A Framework For Wastewater Reuse In Jordan: From Present Status To Future Potential, Applying the Wastewater Reuse Index (WRI) as Indicated.

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Abstract: Pressing water scarcity in Jordan increased the demands of marginal water for agriculture, of which the treated wastewater is the most prominent candidate. Water management studies reveal that no single source could fully solve the nation's water shortage and many integrated actions are needed to ensure water availability, suitability and sustainability. Among these options the developments of new water resources such as treated wastewater and brackish water have the potential to augment water supplies, thereby narrowing the gap between available freshwater and total demand.

Agriculture is an important economic activity in Jordan in general and in the Jordan Valley in particular. Treated waste water 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. Hence, an urgent call for an analysis of current and potential role of treated wastewater seems justified.

Under the umbrella of the project on the Sustainable Management of Available Water Resources with Innovative Technologies (SMART) funded by the German Federal Ministry for Education and Research in Germany an investigation has been carried out in the Jordan Valley to estimate the current wastewater reuse quantities and the potential to increase its utility for agricultural production. In general, the reuse as percentage of total treatment is applied for national and international comparisons. Yet, this index is of limited use for policy decisions as it can not reflect potentialities of waste water use. Therefore, this study introduces a wastewater reuse index (WRI) that reflects the actual proportion of wastewater reused from the total generated wastewater. We found that the WRI in Jordan steadily increased from 30 per cent in 2004 to 38 in 2007. Efficient use of treated waste water requires the application of new technologies in Jordan like dwellings connected to the sewer system, decentralization of treatment plants to rural and urban settlements and prevention of high evaporation rates from stabilization ponds

Key words: *Wastewater – Reuse – Water Reuse Index - Agriculture- Irrigation- Jordan Valley.*

Introduction

Jordan represents a typically water constrained economy that is daily confronted with decisions on its water use. With a fast growing population and an expanding agricultural sector, the demand for alternatives of fresh water resources remains imminent. An important strategy for the Jordanian government is to meet the water demand for agricultural sector by producing more treated wastewater.

The basic principle to use collected wastewater is that their treatment can adjust the quality to serve the following end-users: irrigation, artificial recharge, potable water supply, toilet flushing, and industrial water supply. Reuse of wastewater has been practiced in many areas worldwide for thousands of years and is motivated by two strong economic incentives (Abu-Madi 2004): to decrease the water scarcity in the region, and/or avoid the cost of the deterioration of water resources and the environment caused by untreated or partly treated wastewater.

Reducing the agricultural demand for fresh water in the region is not easy, but non-conventional water sources can assist in reducing the overall water quantities/percentage utilized by the agricultural sector. Wastewater is, therefore, an important additional source as it can be treated and reused not only by the agricultural sector for crop irrigation but also for landscape irrigation, groundwater recharge, and even some recreational purposes.(Aydın and Gür 2002; Monte 2007; Mekala, Davidson et al. 2008)

Measuring wastewater reuse

Water scarcity has made wastewater reuse more prominent in technical and policy literature as well as in national and international professional meetings. Several indicators are being used to quantify achievements and progress in wastewater reuse (Scott, Faruqui et al. 2004; Gabriel 2005). In this study we argue that an appropriate indicator should take into account all wastewater production, both collected and uncollected, so as to provide a sufficient measure of potential reuse. This is, for example, shown in Figure 1, where an index is used that divides wastewater reuse by wastewater treatment. There are two values for Jordan, the highest value, 90.1%, is calculated using the reported volume of treated wastewater. The lower value, 39.7%, is the ratio of wastewater reuse to the estimated generation of wastewater (assumed to be 80% of water withdrawals; Nayif Saider, MWI personal communication). As can be seen in the figure, using treatment in the denominator provides a misleadingly high estimate of the current reuse rate.

Given the potentially large gap between actual and apparent reuse, as shown in Figure 1, we argue that it is important to base measures of wastewater reuse on complete wastewater generation including on-site and low-cost means of reuse, in order to properly capture potential (FAO. and WHO. 2003). Currently available measures of reuse are based on collected urban wastewater and typically omit wastewater that does not pass through conventional collection and treatment. This limits the ability to estimate potential, and makes international comparison difficult. Therefore we propose to use the wastewater reuse index (WRI) that is defined as:

$$WRI = \frac{R}{G} \times 100, \qquad 0 \leq WRI \leq 100 \qquad (1)$$

Where, R is total wastewater reused and G is total wastewater generation.

The WRI offers standard criteria enabling water resource managers and policy makers to put a figure on the gap between achievements at different junctures, and recognizes water saving efforts such as low water consumption and reducing losses.

