التعاون الألماني
DEUTSCHE ZUSAMMENARBEIT

Implemented by

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Funded by the European Union

FINAL REPORT

Mission for the Safe and Efficient Reuse of Treated Wastewater of the Jordanian Pilot Project Decentralized Wastewater Treatment Plant at the Public Security Directorate (PSD) in Moqabalain, Jordan

December 2014

Consultancy was carried out from 08.04.2014 to 30.01.2015

Project: Pilot Projects for Integrated Sustainable Waste Management (SWIM-Sustain Water MED)

GIZ contract no.: 83169994

Amman, Jordan

Consultant MIRRA - Methods for Irrigation and Agriculture
Physical address Shmeisani – Abdelaziz Al-Tha'alibi Str. Bldg. 7
Postal addressP.O. Box 94145411194 Amman, Jordan
T/F 00962(0)6 568 79 73
Email info@mirra-jo.org
Web www.mirra-jo.org

Table of Contents

List of tables

List of Abbreviations

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
EIA	Environmental Impact Assessment
GAM	Greater Amman Municipality
JOD	Jordanian Dinars
LIS	Landscape Irrigation System
MIRRA	Methods for Irrigation and Agriculture
MG/L	milligrams per litre
MWI	Ministry of Water and Irrigation
BA	Baseline Analysis Report
PSD	Public Security Directorate
TN	Total Nitrogen
TP	Total Phosphorous
TWW	Treated wastewater
WAJ	Jordan Water Authority
WWTP	Wastewater Treatment Plant

1. Introduction

The construction of a wastewater treatment plant (WWTP) for the Public Security Directorate (PSD) compound in the Mogabalane area is scheduled for the end of June 2014. The WWTP will treat the wastewater generated in this facility. Treated wastewater (TWW) is to be reused on site for landscape irrigation. In the framework of this project, Methods for Irrigation and Agriculture (MIRRA) is contracted to:

- Design the Landscape Irrigation System (LIS) complete with a site specific and concise user's manuals for PSD's reuse plan and the reuse of potential excess reclaimed water.
- Train the PSD staff about the safe and efficient reuse practices in a landscape irrigation setting.
- Produce educational and demonstrational materials on PSD's reuse activities for the proposed Information Centre.

The proper planning, design and operation of a LIS requires comprehensive data and information about the quality and quantity of water on site and the environmental and climatic conditions in the area. In addition, it requires an operational plan that insures that the system will continue to operate according to the relevant standards and regulations.

A comprehensive baseline analysis (BA) report was prepared for this project in February 2013. In addition, a detailed environmental impact assessment (EIA) was prepared in September 2013. This document reviews the baseline data reported in the PA report and EIA. Furthermore, it draws upon relevant information available in literature pertaining to treated wastewater reuse in landscape irrigation system which has been practiced worldwide for over two decades now.

In particular this report identifies and elaborates on the elements directly related to the planning, design and management of the proposed LSI to be installed at PSD. Furthermore, this report highlights in a comprehensive manner all issues related to the reuse of reclaimed wastewater in landscape irrigation within an urban setting.

2. Background Information and the Study Area

Upon its completion, PSD will have a total number of 2,466 occupants, 10% of whom are on 24 hour call at any particular time. The amount of water use, wastewater generation, water cost and wastewater transportation fees have been identified and quantified in the PA report. Table 1 summarises the most relevant statistics pertaining to PSD, highlighting the size and scope of this facility. Careful examination of these numbers shows the potential benefits and savings if wastewater is treated and reused on site. The significant number of occupants, activities within the directorate, including recreational facilities and restaurants, will result in daily large quantities of water, as will be presented later. In addition to water, land is also available. Combined, after proper treatment of wastewater, will potentially result in great water savings.

Table 1: The Public Security Directorate (PSD) in numbers.

