REUSE OF RECLAIMED WASTEWATER IN JORDAN: A COMPARISON STUDY OF THE INTERNATIONAL VIS-À-VIS JORDANIAN STANDARDS

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ABSTRACT

The purpose of this paper is to compare the Jordanian standards of the reclaimed wastewater with the international standards for the same issues. The Jordanian standards were changing and updating in accordance with the development of the infrastructure and the high demand for the usage of reclaimed water for the different purposes.

Two international standards were considered for the comparison exercise; World Health Organization (WHO) and Environmental Protection Act (EPA) guidelines, which are considered from the most common legislations with this regard. The results of the study showed the positive and negative aspects of the Jordanian standards. The shortcomings were identified and the necessary clauses were recommended. It was concluded that with the current legislations of the reclaimed water and treated sludge, it is difficult to utilize these products in an efficient way with achieving the highest benefits for the country. A number of recommendations were suggested at the end of the paper, these can be considered by the decision makers in Jordan and other regional countries.

INTRODUCTION

With expanding urban development in Jordan, more treated wastewater will be discharged in the natural streams and reservoirs. The rapid demand of conventional water resources for irrigation purposes, make it hard to fully supply all the required quantities for all the purposes in the country from the available conventional water resources. Due to this reason and the fact that Jordan is considered as one of the most needy countries in terms of fresh water, the decision makers in the water sector were forced to think about utilizing non-conventional water resources such as the reclaimed water resources for irrigation purposes.

The subject of utilizing reclaimed wastewater and sewage sludge faced strong objections from the public at the beginning of producing it twenty years ago due to social aspects.

In addition to the shortage of fresh water resources that can fulfill the demand of the irrigation activities, the problem of the poor soil in most of the irrigable areas is another constraint that faced the agricultural sector.

The limited water supply has led to the adaptation of non-conventional water resources as part of the country's water supply-demand budget (Hussein and Abu-Sharar, 2002). The major resource of non-conventional water is the treated domestic wastewater (TWW). As a result of the increasing number of wastewater treatment plants and the subsequent increases in dwelling numbers served by the sewage system, annual volumes of TWW is expected to increase from 115 million cubic meter (MCM) in the year 2005 to 355 MCM in the year 2025. The Section Resource Development and Use of the Country's Irrigation Water Policy (2002) stated: wastewater is considered a resource and can not be treated as waste. It shall be collected and treated to standards that allow its reuse in irrigation unrestricted by health and public health considerations or unduly constrained by high salinity contents.

A number of technical issues involved in planning a TWW reuse system include:

1. Identification and characterization of potential demand and supply volumes of that water resource.
2. Treatment requirements for producing a safe and reliable reclaimed water that is suitable for its intended applications;
3. Storage facilities and/or management policy required to balance seasonal mismatches between supply and demand for that water.
4. Supplemental facilities required to integrate a TWW in the overall irrigation system such as conveyance and distribution networks, operational storage facilities and alternative disposal facilities, and
5. Assessment of potential environmental impacts as a result of TWW application in irrigation.

These technical issues apply broadly to most applications. However, some practices of the TWW reuse in irrigation are not properly conceived, which means that they could fall into one or more of the following categories:

1. Lack of national policies and strategies in this regard.
2. Inadequate commitment from decision-makers.
3. Sub-optimal results due to *ad hoc* planning and management.
4. Long-term sustainability is in doubt.
5. Unnecessarily expensive objectives to be achieved.
6. Major constraints may exist in terms of the lack of adequate funds for operation and maintenance, inadequate monitoring and evaluation and lack of trained manpower.
7. Health and environmental related issues may not be properly considered.

With respect to Jordan, Provided the prevailing aridity and the characteristics organic matter poor-soils of the country, adaptation of appropriate technologies with regard to TWW application to agricultural lands has become of paramount interest to both farmers and respective officials. Quality of the reclaimed wastewater and treated sludge are big concerns for the end-users. Possible socioeconomic impacts due to the

enforcement of the current legislations were analyzed and interpreted and a number of conclusions and recommendations were developed.

RATIONALE

While interest in the reuse of TWW in most Arab countries is of comparatively recent origin, the concept of using TWW in productive agriculture is as old as the age of the area's civilization. The World Resources Institute (ISWA) carried out a study on the percentages of the population served by TWW in Europe and showed that some countries like Denmark had the percentage of 98% of the population served by TWW, France (68%), Germany (90%), Italy (60%), UK (88%) and Sweden (98%). Several Near Eastern cities like Damascus and Marrakech had used indirectly and for many centuries untreated sewage effluents for irrigating orchards and vegetables. TWW is in direct usage at some European countries for irrigation for more than 100 years like in UK and Germany.

Interest in the use of TWW has been accelerating significantly in developing countries since 1980 for a variety of reasons of which:

1. Significant increases in population resulting in more and more wastewater being produced in urban and rural areas.
2. Designation of the 1980s by the United Nations as the International Water Supply and Sanitation Decade, has led to the building of more sewerage treatment works in developing countries. Such centralized works produce large quantities of TWW; making their use for agriculture a viable alternative;
3. Water is becoming an increasingly scarce commodity in many arid and semi-arid countries, and accordingly planners are searching for additional sources. This applies particularly to many Arab countries, where easily usable conventional sources of water have now been generally committed or are about to be fully committed, and no additional sources of water exist for further agricultural development;
4. Wastewater is now being considered as a new nutrient-rich source that can be used in productive agriculture and thus help alleviate food shortages in many countries, with reduced use of fertilizers;
5. An increasing interest in environmental and health issues in developing countries brings an interest in the safe disposal of TWW;
6. Long-term research results have shown that TWW can safely be used for irrigation of agricultural crops; public parks and recreation centers, landscape areas and Golf courses. The TWW could also be used for industrial purposes, groundwater recharge and, in special cases; properly purified TWW could be used for municipal supply.