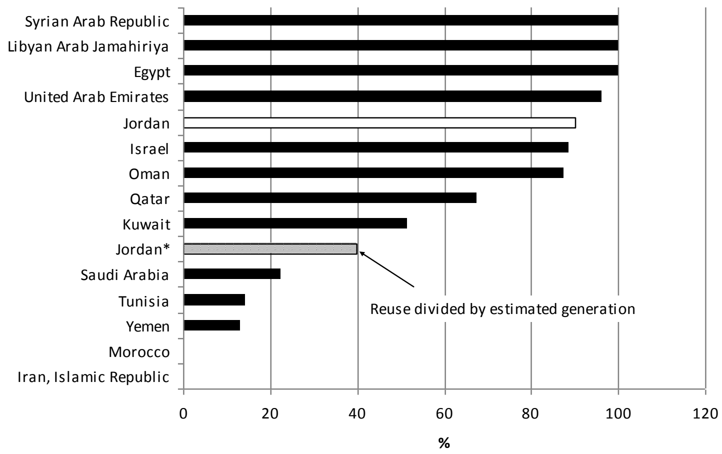

Figure 1: Wastewater reuse as percentage of treatment in the MENA region, 2003-2007 (Data from AQUASTAT, accessed 16 December 2008)

In the following, all quantities are listed in MCM/year. The relevant variables are as follows:

Since the wastewater generation in Jordan is considered 80% of the water distributed to the municipals, then:

$$G = 80\% \times water\ distributed$$

$$C = \frac{x \times G}{100} \quad (2)$$

$$T = \frac{y \times C}{100} \ .....(3)$$

$$R = \frac{z \times T}{100} \gg \quad R = \frac{(x \times y \times G)}{(10^4)} \quad (4)$$

$$WRI = f(R, G)$$

$$WRI = \frac{R}{G} \times 100 = \frac{(x \times y \times G)}{(10^4)} \times 100 \ ....(5)$$

$$WRI = \frac{z \times T}{100 \times G} \times 100 = \frac{z \times T}{G} = \frac{z \times (y \times C)}{100 \times G} = \frac{z \times y \times (x \times G)}{G \times 10^4} = \frac{z \times y \times x}{10^4}$$

$$WRI = \frac{R}{G} \times 100 = \frac{z \times y \times x}{10^4} \quad , \quad 0 \leq WRI \leq 100$$

So $\quad WRI = 34.83\%$

The resulting estimates for the WRI are shown in Table 1

Table 1: WRI data ,(MWI 2007)

Symbol	Values	2004	2005	2006	2007	2006 For JV
G	Total wastewater generation (MCM)	220.62	225.6	229.04	240.7	200.4
C	Amount of wastewater collected(MCM)	101.79	107.364	110.91	113.8	103.5
T	Amount of wastewater treated(MCM)	74.2	78.99	86.79	77.87	79.49
R	Amount of wastewater reused(MCM)	67	72	79.778	90.97	72.69
X	Collection as percentage of total production (%)	46.14%	47.59%	48.42%	47.29%	64%
Y	Treatment as percentage of total collection (%)	72.90%	73.57%	78.25%	68.41%	77%
Z	Reuse as percentage of total treatment (%)	90.30%	91.15%	91.92%	116.8%	91%
	Water Reuse Index (%)	30.40%	31.92%	34.83%	37.79%	45%

The WRI for all of Jordan in 2006 was 34.8 % while it was 45% at the Jordan Valley research area. It is clear that the WRI is quite low in Jordan, even though there is a slight increase in subsequent years, as shown in Table 1. We observe that important efficiency gains can be obtained in the production of reused waste water as currently only 50 per cent of the total generated wastewater is being collected, of which 25 per cent is lost in the process. In general the following measures are recommended to increase the efficiency of the process:

(i) more dwellings would need to be connected to the sewer system. Currently approximately 61% of dwellings in Jordan (MWI 2007) are connected to the sewer network system, while the rest of dwellings are disposed of in cesspools.

(ii) Decentralized WWT could help to increase reuse since many rural areas and some cities have no WWTP due to hilly terrain and lack of investment and there is some unaccounted loss from the network.

(iii) Finally, reduce the high evaporation from the stabilization pond and lagoons at the WWTP.

International comparison

Because of a paucity of international data, it is difficult to carry out a true international comparison for the indicator we are proposing. As is clear from the method used here, if sensible estimates of wastewater generation can be constructed, then it is possible to improve on the estimates of wastewater generation and use those for a preliminary comparison. The discussion in this section will use the measures that have been adopted in the resources cited.

