Case study of sustainable sanitation projects

Use of treated wastewater in agriculture Jordan Valley, Jordan

Fig. 1: Project location

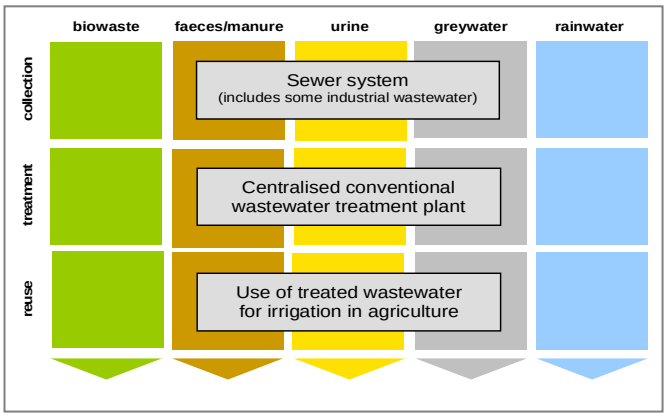

Fig. 2: Applied sanitation components in this project

1 General data

Type of Project:
Full-scale reuse of reclaimed water for irrigation in the Jordan Valley as part of a larger water resources management program

Project Period:
Start of implementation: 2006
Planned project end: open end (GTZ program will end in 2011 but the wastewater reuse will continue)

Project Scale:
About 4,000 farm units with 10,000 ha irrigable area; Overall program budget was EUR 9 million (for program phase 2006-2009), of which this project forms only a sub-component (budget for sub-component unknown)

Address of project location:
Farms in the middle and southern Jordan Valley extending over a length of about 50 km between Kreimeh and the Dead Sea.

Planning Institution:
Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH

Executing Institution:
Jordan Valley Authority

Supporting Agency:
BMZ (German Federal Ministry for Economic Collaboration and Development) via GTZ

2 Objective and motivation of the project

Sustainable use of treated wastewater (or “reclaimed water”) is one of the components in the Water Program carried out by GTZ-Jordan together with Jordanian partners. It builds on the good results of the previous stand-alone GTZ project “Use of reclaimed water”. The goal of this component is to use reclaimed water in the Jordan Valley as a substitute for freshwater for agricultural irrigation in accordance with environmental and public health regulations.

Irrigated agriculture in the Jordan Valley consumes about 42% of the available freshwater resources, which are also urgently needed as drinking water (see Table 1). Therefore, the safe use of marginal water resources, such as brackish and reclaimed water, for irrigation is highly desirable.

3 Location and conditions

The project area is situated in the middle and southern Jordan Valley extending over a length of about 50 km between Kreimeh and the Dead Sea.

Fig. 3: Irrigation and covering plant rows with thin plastic sheets in the Jordan Valley (source: A. Vallentin, GTZ, 2004)

The Jordan Valley is characterised by low annual rainfalls (an average of less than 300 mm at Deir Alla and 100 mm at South Shuneh). However, the mild winter season between November and April allows an off-season production of vegetables under irrigation.

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The majority of the farmers are small scale farmers, with an average farm area of about 3 hectares. Complementary activities of another GTZ project (Water Management in Irrigated Agriculture) support the establishment of water user associations in order to improve the water use efficiency. Both projects belong to the GTZ Water Program in Jordan.