In Jordan, a total number of 19 wastewater treatment plants are under operation by the Government (MoW, 2001). Table (1) shows the names, locations and influent and effluent quantities of the plants. The principal requirements for establishing effective

TWW reuse in productive agriculture have recently been described in new Standards (Institution of Standards and Metrology, 2002). In respect to industrial wastewater, new standards (202/2002) are under revision by the same Institution. The major features of such a revision entails allowing direct reuse of certain industrial raw wastewater in irrigating landscaping plants or crops that are not consumed directly by human provided a previous institutional approval of a study concluding the safe application of such a water with respect to environmental components and public health. The new standards and management recommendations of TWW disposal or reuse can be summarized as follows:

- Discouragement of industrial wastewater discharges into collection systems and supportive measures for direct land application option.
- Capacity building efforts by Jordanian authorities. Technical and financial assistance has been sought from the respective international agencies.
- Encouragement of commercial projects that demonstrate the soundness of SS employment as soil conditioner and, thus, permitting the development of a regulatory framework that reflects global technical standards.

Table (1): Wastewater treatment plants in 2001 (MCM)

No.	WWTP	Operation	Governorate	Influent	Effluent
1	As Samra	1985	Zarqa	62.30	54.64
2	Abu Nusir	1988	Amman	0.59	0.58
3	Wadi Essir	1996	Amman	0.41	0.26
4	Wadi Arab	1999	Irbid	2.19	2.05
5	Irbid	1987	Irbid	1.68	1.65
6	Ramtha	1988	Irbid	0.85	0.68
7	Salt	1981	Balqa	1.24	1.20
8	Baqa’	1988	Balqa	4.09	3.88
9	Fuhais	1996	Balqa	0.44	0.38
10	Ma’an	1989	Ma’an	0.69	0.62
11	Wadi Mousa	2001	Ma’an	***	***
12	Mafraq	1988	Mafraq	0.67	0.54
13	Jarash	1983	Jarash	0.76	0.72
14	Kufranja	1989	Ajloun	0.69	0.59
15	Madaba	1989	Madaba	1.56	1.20
16	Karak	1988	Karak	0.45	0.44
17	Tafila	1988	Tafila	0.26	0.25
18	Aqaba	1987	Aqaba	3.21	2.44
19	Wadi Hassan	2000	Irbid		
	Total			**82.15**	**72.12**

Source: Ministry of Water & Irrigation, Water Evaluation, April 2002

CONSTRAINTS AND PRE-REQUISITES FOR TWW REUSE IN IRRIGATION

Irrespective of the previously-mentioned benefits, TWW use in irrigation can also create specific problems, mainly if the irrigation system and management are not properly designed and operated. The major constraints can be summarized as follows:

1. Damage to the physical and chemical properties of soil especially salinity and alkalinity. This has been observed in the Middle Jordan Valley (MJV)) soils irrigated with a mixed TWW and fresh water provided by King Talal Reservoir.
2. Decrease of crop yields and, for some salt-sensitive crops, low quality of the produce, e.g. straw berry.
3. Potential environmental degradation.
4. Potential risk to public health.

STANDARDS AND POLICIES OF RECLAIMED DOMESTIC WATER

Reclaimed wastewater is used as a source of irrigation water as well as a source of plant nutrients, allowing farmers to reduce or even eliminate the purchase of chemical fertilizer. Recent wastewater use practices range from the piped distribution of secondary treated wastewater (i.e. mechanical and biological treatment) to farmers. Vegetable, fodder and non-food crops as well as green belt areas and golf courses are being irrigated. In the US wastewater is subjected to advanced treatment (secondary treatment, filtration and disinfection) prior to use.

POLICIES, STANDARDS, RULES AND REGULATIONS IN JORDAN

Jordanian Standards for Reclaimed Water

To ensure a nation-wide control of the waste water quality, the first Jordanian Standard (JS) on treated domestic waste water was published by the Jordanian Institution for Standards and Metrology (JISM) in 1994. Already in 1995 the standard was revised and the Standard Specification "Water – Treated Domestic Waste water" No. 893 was published by JISM in 1995. This standard was valid until 2002 and was then replaced by the Standard Specification "Water – Reclaimed Domestic Waste water" No. 893 of 2002. A comparison between the two standards can be shown in Tables (2), (3), (4), (5) and (6). The older standard of 1995 provided criteria for seven "uses" of the treated waste water:

i. Irrigation of vegetables eaten cooked
ii. Irrigation of fruit trees, forests, industrial crops and grains
iii. Discharge to streams and catchment areas
iv. Artificial recharge of groundwater
v. Use in aquaculture (fish hatcheries)

vi. Irrigation of public parks
vii. Irrigation of fodder.

The new Standard 893/2002 is dealing with only three "uses" of reclaimed water:

i. Discharge of water to streams or wadis or water bodies
ii. Use for artificial recharge of groundwater aquifers
iii. Reuse for irrigation
    a) Cooked vegetables, parks, playgrounds, and sides of roads within city limits
    b) Fruit trees, sides of roads outside of city limits and landscape
    c) Field crops, industrial crop and forest trees.

In the following, the changes in the Standard 893/ 2002 are documented in comparison with the old one of 1995.

As mentioned above, one major change is the re-naming of the effluents in question. They could be named as "WWTP's effluents" or simply as "waste water" or as "waste water effluents" or as "treated waste water" or "used water" etc. They can also be named "reclaimed water". That avoids the word "waste" with its most probably negative interpretation by the end users of the water as well as by the consumers of irrigated agricultural products. This new wording will probably help to make the agricultural use of waste water effluents more acceptable for the above mentioned affected groups as well as for exportation of agricultural crops to the neighbouring countries.