Item	Unit	Value	Comments
Current green area	m^2	18,500	
Additional available green area	m^2	15,500	
External potentially available green area	m^2	90,000	Jordan Telecommunication (JT) vacant land used for towers. Final agreement between PSD and JT about irrigating part of JT landscape using the treated effluent has not been reached yet.
Total area of buildings	m^2	57,703	
Potential total number of occupants		2,466	Around 10% of the occupants are expected to be on call over 24 hours.
Total numbers of daily served meals		3,000	
Amount of daily produced laundry	kg	15,000	

Treated wastewater reuse has been practiced for a long time, and in spite of the existence of the best management practices to support optimised application of treated wastewater to soil and plants, the location of PSD in the midst of an urban setting poses a challenge. The present land use pattern around the PSD site is residential, with the presence of a few public administration and commercial buildings. The pilot project is not expected to interact directly with the neighbouring community around PSD in terms of water reuse. However, the mere existence of this activity within such a setting is challenging, unique, and the first of this scale in Jordan. The majority of treated wastewater reuse projects in Jordan are located outside of urban areas therefore, careful analysis of available information for this project is highly warranted.

3. Environmental Conditions

In general, the climate of the area in which PSD is located is considered semi-arid to arid, and is characterised by cold rainy winters and dry hot summers. Most of the precipitation occurs during the rainy season that extends from October to April. The station of Marka Airport is the closest (12km northeast) to the site. The climatic conditions are summarised in Table 2.

Table 2: Climatic data collected from the nearest meteorological station at Marka Airport.

Parameter	Value	Unit
Mean max daily temperature (July)	35	°C
Mean min daily temperature (January)	4.4	°C
Mean total annual precipitation	240	mm
Mean total annual evaporation	183	mm
Peak monthly evaporation (July-2011)	350	mm
Mean monthly wind speed	2.7 – 5.2	Knot
Evapotranspiration*: Cool day – (10°C)	1-3	mm/day
Evapotranspiration: Moderate day (20°C)	4-7	mm/day
Evapotranspiration: Hot day (30°C)	6-9	mm/day

*Estimated by the Food Agricultural Organization according to Allen, et al. 1998 based on data obtained from the Mushaqar agricultural station.

4. Water and Sanitation

PSD is connected to the water supply network and receives municipal water twice a week. In addition, PSD relies on private tanks to satisfy the demand for landscaping. Half of the current water use is for landscape irrigation. Therefore, proper treatment and reuse of treated wastewater on site will reduce fresh water demand. Most likely, it will prove financially feasible and environmental friendly. At PSD, wastewater is collected using a network and is currently discharged to an existing cesspool that is emptied every other day and is transported to Ain Ghazal pre-treatment facility by tankers, after which it is transported again by a main sewer line to Khirbit As-Samra centralized wastewater treatment plant.

The construction and full operation of the wastewater treatment plant at PSD is expected to be completed by the end of June 2014. Treated wastewater will then be used for landscape irrigation on site. The proper design of the irrigation system requires detailed analysis of the expected quantity of generated water. Table 3 summarises all the relevant information pertaining to the current and potential water resources in addition to estimated irrigation demand based on the environmental setting presented in the previous section.

The characteristics of wastewater generated from PSD premises are presented in tables 4 and 5.

Table 3. Summary of water and wastewater information.

Item	Unit	Value	Notes
Current water use	l/d/capita	174	Around 50% of this number will be used for landscaping.
Future water use*	l/d/capita	88	Most of the reduction in the future water use is due to the better management of water resources on the compound and the reuse of reclaimed water in irrigation instead of using fresh water.
Current wastewater generation	m^3/day	31	
Projected wastewater generation	m^3/day	217	70% of this volume is expected to be reclaimed. 30% losses are mainly due to sludge, outdoor surface cleaning and evaporation from paved surfaces.
Rainwater Harvesting Tank	m^3	5000	PSD has a rainwater collection system that is connected to a 5,000 m^3 tank. In the overall management of the landscape irrigation systems, this water will serve two purposes: - Irrigation when the available treated wastewater is not sufficient, - Leaching of salts that will accumulate in the soil due to the use of treated wastewater.
Maximum available reclaimed water	m^3/day	150	
Municipal water cost	JOD / m^3	1	
Private water tankers cost	JOD / m^3	3	
Wastewater Treatment Plant**	Type: Activated sludge process based on the Sequencing Batch Reactor Technology (SBR) with nitrification and de-nitrification.		
Capacity – Water Volume	m^3/day	150	
Capacity – BOD_5 load	BOD_5/day	112	
Operation Cost - Electricity	kW/day	275	1.83 kW/m^3

