, Standard

Introduction:

In Jordan water is becoming an increasingly scarce resource and planners are forced to consider any source of water which might be used economically and effectively to promote further development. This important resource, reclaimed water, has been considered from the highest level of Jordan government that it has a full value to the overall water resources of the country as stated in the Jordan's water Strategy, formally adopted by the Council of Ministers in May 1997 (Wastewater shall not be managed as waste; it shall be collected and treated to standards that allow its use in unrestricted agriculture and other non domestic purposes, including ground water recharge.){2,5}.Since the early 1980s the general approach has been to treat the wastewater and either discharges it to the environment where it mixes with fresh water flows and directly or indirectly reused. Jordan is in the process of rehabilitating and expanding its wastewater treatment plants and reclaimed water, appropriately managed, is viewed as a major component of the water resources supply to meet the needs of growing economy. Appropriate standards and guidelines have been set to allow for a wide range of wastewater reuse activities including, highly treated reclaimed water for landscapes and high value crops and treatment plant discharge requirements. Reclaimed wastewater discharged from domestic wastewater treatment plants is an important component of Jordan water budget. About (113.83) MCM in the year 2007, 111.527 MCM in the year 2008, 114.687 MCM in the year2009 and 117.83 MCM in the year 2010,115.432 MCM in the year 2011, {14,15} were treated and discharged into various watercourses or used directly or indirectly for irrigation and other intended uses and it is expected to increase up to262 MCM in the year 2020{2}.

Greater efforts have been made to conserve water by providing non-conventional water supplies to deal with the demands of agriculture. However, several challenges have still to be over come in terms of wastewater treatment and reuse such as scientific, public acceptance, institutional and legal aspects. The monitoring of reclaimed wastewater quality involves many distinct activities to give reliable and usable data. A monitoring program for domestic wastewater is designed according to standard number 893/2006 to collect representative samples and analyze it through quality assurance and laboratories accreditation process complying with ISO 17025. The generated water quality data from these monitoring programs provide information about the reclaimed water quality and ensure its safety for irrigation, other intended uses, protection of public health and the environment. Decisions for improvements and reuse permission are taken depending on the quality of reclaimed water for each treatment plant and according to the current standard.

Water availability and use:

Jordan, situated in Southwest Asia, covers a territory of about 90,000 km² with 99% land area, of which 95% receives less than 50 mm rainfall annually{2}. The land is characterized by an arid landscape as part of the great North Arabian Desert supporting meager and stunted vegetation thriving for short periods after scanty winter rains. Jordan is considered as one of the four most water scarce countries in the World. The limited water resources are exposed to pollution. Population growth is expected to increase the pressure on available water resources. Conventional water resources in Jordan consist of groundwater and surface water. Twelve groundwater basins have been identified in Jordan. Some of them are exploited to their maximum capacity, and others are overexploited, threatening their future use. The long term safe yield of renewable groundwater has been estimated at 275 million cubic meters /year {8}.

The major surface water sources are the Jordan River, the Yarmouk River and the Zarqa River. Much of the flow of the Jordan and Yarmouk Rivers is diverted by the upstream riparians Israel and Syria, leaving only a small share to Jordan. The Zarqa River is polluted by industry, municipal wastewater and non-point sources.Over the years, conflicts have emerged over use of the water. For Jordan, lack of water is damaging people's health as well as the economy. Available yearly per capita share of fresh water in Jordan is among the lowest in the world estimated at about 145 m^3 {2}. This share is continuously decreasing and is forecasted to go down to 90 m^3 by 2020 with out the construction of the strategic projects (Disi, Red-Dead Sea) {2}.

On the one hand, Jordan has very limited fresh water resources estimated at 780 MCM (million cubic meters) per year split between surface 505 MCM and 275 MCM ground water resources {9}. Furthermore, the average yearly rain fall over Jordan is estimated at about 8.3 BCM (billion cubic meters) of which 94% is evaporated leaving very little addition to available water {7,9}. On the other hand, the demand on water is ever increasing and is estimated at about 1.2 BCM according to MWI-water budget2009-{8} and clearly there is a deficit between the supply and the demand. To bridge this gap, the Government of Jordan has put together a long-term plan to increase the efficiency of water use, improve the management of the water supply and improve wastewater treatment and reuse. Agriculture is considered to be the largest consumer of water in Jordan with 66 % of water allocated to the agricultural sector (540 MCM, 2004) {12}. In spite of that, the output of agriculture only contributes 4% to the annual GDP {12}. This is largely due to planting crops that are, not only water inefficient, but also economically unstable, (e.g. watermelons). However, it is difficult to change attitudes given the socio-economic context of the sector. The municipal sector (hotels, hospitals, schools, houses, government and private bodies) comes in as the second consumer with about 240 MCM (30% of the total consumption), while the industrial sector consumes about 40 MCM {7}. However, it is expected that the total "water demand" will rise up to 1,635 million cubic meters/year in 2020{2}. The government plans to satisfy the rising demand mainly through desalination and to some extent also through increased wastewater reuse.

Wastewater treatment in Jordan:

What is wastewater and why treat it?