The new standard also provides many definitions to ensure that most of the wording used in the standard is now clearly defined when talking about the use of reclaimed water. This was certainly a lack of the old standard. An open question concerning the use of reclaimed water for irrigation is the definition of the term "pure water" that is used in the general requirements and presented in chapter 4 of the new standard 893/2002. The English translation of sub-point 4-3 mentions: "It is not permitted at the treatment plant to dilute by mixing reclaimed water from waste water treatment plants with pure water before discharge intentionally to comply with the requirements set in this standard".

A definition of "pure water" should be included into the standard, which is not yet done so far in the list of definitions of the standard. It should be clarified if the wording "pure water" is used in the standard to characterise the water in a religious sense, for drinking water purposes or in another sense. In addition, it is not clear if the term "pure water" also includes "freshwater". "Freshwater" is a term that is widely used in Jordan agriculture and stands normally for the use of surface waters for agricultural irrigation, like water from King Abdullah Canal (KAC), rivers and reservoirs (like Wadi Arab reservoir) as well as water from springs and groundwater wells.

The standard prohibits blending treated waste water on site with "pure" water to comply with the standard's limiting values. This prohibited blending does not affect

the use of the reclaimed water effluents from WWTPs in case the water complies with the standard. This includes also the use of the reclaimed water for irrigation purposes. Actually it is not known which kind of action will be undertaken in case the water does not comply with the standard. In the opinion of the consultant this item requires further investigations and clarification with the relevant authorities (MoH, MoWI, and MoE). A chapter on that item should be added in the Environmental Impact Study.

Paragraph 5-2 of the standard presents the requirements for reuse of reclaimed water. Paragraph 5-2-2 presents the special requirements for reuse of reclaimed water for irrigation. In contrast to the standard of 1995, the new standard defines two main groups:

a) Standards groups: "is the group of properties and standards presented in Table 3 of the Standard and where operating parties must produce water complying to it and according to the usage mentioned in this standard".

   "Operating parties" are not clearly defined in the standard. It is normally beyond the competence of the WWTPs to decide if the reclaimed water (treated waste water) is finally used for irrigation purposes or not. It is their task to "produce" treated waste water that corresponds to the requirements for a final disposal in the environment (wadis, rivers etc.). They can not produce waters that correspond to different irrigation purposes as mentioned in the standard. If the latter is a task of the WWTPs they must be technically upgraded to comply with the standard requirements for "cooked vegetables". This will be a very costly option. It is hereby mentioned that the treatment plants in question are already quite advanced in water purification (up to 95 % reduction for some parameters) In addition, the treatment plant operators do not know in advance which farmer will use the water and for which crop.

b) Guidelines group: The guidelines group (Table 4 in the Standard) is considered for guidance only. In case of exceeding its values the end user must carry out studies to verify the effect of that water on public health and the environment. Complying with the latter group is therefore not a "must" for the final user and opens the door for additional interpretation.

Both standards (from 1995 and 2002) prohibit the use of reclaimed water for irrigation of vegetables that are eaten uncooked (raw). The older standard gave examples for such fruits. These are not mentioned any more in the new one. This may be a lack. However, the draft of "Treated Waste Water, Saline Water & Brackish Water Usage in Irrigation - Instructions & Conditions" presents some crops that can be irrigated with treated waste water. These instructions also point clearly out that the use of treated waste water is prohibited on lands where the depth of the groundwater table is less than 1.5 m.

The limits of the parameters for cooked vegetables, parks, playgrounds and sides of roads are quite strict. It is also not understandable why the differentiation between the limits for cooked vegetables and other purposes (parks, side of roads inside a city etc.)

are now abolished in comparison to the older standard. Irrigation of agricultural land requires other conditions than irrigation of roads inside the city. BOD and COD are important in agriculture for enhancing and increasing microbiological activity in the soil. It is not clear why the standard requirements for BOD/COD are set so low. The same applies to Nitrate. It is an additional fertilizer when available in the reclaimed water. Restrictions should be only defined and given when the water is applied during the non-vegetative growing periods.

The old standard of 1995 specified pathogenic biological vectors (pathogens, amoeba, giardia, nematode eggs) and total faecal coliforms (TFCC). The new standard only points out E. coli and intestinal helminthes eggs. This does not sufficiently describe the possible biological hazard of the reclaimed water. An assessment of its health hazards is very limited if only the two above mentioned parameters are determined.

Concerning water quality monitoring (paragraph 6, new standard) it is repeated that the waste water treatment plant owner can not know for what the treated effluents finally will be used. It is out of his influence. The standard forces him to produce water that complies with the strictest standard requirements for use in irrigation of vegetables that are cooked prior to consumption. This would be of course a good target concerning domestic waste water purification but in the opinion of the consultant, this can lead to a substantial rise in the treatment costs.

The third edition of the Jordanian Standard No. 893 was issued in 2002 and concerns "Reclaimed domestic wastewater". Compared with the earlier version 893/1995 the allowed limits have been slightly modified. In particular the two former categories "Restricted irrigation (vegetables eaten cooked)" and "Public parks irrigation" have been merged. The most important limits of the new Standard 893/2002, mainly those which can be influenced by the treatment process are hereafter compared with the former version 893/1995 and with international standards.

Table (2) shows the difference in limits of parameters of reclaimed wastewater for possible discharge into wadis and streams, comparing the old with new standard. Compared to the version 893/1995 the prescriptions have been slightly lowered. Table (3) shows the comparison between the two standards, old and new for the possible groundwater discharge. The new version 893/2002 is more rigorous than the older version. Table (4) shows the comparison for restricted irrigation uses and Table (5) for un-restricted irrigation. The new version 893/2002 is more rigorous than the older version. Concerning micro-biological treatment, the new regulations are still stricter than WHO requirements. Compared to the former version of 1995, the standards have been lowered for public parks. Finally, Table (6) shows the comparison for the field crops usage.