Operation Cost	JOD/day	33	0.22 JD/m^3

*agreed upon by the technical committee and PSD.
**see appendix C for a complete description of the wastewater treatment plant.

Table 4: Average wastewater characteristics based on samples taken with and without including restaurant effluent.

Parameter	Unit	Average Value	Average Value w/o Restaurant
pH (Acidity)		8.33	
COD (Chemical Oxygen Demand)	mg/l	1,725	1,262
BOD_5 (Biological Oxygen Demand)	mg/l	745	320
TSS (Total Suspended Solids)	mg/l	788	225
TVSS (Total Volatile Suspended Solids)	mg/l	590*	200
TKN (Total Kjeldahl Nitrogen)	mg/l	175	210
NH_4^+-N (Ammonia Nitrogen)	mg/l	133	190
P_{tot} (Total Phosphorous)	mg/l	52*	49
PO_4-P (Phosphate)	mg/l	12*	
FOG (Fat, Oil & Grease)	mg/l	43	9
MBAS (methylene blue active substance)	mg/l	0.75	0.57
SO_4- (Sulphate)	mg/l	34	33
CL^- (Chlorine)	mg/l	203	217
E.coli (Escherichia coli)	MPN/100ml	$5.7x10^7$	$2.4x10^7$
HCO_3^- (Bicarbonate)	mg/l	759	835
Mg^{++} (Magnesium)	mg/l	18	9
Ca^{++} (Calcium)	mg/l	76	28
Nematode eggs	egg/5l	Not seen	Not seen

*based on one measurement.

Table 5: Trace metal concentration in the PSD wastewater.

Trace metal	Concentration (mg/l)	Trace metal	Concentration (mg/l)
Cu (Copper)	0.049	Cr (Chromium)	0.02
Fe (Iron)	3.74	Co (Cobalt)	0.03
Li (Lithium)	0.01	Mo (Molybdenum)	0.01
Mn (Manganese)	0.081	V (Vanadium)	0.1
Ni (Nicklel)	0.04	As (Arsenic)	0.01
Pb (Lead)	0.09	Be (Beryllium)	0.02
Cd (Cadmium)	0.005	Se (Selenium)	0.01
Zn (Zinc)	0.605	Hg (Mercury)	0.001

The quality of treated wastewater is another major parameter in its successful reuse in landscape irrigation. The EIA study and BA report characterised the biological and chemical composition of generated wastewater from PSD facility. In addition, the two studies reported the expected quality of the treated wastewater based on the approved and currently under-construction wastewater treatment plant, which is designed to be according to the ranges specified by the Jordanian standard (JS:893/2006) and listed in appendix B. As mentioned before, the generated TWW will be used to irrigate the PSD landscape. Negotiations are ongoing between the project and Greater Amman Municipality (GAM) to benefit from the extra amount of TWW generated by PSD WWTP to irrigate public green spaces. The additional TWW in excess of the need of the landscape will be left to flow into a nearby valley.

According to the BA report, wastewater generated from PSD is characterised by concentrations of COD and BOD that are comparable with those reported for domestic wastewater influents to most municipal wastewater treatment plants in the kingdom. However, results show higher than average concentrations of ammonium and nitrogen with average concentrations of 133 mg/l and 175 mg/l, respectively. Average ammonium concentration in domestic wastewater in Jordan is around 80 mg/l. Proper nutrient accounting is a vital irrigation management practice. Available and beneficial nutrients in reclaimed water should be accounted for, which might result in financial savings by cutting fertiliser costs and insuring soil fertility and health.