Wastewater is not just sewage. All the water used in the home that goes down the drains or into the sewage collection systems is wastewater. This includes water from baths, showers, sinks, dishwashers, washing machines, and toilets. Municipal wastewater is mainly comprised of water (99.9%) together with relatively small concentrations of suspended and dissolved organic and inorganic solids. Among the organic substances present in sewage are carbohydrates, fats, soaps, synthetic detergents, proteins and their decomposition products, as well as various natural and synthetic organic chemicals from the process industries connected to the sewer systems. Moreover, table 1 shows the universal levels of the major constituents of strong, medium and weak domestic wastewaters. Comparing the raw wastewater produced in Jordan with the universal concentration tabulated in table number 1 and since water use in Jordan is often fairly low, raw wastewater tends to be very strong as stated in table number 2.

Table 1: Major Constituents of Typical Domestic Wastewater {13}

Constituent	Concentration, mg/l		
	Strong	Medium	Weak
Total solids	1200	700	350
Dissolved solids (TDS)	850	500	250
Suspended solids	350	200	100
Nitrogen (as N)	85	40	20
Phosphorus (as P)	20	10	6
Chloride[1]	100	50	30
Alkalinity (as $CaCO_3$)	200	100	50
Grease	150	100	50
BOD_5	300	200	100

Source: UN Department of Technical Cooperation for Development (1985)

Table 2: Major Constituents of Typical Domestic Wastewater in Jordan {13}

Constituent	Concentration mg/l
Dissolved solids (TDS)	800 – 1300
Suspended solids	600 – 1500
Nitrogen (as N)	30-150
Phosphorus (as P)	20 - 80
FOG	48-206
Sulphate (as SO_4)	200 - 400
BOD_5	600 - 1500
COD	1000 – 2500

Municipal wastewater also contains a variety of inorganic substances from domestic, hospitals and industrial sources, including a number of potentially toxic elements such as arsenic, cadmium, chromium, copper, lead, mercury, zinc,… etc{6}. However, from the point of view of health, a very important consideration in agricultural use of wastewater, the contaminants of greatest concern are the pathogenic micro- and macro-organisms. Pathogenic viruses, bacteria, protozoa and helminthes may be present in raw municipal wastewater and will survive in the environment for long periods. Pathogenic bacteria will be present in wastewater at much lower levels than the coliform group of bacteria. In addition, certain synthetic organics are highly toxic. Pesticides, Benzene, toluene and herbicides are toxic to humans, fish, and aquatic plants and often are disposed of improperly in drains or carried in storm water. They also can damage processes in treatment plants and complicate treatment efforts.

Wastewater Treatment plants in Jordan:

Jordan's first wastewater treatment plant was established in 1970. The total number of treatment plants are 26 as of 2012, treating about 300,000 cubic meters per day (115 million cubic meters/year), or about 98% of the collected wastewater {15}.

Most of the cities of Jordan are equipped with wastewater treatment plants and it was decided to treat wastewater up to the secondary level and meet the current standards and WHO guidelines as a minimum requirements. Discharging raw wastewater to the environment is prohibited by public health law. The existing public–sector wastewater treatment plants in Jordan are 26 using different type of treatment systems and 7 treatment plants are planned or under construction. The systems are divided into activated sludge, trickling filters, and waste stabilization ponds shown in table 3.The aim of Water Authority of Jordan (WAJ) is to increase the volume of treated wastewater through improvements in the existing treatment infrastructure and the construction of new treatment systems ensuring compliance of the treated wastewater with current standards. WAJ has replaced most of the treatment plants working with Stabilization ponds to activated sludge processes to reach high level of the quality of water and increase the public acceptance for wastewater reuse. For example, the old Samra wastewater treatment plant working with stabilization ponds established in 1985, the largest treatment plant in Jordan, serves the greater Amman area, Russeifa and Zarka where about 60%of the population of Jordan lives has been changed to activated sludge system. The new project is a public private partnership (PPP) for financing the construction and operation based on a Build Operate Transfer (BOT) approach over a period of 25 years. The wastewater treatment plant As-Samra, is being operated by a consortium led by SUEZ under a 25-year Build-Operate-Transfer (BOT) contract with WAJand it is the first BOT project in Jordan. The existing wastewater treatment plants are summarized into table 3.

Table-3 Wastewater Treatment Plants in Jordan {14,15}

Plant	Method Of Treatment	Hydraulic Load (m3/day)	Efficiency	Treatment Cost (fils/m3)*
As-Samra	Activated Sludge	221510	98.6%\	BOT
Irbid	Activated Sludge+ Trickling Filter	6696	97%	118.9
Aqaba new	Activated Sludge	6962	98.8%	487.2
Aqaba	Stabilization Ponds	7041	90.7%	16.3
Salt	Extended AERATION	4569.4	97.9%	150.1
Jerash	Extended AERATION	3598.3	95%	66.2
Mafraq	Stabilization Ponds	1958	80%	61.1
Baqa'a	Trickling Filter	10615	93.4%	91.7
Karak	Trickling Filter	1679.3	89%	114.7
Abu-Nusir	Activated Sludge	2240.3	96%	191.1
Tafila	Trickling Filter	1116	95%	173.8
Ramtha	Activated Sludge	3674.7	99%	163
Ma'an	Activated Sludge	2352	99%	489.7

