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POSSIBILITIES OF REUSE OF TREATED WASTEWATER FOR IRRIGATION PURPOSES IN THE NORTHERN JORDAN VALLEY

The possibilities of treated wastewater (TWW) reuse for irrigation purposes in the Northern Jordan Valley have been described. As shown by the analysis of the data, the results indicate a wide non-compliance with the Jordanian Standard 983/2006. Most problematic parameters are BOD, COD, nitrogen content, TSS. TWW will be blended with fresh water prior to use in agriculture. The blended water quality was reviewed after mixing of fresh water with the existing TWW without plant improvements. In general if there are no WWTP upgrades, the blended water quality satisfies the requirements of the Jordanian Water Quality Guidelines.

1. INTRODUCTION

Climate change, water supply limits, and continued population growth have intensified the search for measures to conserve water in irrigated agriculture, the world's largest water user. Many countries have inadequate water supplies to meet their current urban, environmental, and agricultural needs. In the face of increased water scarcity, population and water demands continue to grow. The challenge is to grow enough food for 2 billion more people over the next 50 years while supplying growing urban and environmental needs for water. Some analyses have estimated that 60% of added food required will come from irrigation. Raising food production to support this larger world population requires sustaining improved performance of irrigation [1].

Jordan is considered as one of the ten most water scarce countries in the world. In many Jordanian cities, residents receive water only sporadically, and domestic water consumption is among the lowest in the world, lower than 100 dm^3/capita/days. High population growth, the depletion of groundwater reserves and the impacts of climate

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change are likely to aggravate the situation in the future. Deficit of water shows the necessity for adopting a long term water plan and future scenarios of water management that consider both demand management and non-conventional water resources, in order to decrease the gap between supply and demand [2–4].

So now, wastewater is not just sewage. All water used domestically that enters drains or the sewage collection systems is wastewater, including water from baths, showers, sinks, dishwashers, washing machines, and toilets. In combined municipal sewage systems, water from storm drains is also added to the municipal wastewater sewer system.

The expected very good quality effluent of the new wastewater treatment plant (WWTP) has made it possible to explore new water reuse methods. Seawater desalination is costly, because the sea is very far from highly populated areas, making the cost of transferring. Wastewater reuse has the lowest cost, therefore reuse of reclaimed wastewater is necessity [5].

The possibilities of treated wastewater reuse for irrigation purposes in the Northern Jordan Valley have been described. Two wastewater treatment plants such as Central Irbid and Wadi Arab were analyzed. For each WWTP, the balances of sewage quantity were made and the quality of treated sewage was rated.

2. WATER AND SEWAGE MANAGEMENT IN THE HASHEMITE KINGDOM OF JORDAN

The Hashemite Kingdom of Jordan covers a territory of about 91 880 km^2 with 99% land area. The population of Jordan was 6.5 million at 2011, the natural rate of growth of 2.16% (2010) is one of the highest growth rates in the world. About 70% of the population is urban. The capital of Jordan, Amman is a city of 2 million people, located in the northwest portion of the country [3]. Jordan lies among the mainly semi-arid to arid zone which are characterized by their minimal rainfall and high percentage of evaporation. Climate in this country is a mix of Mediterranean and dry desert climate. Only the highlands that are to the east of the Jordan Rift Valley are blessed with a Mediterranean climate, where the weather is cold and wet in winter and hot and dry in summer. In the rest of the Kingdom, the temperatures are usually very high during the summer season (around 46 °C) and low in winter (a few degrees below zero). Snowfall occurs generally once or twice a year over the highlands. The rainy season extends from October to April, with the peak of precipitation taking place during January and February [3]. Only around 0.7% of Jordan's area receives an average annual precipitation of more than 500 mm, 3.3% between 300 and 500 mm, 2.2% between 200 and 300 mm, 22.3% between 100 and 200 mm and the rest, 71.5%, receive less than 100 mm/year [2, 3]. Approximately 92.2% of the rainfall evaporates, 5.4% recharges the groundwater and the rest 2.4% goes to the surface water [2, 3]. Surface water resources in Jordan are limited. There are only a few small streams – the Zarqa, Yarmouk and Wadi Shuib Rivers – and essentially no natural lakes exist.