5. Landscape Irrigation System Using Treated Wastewater

This section discusses the anticipated adverse impacts on soil and plants along with the appropriate mitigation measures. It also highlights the direct and indirect positive impacts as a result of the utilisation of treated wastewater in landscape irrigation. Finally, the potential nutritional (fertiliser) benefits of treated wastewater are discussed.

For the efficient and sustainable operation of a landscape drip irrigation system, recommended water quality parameters as presented in Table 6 should be met otherwise the plants, soil and/or the irrigation system itself are subject to adverse impacts. In Table 6 shows the ideal range for each quality parameter and the potential adverse impacts.

Table 6: Recommended quality parameters for the use in a landscape drip irrigation system with potential adverse impacts if recommended ranges are not met (Source: several, mainly Irrigation Water Quality Guidelines, 2006).

Parameter	Ideal Range	Potential Adverse Impacts if Ideal Range is not met
Potential of Hydrogen – acidity or alkalinity (pH)	6.0 – 9.0 Generally, this range has no significant negative impact on plants or soils.	▪ Nutrient availability for plants. Corrosion, scaling and carbonates precipitants of/on irrigation equipment.
Salinity expressed as Electrical Conductivity (EC)	EC (dS/m) > 7.5 for highly tolerant species 3 – 7 for tolerant species 1.7 – 3 for moderately sensitive species < 1.7 for sensitive species	▪ Growth of plants declines if irrigated with higher salinity water
Total Suspended Solids (TSS)	< 50 mg/l (milligram per litre)	▪ Clogging, precipitating and calcinations of the irrigation system ▪ Reduction of soil surface permeability
Biological Oxygen Demand (BOD_5)	< 60 mg/l	Harmful to plant growth
Chemical Oxygen Demand COD	< 120 mg/l	
Calcium	< 400 mg/l	

(Ca)		
Magnesium (Mg)	< 150 mg/l	
Potassium (K)	< 80 mg/l	Higher values reduce plant uptake of Ca
Bicarbonate (HCO_3)	< 250 mg/l	Higher values negatively impact plants and soils
Sodium (Na) and Chloride (Cl)	▪ Na and Cl are the major salinity parameters in irrigation water. ▪ Excessive Na in irrigation water promotes soil dispersion and structural breakdown. ▪ Their effect is bound to the Ca content of the soil. The higher the Ca content, the less negative impacts to be expected of Na and Cl.	
Sodium Adsorption Ratio (SAR)	< 6 no problems expected 6 – 9 results in reduced soil permeability > 9 results in soil clogging	The unit of SAR is milliequivalents per litre (meq/l)
Nitrogen Compounds	Nitrate (NO_3) and Ammonium (NH_4) < 16 mg/l Total Nitrogen < 50 mg/l	Higher values results in excessive vegetative growth, which is a problem in classical agriculture because it delays crop maturity. However, in landscape agriculture this is not a serious issue.
Sulphate (SO_4)	< 960 mg/l	Harmful to plants and soils if higher values are found in irrigation water
Boron (B)	< 6 mg/l	
Iron (Fe)	< 1 mg/l	
Manganese (Mn)	< 2 mg/l	This is true for alkaline soils such as in Jordan
Zinc (Zn)	< 2 mg/l	
Copper (Cu)	< 1 mg/l	
Pathogens	< 1 Intestinal Helminthes Egg / litre < 1000 Faecal Coliform per litre	

The operation of a wastewater treatment plant and a landscape drip irrigation system requires a skilful operation and continuous monitoring and evaluation. Adverse impact might result from improper management of the wastewater treatment plant or accidental failures of the plant. In addition, and as presented in Table 6, adverse impacts might result if reclaimed water quality is not maintained within the recommended ranges. Table 7 further elaborates on the potential adverse impacts as a result of any failures in the process, the mechanism in which they might occur, and the associated mitigation measures.