Madaba	Activated Sludge	4660.5	99.4%	191.9
Kufranja	Trickling Filter	2794.6	88%	225.6
Wadi Al Seer	Aerated Lagoon	2762	95%	86.7
Fuhis	Activated Sludge	1606.3	98%	207
Wadi Arab	Activated Sludge	8316	98.8%	106.5
Wadi Hassan	Activated Sludge	1140.7	99.0%	586.3
Wadi Mousa	Activated Sludge	1820.4	99%	788.4
Tal-Almantah	Activated Sludge+ Trickling Filter	271.5	96%	250
AL- Ekeder	Stabilization Ponds	3156	88%	34.1
Alljoon	Stabilization Ponds	634.8	88%	24.3
AL-marad	Activated Sludge	853	96%	536.8
Al-JIZA	Activated Sludge	703.9	95%	766.7

*:1 JD=1000 fils, 1 US$=710 fils.
Source: WAJ Technical Sector Annual Report 2011

Wastewater use/disposal:
The reuse of treated wastewater can be a valuable alternative to freshwater resources, especially in Jordan as a scarce water country. Today, various technically proven wastewater treatment and purification processes exist to produce water of almost any quality desired. In the planning and implementation process, the intended water reuse applications dictate the extent of wastewater treatment required or in other words the quality of the available wastewater limits the reuse options. Jordan's desperate need for water has necessitated the reuse of treated wastewater in agriculture for many years. The agricultural sector is the largest water consumer in Jordan, where 62%of the total water budget is being used for irrigation {8}.However; the farmers feel the pressure of the increasing demand on water by the domestic sector and industry. For example, farmers in the Jordan valley are suffering from the continuous decline in fresh water resources coming from Yarmouk River through King Abdullah Canal (KAC) as more water is pumped to Amman for drinking purposes. Accordingly, they are forced to tap unconventional water sources such as brackish water and treated wastewater. Treated wastewater quantities have been increasing due to the growing number of households being connected to the sewer system. This makes it as an available water source all over the year. Currently, more than 115 MCM of reclaimed water is produced from 26 treatment plants all over the country, where 79.6 MCM is generated from Samra treatment plant which is the main supplier to King Talal Dam (KTR),(JVA record 2009){12}.
Treated wastewater can be either used directly in restricted agriculture or indirectly in unrestricted agriculture after mixing it with other water sources. For the indirect use, treated wastewater is usually released in natural wadis and stored in reservoirs, where it is blended with other fresh water resources such as rainfall and spring water and then used in irrigation. In Jordan ,about 61 MCM of the total quantities of the generated reclaimed water are being stored in reservoirs and only used indirectly in unrestricted agriculture in the Jordan valley, while about 45 MCM are used directly for restricted irrigation and 2 MCM for industrial purposes at Aqapa Special free Zone (ASEZA).The remaining quantities are left without any use {12}. Therefore, and based on the above

mentioned facts ,MWI has updated the national water strategy for Jordan to control and manage the use of all water resources according to the environmental and public health regulations with a great emphasis on encouraging the (direct and indirect)use of reclaimed water as one major resource in agriculture{3}. There are several projects for the direct reuse of treated wastewater in Wadi Musa, Aqaba, Irbid, Madaba, Ramtha, Akeder, and Mafraq and others. One of the first pilot projects for direct reuse was implemented in Wadi Musa with support from USAID. This pilot project is located near the historic Petra funded by the United States Agency for International Development(USAID) and was initiated in 2003 and included a 69-duunum demonstration site and 300 dunums of farm plots divided among 14 farmers, who used reclaimed water to cultivate fruit trees, alfalfa and other fodder crops. Building on the project's success, 6 women farmers were incorporated the following year. By the mid of 2006 ,an additional 450 dunums of irrigated plots have been added to the site, allowing 20 additional farming families to benefit from the project, rendering a total cultivable area of around 800 dunums and 40 men and women farmers allowing them to earn JD 1000-2000/year from their plots. The demonstration site receives regular visits from professionals, school children, journalists and residents of nearby towns who come to enjoy the lush greenery. Olive trees, ornamental trees, fodder crops, geraniums and spruce are just a few of the crops on display at the site.

Water was first used to irrigate a demonstration farm, and then the fields of nearby farmers {14}. Another pilot project was initiated using wastewater from the small Wadi Hassan treatment plant to irrigate green spaces on the campus of the University of Irbid, and commercial fruit plantations {14}. Under other projects the Water Authority of Jordan, the operator of most municipal wastewater treatment plants in Jordan, has concluded contracts with farmers that irrigate mainly fodder crops, and in some cases tree crops. The total area irrigated under contracts with WAJ is 760ha {16}.

