Agricultural Use of Reclaimed Water - Experiences in Jordan

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Abstract

Due to extreme water scarcity Jordan is integrating reclaimed water resources in the national water management system. This paper describes the recent framework conditions for reclaimed water use in agriculture in Jordan, with a focus on the central and southern Jordan Valley. The possible impacts of lower quality irrigation water on soil, groundwater, crops and human health are considered while appropriate guidelines and monitoring proposals are being developed. Testing of the guidelines and implementation of the monitoring systems have started with the final purpose of integrating them into the Jordanian standard and legal system and thus ensuring safe food for consumers and protection of the environment.

Keywords

Agricultural reuse, crop quality, environmental impacts, irrigation water quality, reclaimed water.

Introduction

Due to Jordan's limited water resources, in 1997 the Government of Jordan decided, as part of Jordan's Water Strategy, that "wastewater should not be managed as 'waste'. It should be collected and treated to standards that allow its reuse in unrestricted agriculture and other non-domestic purposes, including groundwater recharge."

In the case of the Jordan Valley diluted reclaimed water has been used for irrigation for more than 20 years. However, there have not been any binding guidelines or standards governing the agricultural reuse and there has been increasing concern with regard to possible health hazards and environmental risks.

Initial Situation and Problems

Jordan has 23 wastewater treatment plants distributed throughout the country. The total discharge of all treatment plants in 2005 was 79 million cubic meters (mcm). Since 2002 Jordan has had the standard JS 893/2002 for the effluent (also called reclaimed water) from wastewater treatment plants that is released into streams, valleys (wadis) or water bodies and used for artificial recharge of groundwater aquifers that are not used for drinking purposes or used for restricted agriculture. Within the treatment plants and in their vicinity about 1.400 ha are used for restricted agriculture, mainly fodder crops, cereals and trees. In the central and southern Jordan Valley diluted reclaimed water is used for unrestricted irrigation on about 11.000 ha. The reclaimed water used for agricultural irrigation in the central and southern Jordan Valley originates from Jordan's largest treatment plant at As Samra, which is located about 80 km east of the Jordan Valley. The plant at As Samra treats the domestic wastewater of the capital Amman and of Jordan's second largest city Zarqa. On its course to the Jordan Valley the reclaimed water is mixed with surface run-off from side wadis and surrounding catchment areas before it is temporarily stored in the country's largest reservoir, the King Talal Reservoir (KTR), which has a storage capacity of 75 mcm. About 20 km downstream from the KTR outlet, Zarqa Carrier I and II divert part of the KTR water directly to fields in the Jordan Valley. The rest of the reclaimed water is diverted into the Abu Zighan Canal and finally released into the King Abdullah Canal (KAC) at the so called 'mixing point'. The KAC brings fresh water from the Yarmouk river in the north to the Jordan Valley. It is important to mention that about 2 km upstream from the confluence of the water of KAC and KTR there is an intake structure in the KAC from where water is pumped to Amman. After purification in a treatment plant it is used for domestic and drinking purposes. In 2005 about 54 mcm was pumped to Amman (WAJ, 2005). This illustrates how Jordan is attempting to substitute reclaimed water and use it in other sectors for fresh water resources originally used for agricultural irrigation.

In 2005 the total volume of reclaimed water released into the Jordan Valley was about 88 mcm. The area irrigated by reclaimed water from KTR and KAC-south in the middle and southern Jordan Valley is about 11.000 ha. There are also plans for the wastewater of the third largest city, Irbid, to be used for agricultural irrigation in the northern Jordan Valley (Kreditanstalt für Wiederaufbau, Ministry of Water and Irrigation and Water Authority of Jordan, 2005).

The wastewater treatment plant at As Samra has been operational since 1985. The design capacity is 68.000 m^3/d, while the inflow in 2005 was 140.763 m^3/d. This means a 207 % degree of use that has led to a deterioration in effluent quality (Water Authority of Jordan, 2005).

The growing public discussions and concerns regarding health and environmental aspects of reclaimed water use in the Jordan Valley led to the launching of the Reclaimed Water Project (RWP), which has been implemented jointly by the Jordan Valley Authority (JVA) and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) with the support of the Jordanian and German Governments. When the project commenced in 2003 the legal and institutional framework for the agricultural use of reclaimed water, especially of diluted reclaimed water as applied for unrestricted agricultural irrigation in the central and southern Jordan Valley, was not clear. There were no guidelines for blended reclaimed water or the quality of irrigation water in general. With regard to crop production there were no safety guidelines for the occupational health of the irrigators and there was no monitoring of the safety of fresh fruit and vegetables. Furthermore there was no regular monitoring of the impact of the use of reclaimed water for irrigation on soils and groundwater.