As part of the operation and management plan of the landscape irrigation system, a salt-leaching programme will be designed. The objective of this program is to leach the salts that accumulate in the soil due to the use of treated wastewater. Harvested rain water will be used for this purpose. The available 5,000 m^3 rain harvesting tank will aid in this regard.

Table 7: Potential adverse impacts of reclaimed water reuse in irrigation and associated mitigation measures.

Adverse impact	Mechanism	Mitigation measure
Direct flow of wastewater from treatment plant onto soil	▪ Seepage due to cracks ▪ Overflow due to storm water	▪ Proper design and supervision of concrete structure to ensure sustainable and reliable tanks with no chance of wastewater outflow

		▪ Proper runoff diversion channels and structures should be designed to eliminate flood risk ▪ Wastewater sewer network should be protected from storm water to avoid overloading during heavy rain events
Alteration of the soil quality due to irrigation using reclaimed wastewater	▪ Chemical and biological constituents of the reclaimed water ▪ Irrigation scheduling and irrigation practices	▪ Adopt adequate irrigation scheme and schedule that considers the crop pattern as well as the potential evapotranspiration rates. Hence, protecting crop and soil from residuals
Biodiversity - Degrading natural vegetative cover	▪ Plant edible species ▪ If trees are planted in species-rich unimproved grassland they may reduce biodiversity by shading out the ground flora	▪ Planting fast-growing trees to provide shade should be considered. The addition of trees is beneficial to biodiversity by providing insect and bird habitats with suitable environment ▪ Genetically diverse tree stands will offer positive effects for soil microorganisms and insects
Occupational Health and Safety	▪ Direct exposure to treated wastewater water during irrigation	▪ Proper design of irrigation system ▪ Adoption and compliance with relevant reuse standards and reuse practices ▪ Concerned staff/operators to receive training on the safe and efficient operation of such wastewater treatment facilities ▪ Placement of warning signs around the unit and warning notices to be distributed/circulated particularly in the events of maintenance and sludge disposal

One aspect of the operation and management of treated wastewater plants that should not be overlooked is the control of incidental runoff of wastewater. Incidental runoff is defined as the unintended volume of runoff from TWW reuse area. Water leaving the area due to excessive application especially during rain events should be prevented. Incidental runoff may be regulated by proper design and management of the irrigation system. In addition, implementation of an operations and management plan that insures continuous detection of leaks, for example, from broken irrigation pipes, and correction either within 72 hours of learning of the runoff, or prior to the release of 1,000 gallons, whichever occurs first.

According to the EIA report, groundwater under PSD is more than 100m deep and the study of soil and geology indicated no presence of geological faults. Moreover, the soil structure of the site is thick plastic silty clay of about 2m deep, which acts as a protective barrier of groundwater underneath. Therefore no significant adverse impacts are anticipated from the use of TWW in irrigating the landscape.

The proper management of the wastewater treatment plant and the landscape drip irrigation system can result in an array of positive impacts both environmentally and financially. The EIA report outlines a number of significant positive impacts on the different environment components and human health, which are summarised in Table 8. Alleviating the stress on fresh water resources in Jordan is one of the major positive impacts of this endeavour. Another major contribution to the water culture of Jordan is the practical implementation and adaptation of decentralised wastewater treatment, which is an important source of water.

Table 8: Expected direct and indirect impacts of TWW water reuse in landscape irrigation at PSD.