Research /Practice on different aspects of wastewater:

Existing water reuse in the Jordan’s 2008 water strategy has focused on the importance of research on treated wastewater and asked the researchers to conduct all possible subjects to demonstrate and set positive examples for the safe use of reclaimed water{2}. Several research projects have been conducted in Jordan by universities, research centers, governmental agencies and NGOs for treated wastewater through experimental sites. It includes determining soil characteristics prior to irrigation, Physical, chemical and biological characteristics of the effluent during the growing season. Suitability of the effluent for irrigation was studied. The crop and soil were tested for pathogenic pollution. The accumulation of salts and heavy metals in the soil as well as concentration of the nutrients and heavy metal accumulation in the plant tissues were determined. Results of the study showed that the effluent has low heavy metal content. MWI has participated in different international research projects, For example, the recently opened demonstration plant in Fuheis is part of the international research project SMART (**S**ustainable **M**anagement of **A**vailable Water **R**esources with Innovative **T**echnologies) funded by German Ministry of Research. Jordanian and German researchers, ministries and companies are working together within the project to draw up an integrated water resources management strategy for the Jordan River drainage basin, which extends over several Middle Eastern countries. Because of the high water requirements and low water volumes, the strategy has to include all available resources: groundwater, surface water, wastewater, brackish water and rainwater. Recycling wastewater is therefore as much a part of the concept as the protection of water resources against pollution, artificial groundwater recharge, and demand management. The experiences in Fuheis will help MWI to optimize operating costs and the stability of the wastewater technology pilot plants in the arid Arab climate by putting the know-how into practice on a larger scale. At the moment, the UFZ researchers, the Jordanian Ministry of Water and the research team are planning to implement decentralized wastewater treatment technologies and the associated operator concept in a pilot village in Jordan. Later on, the idea is to introduce decentralized wastewater treatment to larger scales thereby making additional water resources available for reuse. The research activities will be continued to the end of the year 2013.Hover several other projects are ongoing and the outcomes will be taken in consideration from the ministry of water and irrigation.

Wastewater standards in Jordan:

The Institution for Standards and Metrology (JISM) is the national entity responsible for issuing standards in Jordan. Standards are set by technical committees formulated by the Institution for Standards and Metrology from members representing main parties concerned with the subject. All concerned parties have the right to express their opinion and comments on the final draft of the subject standard during the notification period in order to make the Jordanian standards in harmony with international standards, to alleviate any technical boundaries facing trade and to facilitate flow of commodities between countries. Based on this, the permanent technical committee for water and wastewater No.17 has set the Jordanian Standard 893/2002 dealing with "Water-Reclaimed Domestic Wastewater" and recommended its approval as a Jordanian Technical base No. 893/2006 in accordance with article (11) paragraph (b) of the Standards and Metrology Law No. 22 for the year 2000. Jordan standard number 893\2006 of reclaimed water determine the standard ,regulations and guidelines that are required for water reuse in the present and for the future{10}. In fact, the higher the standards, the higher is the level of treatment leading to a better quality of reclaimed water intended for reuse. Jordan controls water reuse activities through country wide standards and signed official agreement with the users. The legal basis governing use of reclaimed water is encoded in the Jordanian standard. This Jordanian standard is purposely set to specify the conditions that the reclaimed domestic wastewater discharged from wastewater treatment plants should meet in order to be discharged or used in the various fields mentioned in this standard .The standard consists of several items discussed below and also a summary of selected water reuse guidelines, criteria and standard are presented in table number 4{1, 4}.

Jordan standard 893/2006{4}:

This standard identifies several Requirements and it has two primary components:

a) Reclaimed water discharged to streams, wadis or water bodies.
b) Reclaimed water for reuse.

1.0 General Requirements:

The main general conditions are summarized into:

- Reclaimed water must comply with the conditions stated in this standard for each of its planned end uses.

- It is not permitted to dilute by mixing reclaimed water before being discharged from wastewater treatment plants with pure water intentionally to comply with the requirement set in this standard.
- Should reclaimed water be used for purposes other than those mentioned in this standard (such as for cooling or for fire distinguishing), special standards or guidelines are to be applied in each case after conducting the necessary studies taking into consideration the health and environmental dimension.
- Official and specialized concerned parties overseeing the operation and development of wastewater treatment plants must always work towards improving the effluent quality to levels, maybe, exceeding those presented in this standard to ideally use the reclaimed water and protect the environment and public health.

2.0 Standard Requirements:

Reclaimed Water to be discharged to streams, wadis or water bodies:

- It is allowed to discharge reclaimed wastewater to streams or wadis or water bodies or reuse it when its quality complies with the properties and criteria mentioned in table (4) and measures must be taken to prevent the leakage of the reclaimed water to ground waters.
- It is prohibited to discharge it into wadis draining to the Gulf of Aqaba.

3.0 Reclaimed Water for reuse:

A) Artificial recharge of groundwater aquifers:

This part of the standard consists of reusing reclaimed water for artificial recharge of groundwater aquifers used for irrigation purposes if its quality complies with the criteria mentioned in Table 4 and technical studies must be performed to verify that there is no effect from artificial recharge activities on groundwater aquifers used for drinking purposes.

B) Reuse for irrigation purposes:

.The part of the standard is concerned with reclaimed water reuse for irrigation purposes and it consists of two main groups; standards group and guidelines.

- Standards group: is the group of properties and standards that are presented in Table 4 part A and where operating parties must produce water complying to it and according to the usages mentioned in this standard.
- Guidelines group: The guidelines group shown in Table 4 part B is considered for guidance only and in case of exceeding its values the end user must carry out scientific studies to verify the effect of that water on public health and the environment and suggest ways and means to prevent damage to either.
- It is prohibited to use reclaimed water for irrigating vegetables that are eaten uncooked (raw).
- It is prohibited to use sprinkler irrigation except for irrigating golf courses and in that case irrigation should practiced at night and the sprinklers must be of the movable type 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.
- Allowable limit for properties and criteria for reuse in irrigation is tabulated in table number 4.