Table 2: Discharge into wadis and streams

Parameter	Unit	Jordanian Standard 893/1995	Jordanian Standard 893/2002
BOD_5	mg/l	50	60
COD	mg/l	200	150
DO	mg/l	> 2	> 1
TDS	mg/l	2,000	1,500
TSS	mg/l	50	60
Ph	-	6 to 9	6 to 9
Turbidity NTU	-		
NO_3 –N	mg/l	25	45
NH_4 –N	mg/l		
Total N	mg/l	50	70
E. coli	CFU/100 ml	1,000	1,000
Intestinal Helminthes Eggs	egg/l	< 1	< or =1
Fat or grease	mg/l	8	8.0
Total PO_4	mg/l	15	15

Table 3: Groundwater recharge

Parameter	Unit	Jordanian Standard 893/1995	Jordanian Standard 893/2002
BOD_5	mg/l	50	15
COD	mg/l	200	50
DO	mg/l	> 2	> 2
TDS	mg/l	1,500	1,500
TSS	mg/l	50	50
pH	-	6 to 9	6 to 9
Turbidity NTU	-	-	2
NO_3 –N	mg/l	25	30
NH_4 –N	mg/l	15	5
Total N	mg/l	50	45
E. coli	CFU/100 ml	1000	< 2.2
Intestinal Helminthes Eggs	egg/l	-	< or =1
Fat or grease	mg/l	none	
Total PO_4	mg/l	15	15

Table 4: Agricultural Use – Restricted Irrigation (Vegetables eaten cooked, parks, playgrounds, trees along streets inside of cities)

Parameter	Unit	Jordanian Standard 893/1995		Jordanian Standard 893/2002	Tunisian Standard NT 106.03 (1989)	WHO (778) Crops eaten uncooked, sport field, pubic parks
		Vegetables	Parks			
BOD_5	mg/l	150	50	30	30	
COD	mg/l	500	200	100	90	
DO	mg/l	> 2	> 2	> 2		
TDS	mg/l	2,000	2,000	1,500		
TSS	mg/l	200	50	50	30	
PH	-	6 to 9	6 to 9	6 to 9	6.5 to 8.5	
Turbidity NTU	-			10		
NO_3 –N	mg/l	50	25	30		
NH_4 –N	mg/l	-	50			
Total N	mg/l	100	100	45		
E. coli	CFU/100 ml	1,000	200	100		1,000
Intestinal Helminthes Eggs	egg/l	< 1	< 1	< or =1	< 1	≤ 1
Fat or grease	mg/l	8	8	8.0		
Total PO_4	mg/l	-	15	30		

Table 5: Agricultural use (Fruit trees, trees along roads outside of cities, and landscape)

Parameter	Unit	Jordanian Standard 893/1995		Jordanian Standard 893/2002	Tunisian Standard NT 106.002 (1989)
		Trees	Public Parks		
BOD_5	mg/l	150	50	200	30
COD	mg/l	500	200	500	90
DO	mg/l	> 2	> 2	-	
TDS	mg/l	2,000	1,500	1,500	
TSS	mg/l	200	50	150	30
PH	-	6 to 9	6 to 9	6 to 9	6.5 to 8.5
Turbidity NTU	-			-	
NO_3 –N	mg/l	50	25	45	
NH_4 –N	mg/l	.	15		
Total N	mg/l	100	50	70	
E. coli	CFU/100 ml	-	1,000	1,000	
Intestinal Helminthes Eggs	egg/l	-	-	< or =1	< 1
Fat or grease	mg/l	8	None	8	
Total PO_4	mg/l	-	15	30	

Table 6: Agricultural use (Field crops, industrial crops and forest trees)

Parameter	Unit	Jordanian Standard 893/1995		Jordanian Standard 893/2002	Tunisian Standard NT 106.002 (1989)	WHO (778) Cereals, industrial crops fodder, pasture, trees
		Industrial crops & cereals	Fodder crops			
BOD_5	mg/l	150	250	300	30	
COD	mg/l	500	700	500	90	
DO	mg/l	> 2	> 1	-		
TDS	mg/l	2,000	2,000	1,500		
TSS	mg/l	200	250	150	30	
PH	-	6 to 9	6 to 9	6 to 9	6.5 to 8.5	
Turbidity NTU	-			-		
NO_3 –N	mg/l	50	50	45		
NH_4 –N	mg/l	-	-			
Total N	mg/l	100	-	70		
E. coli	CFU/100 ml	-	-	-		No standard recommended
Intestinal Helminthes Eggs	egg/l	-	< 1	< or =1	< 1	≤ 1
Fat or grease	mg/l	8	12	8		
Total PO_4	mg/l	-	100	30		

Selected International standards and policies

WHO Guidelines

Representatives from UN agencies, including the World Bank, and various research institutions convened in 1985 (IRCWD 1985) and in 1987 to discuss and propose a new paradigm to quantify the health impacts of human waste utilization. The meetings resulted in the formation of a WHO Scientific Group, which was mandated to recommend revised wastewater reuse guidelines. WHO published the current guidelines in 1989 (WHO 1989). Table (7) shows the recommended microbiological quality guidelines for wastewater use in agriculture (WHO 1989).

Table (7): Recommended microbiological quality guidelines for wastewater use in agriculture (WHO 1989)

Cat.	Reuse conditions	Exposed group	Intestinal nematodes (/liter*[c])	Fecal coliforms (/100ml**[c])	Wastewater treatment expected to achieve required quality
A	Irrigation of crops likely to be eaten uncooked, sports fields, public parks [d]	Workers, consumers, public	£1	£1000	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees [e]	Workers	£1	None set	Retention in stabilization ponds for 8-10 days or equivalent helminthes removal
C	Localized irrigation of crops if category B exposure of workers and the public does not occur	None	n/a	n/a	Pre-treatment as required by the irrigation technology, but not less than primary sedimentation

[a] In specific cases, local epidemiological, socio-cultural and environmental factors should be taken into account, and the guidelines modified accordingly
[b] *Ascaris* and *Trichuris* species and hookworms
[c] During the irrigation period
[d] A more stringent guideline (£200 faecal coliforms/100ml) is appropriate for public lawns with which the public may come into direct contact
[e] In the case of fruit trees, irrigation should cease two weeks before the fruit is picked and none should be picked off the ground
* Arithmetic mean
** Geometric mean

In this way, crop restrictions would reduce consumers' exposure to contaminated raw vegetables, wastewater application through drip irrigation would reduce contamination of low-growing crops and farm worker exposure, and wearing protective clothing would reduce the risk for farm workers. Figure (1) shows the generalized model illustrating the effect of different control measures in reducing health risks from wastewater reuse (adapted from Blumenthal *et al.* 1989; WHO 1989).