Direct	Indirect
Controlled approach for the collection and treatment of wastewater	▪ Eliminating any unsafe disposal options and associated environmental and health impacts ▪ Contributing to the improvement of public health and sanitation
Providing marginal water for landscape irrigation	▪ Alleviating stress on fresh water ▪ Reducing the usage of inorganic fertilisers leading to soil conservation ▪ Improving the aesthetics of the landscaping along the site perimeter
Acting as knowledge transfer and public awareness opportunities toward reclaimed water	▪ Setting a practical example for adopting decentralised wastewater treatment as part of the national strategies toward the use of unconventional water resources
Enhancing biodiversity at and around the compound	▪ Reducing soil erosion ▪ Congregating important birds and other fauna around the site
Social acceptance and understanding of the benefits of treated water reuse at the study site	▪ Transferring this social value and knowledge to community outside the study site

Nutrient Management

A frequently overlooked aspect of TWW is the nutrients content, particularly nitrogen and phosphorus. Nitrogen promotes plant growth. It is associated with leafy, vegetative growth. Nitrogen is part of every protein in the plant, so it's required for virtually every process, from growing new leaves to defending against pests. Nitrogen is part of the chlorophyll molecule, which gives plants their green color and is involved in creating food for the plant through photosynthesis; lack of nitrogen shows up as general yellowing of the plant. Phosphorus is involved in metabolic processes responsible for transferring energy from one point to another in the plant. It's also critical in root development and flowering. For application to the landscape these nutrients can be beneficial and can supply a significant portion of plant needs, which reduces the amount of needed fertiliser. The nutrients in TWW are believed to be efficiently used by plants since they are applied on a regular basis by irrigation even if they are only present in low concentrations. Nevertheless, supplemental fertilisation with specific nutrients that are not provided by TWW may still be required depending on the plant species. Ordinarily, the nutrient content of TWW varies depending on the treatment processes used. In general, treatment plants that use advanced treatment methods, such as tertiary treatment typically produce reclaimed water with lower nutrient levels than those that use secondary treatment methods. Still, the nutrient content of advanced treated wastewater is often higher than that of drinking-quality water or rainfall.

The performance of SBRs is typically comparable to conventional activated sludge systems and depends on system design and site-specific criteria. Depending on their mode of operation, SBRs can achieve good BOD and nutrient removal. For SBRs, the BOD removal efficiency is generally 85 to 95 percent. SBR manufacturers will typically provide a process that is guaranteed to produce an effluent of less than (EPA, 1999):

- 5 - 8 mg/L TN (total nitrogen)
- 1 - 2 mg/L TP (total phosphorus)

In addition to that, other factors affect the nutrient content of TWW. For instance, it can vary from one utility to another, and can vary at different times of the year.

The timing of irrigation water application is also crucial since the relatively constant, low dosage provided by irrigation with TWW may not supply the right amount of nutrient at the right time. It is also possible that some nutrients are lost between the treatment plant and the point of irrigation. Loss of nutrients can occur if storage is in open ponds, where algae and

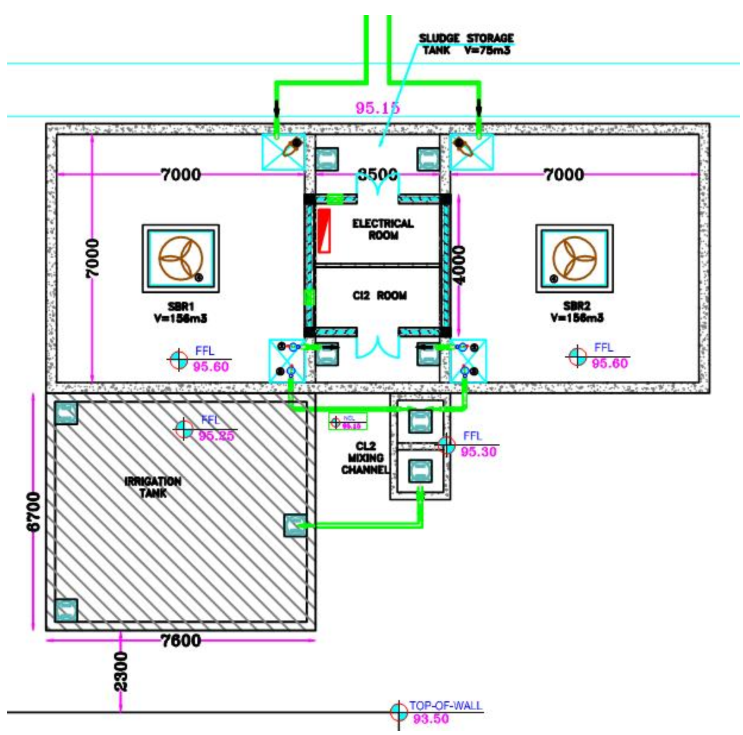

Figure 1 : Top view plan of the PSD wastewater treatment plant.