Jordan shares the rivers providing much of its water with Israel and Syria. Jordan does not possess rivers in the worldwide known scale, except the Jordan River which used to discharge around 1400 million m^3/year into the Dead Sea before the development of the water resources in its catchment. Even this river is a very small source compared with international rivers like the Nile or Euphrates, because its total annual discharge amounts to only 1.5% of the former and 4.3% of the latter. Other surface water resources in Jordan are found in the Yarmouk and Zerka rivers and in wadis like Karak, Mujib, Hasa, Yabis and El-Arab, in addition to flood flow wadis in various parts of the country [6, 7].

The average annual renewable fresh water resources that can be safely exploited in Jordan amount to 780 million m^3, of which 277 million m^3 is from groundwater and the rest is from surface water resources. In additional, reused treated wastewater and nonrenewable water resources are also employed. Jordan water resources consist primarily of surface and ground water, the renewable water resources in 2010 were estimated to be about 1203 million m^3, including ground water (277 million m^3 distributed among 12 basins), usable surface water (234 million m^3 distributed among 15 catchments basins) and treated wastewater 177 million m^3, an additional 140 million m^3/year of ground water is estimated to be available from fossil aquifers [3, 7, 8].

The groundwater aquifers of Jordan are divided into three main complexes: Deep Sandstone Aquifer Complex, Upper Cretaceous Aquifer Complex, Shallow Aquifer Complex. Brackish aquifers are not yet fully explored, but at least 55 million m^3/year is expected to be available for urban uses after desalination. In arid countries like Jordan, even slight changes in water levels have significant impacts on agriculture, industry, nutrition, and health. In 2010, approximately 1002 million m^3 of water was used for agricultures, 435 million m^3 – for municipal purposes, 102 million m^3 – for industrial purposes, and 7 million m^3 – for livestock purposes. Table 1 shows the water demand for various sectors in 1995–2020 [3, 8].

Table 1

Water demand [10^6 m^3/year] for various sectors [3, 8]

Sector	Year					
	1995	2000	2005	2010	2015	2020
Agricultural	790	922	981	1002	992	963
Municipal	274	321	382	435	520	615
Industrial	37	54	80	102	134	168
Total	1101	1297	1443	1539	1646	1746

Wastewater is about 99.85% water by weight and is generally referred to as influent when it enters the treatment plant. Domestic wastewater primarily comes from individuals, and does not generally include industrial wastewater [9].

Wastewater will be collected, treated managed and used as a resource in an efficient and optimized manner. Treated wastewater will comply with national standards and will be treated to a level appropriate for agriculture and possibly for ground water aquifer recharge. Table 2 shows the water supply for various demand (2006/2007) [10].

Table 2

Water supply [10^6 m^3/year] for various demand at 2006/2007

Demand requirements	Ground water	Surface water	Treated wastewater	Total
Domestic	214.0007	79.75	0	293.751
Rural area	0.745	7	–	7.745
Industry and remote areas	44.894	3.527	0	48.421
Agriculture	244.81	176.366	90.97	512.146
Agriculture (high land)		77.46	–	77.460
Total supply demand	504.4497	344.103	90.97	939.523

To 2020, Jordan will be facing considerable water deficits each year. As shown in Table 3, the water deficit for all uses will grow from 260 million m^3 in 2000 to 408 million m^3 by the year 2020 [10].

Table 3

Projections of water supply and demand [10^6 m^3]

Year	Supply	Demand	Deficit
2000	993	1.253	260
2005	1.169	1.407	238
2010	1.206	1.457	251
2015	1.225	1.550	325
2020	1.250	1.658	408

3. THE JORDANIAN STANDARD AND THE IRRIGATION WATER QUALITY GUIDELINES IN THE INTERNATIONAL CONTEXT

Parameters of treated wastewater were compared with the requirements for their use for agricultural irrigation. Two standards which address treated wastewater reuse are available in Jordan:

- Jordanian Standard JS 893/2002 (last amended 2006) addresses the properties, quality control and other requirements for reclaimed water, specifically those that domestic wastewater must meet before being discharged to any receiving body or reused for agriculture or other intended uses [11].
- The Jordanian Irrigation Water Quality Guidelines deal with brackish water, surface and ground water and blended water that can be used in unrestricted irrigation [12].