4.0 Quality Monitoring:

The Wastewater Treatment Plant Owner Party and the Regulatory body must ensure that the reclaimed water quality complies to the standards and according to its end use. Operating and Monitoring parties must carry out the required laboratory tests according to the frequency of sampling mentioned in JS893/2006.

5.0 Evaluation Mechanism:

For the purpose of evaluating the quality of reclaimed water as per the different uses allowed in this standard the periods mentioned in the standard are followed and when any value violate the standards set for discharge of reclaimed water to streams, wadis or water bodies an extra-confirmatory sample must be taken. If the two samples exceeded the allowable standard limits the concerned party will be notified in order to conduct the necessary correction measures in the shortest possible time.

Table-4 Water – Reclaimed domestic wastewater Standard 893/2006{4}

Discharge to water bodies and wadis		Artificial Recharge		Irrigation			
Group A		**Group A**		**Cut flowers**	**C**	**B**	**A**
BOD_5	60	BOD_5	15	30	300	200	30
COD	150	COD	50	100	500	500	100
DO	>	DO	>2	>2	-	-	>2
TSS	60	TSS	50	15	300	200	50
PH	(6-9)	pH	(6-9)	(6-9)	(6-9)	(6-9)	(6-9)
NO_3	70	NO_3	30	45	-	-	30
T-N	70	T-N	30	70	70	45	45
E. coli	1000	*E. coli*	<1.1	<1.1	-	1000	100
Intestinal Helminthes Eggs	≤1	Intestinal Helminthes Eggs	≤1	≤1	≤1	≤1	≤1
FOG	8.0	FOG	8..0	2	8..0	8..0	8..0
Group B				**Cut flowers**	**A**	**B**	**C**
Phenol	<0.002	Phenol	<0.002	Phenol	<0.002		
MBAS	25	MBAS	25	MBAS	100(15) Cut flowers		
TDS	1500	TDS	1500	TDS	1500		
T-PO_4	15	T- PO_4	15	T-PO_4	30		
Cl	350	Cl	350	Cl	400		
SO_4	300	SO_4	300	SO_4	500		
HCO_3	400	HCO_3	400	HCO_3	400		
Na	200	Na	200	Na	230		
Mg	100	Mg	100	Mg	100		
Ca	200	Ca	200	Ca	230		
SAR	6.0	SAR	6.0	SAR	9.0		
Al	2.0	Al	2.0	Al	5.0		
As	0.05	As	0.05	As	0.1		
Be	0.1	Be	0.1	Be	0.1		
Cu	0.2	Cu	0.2	Cu	0.2		
F	1.5	F	1.5	F	1.5		
Fe	5.0	Fe	5.0	Fe	5..0		
Li	2.5	Li	2.5	Li	2.5 0.075)		
Mn	0.2	Mn	0.2	Mn	0.2		
Mo	0.01	Mo	0.01	Mo	0.01		
Ni	0.2	Ni	0.2	Ni	0.2		
Pb	0.2	Pb	0.2	Pb	5.0		
Se	0.05	Se	0.05	Se	0.05		
Cd	0.01	Cd	0.01	Cd	0.01		
Zn	5.0	Zn	5.0	Zn	5.0		
Cr	0.02	Cr	0.02	Cr	0.1		
Hg	0.002	Hg	0.002	Hg	0.002		
V	0.1	V	0.1	V	0.1		
Co	0.05	Co	0.05	Co	0.05		
B	1.0	B	1.0	B	1.0		
CN	0.1	CN	0.1	CN	0.1		

WHO water reuse Guidelines and JS 893/2006:

The current water quality laws, regulations and application standards for discharge of wastewater into rivers,Wadis, lakes and reuse in irrigation systems in some countries such as Sudia Arabia, Egypt, Jordan and the Palestinian Authority follow the rules developed by the World Health Organization (WHO, 1989,2004) or they follow more stringent rules developed in the United States by the State of California. The basis for these standards is essentially the protection of public health against risk of exposure to microorganisms and chemicals that are typically found in raw wastewater. None of the standards are strictly based on the level of risk associated with the limits in those standards (Risk Management Assessment). The standards of reclaimed water were developed to protect health of the agricultural workers, those who might enter a field in which wastewater is used as irrigation water, and the general public. The standards specify chemical, physical and a microbiological quality guideline values or a method of wastewater treatment that will achieve the required quality by trained operators who carefully operate and monitor the wastewater treatment plants. The long-term goal of Jordan is to treat wastewater used in agriculture to minimum secondary level and it has a unique system of rules and regulations to protect the quality of water resources and to regulate wastewater use and applications. In fact, in 1989, the World Health Organization published the Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture (WHO, 1989), {17} focusing on microbiological parameters, to protect public health . In the old guidelines, WHO1989 recommended the implementation of a rather stringent procedure depending mainly on a single barrier approach. This approach requires treating wastewater at a state-of –the art treatment plant to render treated water of an acceptable quality for reuse purposes. In the year 2006,WHO-FAO-UNEP issued the new guide lines the use of multiple barriers approach which is more flexible and less stringent. This approach combines treatment and post-treatment barriers compared to the old approach that relies solely on the treatment plant as the only reliable control measures.However, it is by no means acceptable to use treated wastewater in a way that compromises the health of the people for a rational adaptation and implementation of the new guidelines risk management system shall be in place in areas where treated water is used for irrigation and the three types of risks (microbiological, chemical ,physical) are associated with treated wastewater use.. The German technical cooperation agency GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) supports the *Management of Water Resources Programme* initiated in 2006. The Jordanian partner is the MWI. The main objective of the program is to increase sustainable use of the available water resources and enhance the use of treated wastewater by farmers and the establishment of water user associations is encouraged. Moreover, GIZ works on the risk assessment and risk management for the use of treated wastewater in irrigation in cooperation with the concerned ministries to make use of the new WHO guidelines based on the comparison between the old and the new guidelines as it is stated on table number (5).