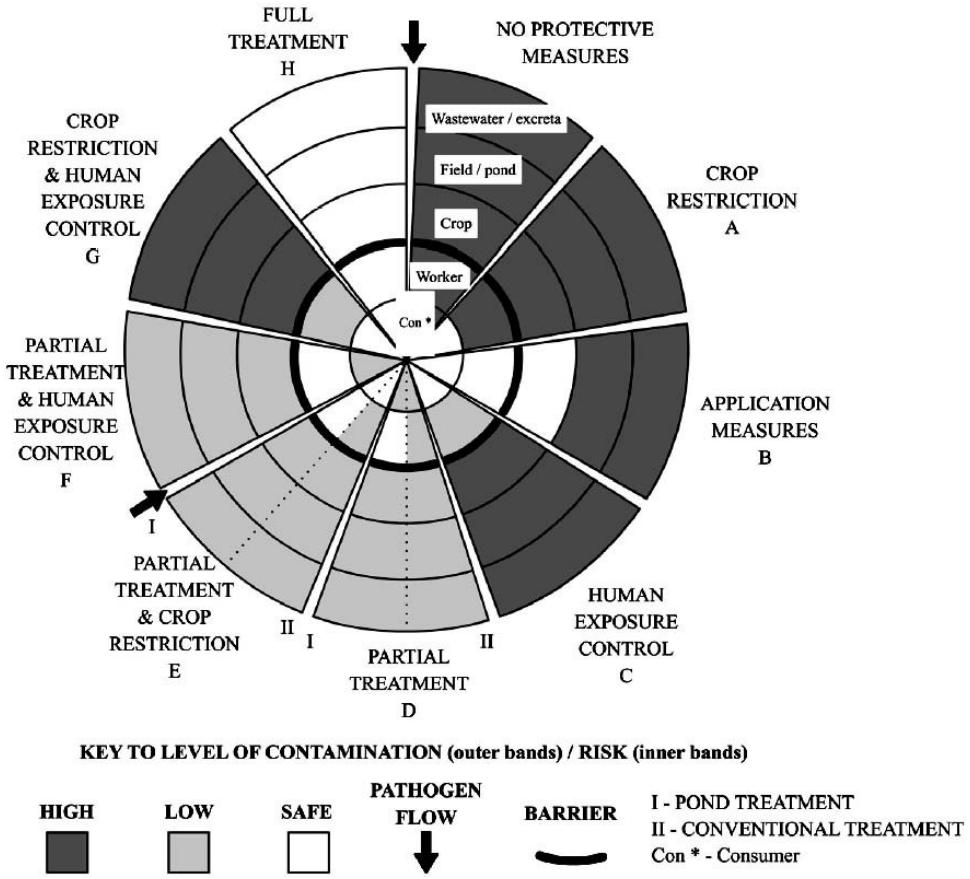

Figure (1): Generalized model illustrating the effect of different control measures in reducing health risks from wastewater reuse (adapted from Blumenthal *et al*. 1989; WHO 1989)

Combinations of measures could be selected to suit local circumstances. For example, where there was a market for cereal crops and good institutional capacity but insufficient resources to treat wastewater to category A quality, crop restrictions with partial wastewater treatment could be used. In situations where wastewater treatment could not be provided for a number of years, combinations of management options could be used in the interim (e.g. crop restrictions and human exposure control). The model of combinations of management practices and treatment processes drew on experience of reuse practices in the field (Strauss and Blumenthal 1990).

The main features of the WHO (1989) guidelines for wastewater reuse in agriculture are therefore as follows:

- Wastewater is considered as a resource to be used, but used safely.
- The aim of the guidelines is to protect against excess infection in exposed populations (consumers, farm workers, populations living near irrigated fields).
- Faecal coliforms and intestinal nematode eggs are used as pathogen indicators.

- Measures comprising good reuse management practice are proposed alongside wastewater quality and treatment goals; restrictions on crops to be irrigated with wastewater; selection of irrigation methods providing increased health protection, and observation of good personal hygiene (including the use of protective clothing).
- The feasibility of achieving the guidelines is considered alongside desirable standards of health protection.

EPA Water Reclamation and Reuse Standards

These standards have been developed under the authorization and specific requirements delineated with RCW 90.46 (Reclaimed Water). "Reclaimed Water" means effluent derived in any part from sewage from a wastewater treatment system that has been adequately and reliably treated, so that as a result of that treatment, it is suitable for a beneficial use or a controlled use that would not otherwise occur and is no longer considered wastewater.

The type of uses, treatment and legal definition within the standards were developed in association with the Reuse Advisory Committee established under RCW 90.46.

Reclaimed water suitable for reuse requires significant treatment and disinfection that is generally over and above conventional waste treatment facilities. Disinfection practices for Class A, B, C, and D reclaimed water are measured in total coliform, rather than fecal coliform traditionally used to measure wastewater disinfection effectiveness. Sampling is to be performed daily and Class A and B require less than 2.2 total coliforms per 100 milliliters based on a 7 day average.

These standards require:

- Emergency storage or alternate permitted discharge locations for reclamation facilities for use during upset conditions.
- Automated alarms.
- Redundancy of treatment units.
- Stringent operator training and certification to meet the reliability criteria.