The Approach

In order to improve the situation an appraisal of the existing laws and regulations and the responsibilities of the relevant authorities was conducted. Following this, a number of activities were initiated by the Reclaimed Water Project.

With regard to irrigation water quality, it was found that the Jordanian Standard JS 893/2002 does not cover the water quality of the water in streams or wadis after the reclaimed water is discharged into them and blended with other water sources. Therefore, the project initiated a national interdisciplinary working group that elaborated irrigation water quality guidelines (see Table 1) based on the guidelines of the Food and Agricultural Organisation of the United Nations (1985) and the World Health Organisation (1989).

Table 1: Proposed irrigation water quality guidelines for Jordan (Reclaimed Water Project, 2005b)

Parameter	Unit	Limit value/ranges
pH		6 - 9
EC	dS/m	sensitive plants: <1.7 medium tolerant plants: 1.8 - 3.0 tolerant plants: 3.0 - 8.0
Temperature	° C	4° C - 30° C
BOD_5	mg/l	60
COD	mg/l	120
Ca	mg/l	< 400
Mg	mg/l	< 150
SAR		6 - 9
K	mg/l	< 80
HCO_3	mg/l	< 520
NO_3-N	mg/l	30
SO_4	mg/l	960
B	mg/l	very sensitive plants: 0.5 - 0.75 sensitive plants: 0.75 - 1.0 moderate sensitive plants: 1.0 - 2.0 moderate tolerant plants: 2.0 - 4.0 tolerant plants: 4.0 - 6.0 very tolerant plants: 6 - 15
Fe	mg/l	5
Mn	mg/l	5
Zn	mg/l	5
Cu	mg/l	5

E. coli	MPN/100 ml	1.000
Intestinal helminth eggs	eggs/l	1

These guidelines take into account the specific conditions in Jordan, i.e. the reality in the field and the institutional situation. They are less strict for BOD_5, COD, NO_3-N and for E. coli. The boron ranges in the guidelines follow Maas (1990). The fact that some of the proposed limit values are more relaxed than the JS 893/2002 does not mean that the health of farm workers and consumers is put at risk as the complementary agronomic guidelines, also elaborated by the RWP, recommend irrigation methods and practices that prevent direct contamination with pathogens (e.g. drip irrigation in combination with plastic mulch) and because crop monitoring with regard to possible contamination is also recommended. The proposed irrigation water quality guidelines were distributed to the relevant authorities and institutions in April 2005 and tested during one year. The feedback was evaluated and, based on the results, a decision will be taken as to whether they need adjustment. The project strongly recommends that the guidelines should be transformed into a national standard. The other important aspect of the water quality monitoring is the dissemination of the quality data to the farmers on a monthly basis in order to enable them to adjust their farming practices.

Guidelines covering the production of safe fresh fruit and vegetables, including irrigation and fertilizing practices and occupational health recommendations, are currently being elaborated. The agronomic guidelines are based on an intensive farm monitoring program, which was conducted by the project staff on 70 fields of 30 different farms in the central and southern Jordan Valley and covered the main crops grown during the cropping seasons 2003/2004 and 2004/2005. The data were analysed and findings included that farmers tend to over-irrigate and over-fertilize, especially under green house cultivation (Reclaimed Water Project, 2004d). One of the reasons for high fertilizer input is the lack of knowledge and information about the nutrient content of the reclaimed water, as was found out in a baseline survey in 2003. Accordingly the agronomic guidelines recommend basing the nutrient application rates on the actual requirements of the crops, on the nutrient contents of the soils and the irrigation water and on the amount of manure applied. During the cropping season 2004/2005 demonstration plots that compared the recommendations of the project with conventional farmers' practices showed that farmers can save on average 66 % or about 500 Jordanian Dinar (700 US$) per hectare for cucumbers in green houses when applying the RWP recommendations. Other essential topics of the guidelines cover irrigation methods, health aspects and post-harvest practices. In order to train farmers, the project has regularly conducted field days to familiarize them with findings and results and workshops and seminars for agricultural extension workers. The project staff also participated in 30 agricultural radio transmissions informing about good practices when irrigating with reclaimed water.