other microorganisms take up some of the nutrients, removing them from the water. Loss during storage is of less concern when closed tanks are used as is the case in the PSD's WWTP (see Figure 1). Closed tanks are preferred by utilities since the algae produced in open ponds can clog irrigation systems and increase maintenance requirements by the utility before the water enters the distribution system.

Based on the characteristics of the effluent at PSD, it is recommended not to provide any supplementary fertilization.

6. INSTITUTIONAL AND LEGAL FRAMEWORK

Monitoring the performance of wastewater treatment plants is under the mandate of the Ministry of Water and Irrigation (MWI) through the Jordan Water Authority (WAJ). In particular, the Water Demand Management and the Reclaimed Water Reuse units are directly responsible. Reclaimed and TWW reuse in irrigated agriculture is also subject to the supervision and routine checks from the Ministry of Environment and the Ministry of Agriculture. Table 7 below presents a summary of the institutional framework pertaining to this project.

Table 9: Institutional framework and responsibilities of decentralized WWTP.

Institution	Authority/Task	Procedures	Responsibility
▪ Ministry of Water and Irrigation (MWI) ▪ Water Authority of Jordan (WAJ) ▪ Water Demand Management Unit (WDM) ▪ Reclaimed Water Reuse Projects Unit	▪ Water supply. ▪ Treated Wastewater quality monitoring.	Routine checks on the performance of the WWTP based on JS 893/2006.	PSD or Wastewater treatment plant operation contractor
Ministry of Health		A proper management plan has to be in place to avoid health risk due to the use of reclaimed water.	PSD or Irrigation Systems Operation Contractor
Ministry of Environment	Not applicable in the case of using reclaimed water in landscape irrigation. The only requirement is an Environmental Impact Assessment study, which w prepared by the PSD, BAU and IUCN.		
Ministry of Agriculture	Not applicable since reclaimed water will not be used in the production of edible products.		
Jordanian Institution for Standards and Metrology (JISM)	Reclaimed domestic wastewater (JS 893:2006) Sludge disposal (JS 1145/2006).		Wastewater treatment plant operation contractor

7. Conclusion

Wastewater is a valuable resource. This is the message that Methods for Irrigation and Agriculture (MIRRA) will ultimately highlight in partnership with the Public Security Directorate (PSD), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Balqa Applied University (BAU) and the International Union for the Conservation of Nature (IUCN).

The successful implementation of this task requires: i) the careful consideration of the geographical, environmental and social settings of the PSD, which was accurately assessed in the baseline assessment report and has been summarised and augmented by additional information in this review report, ii) accurate investigation of the potential adverse impacts from this activity and enacting the appropriate mitigation measures, which was carefully performed by the environmental impact assessment study and was further extended by this review report by highlighting the positive and adverse impacts of using reclaimed water in the irrigation of landscape plants.

Successful operation and continued performance of such a project requires continuous monitoring and coordination with the relevant institutions as described the institutional and legal framework section of this report.

8. References

A compendium of standards for wastewater reuse in the Eastern Mediterranean Region. 2006. World Health Organization Regional Office for the Eastern Mediterranean Regional Centre for Environmental Health Activities. Document WHO-EM/CEH/142/E

Baseline Assessment Study for SWIM-Sustain Water MED - Wastewater Treatment Plant for Public Security Directorate Compound in Moqablain Area in Amman. 2013. Bassam Hayek.