In the Middle East there is a significant increase in water reuse to meet an ultimate objective of reusing 50 to 70 percent at least of the total wastewater volume (EPA 2004). In Israel during the drought year of 1990-91, agricultural allocations were severely cut and the proportion of wastewater reuse (which constituted a safe supply) rose to over 24 percent of total allocations (Shelef and Azov 1996). In normal years, Israel reuses more than 65% of its total domestic sewage production (Friedler 2001). Some nations evaluate reuse through the comparison of water reuse potential with total water use. In the United States, municipal water reuse accounted for 1.5% of total freshwater withdrawals in 2000. In Tunisia, recycled water accounted for 4.3% of available water resources in 1996. In Israel, it accounted for 15% of available water resources in the year 2000. The volume of treated wastewater compared to irrigation water resources is

7% in Tunisia, 8% in Jordan, 24% in Israel, and 32% in Kuwait. Approximately 10% of the treated effluent is being reused in Kuwait, 20-30% in Tunisia, 85% in Jordan, and 92% in Israel (G. Kamizoulis, A. Bahri et al. 1999).

Wastewater and Reuse in Jordan

In Jordan, the agricultural sector consumes around 64% of available water per year with one-third of this amount consumed in the Jordan Valley, of which about 50% is reclaimed water (TWW). All in all, agriculture consumes less than 20% of the total amount of freshwater available in the Jordan Valley (Table 2). Of the 22 WWTPs in Jordan only three receive TWW (Annex, Table 2) from septic tanks and not through the wastewater network.. In 2006 the total effluent was 87 MCM, of which 91.9% was reused by agriculture after mixing it with fresh water during its inflow in the wadis (blended water). Jordan wants to increase the amount of TWW by improving the sewer network since TWW is vital to the water balance, then reallocate the fresh water used in agriculture to domestic use (data Ministry of Water and Irrigation 2006/ 2007).

The effluent from the 22 operating WWTP in Jordan is used primarily for agriculture purposes in the immediate vicinity, while surplus TWW flows along wadis where it either evaporates or is captured in water bodies like dams and ponds. It is known that farmers alongside the wadis are illegally pumping the effluent to irrigate their crops thwarting the intended destination and intended reuse of that water. However, the volumes of these illegal flows are unknown.

Table 2: Water supply for different sector and the actual demand, Ministry of Water and Irrigation data (2006/ 2007)

Demand Requirements	Ground Water	Surface water	Treated Wastewater	Total
	MCM			
Domestic	214.0007	79.75	0	293.751
Rural area	0.745	7		7.745
Industry & Remote Areas	44.894	3.527	0	48.421
Agriculture	244.81	176.366	90.97	512.146
Agriculture (High land)		77.46		77.46
Total Supply Demand	504.4497	344.103	90.97	939.523
Actual Demand				1512
Deficit				572.477

In the year 2006, the amount of water supplied was about 925 million cubic meters (MCM) while the actual demand was 1512 MCM, the municipal uses represented around 32 %, irrigation around 63 %, and industrial uses around 5% of the total consumption. According to MWI assumption “the wastewater (WW) generated is assumed to be 80% of the total volume” that mean (WWG = 230 MCM/year) with only approximately 111 MCM reaching the WWTP. Several reasons are cited for this loss the most important being that only approximately 61% of the total households are connected to the sewer system. This means that approximately 39 % of Jordanian households are not connected to the sewer network system. In other words, there is a considerable amount of the influent lost without recycling or reuse. Most of the non-connected households depend on cesspools, which can lead to groundwater contamination.

Irrigated area in the JV:

The Jordanian Highland consumes around 300 MCM of fresh ground water per year for irrigation, whereas total consumption per year in the Jordan Valley is 220 MCM of which only approximately 100 MCM is fresh water. That means that the Jordan Valley uses approximately 42 % of the total available fresh water for irrigation purposes while 58% of the total fresh water is consumed in the Highland. The Jordan Valley consumes almost 90 MCM freshwater and 90 MCM treated wastewater. The Middle Jordan Valley consumes nothing of the available fresh water totally depending on blended water.

The objective of this study is to quantify the gap between achievements in wastewater reuse and real consumptions so as to provide a better insight into the problem of reuse efficiency, through using the wastewater reuse index (WRI). We argue that this index provides a clear picture of the quantities of influents and effluents, as well as the potential reuse of effluents presently.

Generally there are two types of WWTPs in Jordan; one is the centralized WWTP recognised as a governmental institution, while the other is the decentralized WWTP such as those installed at airports, universities and private companies. There are 22 governmental (87 MCM in 2006) and 23 private WWTPs (less than 3 MCM in 2006) (Figure 2).