Table 4

Comparison of Jordanian and FAO irrigation Standards and Guidelines

Parameter	Unit	Jordan JS 893/2006				Jordan[1]	FAO[2]		
							Degree of reduction on use		
		A. Cooked vegetables parks, playgrounds roadsides in the city	B. Fruit trees landscaped roadsides of highways	C. Industrial crops forest trees	D. Cut flowers		None	Slight to moderate	Severe
1	2	3	4	5	6	7	8	9	10
Physicochemical characteristics									
TSS	mg/dm^3	50	200	300	15	<50			
COD		100	500	500	100				
BOD_5		30	200	300	30				
EC	dS/m	(EC: 2.34)					<0.7	0.7–3.0	>3.0
salt sensitive						<1.7			
medium salt tolerant						1.7–3			
salt tolerant						3–7.5			
higly salt tolerant						>7.5			
TDS	mg/dm^3	1500					<450	450–2000	>2000
$N–NH_4$						<16			
$NO_3/NO_3–N$		30/6.8	45/10.4	70/16.1	45/10.4	<16	<5	5–30/1.2–6.8	>30/>6.8
Total nitrogen		45	<70	100	70	<50			
$PO_4–P$		30							
Chloride		400					<400	400–1000	>1000
Bicarbonate		400				<520	<1.5	1.5–8.5	>8.5

Table 4 continued

Microbiological characteristics							
1	2	3	4	5	6	7	8–10
Eschericha coli or *Feacal coli*	MPN/ 100 cm^3	100	1000		<1.1	1000 *F. coli* or 100 *E. coli*	1000 *E.coli* (irrigation of crops likely to be eaten uncooked; otherwise no standard recommended)
Intestinal nematodes	viable eggs/dm^3					<1	
Intesinal helminthes		<1	<1	<1	<1		1 (irrigation of crops likely to be eaten uncooked)
Heavy metals/trace elements							
Arsenic	mg/dm^3	0.1					0.1
Cadmium		0.01					0.01
Chromium		0.1					0.1
Copper		0.2				<1	0.2
Lead		0.2					5.0
Mercury		0.02					
Nichel		0.2					0.2
Zinc		5.0				<2	2.0
Aluminium		5.0					5.0
Lithium		2.0 (0.075 for citrus)					2.5 (0.075 for citrus)
Iron		5.0				<1	5.0

[1]The Jordanian Irrigation Water Quality Guidelines.

[2]FAO irrigation and drainage paper 47. Wastewater treatment and use in agriculture.

Jordanian standards for reclaimed wastewater 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, DO, TSS, *Escherichia coli* bacteria, and helminthes eggs. In the present time, the reclaimed wastewater is used for restricted agriculture either near the plants or downstream after mixing with natural surface water.

The applicability of Jordanian Standard JS 893/2006 and the Irrigation Water Quality Guidelines to serve in the Jordan Valley has been controversially discussed, especially in the context of design parameters for the WWTP improvements.

Therefore, both Jordanian standards are compared in Table 4 with FAO guidelines published in the *FAO irrigation and drainage paper 47. Wastewater treatment and use in agriculture* [13]. Four classes (A–D) of selected agricultural products or selected services (parks, road sites) are also outlined for direct reuse of effluent in agriculture. Hereby, the classes A (uncooked vegetables) and D (collecting flowers) represent the more stringent quality, while classes B (fruit trees) and C (industrial crops) are regulated less stringent.

Agriculture is an important economic activity in Jordan. Treated wastewater could be a valuable source for irrigation in the agricultural sector, as an alternative for fresh water resources that is urgently needed for the rapidly growing urban populations. Currently there is an increasing percentage of irrigated areas using treated wastewater. With a fast growing population and expansion of the irrigated areas to meet the food demand the pressure on water resources in Jordan remains of imminent importance. In Jordan the agricultural sector consumes approximately 64% of available water per year with one-third of this amount consumed in the Jordan Valley and about 50% reclaimed water. All in all, agriculture consumes less than 35.5% of the total amount of freshwater available in the Jordan Valley [14].

The preferred irrigation method is drip irrigation in combination with very thin plastic sheets (in Jordan called "mulch") which cover the plant rows. The main crops that are grown in the Jordan are citrus, vegetables, bananas, grapes and certain stone fruits in open field and greenhouse cultivations.

4. CHARACTERISTICS OF WASTEWATER TREATMENT PLANT IN THE NORTHERN JORDAN VALLEY

Over 63% of the Jordanian population is connected to sewerage systems, all of which will be treated in the next few years. Generally there are two types of WWTPs in Jordan; one is the centralized WWTP recognized as a governmental institution, while the other is the decentralized WWTP such as those installed at airports, universities and private companies.