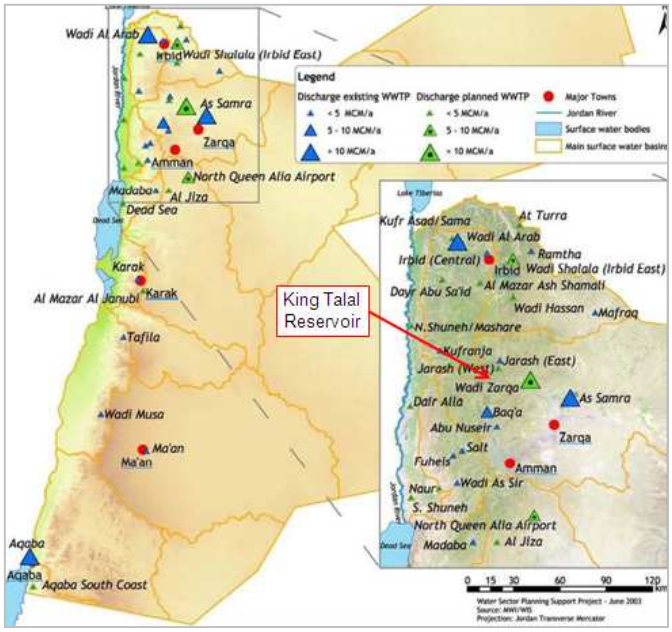
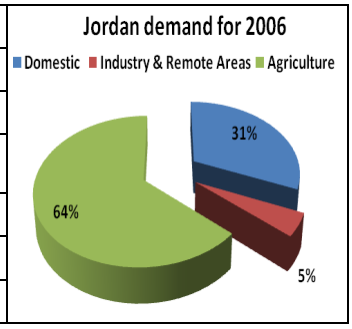


Fig. 4: Project area in Jordan; for orientation: to the left of the map is Israel, to the right is Saudi Arabia (source: GTZ-Jordan)

Table 1: Water supply and demand in Jordan (source: Ministry of Water and Irrigation, 2006)

	[M m^3]
Water supply	**925**
Domestic	290
Industry & Remote Areas	46
Agriculture	589
Water Demand	**1512**
Deficit	**-587**



4 Project history

The project was, and still is, part of three consecutive GTZ programmes (carried out on behalf of the German ministry BMZ):

1. from 2003-2006: Reclaimed Water Project
2. 2006-2009: Water Management in Irrigated Agriculture
3. 2009-2011: Water Resource Management

The first step of the project in 2004 was a baseline survey regarding the legal situation and the mandates of the organisations and stakeholders involved. Then, with national and international expertise, guidelines for irrigation water quality and crop quality, and for monitoring and information systems were proposed in 2005.

Interdisciplinary working groups adjusted these guidelines to the conditions in Jordan and proposed applicable concepts. At present the project team coordinates between the involved agencies to initiate the implementation of the proposals and concepts.

With regards to the agricultural guidelines, the field staff identified 20 representative farm units irrigating with reclaimed water in 2003. These farm units are regularly monitored and the data is analysed at the end of the respective cropping season. First results about appropriate agricultural practices were disseminated in 2004 during two seminars for agricultural extension workers and two field days for farmers in the Jordan Valley.

Project staff members have tested the agronomic guidelines through a series of demo sites with pilot farmers. To ensure the widespread application of these guidelines by farmers, simplified fertigation (irrigation and fertilisation) sheets were developed and disseminated to farmers in 2007 and 2008 through intensive training sessions with local extension agencies in the Jordan Valley.

Fig. 5: Workshop in Jordan Valley with local extension agencies and farmers (source: A. Vallentin, GTZ, 2006)

In 2009 these guidelines were transformed by the reclaimed wastewater project into an information system (a computer-based program that allows extension workers and educated farmers to optimise their fertigation in light of the irrigation water quality, location, crop, soil type and other factors). Governmental and private extension providers[1] were trained on the use of this software to be able to provide extension advice in accordance with this tool.

Regarding public health and market acceptance, the project team came up in 2005 with proposals and concepts for a state monitoring system and safety control guidelines for fresh fruit and vegetables with a focus on irrigation water quality in the Jordan Valley.

[1] In Jordan agricultural suppliers play a major role in advising farmers to promote their products. Therefore, they are considered as "private extension advisers" compared to the governmental officers. They are well accepted amongst farmers. However, farmers sometimes doubt their advice as they fear the advisers simply follow their own interests in selling their products.

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Fig. 6: Training of extension workers in use of information system (source: Abdel-Jabbar, GTZ, 2008)

5 Technologies applied

In Jordan there are 22 wastewater treatment plants (WWTPs) treating approx. 250 ML/d of wastewater. Most of the treatment plants are small, except for the plant as As-Samra, which treats more than 80% of this quantity. The As-Samra Treatment Plant was rehabilitated and upgraded in August 2008. The effluent quality has improved significantly and today it conforms to requirements of Jordanian standards for discharge into streams and rivers.