Cadillon M. 2003. Report 2 Monitoring Protocol for Beit Lahia Experiment. TECHNICAL SUPPORT MISSION FOR REFERENCE SITES INSTALATION- REGIONAL PROGRAM « AGRICULTURAL WATER MANAGEMENT AND WATER SAVINGS IN THE MIDDLE EAST ». Mission Régionale Eau et Agriculture, Amman, Jordan.

Environmental Impact Assessment for Wastewater Treatment Unit at Public Security Compound in Amman, Jordan. 2013. International Research Center for Water, Environment & Energy. Al Balqa' Applied University.

EPA United States Environmental Protection Agency 1999. Wastewater Technology Fact Sheet: Sequencing Batch Reactors. Office of Water Washington, D.C.EPA 832-F-99-073.

Gabriel Lambert, Sebastien Guery, Alice Arrighi de Casanova and Ehab Ashour. 2007. Water Savings in the Middle-East- Waste Water Reuse Project. The First Experiment of Waste Water Reuse in the Gaza Strip.

Irrigation Water Quality Guidelines. 2006. German-Jordanian Programme "Management of Water Resources".

Policy for Water Quality Control for Recycled Water (Recycled Water Policy). 2013. STATE WATER RESOURCES CONTROL BOARD RESOLUTION NO. 2013-0003.

Towards the Safe Use of Treated Wastewater. The National Plan for Risk Monitoring and Management System for the Use of Treated Wastewater in Irrigation. 2011. German-Jordanian Programme "Management of Water Resources".

Using Reclaimed Water for Landscape Irrigation. Christopher J. Martinez and Mark W. Clark. 2012. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611.

Water- Reclaimed domestic wastewater. Jordan Institution for Standards and Metrology (JISM). Technical Regulation; Mandatory. Jordanian Standard No. 893:2006.

9. Appendices

Appendix A: Jordanian Standard (JS: 893/2006) for the use of treated wastewater in Agriculture. Microbiological quality guidelines for wastewater use in agriculture.

Category	Reuse Conditions	Exposed group	Intestinal nematodes (arithmetic mean number of eggs per litre)	Faecal coliforms (geometric mean number per 100ml)*
A	Cooked vegetables, parks, playgrounds and side roads inside cities.	Workers, consumers, public	≤ 1	100
B	Fruit trees, side roads inside cities outside of cities, green areas.	Workers/ agricultural labour	≤ 1	1,000
C	Field crops, industrial crops, and Forest trees	None	≤ 1	-

* During the irrigation period.

Appendix B: Jordanian Standard (JS: 893/2006) for different effluent reuse options.

Parameter	Unit	Cooked vegetables, parks, playgrounds and side roads inside cities Category (A)	Fruit trees, side roads inside cities outside of cities, green areas Category (B)	Field crops, industrial crops, and Forest trees Category (C)	Flow into streams and valleys
BOD_5	mg/l	30	200	300	60
COD	mg/l	100	500	500	150
DO	mg/l	>2	-	-	>1
TSS	mg/l	50	200	300	60
pH	mg/l	6 - 9	6 - 9	6 -9	6 -9
NO_3	mg/l	30	45	70	80
Total Nitrogen	mg/l	45	70	100	70
E.-coli	MPN*/100 ml	100	1,000	-	1,000
Intestinal helminth eggs	egg/litre	≤ 1.0	≤ 1.0	≤ 1.0	≤ 0.1

*MPN = Most Probable Number.

هذا المشروع ممول من قبل الاتحاد الاوروبي والوزارة الفدرالية الألمانية للتعاون الاقتصادي والتنمية (BMZ)

SWIM – Sustain MED is a Project Funded by the European Union (EU) and the German Federal Ministry for Economic Cooperation and Development (BMZ).

Project Partners:

وزارة الميــاه والـــري
Ministry of Water & Irrigation

Al Balqa Applied University
جامعة البلقاء التطبيقية

The International Union for Conservation of Nature
الاتحاد الدولي لحماية الطبيعة

This publication has been produced with the financial assistance of the European Union (EU).The views expressed herein can in no way be taken to reflect the official opinion of the European Union (EU).