Table (5): Comparison between old and new WHO guidelines {17, 18)

WHO-1989	WHO-2006
E.coli <1000MPN/100ml	E.coli threshold varies depending on the set health based target.
Depends on one single approach (WWTP)	Depends on a multiple barriers approach(drip irrigation)
Do not provide feasible risk-management solutions or guidance.	Provide an integrated approach that combines risk assessment & risk management to control water related diseases.
Unachievable under local circumstances.	Can be adopted according to the local socio-economic conditions.

Monitoring and reporting for reclaimed water:

Effluent quality and quantity may change with time as a result of available water quantity, the seasonal nature of some industries connected to sewerage system or operational problems in treatment processes. The regulatory body and operational party have to monitor reclaimed water regularly to maintain compliance with the approved JS 893\2006. In general, monitoring programs are implemented by environmental monitoring division at WAJ through collecting samples from the point of entry to the treatment plant, the effluent point from treatment plant and selected samples from sails,wadis and dams receiving reclaimed water. This Jordan standard illustrates the reclaimed water monitoring programs which have to be implemented by the regulatory body such as Ministry of Health and Ministry of Environment and the operational party responsible for managing and treating wastewater in Jordan{10}.

Wastewater Analysis Carried at WAJ Central Laboratories:

Various types of pollutants are present in domestic wastewater that can be measured by many different parameters. Wastewater chemistry analysis which are carried at WAJ laboratories including (Iron, Manganese, Copper, Chromium, Cadmium, Nickel, Lead, Zinc, Vanadium, Cobalt, Aluminum, Silver, Tin, Lithium, Molybdenum, Barium, Beryllium Arsenic, Selenium and Mercury), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), pH ,Turbidity, Total Suspended Solids, Total Dissolved Solids ,Phosphate Ammonium, Nitrate, Total Nitrogen, Boron, Sodium, Potassium, Calcium, Magnesium, Chloride, Sulfate FOG, MBAS, Cyanide and Phenol. The second class of wastewater analysis is Total Coliforms, *Escherishia coli and* Helminthes Eggs Count & Identification {3, 13}.

Wastewater Evaluation:

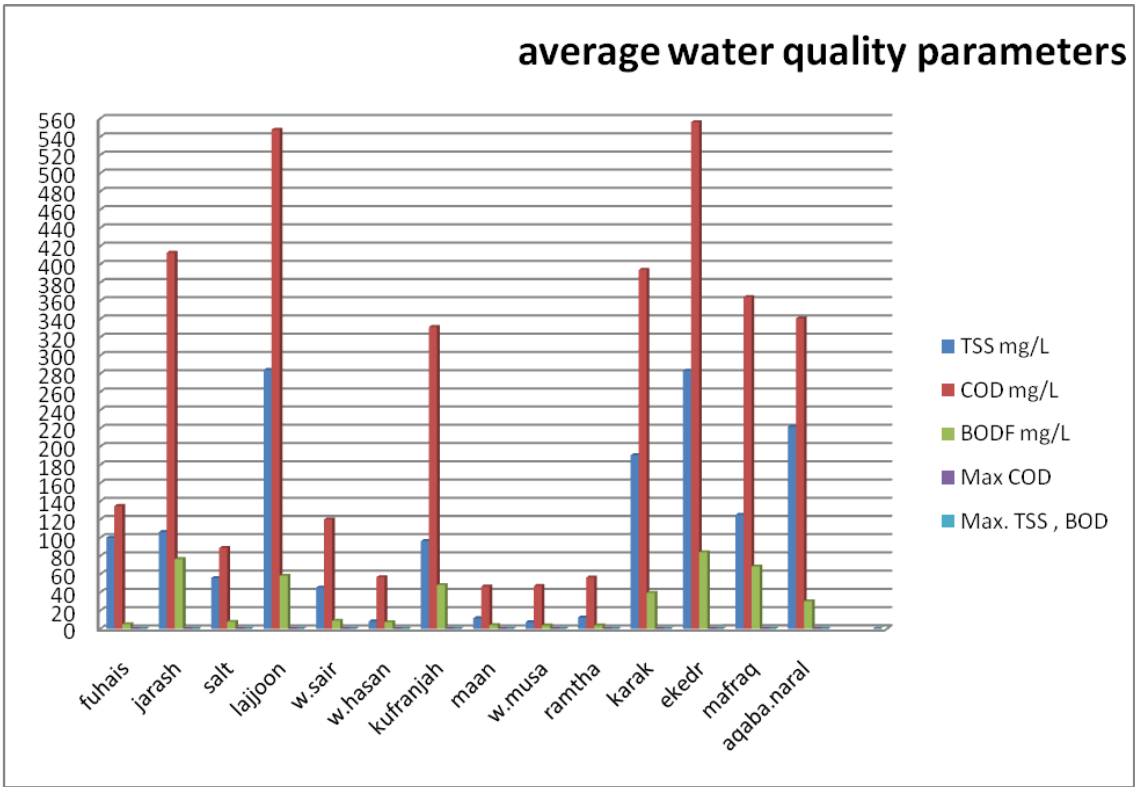
The generated water quality data analyzed at WAJ central laboratories shown in table (6) evaluated according to the reclaimed wastewater standard number 893/2006{4}. It is clear from these tables that some water quality parameters in some treatment plants such as phosphate, total nitrogen are exceeding the allowable limits because these treatment plants are not designed to deal with nitrogen compounds and phosphate removal Moreover, the water quality differs from treatment to another depending on the operation conditions, water quantity, and the type of treatment system. A number of elements of heavy metals and trace elements are normally present in relatively low concentrations, usually less than the allowable standard limits, and they tend to concentrate in the sludge (biosolids).Heavy metals and trace elements are rarely a proper concern of any of the uses of reclaimed water in Jordan and they are normally monitored on quarterly basis for regular irrigation water and other uses, but more attention is given to them when using sewage effluents, particularly if contamination with industrial wastewater discharges is suspected**.** The *E. coli* count and Intestinal Nematodes are the most satisfactory indicators for wastewater use in agriculture and public health. They comply with the current standard according to intended uses taken in consideration that reclaimed water is chlorinated before being discharged to receiving bodies. The total dissolved solid is one of the most important agricultural water quality parameters and it ranges from 552 mg\l for Aqaba treatment plant to 1877.18 mg\l for Lajjoun treatment plant. In conclusion, most of the reclaimed water quality produced in Jordan is suitable for restricted irrigation{16}.