The old treatment plant at As-Samra consisted of stabilisation ponds, and the influent flowrate was always exceeding the plant's design capacity. The new plant is using the activated sludge process with nutrient removal and chlorine for disinfection. It receives only 50% of its design flowrate. It serves 2 million people in the two cities Amman and Zarqa (these are the two most populated cities of Jordan) and has a capacity to treat 276 ML/d.

During the rehabilitation of the wastewater treatment plant, an upgrade for nutrient removal was included. The concentrations of nutrients to the King Talal Reservoir, the country's largest reservoir that receives effluent flows of As-Samra WWTP (effluents of this WWTP: TN 30 mg/L; PO_4-P 5.5 mg/L; COD 36 mg/L) and other small treatment plants, is still significant. The treated effluent of As-Samra still contributes considerably to fertilisation even though the nitrogen and phosphorus content is reduced now (see Table 2). The wastewater effluent in the reservoir mixes with other sources like rain water and some springs.

Table 2: Average values (mg/L) for N, P and K in irrigation water of King Talal Reservoir (KTR) before and after As-Samra plant upgrade (source: Water Quality Monitoring Reports, 2000-2009)

Water source	Nitrate-N plus ammonia-N	Phosphate-P	Potassium (K)
KTR (before WWTP upgrade)	18.6	3.9	26
KTR (after WWTP upgrade)	11.5	2.1	26

Fig. 7: King Talal Reservoir, receiving treated effluent from As-Samra WWTP, and used as source of irrigation water (source: A. Vallentin, GTZ, 2006)

6 Design information

Since this project is part of a water resources management program for the sustainable reuse of reclaimed water, no physical infrastructure was constructed. Irrigation infrastructure was already provided at an earlier stage.

7 Type and level of reuse

Approximately 66% of Jordan's WWTP effluent of 250 ML/d is used for irrigation in the Jordan Valley. In the project region the main source of reclaimed water for irrigation is the treatment plant at Khirbet As-Samra, the country's largest treatment plant with a yearly effluent of currently 137 ML/d.

From King Talal Reservoir (KTR) the discharged effluent is led via further wadis (small streams) and canals to the middle and southern Jordan Valley. The reservoir is solely used for agriculture and has a capacity of 75 Mm^3.

The distance to the main canal in the Jordan valley is 14 km, and this main canal has an extension from north to south of 90 km. At the end of these canals, the reclaimed water is finally used to irrigate about 4,000 farms with an area of approx. 10,000 ha.

Treated effluent, which is reused for irrigation, is diluted with surface and precipitation water by the passage through the wadies etc. The water flows by gravity from the WWTP via KTR to the agricultural fields. Pumping is not required as KTR is located 600 m above sea level and the valley 200 m *below* sea level.

The preferred irrigation method is drip irrigation in combination with very thin plastic sheets (in Jordan called "mulch") which cover the plant rows as shown in Fig. 8. The typical crops are all kind of vegetables in open field and greenhouse cultivations.

In theory, untreated industrial wastewater is not allowed to be mixed in before treatment at Khirbet As-Samra WWTP, however it happens very often[2]. GTZ has helped in preparing a risk assessment study on the hazards associated with the use of treated wastewater in irrigation and its impact on soil and agriculture, especially if the sewage contains industrial

[2] In the last years, more and more industry developed (beverage, food production, tanning and textile, paper and aluminium production). Although untreated discharge to the sewer network is prohibited, it still happens. Government officials do not control very strictly to avoid an impact on the companies' profits and hence number of employees in the long run.

effluent. Currently, the Ministry of Environment supervises the enforcement of the environmental law that prohibits illegal dumping of industrial waste before it receives treatment.

Fig. 8: Demo plot showing agricultural engineers and farmers inspecting plant growth after irrigation (source: A. Vallentin, GTZ, 2006)

8 Further project components

Further project components include:

- Support of coordination between the involved organisations and stakeholders with regards to irrigation water quality, health and environment.
- Awareness raising among water users and agricultural producers regarding possible health and environmental risks.
- Dissemination of good agricultural practices to extension workers and farmers with regards to reclaimed water use.