Governmental WWTPs receive sewage water from the public sewage network system that fall under the Water Authority of Jordan (WAJ) jurisdiction. Private WWTPs handle wastewater drained from local premises with no connection to the public network and are not part of the WAJ mandate.

At this paper only the centralized governmental WWTPs was considered due to the fact that it has a significant mandate to treat and reuse effluent compared to the effluents from the decentralized (private) WWTPs.

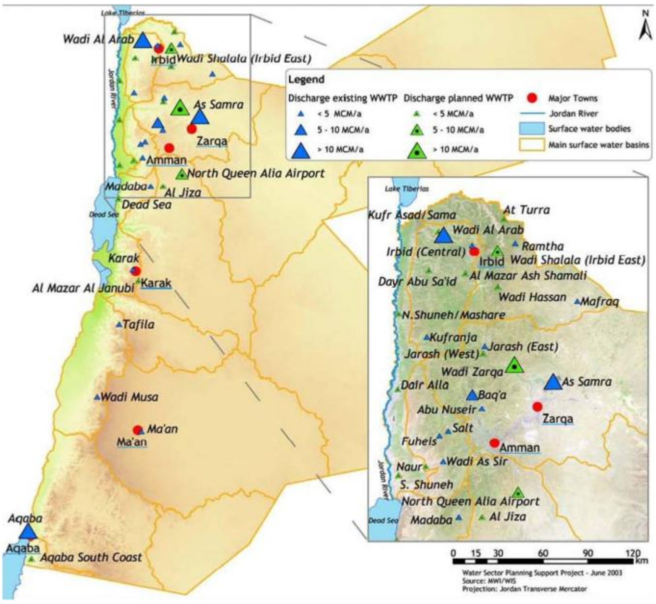

Figure 2: Centralized and decentralized WWTP in Jordan.

Sewage System in Jordan

There are 39% of households using private cesspools for discharging sewage water, which indicates a huge deviation in the share of dwellings connected to the public sewage network system among the governorates. The highest percent of connection (80 %) is in Amman governorate whereas the Karak governorates have the lowest percent (13 %). The Amman Governorate, which receives the biggest share of municipal potable water (more than 40 %), has almost 78 % of its dwellings connected to the public sewage network system (Annex, Table 5).

Influents and effluents of WWTP's

The total municipal water distribution for domestic use according to the data of MWI was approximately 286.3 MCM in 2006; as shown in (Annex, Table 7), where approximately 110.9 MCM was received as influents at the WWTPs. Meanwhile, the MWI assumes that 80 % (or 229 MCM) of domestic water will be generated as wastewater this assumption by the ministry was made during mid of eighties. This means 48.42% of the generated wastewater from domestic uses does not reach WWPs due to the following reasons:

(i) Approximately 61% of dwellings (Annex, Table 6) in Jordan are connected to the sewer network system, while the remaining use cesspools;

(ii) Some municipal water is lost to illegal water abstraction;

(iii) Technical loses due to leakage in the water supply networks estimated around 25-40%, according to WAJ; and,

(iv) Percolation of cesspools to groundwater (40% of the dwellings drain their wastewater into cesspools).

It is estimated that the total amounts of wastewater subject to deep percolation to groundwater are significant, due to the above reasons. In the long term this could cause serious groundwater contamination.

As'samra WWTP receives a 73.8% of the total amount of influents and is the largest WWTP in Jordan and even of the Middle East; Al Zarqa and Amman are its largest suppliers (Table 7). The effluent of this WWTP is also the main supplier of reclaimed water for the King Talal Reservoir (KTR) that is used for the agricultural sector in the JV.