Table-6Reclaimed water quality in Jordan for the year 2011{16}

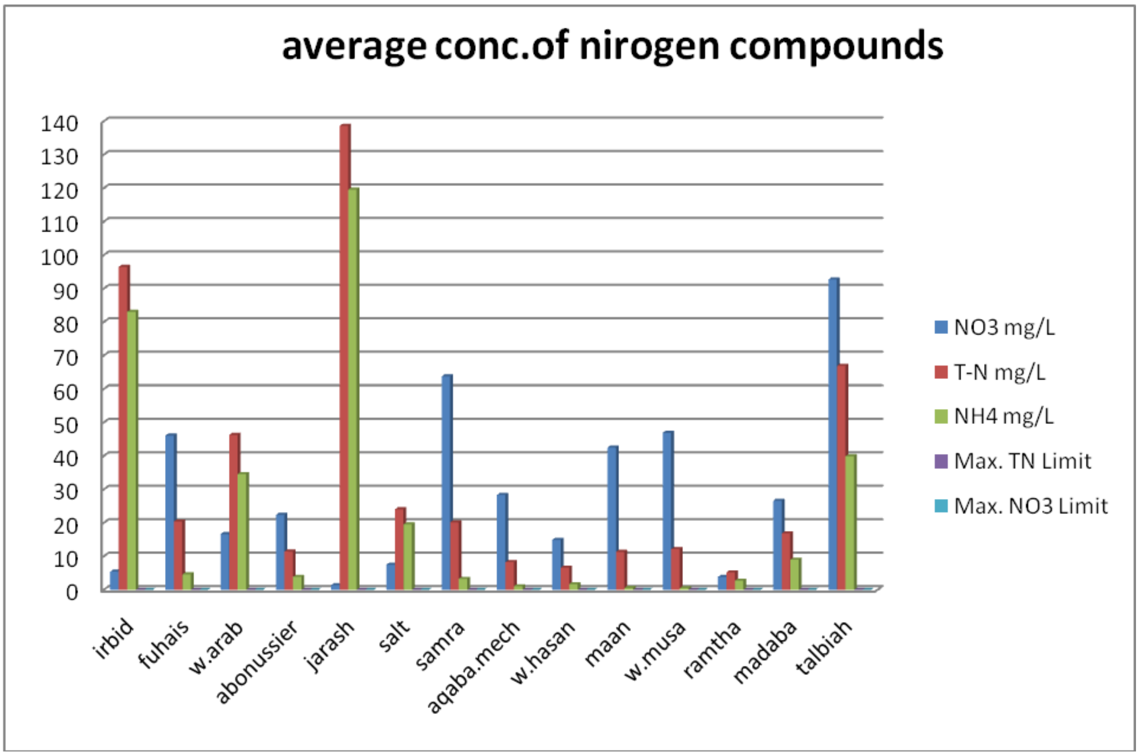
Treatment plant	E.Coli	PO4 As PO4	T-N	TDS	TSS	COD	BOD_F	BOD_5	pH
	MPN/100 ml	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Unit
Irbid	208971	19.58	96.49	1064.73	87.64	183.77		34.18	8.13
Fuheis	11388	19.38	20.41	980.64	100	134.77	5.1	4	7.94
Wadi Arab	45121	17.8	46.27	984.77	22.73	88		19.98	8.05
Abu Nuseir	5	14.59	11.45	1084.61	8.68	58.79		6.98	7.64
Jerash	277353	44.86	138.65	1408.36	106.14	412.86	76.55		7.86
Salt	14620	18.07	24.08	827.73	55.82	88.77	7.73		7.95
Tal Mentah	4985	36.1	137.55	1877.18	97.77	179.36		35.18	6.87
Samra	18	15.84	20.17	1109.82	17	71.09		9.91	7.85
Baqa	1027803	12.95	44.55	1169.34	33	109.52		49.5	8.09
Tafilla	2244119	36.15	87.97	796.73	97.86	214.82		49.55	8
Lajoun	22658	42.48	177.5	1491.18	284.09	547.73	58.36		8.17
Wadi Esseir	38	29.54	78.57	864.73	45.09	120.09	8.91		7.87
Aqaba Mech	6	5.91	8.27	552.09	5.45	26.09	3	4.65	7.89
Wadi Hassan	11	19.58	6.59	1107.82	8.14	56.73	7.2		7.76
Kufranjah	2150640	39.95	133.57	1077.27	96.32	331.18	48.09		8.1
Maan	12	10.38	11.34	1054.64	11.64	46.45	4		8.39
Wadi Mousa	3	15.97	12.2	835.55	7.35	47	3.68		8.02
Ramtha	57	11.27	5.21	1393.45	12.5	56.41	3.64		8.09
Madaba	254722	2.96	16.86	1178	13.05	58.14	#DIV/0!	8.64	8.03
Karak	3060615	29.3	126.6	963.64	190.55	393.95	39.55		7.92
Jiza	2130	24.42	66.91	1271.45	14.91	76.82	#DIV/0!	7.82	8
Ekeider	422582	42.17	154.76	1241.45	283.18	556.09	83.91		8.1
Mafraq	2628923	41.33	138.73	1032.36	125.09	364.18	68.36		7.98
Aqaba Natural	51293	19.2	60.63	767.82	221.73	340.55	30.18		8.08