The standards describe allowable beneficial uses, the required level of reclaimed water treatment appropriate for each beneficial use, and any specific statutory requirements from RCW 90.46.

"Beneficial Use" means the use of reclaimed water, which has been transported from the point of production to the point of use without an intervening discharge to waters of the State, for a beneficial purpose.

Some treatment and beneficial uses are regulated uniquely to reclaimed water projects. The key to these uses is that it specifies “Reclaimed Water” must be generated prior to the allowance for a specific beneficial use. All reclaimed water generation and use

must be covered under a reclaimed water permit that is issued jointly between Ecology and Health.

Table (8) shows the treatment and quality requirements for reclaimed water use under EPA regulations. Table (9) shows the monitoring requirement for the reclaimed wastewater and Table (10) shows the setback distances.

Table 8: Treatment and Quality Requirements for Reclaimed Water Use

Use	Type of Reclaimed Water Allowed			
	Class A	**Class B**	**Class C**	**Class D**
Irrigation of nonfood Crops				
Trees and Fodder, Fiber, and Seed Crops	YES	YES	YES	YES
Sod, Ornamental Plants for Commercial Use, and Pasture to Which Milking Cows or Goats Have Access	YES	YES	YES	NO
Irrigation of Food Crops				
Spray Irrigation				
All Food Crops	YES	NO	NO	NO
Food Crops Which Undergo Physical or Chemical Processing Sufficient to Destroy All Pathogenic Agents	YES	YES	YES	YES
Surface Irrigation				
Food Crops Where There is No Reclaimed Water Contact With Edible Portion of Crop	YES	YES	NO	NO
Root Crops	YES	NO	ON	NO
Orchards and Vineyards	YES	YES	YES	YES
Food Crops Which Undergo Physical or Chemical Processing Sufficient to Destroy All Pathogenic Agents	YES	YES	YES	YES
Landscape Irrigation				
Restricted Access Areas (e.g., Cemeteries and Freeway Landscapes)	YES	YES	YES	NO
Open Access Areas (e.g., Golf Courses, Parks, Playgrounds, Schoolyards, and Residential Landscapes)	YES	NO	NO	NO

Table 9: EPA Monitoring Requirements

Parameter	Sample Type & Frequency	Compliance Requirements
Biochemical Oxygen Demand [1]	24-hour composite, collected at least weekly	Shall not exceed 30 mg/L determined monthly, based on the arithmetic mean of all samples collected during the month.
Total Suspended Solids [2]	24-hour composite, collected at least daily*	Shall not exceed 30 mg/L, determined monthly, based on the arithmetic mean of all samples collected during the month.
Total Coliforms	Grab, collected at least daily	Compliance determined daily, based on the median value determined from the bacteriological results of the last 7 days for which analyses have been completed.
Turbidity	Continuous recording Turbidimeter	Filtered wastewater [3] shall not exceed an average operating turbidity of 2 NTU, determined monthly, and shall not exceed 5 NTU at any time.
Dissolved Oxygen	Grab, collected at least daily	Shall contain dissolved oxygen.

[1] *"Biochemical Oxygen Demand (BOD5)"* means the quantity of oxygen utilized in the biochemical oxidation of organic matter present in water or wastewater, reported as a five-day value established as determined using approved methods.

[2] *"Total Suspended Solids (TSS)"* means solids that either float on the surface of, or are suspended in, water or wastewater; the quantity of material removed from a sample in a laboratory test referred to as filterable residue, as determined using approved laboratory methods.

[3] *"Filtered Wastewater"* means an oxidized, coagulated wastewater which has been passed through natural undisturbed soils or filter media, such as sand or anthracite, so that the turbidity as determined by an approved laboratory method does not exceed an average operating turbidity of 2 nephelometric turbidity units (NTU), determined monthly, and does not exceed 5 NTU at any time.
TSS sampling may be reduced for those projects generating Class A reclaimed water on a case by case basis by Health and Ecology.

Table 10: Setback Distances

Conditions	Setback Distance (Feet) by Type of Reclaimed Water			
	Class A	Class B	Class C	Class D
Minimum distance between any reclaimed water pipeline and potable water supply well.	50	100	100	300
Where reclaimed water is used for spray or surface irrigation, minimum distance between the area subject to irrigation, and any potable water supply well.	50	100	100	300
Where reclaimed water is used for spray irrigation, minimum distance between the area subject to irrigation and areas accessible to the public and the use area property line.	0	50	50	100

Comparison of Jordanian standards with WHO and EPA standards

An overview of the Jordanian (national standards) and two international standards (WHO and EPA) for waste water reused for irrigation of food crops for human consumption is shown in Table 11.

Table 11: Comparison of Jordanian standards with WHO and EPA standards

Parameter	Unit	USA* 1989	WHO 1985	Jordan**
BOD	Mg/L	30	no	30
COD	Mg/L	no	no	100
TSS	Mg/L	30	no	50
Oil and grease	Mg/L	no	no	8
pH	-	6-9	6-9	6-9
Chlorine residual	Mg/L	1	no	0.5
Health				
Fecal coliforms	MPN/100ml	200	1,000	200
Nematodes	Eggs/L	no	<1	<1

*USA: EPA recommendations
**Jordon: Jordan Standard 893/2002

It can be seen that the new Jordanian standards are close enough to the international standards in terms of BOD, TSS, pH, E.Coli and Nematodes. The old national standards were far from these international standards.

With regard to institutional aspects, In Jordanian; responsible institutions for monitoring reclaimed water quality used for irrigation are:

a. Jordan valley authority (JVA)
b. Ministry of agriculture (MoA)
c. Ministry of environment (MoEnv)
d. Ministry of health (MoH)
e. Ministry of water and irrigation (MoWI)
f. Waste water treatment plant.
g. Water authority of Jordan (WAJ)

Internationally; each reclamation plant shall be provided with a sufficient number of qualified personnel to operate the facility effectively so as to achieve the required level of treatment at all times.