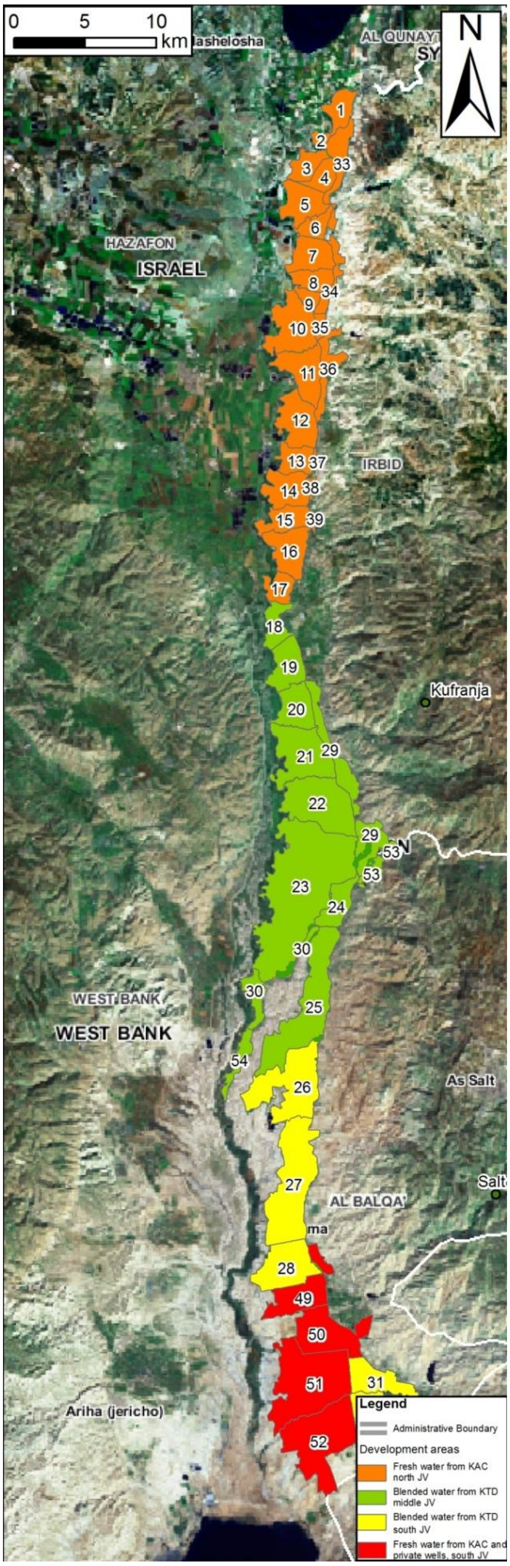

Figure 3: Development's area in JV

Effluents Outlet

The net effluents (Table 8) refer to the actual effluent passing through the WWTPs and equal the gross effluent of each WWTP minus the amount of water consumed by agriculture at the premises and vicinities of the WWTPs (licensed consumption).

There is a significant amount of effluents that come from Assamra, Baq'a, Wadi Arab and Irbid as can be seen from (Table 8), but only effluents coming from Assamra and Baq'a are used in irrigation. This means that approximately 6 MCM per year is not utilized; the effluent from North treatment plant like Irbid has poor quality and is rejected for use in the Jordan River.

There are three dams (King Talal Reservoir (KTR), Shu'aeb, and Kafrain) that receive effluents from some WWTP. Since these effluents run through wadis and are mixed with fresh surface water it becomes blended water. All amounts of water stored in these dams are designated for agricultural use in the Jordan Valley. The total effluent water draining into these dams is around 58 MCM annually, of which 55 MCM is received by KTR alone. KTR is considered a vital water source for agriculture sustainability in the middle Jordan Valley, since it is the principal recipient of effluents (53 MCM /year) mainly from As’samra, Baq'a, Jerash and Abu-Nusier WWTP’s. In addition, many springs and stormwater runoff accumulate into KTR.

Farmers at the middle Jordan Valley depend entirely on the KTR as a source of irrigation water, and they do not receive any surface water from King Abdulla Canal (KAC). Furthermore, they have to share this limited resource with new development areas (DAs) recently connected to the KTR system (DA 19, 20, 21) (Figure 3)

In addition, farmers alongside Wadi Al-Zarqa’ use TWW for uncontrolled cultivation. No data and relevant information about the cultivated areas along wadi Zarqa, crop pattern, and the actual consumption of water amounts is presently available.

Table 3: Effluents of WWT Plants flowing into dams, (MWI 2007)

Dam	WWT Plant feed dam	Effluent of WWT Plant (MCM/ **Year**)
KTR	As’samra	49.65
	Baq'a	3.59
Total		53.24
Shu'aeb	Salt	1.42
	Fuhais	0.61
Total		2.03
Kafrain	Wadi Al-Seer	1.05
Total effluents (MCM/ Year)		56.32

Wastewater Reuse

The collected wastewater must be treated to adjust its quality to the following end-users: irrigation, artificial recharge, potable water supply, toilet flushing, and industrial water supply. Reuse of wastewater has been practiced in many areas worldwide for thousands of years.

Reuse for agricultural irrigation

In most cases it is used for unrestricted irrigation. Reclaimed wastewater can be used for all crops even those consumed raw or uncooked. The reuse of WW in agriculture has been practiced worldwide in developed and development countries such as in Australia, Federal Republic of Germany, India, Mexico, Tunisia, China, Guatemala, India and United States of America (Buechler, Mekala et al. 2006).