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 m^3 per day (115 million m^3/year), or about 98% of the collected wastewater [15]. There are 26 governmental and 23 private WWTPs [16]. Most of the treatment plants are small, except for the plant as As-Samra, which treats more than 80% of this quantity. The area under study is located in the Northern Jordan Valley. The Greater Irbid Area is the catchment of effluent of the Waste Water Treatment Plants (WWTP) of Wadi Arab, Wadi Hassan, Central Irbid and Wadi Shallala. An unrestricted use in irrigated agriculture requires upgrading and improvement measures at the existing WWTP, especially at Central Irbid.

5. WWTP CENTRAL IRBID

Irbid wastewater treatment plant has been in operation since 1986 [17]. It is in charge of treating of 10 000 m^3/day (2010) of wastewater flowing from the city of Irbid. The incoming wastewater flow is measured in a venturi channel after passing through two automatic screens. Due to favorable topographic conditions, no pumps are necessary at the plant inlet. After metering, the flow is divided into two aerated grit chambers and then, two rectangular primary clarifiers. The primary sludge is conveyed to the digester. The trickling filter pumping station conveys the pretreated sewerage from the primary clarifies to the first biological stage consisting of two trickling. The water is distributed by sprinklers over the surface and, dripping down, passes sessile organism. The second biological stage consist of two aeration tanks. After the aeration in the tanks the wastewater undergoes clarification in two final circular sedimentation tanks, then flows to the chlorination station and the subsequent effluent flow metering venturi channel.

Table 5

Characteristic of treated wastewater of Central Irbid WWTP in 01.2010–05.2011

Parameter	Unit	2010	2011	JS 893/2006 (Class A. Cooked vegetables)
BOD_5	mg/dm^3	15–59	55–170	30
COD		69–328	75–801	100
TSS		17–181	64–197	50
Total N		54–122	56–136	45
NH_4-N		29–87	15–136	–
NO_3		0,3–14	0.6–1.5	30
PO_4-P		2.0–24	17–60	30
E. coli	MPN/100	490–5.5160000	2.190–241.920	100

The average daily flow during 2010–2011 period amounts to 8132 m^3/d. The maximum daily dry weather wastewater flow can be assumed to amount 10 000 m^3/d. In the plant, monitoring diary gives a few indications about rainy days when inflows of sewage exceeding 10 000 m^3/d (maximum ca. 15 000 m^3/d). Analyzed samples (Table 5) of the plant effluent indicate that the plant does not always meet the effluent criteria of JS 893/2006 [11]. Part of the treated wastewater as well as untreated sewage eventually flows to Jordan River and the rest will flow into the ground water aquifer downstream.

6. WWTP WADI AL ARAB

The Wadi Al Arab WWTP has been in operation for 13 years (operation started in 1999) [17]. There are not any built-up areas in the vicinity of the plant. The incoming wastewater flow is measured in a venturi channel before passing two automatic screens. Due to favorable topographic conditions, no pump is necessary at the plant inlet. After the screens, the wastewater flows into an aerated grit chamber. The biological stage consists of six rectangular aeration tanks, each equipped with four surface aerators. Here the organic carbon removal and sludge stabilization is achieved through the extended aeration activated sludge process. The running aerators work 24 hours per day. After the aeration tanks, the wastewater is clarified in six final circular sedimentation tanks, then flows to the chlorination station and reaches the subsequent effluent flow metering venturi channel. Only during few rainy days the inflow to the WWTP exceeds its capacity. The average daily flow amounts to 11 052 m^3/d. Table 6 shows effluent indicates of wastewater in comparison the effluent criteria of JS 893/2006 [11].

Table 6

Characteristic of treated wastewater of Wadi Al Arab WWTP in 01.2010–05.2011

Parameter	Unit	2010	2011	JS 893/2006 (Class A. Cooked vegetables)
BOD_5	mg/dm^3	3–13	25–76	30
COD		20–104	45–154	100
TSS		8–44	38–174	50
Total N		8–44	12–52	45
NH_4-N		0.4–10	0.1–42	-
NO_3-N		2–34	0.6–10	30
PO_4-P		10–27	23–52	30
E. coli	MPN/100	5.8–330.000	24–241.920	100

Analyzed samples (Table 6) of the plant effluent indicates that the plant does not always meet the effluent criteria of JS 893/2006 [11]. To meet the quality standard of the treated wastewater, there is a plan to construct a new wastewater plant. At the Central Irbid WWTP, the results reviewed show a wide non-compliance with the Jordanian

Standard. Most problematic parameters are BOD, COD, total nitrogen, TSS and phosphate. At the Wadi Al Arab WWTP, the analyses show some compliance with the Jordanian Standard, but the most problematic parameters are the total nitrogen and TSS.