Qualified personnel shall be those meeting wastewater treatment plant certification and other requirements established.

The national limits of the parameters for cooked vegetables, parks, playgrounds and

sides of roads are quite strict. Jordanian standard prohibits the use of reclaimed water for irrigation of vegetables that are eaten uncooked (Fruits touching the ground during harvesting must be excluded and it is prohibited to sell or dry or manufacture these fruits in intention to sell to citizens or as feed) while WHO permits this but under standard requirements.

Concerning micro-biological treatment; the Jordanian Standard 893/2002 is stricter than WHO requirements. Internationally and according to *(Water Reclamation and Reuse Standards(1997)/Washington state department of ecology/Article 11/Alternative Reliability Requirements/Section2/ Biological Treatment);* All biological treatment unit processes shall be provided with one of the following reliability features:

(1) Alarm and multiple biological treatment units capable of producing oxidized wastewater with one unit not in operation;
(2) Alarm, short-term storage or disposal provisions, and standby replacement equipment;
(3) Alarm and long-term storage or disposal provisions; or
(4) Automatically actuated long-term storage or disposal provisions
(5) In the Jordanian standard it is not clear if there are applicable and valid quality restrictions or not. These are irrigation of grains, fodder and aquaculture. It is excluded because both fodder and grains can be irrigated unrestricted with reclaimed water.

Paragraph 5-2-2 of the Jordanian standard presents the special requirements for reuse of reclaimed water for irrigation. The standard defines two main groups:

a) Standards groups: "is the group of properties and standards presented in Table 3 of the Standard and where operating parties must produce water complying to it and according to the usage mentioned in this standard".

   "Operating parties" are not clearly defined in the standard. It is normally beyond the competence of the WWTPs to decide if the reclaimed water is finally used for irrigation purposes or not.

b) Guidelines group: The guidelines group is considered for guidance only. In case of exceeding its values the end user must carry out studies to verify the effect of that water on public health and the environment.

Internationally; reclaimed water suitable for reuse requires significant treatment and disinfection that is generally over and above conventional waste treatment facilities. It is classified into four categories:

1. **Class A Reclaimed Water:** means reclaimed water that, at a minimum, is at all times an oxidized, coagulated, filtered, disinfected wastewater. The wastewater shall be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 2.2 per 100 milliliters, as determined from the bacteriological results of the last 7 days for which analyses have been completed, and the number

of total coliform organisms does not exceed 23 per 100 milliliters in any sample.

2. **Class B Reclaimed Water:** means reclaimed water that, at a minimum, is at all times an oxidized, disinfected wastewater. The wastewater shall be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 2.2 per 100 milliliters, as determined from the bacteriological results of the last 7 days for which analyses have been completed, and the number of total coliform organisms does not exceed 23 per 100 milliliters in any sample.

3. **Class C Reclaimed Water:** means reclaimed water that, at a minimum, is at all times an oxidized, disinfected wastewater. The wastewater shall be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 23 per 100 milliliters, as determined from the bacteriological results of the last 7 days for which analyses have been completed, and the number of total coliform organisms does not exceed 240 per 100 milliliters in any sample.

4. **Class D Reclaimed Water:** means reclaimed water that, at a minimum, is at all times an oxidized, disinfected wastewater. The wastewater shall be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 240 per 100 milliliters, as determined from the bacteriological results of the last 7 days for which analyses have been completed.

Disinfection practices for Class A, B, C, and D reclaimed water are measured in total coliform, rather than fecal coliform traditionally used to measure wastewater disinfection effectiveness. Sampling is to be performed daily and Class A and B require less than 2.2 total coliforms per 100 milliliters based on a 7 day average.

Concerning public health and the health of workers:

- In Jordan;
    - Concerns for public health and the health of workers shall be a focus in the programs of reuse of treated waste water.
    - Farmers shall be encouraged to use modern and efficient irrigation technologies.
    - Protection of on-farm workers and of crops against pollution with waste water shall be ensured Programs on public and farmers' awareness shall be designed and conducted to promote the reuse of treated waste water, methods of irrigation, handling of produce. Such programs shall concentrate on methods of protection of farmers' health, animal and bird health and the environment.
    - It is prohibited to use TWW in irrigation near drinking water wells, in a distance not less than 500 m for maintaining public health and safety.

- The farm workers must wear protective clothes and long rubbery shoes and gloves to prevent contact with TWW.

- Internationally; (by *Water Reclamation and Reuse Standards/1997/Washington state department of ecology*).

    - Adequate measures shall be taken to prevent the breeding of vectors of health significance and the creation of odors, slimes, or aesthetically displeasing deposits
    - For any irrigation use of reclaimed water, the hydraulic loading rate of reclaimed water shall be determined based on a detailed water balance analysis. The calculated loading rate(s) and the parameters and methods used to determine the loading rate(s) shall be submitted to the Departments of Health and Ecology for approval.
    - There shall be no application of reclaimed water for irrigation purposes when the ground is saturated or frozen.
    - Where Class A reclaimed water is used for surface irrigation, there shall be a minimum of 50 feet between the area subject to irrigation and any potable water supply well Where Class C reclaimed water is used for surface irrigation, there shall be a minimum of 100 feet between the area subject to irrigation and any potable water supply well.
    - Where Class D reclaimed water is used for surface irrigation, there shall be a minimum of 300 feet between the areas subject to irrigation any potable water supply well.
    - Exceptions to the setback distances noted in Article 12, Section 4 (a), (b), (c), and (d) may be approved by country's departments of health and/or ecology if lesser setback distances can be demonstrated to the satisfaction of the departments to assure an equal degree of public health protection.

By the Jordan's Agriculture Law # 44/2002 and its Amendments Article (15C):

- The irrigation pipes color should be purple and not black as those used with pure water.
- Stoppers color should different from those used with pure water.
- Warning signs should be placed in clear spots and at stoppers showing that the used water is TWW.