9 Costs and economics

The hydraulic infrastructure in the Jordan Valley was constructed and is operated and maintained by the Jordan Valley Authority supported by international donors. There are no investments in physical infrastructure by this project.

The project described in this case study is an integral part of the GTZ Water Program in Jordan, and the budget for just the reuse activities (being one component of the program) is not known separately. The whole budget of the water program in the first phase (2006-2009) was EUR 9 million, and it is EUR 4.5 million for the second phase (2009-2011).

10 Operation and maintenance

The impact of irrigation with reclaimed water on soils and groundwater is monitored at selected sites in order to develop recommendations for long-term monitoring needs regarding possible adverse effects on the environment.

At present, crops produced on reclaimed water are frequently tested for biological contamination and heavy metals by the Jordan Food and Drug Administration (JFDA). Currently the project team is working with stakeholders on developing a risk monitoring and management system for the unrestricted use of reclaimed water in agriculture based on the WHO Guidelines of 2006 for the safe use of wastewater in agriculture[3].

In the long run it is foreseen to transfer operation and maintenance responsibilities for parts of the irrigation infrastructure to water user associations.

11 Practical experience and lessons learnt

The use of reclaimed water for irrigation is generally a sensitive topic in the public due to lack of information. No country-wide crop monitoring system for crops irrigated with reclaimed water has been established yet due to unclear roles (and overlapping of roles) between involved agencies with regards to who should be in charge of such a scheme for monitoring biological contamination of crops.

Providing guidelines in this field helps to clarify and improve the situation. The majority of farmers in the project area are not aware of the nutrient content of the reclaimed water and are beginning to appreciate information regarding reclaimed water quality.

Results of the crop monitoring program and a rapid assessment of consultants revealed that use of treated wastewater in Jordan meets the health-based target recommended by the WHO guidelines for the safe use of treated wastewater.

The results from the demo sites revealed that fertiliser expenditures can be reduced by 60%. Moreover, between 2006 and 2009 a lot of emphasis was placed on training the farmers. A survey showed that 90% of the farmers started to incorporate the recommendations of the advisers but in general it is a very slow process to change their attitudes.

Nevertheless, it has to be pointed out that the surrounding situation changed since the program started: More and more industry has been established in Jordan, and in most cases the factories do not have onsite treatment of their wastewater but lead it untreated into the sewer. The municipal wastewater treatment plants are not equipped to treat this industrial effluent adequately. This now poses a threat for the treated wastewater reuse scheme in agriculture.

[3] These guidelines are available here: http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index.html

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12 Sustainability assessment and long-term impacts

A basic assessment (Table 3) was carried out to indicate in which of the five sustainability criteria for sanitation (according to the SuSanA Vision Document 1) this project has its strengths and which aspects were not emphasised (weaknesses).

Table 3: Qualitative sustainability assessment of the system. The crosses indicate the relative sustainability for each project component (column) and sustainability criterion (row). (+): strong point of project, (o): average strength for this aspect, (-): no emphasis on this aspect in the project.

	collection and transport[1]			treatment[1]			transport and reuse		
Sustainability criteria:	+	o	-	+	o	-	+	o	-
• health and hygiene								X	
• environmental and natural resources								X	
• technology and operation							X		
• finance and economics								X	
• socio-cultural and institutional							X		

[1] Not part of this project

Sustainability criteria for sanitation:

Health and hygiene include the risk of exposure to pathogens and hazardous substances and improvement of livelihood achieved by the application of a certain sanitation system.

Environment and natural resources involve the resources needed in the project as well as the degree of recycling and reuse practiced and the effects of these.

Technology and operation relate to the functionality and ease of constructing, operating and monitoring the entire system as well as its robustness and adaptability to existing systems.

Financial and economic issues include the capacity of households and communities to cover the costs for sanitation as well as the benefit, e.g. from fertiliser and the external impact on the economy.

Socio-cultural and institutional aspects refer to the socio-cultural acceptance and appropriateness of the system, perceptions, gender issues and compliance with legal and institutional frameworks.

For details on these criteria, please see the SuSanA Vision document "Towards more sustainable solutions" (www.susana.org).