Treatment plants efficiency:

The efficiency of 24 treatment plants is different from plant to another measured by BOD_5 as an indicator of removing dissolved organic matter from treated sewage; it ranges from 80% for Mafraq T.P to 99 % for Wadi Hassan T.P. The average annual BOD5 and other water quality parameters for the wastewater treatment plants & the operation systems used in Jordan are shown in Figure No (1, 2). This figure clarifies that the activated sludge system is very effective in removing dissolved organic matter and WAJ can rely on it as a first choice and after that the trickling filter followed by wastewater stabilization ponds{15,16}.



Annual BOD5 for wastewater treatment systems-Fig. 1 – {16}



Annual water quality parameters for wastewater treatment systems-Fig. 2 – {16}

Treated wastewater quantity:

The wastewater quantity flows to treatment plants is about 117 MCM for the year 2010 and 115 MCM for the year 2011 {15}. It was decreased by (2%) from the year 2010 due to the shortage of water flowing to these treatment plants. More over, about 72.5% of wastewater quantity was treated at Sammra T.P. The discharged and used quantity of reclaimed water from all treatment plants is about (111) MCM for the year 2011 {15}, In fact, reclaimed water has long been recognized as a valuable resource for use in irrigation and other intended uses and considered as an important water resource according to Jordan Water Strategy. WAJ has a goal of attaining total water reuse by having highly treated effluent to be used in the intended aspects.

How well are we doing?

In Jordan, the government's policy is to achieve and improve wastewater collection, conveyance, treatment, and disposal and reuse systems. WAJ so far has provided the service on sewer and treatment systems, 26 treatment plants exist all over the country working 24 hours a day and the number of carried out connections is (275243) at the end of the year 2011, 68.8% of these connections flow to Samra T.P{15}. Water reuse is now a part of Jordan's overall water resources balance and also it is a tool of protecting water resources, coastal areas and receiving bodies from pollution effects. Planned reclaimed water reuse has been practiced in Jordan and some pilot projects have been launched or are under study for irrigation& other intended uses taken in consideration that the percentage of the public acceptance has been increased for the last ten years. Moreover, a crop monitoring program carried by Jordan FDA confirmed that use of treated wastewater in Jordan meets the health-based target recommended by the WHO guidelines for the safe use of treated wastewater{12}.

Conclusions:

Jordan experience in quality aspects of reclaimed water and standards gives an excellent example of how developing countries can proceed forward and take full advantage of reclaimed wastewater as a valuable resource depending on numerical standards for intensive monitoring, control and legal enforcement. The first step toward capturing this important resource is implementing and enforcement reclaimed water standard 893 for the year 2006.This standard varies with the type of application and the overall risk perception and there will be different water quality requirements and criteria for each aspect. Generated reclaimed water quality from most of the treatment plants in Jordan is suitable for restricted irrigation. Public acceptance and awareness are a major issue with all reuse activities and can be crucial to all project outcomes. Generally, acceptance of water reclamations has increased over the past two decades, along with a growing familiarity with the subject. In an effort to integrate reclaimed water resources in national water planning, the government of Jordan, with support from the US Agency for International Development (USAID) and German International (GIZ), has been for the past 10 years implementing several direct water reuse activities that seek to demonstrate that reclaimed water reuse can be reliable, commercially viable, socially acceptable, environmentally sustainable and safe.

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