Internationally, *Water Reclamation and Reuse Standards/September 1997/Washington state department of ecology* includes:

- All reclaimed water piping, valves, outlets, and other appurtenances shall be color coded purple [Pantone 522 or other shades of purple acceptable to review agencies], taped purple [Pantone 512 or other shades of purple acceptable to review agencies], or otherwise marked to identify the source of the water as being reclaimed water.
- All reclaimed water piping and appurtenances shall be either colored purple [Pantone 522 or other shades of purple acceptable to review agencies] and embossed or integrally stamped or marked "CAUTION: RECLAIMED

WATER - DO NOT DRINK" or be installed with a purple [Pantone 512 or other shades of purple acceptable to review agencies] identification tape or polyethylene vinyl wrap. The warning shall be stamped on opposite sides of the pipe and repeated every three feet or less.

- Identification tape shall be at least three inches wide and have white or black lettering on a purple [Pantone 512 or other shades of purple acceptable to review agencies] field stating "CAUTION: RECLAIMED WATER - DO NOT DRINK." Identification tape shall be installed on top of reclaimed water pipelines, fastened at least every ten feet to each pipe length, and run continuously the entire length of the pipe.

After reviewing the EPA standards and compare it with the national one, it can be shown that the later lack the details of the monitoring requirements and the set back distances. It means that the national standards still lack the proper safety measures during the usage of the treated wastewater. WHO standards were very general in this term.

The EPA standards mentioned quoted examples for the non-food and food crops that can be considered for this type of water. The new Jordanian standards missed that point which could be a shortcoming in elaborating the possible irrigation uses. In the national standards there are not enough details regarding the possible usage of treated wastewater for industrial purposes, where the EPA standards elaborated more under this subject.

In comparing the Jordanian and WHO standards with regard to setting the parameter limits, the former was more specific for most of the parameters, where the WHO lack such specificity like the BOD, COD and TSS concentrations.

CONCLUSIONS AND RECOMMENDATIONS

After discussing the technical and administrative aspects of the Jordanian and two international standards related to the reclaimed wastewater, a number of conclusions and recommendations can be stemmed, these are as follows:

(1) A definition of “pure water” should be included into the Jordanian standard, which is not yet done so far in the list of definitions of the standard. It should be clarified if the wording “pure water” is used in the standard to characterise the water in a religious sense, for drinking water purposes or in another sense. In addition, it is not clear if the term “pure water” also includes “freshwater”. “Freshwater” is a term that is widely used in Jordan agriculture and stands normally for the use of surface waters for agricultural irrigation, like water from King Abdullah Canal (KAC), rivers and reservoirs (like Wadi Arab reservoir) as well as water from springs and groundwater wells.

(2) The standard prohibits blending treated waste water on site with “pure” water to

comply with the standard's limiting values. This prohibited blending does not affect the use of the reclaimed water effluents from WWTPs in case the water complies with the standard. This includes also the use of the reclaimed water for irrigation purposes. Actually it is not known which kind of action will be undertaken in case the water does not comply with the standard. In the opinion of the consultant this item requires further investigations and clarification with the relevant authorities (MoH, MoWI, and MoEnv).

(3) "Operating parties" are not clearly defined in the standard. It is normally beyond the competence of the WWTPs to decide if the reclaimed water (treated waste water) is finally used for irrigation purposes or not. It is their task to "produce" treated waste water that corresponds to the requirements for a final disposal in the environment (wadis, rivers etc.). More elaboration should be added with this regard.

(4) Both standards (from 1995 and 2002) prohibit the use of reclaimed water for irrigation of vegetables that are eaten uncooked (raw). The older standard gave examples for such fruits. These are not mentioned any more in the new one. This may be a lack.

(5) The limits of the parameters for cooked vegetables, parks, playgrounds and sides of roads are quite strict. It is also not understandable why the differentiation between the limits for cooked vegetables and other purposes (parks, side of roads inside a city etc.) are now abolished in comparison to the older standard. Irrigation of agricultural land requires other conditions than irrigation of roads inside the city. BOD and COD are important in agriculture for enhancing and increasing microbiological activity in the soil. It is not clear why the standard requirements for BOD/COD are set so low. The same applies to Nitrate. It is an additional fertilizer when available in the reclaimed water. Restrictions should be only defined and given when the water is applied during the non-vegetative growing periods.

(6) The old standard of 1995 specified pathogenic biological vectors (pathogens, amoeba, giardia, nematode eggs) and total faecal coliforms (TFCC). The new standard only points out E. coli and intestinal helminthes eggs. This does not sufficiently describe the possible biological hazard of the reclaimed water. An assessment of its health hazards is very limited if only the two above mentioned parameters are determined.

(7) A new chapter should be added with regard to water quality monitoring (paragraph 6, new standard) it is repeated that the waste water treatment plant owner can not know for what the treated effluents finally will be used. It is out of his influence. Adopting standards and guidelines for water used in irrigation, in co-operation with Jordan's Ministry of Agriculture, increases the availability of water that can be used in irrigation. An effective monitoring program has to be adopted. Such a program requires that analytical methodology equipped laboratories and qualified personnel be provided.

(Jordan's Water Utility Policy topic 7)

Influent to and effluent from the plants and throughout water courses in Jordan shall be measured and monitored against all appropriate parameters to ensure that public health objectives and treatment efficiency goals are attained.

(8) The Jordanian standard only points out E. Coli and intestinal Helminthes eggs and does not specify pathogenic biological vectors (pathogens, Amoeba, Giardia, Nematode eggs) and total faecal Coliforms (TFCC).

To help in the assessment of reclaimed water health hazards; it is advised to sufficiently describe the possible biological hazard of the reclaimed water by determining all the above mentioned parameters.

All crops irrigated with treated and mixed waters in Jordan shall be analyzed and monitored periodically.

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