With regards to long-term impacts of the project, the main impacts are:

1. The reduction of artificial mineral fertiliser use in the middle and southern part of the Jordan Valley, lowering the soil salinisation pace.
2. It is estimated that farmers would save up to 60% of their fertilisation cost, which is equivalent to EUR 564 per ha and can be translated into income improvements of 30%.
3. At national level more than 80% of fertilisers used in Jordan are imported; therefore any saving in fertilisers means reduction in foreign currency transmittance to the exporting countries. As such making use of nutrients in treated wastewater saves Jordan about EUR 3.8 Mio/year.
4. With the farmers' appreciation of the added value of reclaimed water and the acceptance of its reuse, water conflicts on fresh water sources are dwindling. This reduces the pressure on barely sufficient drinking water resources.
5. Aside from the fact that reuse of treated wastewater in agriculture is a productive approach, it has several positive impacts on the environment. Reduced salinity, energy consumption and CO_2-emissions are among the indirect benefits.
6. Nutrients in treated wastewater are leading to 5839 t/year reduction in the consumption of fertilisers. This amount is equivalent to saving 86 GWh/a (about 1% of the current Jordanian electricity consumption).
7. Another important aspect of reduction in fertiliser use is the reduction of greenhouse gases generated during fertiliser production. CO_2 emission for producing 1 kg of fertiliser was estimated to be 1.7 kg CO_2. Based on this value, reduction in fertiliser use in Jordan Valley would lead to a reduction of 11,000 tons of CO_2 emissions.

13 Available documents and references

The following documents are available (either on the internet or on request) :

- Use of Reclaimed Water in the Jordan Valley (2002). Available: http://www2.gtz.de/Dokumente/oe44/ecosan/en-use-of-reclaimed-water-in-the-Jordan-Valley-2002.pdf
- Baseline Report (2003). Available on request.
- Proposal for a State Monitoring System for Fresh Fruit and Vegetables (2004) and Proposal for Safety Control Guidelines for Fresh Fruit and Vegetables (2004). Both available within this document: http://www2.gtz.de/Dokumente/oe44/ecosan/en-concepts-on-fresh-fruit-and-vegetables-2004.pdf
- Proposed Steps to a Crop Quality Assurance System with focus on irrigation water quality in the Jordan Valley (E. W. Kingcott, 2004). Available: http://www2.gtz.de/Dokumente/oe44/ecosan/en-proposed-steps-to-a-crop-quality-assurance-system-2004.pdf
- Groundwater Monitoring Concept (B. Hanauer, 2004). Available: http://www2.gtz.de/Dokumente/oe44/ecosan/en-ground-water-monitoring-concept-2004.pdf
- Concept for Soil Monitoring (2004). Available on request.
- Practical Recommendations for Nutrient Management und Irrigation with Reclaimed Water (D. Meerbach, 2004). Available: http://www2.gtz.de/Dokumente/oe44/ecosan/en-practical-recommendations-for-nutrient-management-2004.pdf
- Agricultural Use of Reclaimed Water - Experiences in Jordan (A. Vallentin, 2006). Available: http://www2.gtz.de/Dokumente/oe44/ecosan/en-agricultural-use-of-reclaimed-water-2006.pdf
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- Reuse of treated wastewater in the Jordan Valley. An added value outweigh risks (S. Abdel-Jabbar, 2009). Available: http://www2.gtz.de/Dokumente/oe44/ecosan/en-reuse-of-treated-wastewater-in-the-jordan-valley-2009.pdf

- Assessment of use of reclaimed water in unrestricted agriculture in Jordan Valley in the light of the new WHO Guidelines (S. Abdel-Jabbar, 2009). Available: http://www2.gtz.de/Dokumente/oe44/ecosan/en-assessment-of-use-of-reclaimed-water-in-unrestricted-agriculture-2009.pdf

14 Institutions, organisations and contact persons

The main institutions and organisations involved in this project are:

- Jordan Valley Authority (JVA): http://www.jva.jo (website temporarily unavailable)
- Jordan Food and Drug Administration (JFDA): http://www.jfda.jo

Contact person:

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SuSanA 2009

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