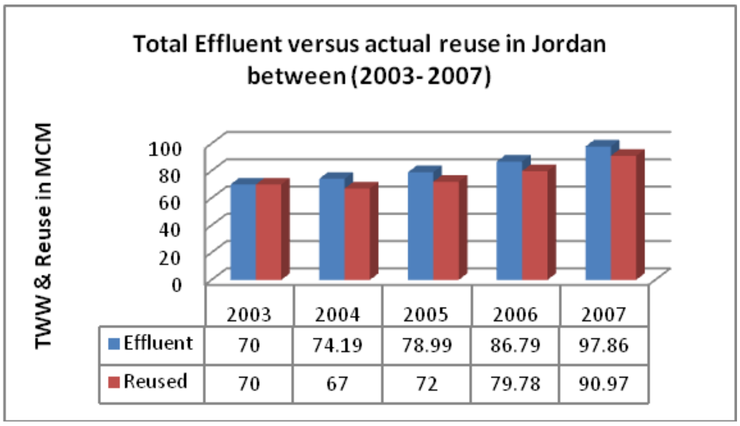

Figure 4: the Total Effluent versus actual reuse in Jordan between (2003- 2007) in MCM/year

Rural and suburban areas without large-scale wastewater collection and treatment systems commonly depend on septic systems. Wastewater is collected in a tank, and then distributed to the surrounding soil through perforated pipes. Septic systems work effectively only in very low density development. In higher-density developments, septic systems can severely impair groundwater quality.

Compared to conventional systems (the centralized WWT), an alternative collection systems such as adapting new technologies is less expensive and require less excavation. Reduced excavation means that less polluting sediment is disturbed into streams. This alternative sewer system tends to resist leakage better than conventional gravity collection systems.

This can lead to an increased amount of treated wastewater in Jordan through applying new technologies such as decentralized wastewater treatment system (On-site and/or cluster system used to collect, treat, and disperse or reclaim wastewater from a small community or service area.) or by using composting toilet systems (a technology that uses a biological process to degrade human waste into a humus-like end product, sometimes called biological toilets, dry toilets and waterless toilets) that contain and control the composting of excrement, toilet paper, carbon additive, and, optionally, food wastes. Unlike a septic system a composting toilet system relies on unsaturated conditions (material cannot be fully immersed in water), where aerobic bacteria and fungi break down wastes, just as they do in a yard waste composter. Sized and operated properly, a composting toilet breaks down waste to 10 to 30 percent of its original volume. The resulting end-product is a stable soil-like material called "humus", which legally in other countries such as United States must be either buried or removed by a licensed seepage hauler. In other countries, humus is used as a soil conditioner on edible crops. The primary objective of the composting toilet system is to contain, immobilize or destroy organisms that cause human disease (pathogens), thereby reducing the risk of human infection to acceptable levels without contaminating the immediate or distant environment and harming its inhabitants. A secondary objective is to transform the nutrients in human excrement into fully oxidized, stable plant-available forms that can be used as a soil conditioner for plants and trees. So that means it will be directly used at the area surrounding for house garden and agriculture.

Conclusion and Recommendation

In this paper we introduced a wastewater reuse index (WRI) which is defined as the ratio of actual wastewater reused to total generated wastewater. Arguing that WRI can better reflect the potential of wastewater reuse of a country compared with the more generally used indicator which is defined as the ratio of reuse to total treatment, since it is of limited use for policy decisions as it cannot reflect potentialities of waste water use.

Representing Jordan as a case study, we argue that the wastewater reuse index is a useful measure for estimating the potential for wastewater reuse and that it can be used for policy guidance. We observed that the WRI in Jordan increased steadily from 30%-38% between 2004 and 2007. As such the WRI indicates that there is considerable scope for expanding wastewater reuse, which prompted a more detailed look at the constraints on wastewater treatment and reuse in different areas in the study area within the Jordan Valley. The appropriate approach to increasing wastewater treatment depends on local conditions. In some cases the appropriate response is to increase the connection of dwelling to sewer system. In others, particularly in hilly or rural areas, a better option is to adopt technology such as composting toilet or decentralized wastewater treatment plant.

The decentralized approach to wastewater collection and treatment offers a new means of addressing wastewater management. Common to all of these options is on-site wastewater treatment by means of low-cost treatment systems, combined with direct use the treatment products (water, compost, and biogas). This approach can sustainably meet wastewater management requirements.

References:

Abu-Madi, M. (2004). Incentive Systems for Wastewater Treatment and Reuse in Irrigated Agriculture in the MENA Region: Evidence from Jordan and Tunisia. TU Delft / UNESCO-IHE Delft. Delft, Delft University. **PhD:** P.250.

Aydın, M. E. and K. Gür. (2002). "Using Reclaimed Municipal Wastewater for Irrigation ", 2008, from http://www.toprak.org.tr/isd/can_38.htm#sayfa.