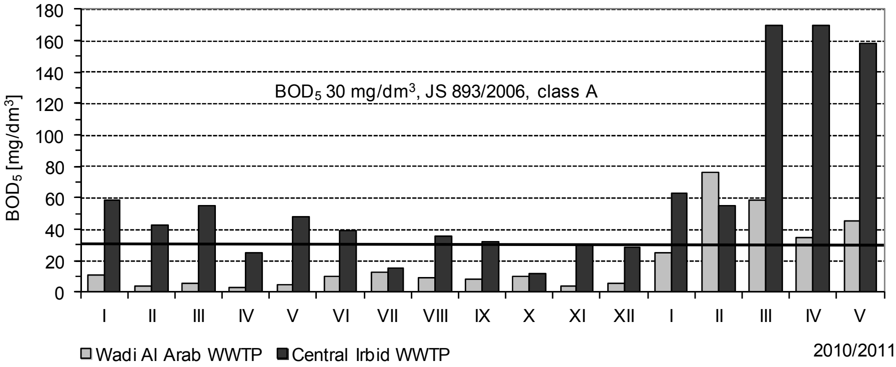

Fig. 1. BOD_5 values in treated wastewater

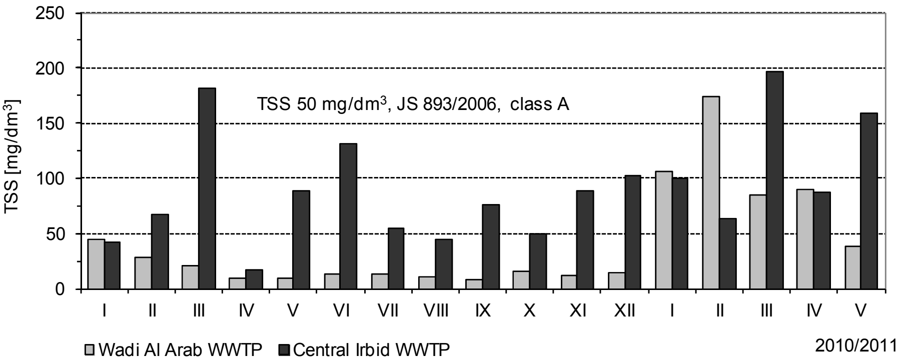

Fig. 2. TSS concentrations in treated wastewater

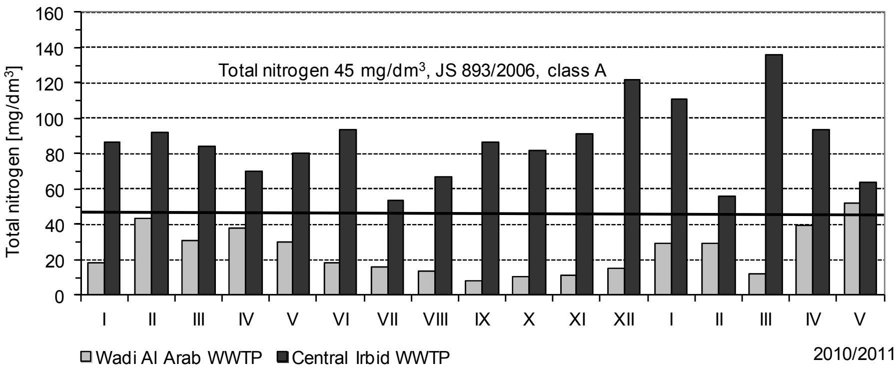

Fig. 3. Concentrations of total nitrogen in treated wastewater

Figures 1–3 show mean monthly values of such parameters as BOD_5, TSS and total nitrogen in the period 2010/2011 and marked their limit values according to the JS893/2006 for the Class A (cooked vegetables).

To meet the quality standard of the treated wastewater flowing from the Irbid city, there is a plan to construct a new wastewater plant on the lower altitude of the city, which will cover the population currently not connected to the Irbid treatment plant. To reach the requirements for BOD_5, COD, TSS and P-PO_4 secondary wastewater treatment with adequately designed sedimentation tanks will be necessary. To reach the requirements for TKN and N-NH_4, nitrification and denitrification will become necessary. The same needs like the Central Irbid WWTP, to reach the requirements for BOD_5, COD, TSS and P-PO_4 secondary wastewater treatment with adequately designed sedimentation tanks will be necessary to Wadi Al Arab WWTP. To reach the requirements for TKN and N-NH_4, nitrification and denitrification will become necessary.

7. POSSIBILITY OF USING TREATED WASTEWATER FOR IRRIGATION IN AGRICULTURE IN THE NORTHERN JORDAN VALLEY

The first feasibility study on the reuse of treated wastewater for irrigation purposes in the Northern Jordan valley was completed in 2005 [18–20]. With this option, the two existing wastewater treatment plants: Wadi Al Arab and Central Irbid will be upgraded to provide effluent suitable for irrigation. The treated wastewater (TWW) will then be conveyed by a single transmission pipeline from the three plants at Wadi Ash Shallalah, Central Irbid and Wadi Al Arab to a mixing station in the Northern Jordan Valley, where it shall be blended with fresh water from King Abdullah Canal and Wadi Arab Reservoir. From there, the blended water will be injected into the pressurized irrigation system of the Northern Jordan Valley and used for irrigation. Crops to be irrigated are all kinds of orchards (mainly citrus), fodder and vegetables commonly eaten cooked. The existing irrigation system is entirely pressurized either by pump pressure or by gravitational head.

The Wadi Ash Shallalah WWTP will be connected to the irrigation system, as soon as the plant is put into operation by 2015, thus it has been skipped in this paper, and considerations apply to the other two wastewater treatment plants [19, 20].

Table 7 shows total water demand for cropping pattern of project area and potential sources of supply for 2015: fresh water volume from the King Abdullah Canal and Wadi Arab Reservoir, and treated wastewater volume for 2015 [20].

TWW will contribute about 10% to 35% to the total irrigation water supply in the years 2010 and 2035 respectively. That means that the major share of the irrigation water will be freshwater and the both waters will be mixed at given blending ratios before injection into the piped irrigation system. Blended TWW will be distributed uniformly to all farms throughout the entire irrigation area.

Table 7

Total water demand for cropping pattern of project area and potential sources of supply for 2015

Crop	Cultivation area [ha]	Total water demand of project area (MCM)												
		Month												Total
		J	F	M	A	M	J	J	A	S	O	N	D	
Citrus	3048	1.11	1.57	0.67	3.57	5.08	5.46	5.73	5.35	3.92	2.61	1.28	0.15	36.52
Other tree	270	0.19	0.21	0.29	0.42	0.64	0.70	0.73	0.73	0.55	0.36	0.24	0.16	5.26
Banana	162	0.02	0.04	0.12	0.21	0.34	0.40	0.47	0.47	0.36	0.24	0.11	0.07	2.84
Vegetable	1082	0.34	0.04	0.68	1.48	0.37	0.00	0.00	0.00	0.78	1.39	0.73	0.39	6.19
Date palm	202	0.01	0.13	0.10	0.23	0.45	0.50	0.52	0.51	0.38	0.25	0.14	0.00	3.22
Fodder	551	0.20	0.23	0.45	0.68	1.12	0.92	0.59	0.30	0.21	0.09	0.02	0.05	4.85
Grain	80	0.00	0.00	0.04	0.11	0.17	0.10	0.02	0.00	0.00	0.00	0.00	0.00	0.45
Total	5394	1.88	2.22	2.36	6.70	8.16	8.08	8.10	7.36	6.19	4.95	2.52	0.81	59.33
		Fresh water volume, FW (MCM)												
		J	F	M	A	M	J	J	A	S	O	N	D	Total
Monthly releases from King Abdullah Canal		1.88	2.22	2.36	6.45	7.66	7.08	6,10	5.36	5.19	4.20	5.52	0.81	51.83
Monthly releases from Wadi Arab Reservoir		0.00	0.00	0.00	0.25	0.50	1.00	2.00	2.00	1.00	0.75	0.00	0.00	7.50
Total		1.88	2.22	2.36	6.70	8.16	8.08	8.10	7.36	6.19	4.95	2.52	0.81	59.33
		Treated wastewater volume, TWW (MCM)												
		J	F	M	A	M	J	J	A	S	O	N	D	Total
TWW total		–	–	1.54	1.54	1.20	1.20	1.20	1.20	1.20	1.37	1.54	–	11.99
blending ratio TWW:FW 1:		5.0												