Buechler, S., G. D. Mekala, et al. (2006). Wastewater Use for Urban and Peri-urban Agriculture. CITIES FARMING FOR THE FUTURE -Urban Agriculture for Green and Productive Cities. R. v. Veenhuizen, IIRR/RUAF/IDRC P. 223.

EPA (2004). Guidelines for Water Reuse. EPA/625/R-04/108. Washington, DC, U.S. Environmental Protection Agency- Municipal Support Division Office of Wastewater Management Office of Water**:** P.478.

FAO. and WHO. (2003). Expert Consultation for Launching the Regional Network on Wastewater Re-use in the Near East. Cairo, Food and Agriculture Organization of the United - Nations - Regional Office for the Near East and World Health Organization -Regional Office for the Eastern Mediterranean**:** P.160.

Friedler, E. (2001). "Water reuse -- an integral part of water resources management:: Israel as a case study." Water Policy **3**(1): 29-39.

G. Kamizoulis, A. Bahri, et al. (1999). WASTEWATER RECYCLING AND REUSE PRACTICES IN MEDITERRANEAN REGION: Recommended Guidelines, World Health Organization. Regional Office for the Eastern Mediterranean. Regional Center for Environmental Health Activities (CEHA). 25.

Gabriel, B. (2005). Wastewater Reuse. Wastewater Microbiology (Third Edition)**:** 589-607.

Mekala, G. D., B. Davidson, et al. (2008). A Framework for Efficient Wastewater Treatment and Recycling Systems. Working Paper 129, International Water Management Institute (IWMI**:** P.25.

Monte, M. H. F. M. d. (2007). Guidelines for Good Practice of Water Reuse for Irrigation: Portuguese Standard NP 4434 Wastewater Reuse–Risk Assessment, Decision-Making and Environmental Security. Netherlands, Springer Netherlands. **2007:** P. 253-265.

MWI (2006). Data Base. J. V. Authority, Ministry of Water and Irrigation - Amman, Jordan.

MWI (2007). Data base for ministry of water and irrigation, Ministry of water and irrigation - Amman, Jordan.

Scott, C., N. Faruqui, et al. (2004). Wastewater Use in Irrigated Agriculture: Coordinating the Livelihood and Environmental Realities, International Water Management Institute (IWMI), International Development Research Centre (IDRC) ,International Water Management Institute (IDRC).

Shelef, G. and Y. Azov (1996). "The coming era of intensive wastewater reuse in the Mediterranean region." Water Science and Technology **33**(10-11): 115-125.

Annexes:

Table 4: the total effluent from WWTP and the actual amount of WWT reused in 2006(MWI 2006)

WWTP's	Effluent MCM	Actual reuse	WWTP's	Effluent MCM	Actual reuse
AS-SAMRA	58.775	58.775	TAFILA	0.333	0.125
AQABA	4.921	4.921	WADI AL SEER	0.892	0.892
RAMTHA W.S.P	1.23	1.23	FUHIS	0.577	0.577
MAFRAQ W.S.P	0.636	0.636	WADI ARAB	3.516	0
MADABA W.S.P	1.493	1.493	WADI HASSAN	0.388	0.388
MA'AN W.S.P	0.862	0.862	WADI MOUSA	0.631	0.631
IRBID	2.235	0	TALL – MANTAH	0.091	0
JERASH	1.179	1.179	AKADEER	1.152	1.152
KUFRANJA	1.058	1.058	AL- LAJJOUN	0.232	0
ABU-NUSIER	0.808	0.08	TOTAL M.C.M (per year)	86.787	79.778

Table 5: Municipal water consumption for each governorate in Jordan (MWI , 2006)

Governorate	2004	2005	2006	Consumption 2006
	m^3/year			%
Amman	118,536,066	119,869,739	121,953,318	42.6
El Zarqa	37,687,744	38,447,913	40,324,912	14.08
IRBID	32,754,703	34,376,280	34,195,729	11.94
MAFRAQ	16,903,277	17,482,806	17,604,297	6.15
El Balqa	20,177,343	21,274,250	21,168,767	7.39
KARAK	11,030,435	11,023,232	11,466,121	4
TAFILA	3,070,173	3,496,374	3,705,131	1.29
MA'AN	7,068,872	7,107,804	7,452,019	2.6
JERASH	4,362,633	4,081,985	4,135,507	1.44
AL- LAJJOUN	3,101,994	3,649,708	3,643,033	1.27
MADABA	6,057,704	6,172,765	6,369,242	2.22
AQABA	15,020,565	15,012,503	14,285,763	4.99
Total	275,771,509	281,995,359	286,303,839	

Source: Ministry of water and Irrigation(MWI) , Water Authority of Jordan (WAJ)

Table 6:. Total Subscribers to water and sanitation system in Jordan, 2006(MWI 2006).