The quality of the blended water is of critical importance for such use. In order to determine an appropriate treatment approach, the blended water quality was estimated for different wastewater treatment approaches as follows. Table 8 shows characteristics of treated wastewater from the Central Irbid WWTP and Wadi Al Arab WWTP, fresh water from the King Abdullah Canal and Wadi Arab Reservoir, and comparison characteristic of blended water with Jordan standard [20]. Table 8 shows the concentration of each parameter for the case considered, resulting in a "mixed TWW" quality. Mixing of TWW with freshwater will results in a "blended TWW" quality to be finally injected in the agricultural irrigation network. Estimate is made assuming modernization of both wastewater treatment plants, taking into account the requirements of the quality of treated sewage used for irrigation in accordance with the Jordanian standards.

Table 8

Characteristic of treated wastewater from Central Irbid WWTP and Wadi Al Arab WWTP, fresh water from King Abdullah Canal and Wadi Arab Reservoir, and comparison characteristic of blended water with the Jordan standard

Parameter [mg/dm^3]	Central Irbid WWTP	Wadi Al Arab WWTP	Mixed TWW	Fresh water	Blended TWW	Jordan guideline	JS 893
TSS	94.4	72.6	82.4	28.0	34.36	<50	<50
BOD_5	77.5	44.4	59.34	2.00	8.70	<60	<30
COD	249.8	83.8	168.71	13.00	30.03	<120	<100
NH_4-N	1.0	1.0	1.00	0.10	0.21	<16	not defined
NO_3-N	30.0	30.0	30.0	1.10	4.48	<16	<30
Total nitrogen	33.0	33.0	33.0	33.00	4.50	<50	<45

At the Central Irbid and Wadi Al Arab WWTPs, the parameter TSS is permanently exceeding the target value of 50 mg/dm^3, thus the mixed TWW concentration also exceeds the target value. COD and BOD parameters by the Central Irbid WWTP are negatively influenced on mixed TWW characteristic. Even when the blended TWW quality is in accordance with the target value, a trend to increase concentrations is obvious. To meet the quality standard of the treated wastewater flowing from WWTPs, secondary wastewater treatment with adequately designed sedimentation tanks and nitrification/denitrification processes will be necessary.

With this solution, the results indicate that the quality of the blended TWW is in accordance with the Irrigation Water Quality Guidelines and JS 893 [11, 12].

8. CONCLUSION

In April 1997, the Ministry of Water and Irrigation of Jordan prepared a draft Water Strategy for Jordan. The strategy defines long term goals that the government of Jordan seeks to achieve in the water and wastewater sector, and the main goals is Wastewater shall not be managed as “waste”. It shall be collected and treated to standards that allow its reuse in unrestricted agriculture and other non-domestic purposes, including groundwater recharge. An important strategy for the Jordanian government is to meet the water demand for agricultural sector by producing more treated wastewater.

The expected very good quality effluent of the WWTP has made it possible to explore new water reuse methods in Jordan. Among the non-conventional water resources, wastewater reuse has the lowest cost. Seawater desalination is costly, because the sea is very far from highly populated areas, making the cost of transferring. Therefore reuse of reclaimed wastewater in Jordan is necessity.

The characteristics of raw wastewater in Jordan are somewhat different from other countries. Wastewater in Jordan can be characterized as very strong with high salinity and insignificant heavy metals and toxic organic compounds. The average domestic water consumption is low. This results in very high organic loads. Therefore, to meet requirement quality of effluent are necessary highly effective wastewater treatment plants.

As shown by the analysis of the data from the Central Irbid WWTP, the results reviewed indicate a wide non-compliance with the Jordanian Standard 983/2006. Most problematic parameters are BOD, COD, nitrogen, TSS, and *E. Coli*. At the Wadi Arab WWTP, the results show compliance with JS 983/2006, where the most problematic parameters are BOD and TSS. TWW will be blended with fresh water prior to use in agriculture in the Northern Jordan Valley and the quality of the blended water is of critical importance for such use. The blended water quality was reviewed after mixing of the fresh water with the existing TWW without plant improvements. In general if there are no WWTP upgrades, the blended water quality generally satisfies the requirements of the Jordanian Water Quality Guidelines.

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