WAJ Directorate	Total Subscribers to water	Total Subscribers to sanitation	Served % Per Directorate	Served % Per Governorate
Amman	409222	328230	80%	80%
Irbid	78840	41581	53%	
Al Kourah	11475	0	0%	
Al Ramth	11466	4917	43%	
Bani Kinanah	10726	2	0%	
Bani Obiead	15644	5093	33%	
North Ghor	10768	0	0%	37%
Al Zraqa	83483	57675	69%	
Al Risyafa	33398	25580	77%	71%
Maádaba	15352	7336	48%	
Theiban	4388	2	0%	37%
Al Salt	21662	11765	54%	
Ain Albasha	16671	14399	86%	
Al Fuhis	5215	4290	82%	
South Shouna	6082	0	0%	
Maadi	6207	0	0%	55%
Al Karak	16238	4340	27%	
Ghor Al safi	3856	0	0%	
Al Qaser	4978	0	0%	
South Mazar	9622	45	0%	13%
Al Tafila	11990	2359	20%	20%
Maán	8939	1900	21%	
Wadi Mousa	6330	2059	33%	
Al Shoubak	2078	0	0%	23%
Al Mafraq	25368	4915	19%	
North Badia	7712	0	0%	15%
Ajloun	15202	4739	31%	31%
Jarash	20882	7252	35%	35%
Al Aqaba	23275	16904	73%	73%
Total	897069	545383	61%	61%

Source: MWI /WAJ, 2008

Table 7: Influents and effluents of WWT Plants, 2006(MWI 2006)

WWTP	Influent		Effluent	
	MCM/Year	%	MCM/Year	
AS-SAMRA W.S.P	81.84	73.79	58.78	67.72
AQABA MECH	2.46	2.22	2.64	3.04
AQABA W.S.P	2.27	2.05	2.28	2.63
RAMTHA W.S.P	1.28	1.15	1.23	1.42
MAFRAQ W.S.P	0.68	0.61	0.64	0.73
MADABA W.S.P	1.67	1.51	1.49	1.72
MA'AN W.S.P	0.97	0.87	0.86	0.99
IRBID	2.32	2.09	2.23	2.58
JERASH	1.21	1.09	1.18	1.36
KUFRANJA	1.24	1.11	1.06	1.22
ABU-NUSIER	0.84	0.76	0.81	0.93
SALT	1.58	1.42	1.42	1.64
BAQA'	4.01	3.61	3.81	4.39
KARAK	0.59	0.53	0.55	0.63
TAFILA	0.37	0.33	0.33	0.38
WADI AL SEER	0.99	0.89	0.89	1.03
FUHIS	0.61	0.55	0.58	0.67
WADI ARAB	3.64	3.28	3.52	4.05
WADI HASSAN	0.4	0.36	0.39	0.45
WADI MOUSA	0.61	0.55	0.63	0.73
TALL – MANTAH	0.1	0.09	0.09	0.1
AKADER	1.05	0.95	1.15	1.33
AL- LAJJOUN	0.18	0.17	0.23	0.27
TOTAL M.C.M (per year)	110.91		86.79	

Table 8: Net effluent exiting WT Plants,(MWI 2006).

WWTP	Effluent	Water consumption before the outlet	Net effluent*
	(MCM/ Year)		
As'samra	69.65	20	49.65
Aqaba	4.2	4.2	0
Ramtha	1.18	1.18	0
Mafraq	0.6	0.6	0
Madaba	1.57	1.57	0
Ma'an	0.87	0.22	0.65
Irbid	2.25	0	2.25
Jerash	1.22	0	1.22
Kufranja	1.22	0.63	0.59
Abu-Nusier	0.83	0	0.83
Salt	1.47	0.05	1.42
Baq'a	4.08	0.49	3.59
Karak	0.55	0.64	0
Tafila	0.37	0.12	0.25
Wadi Al-Seer	1.12	0.07	1.05
Fuhais	0.61	0	0.61
Wadi Arab	3.7	0	3.7
Wadi Hassan	0.27	0.27	0
Wadi Musa	0.71	0.71	0
Tall Al-Mantah	0.1	0	0.1
Al-Akader	1.16	1.16	0
Al-Lajjoun	0.17	0	0.17
Total (MCM/ Year)	97.9	31.91	66.08

* Net effluent is the effluent minus water amounts consumed in premises and vicinities of WT Plants