In the area of public health, a state monitoring system for the quality of fresh fruit and vegetables under reclaimed water irrigation has been established. As a first step a national multidisciplinary working group with members from Jordan Valley Authority, Ministry of Health, Ministry of Agriculture, Jordan Food and Drug Administration, and the National Centre for Agricultural Research and Technology Transfer was initiated in 2003 and elaborated a proposal for the monitoring program, including crop safety guidelines for Salmonella, E. coli, nitrate, lead and cadmium (Reclaimed Water Project, 2004c). Inputs for the working group were supplied by external consultants based on European guidelines (Reclaimed Water Project, 2004b). In August 2005 a memorandum of understanding was signed by the Jordan Valley Authority, Ministry of Health, Ministry of Agriculture, Jordan Food and Drug Administration, and the National Centre for Agricultural Research and Technology Transfer. The memorandum defines the responsibilities and the frame of commitments. Implementation started in December 2005. Due to budget restrictions the sampling is random and limited with five samples of crops eaten uncooked (like tomato, sweet pepper, cucumber, carrot, lettuce) collected weekly by the staff of the Ministry of Agriculture from farms in the Jordan Valley irrigated with reclaimed water and shipped to Amman. Another 5 samples are taken from local markets in the Jordan Valley and wholesale markets in Greater Amman. The samples are analysed for Salmonella and E. coli by the Amman Food Laboratory and for nitrate, lead and cadmium by the laboratory of the National Centre for Agricultural Research and Technology Transfer. The monitoring covers the harvesting period in the Jordan Valley from December to April and the process is steered by a technical committee with members from the involved institutions. The Jordan Food and Drug Administration is responsible for compiling, evaluating and disseminating the results.

Furthermore the project is conducting an awareness campaign regarding irrigation practices, occupational health and hygiene habits as well as sanitation on the farms. These issues are included in

field days and radio transmissions as well as in information material which is distributed to relevant stakeholders.

With regard to environmental impacts, the first activity was designing concepts for a groundwater monitoring program (Reclaimed Water Project, 2004a) and a soil monitoring program (Reclaimed Water Project, 2004e) while two sampling campaigns were conducted in September 2004 and April 2005. The main findings were that phosphorous and potassium levels are generally high and nitrogen levels are high during the cropping season in both soil and shallow groundwater (Reclaimed Water Project, 2005a). These effects are mainly related to high fertilizer application rates, which is also confirmed by the observations of the farm monitoring program. So far no accumulation of heavy metals has been detected (Reclaimed Water Project, 2005a). Based on the two concepts and the results of the sampling campaigns a combined long-term soil and groundwater monitoring concept was elaborated, introduced and discussed with staff members from Jordan Valley Authority, Water Authority of Jordan, Ministry of Water and Irrigation, National Centre for Agricultural Research and Technology Transfer, Ministry of Environment, and University of Jordan in October 2005 (Reclaimed Water Project, 2005c). The concept was accepted and implementation started in April 2006.

Conclusions and Outlook

Reclaimed water is badly needed for agricultural irrigation in Jordan and has been used in the Jordan Valley for unrestricted agriculture since 1987. Due to the increasing overload of Jordan largest wastewater treatment plant at As Samra, public concern with regard to the quality of the agricultural produce irrigated with reclaimed water and impacts on human health has been growing and was also fuelled by the ban of vegetable imports from Jordan by Saudi Arabia and other Gulf States. In order to improve the situation an integrated approach has been implemented that suits the local conditions, is realistic and affordable and has the chance to be enforced. It comprises guidelines for irrigation water quality, good agricultural practices and crop safety as well as monitoring concepts with the purpose of controlling the safe use of reclaimed water.

Summarizing the experiences, the main conclusions are that it is vital to create the necessary awareness among the involved agencies, such as the Ministry of Water and Irrigation, Ministry of Agriculture, Ministry of Health, Ministry of Environment and other stakeholders. It has proven efficient and successful to initiate national interdisciplinary working groups with specialists of the involved authorities for the elaboration of guidelines and monitoring programs. Furthermore it is not sufficient to intervene in only one field of activities, such as guidelines for irrigation water quality. Other relevant issues including agricultural use of reclaimed water, crop quality monitoring and awareness campaigns have to be included and to complement each other.

Meanwhile, the prerequisites for a sound legal framework in Jordan for safe and environmentally harmless agricultural use of reclaimed water are in place. The implementation of monitoring activities has started and contributes to more transparency regarding health and the environmental impacts of irrigation with reclaimed water. What still needs to be done is to transform the guidelines effectively into standards and to ensure the subsequent implementation of the proposed monitoring programs and the enforcement of the recommended threshold values.

References

Food and Agricultural Organisation of the United Nations (1985): Water Quality for Agriculture. Irrigation and Drainage Paper 29, Review 1, Rome, Italy.

Kreditanstalt für Wiederaufbau, Ministry of Water and Irrigation and Water Authority of Jordan (2005): Feasibility Study for the Reuse of Treated Wastewater in Irrigated Agriculture in the Northern Jordan Valley. Final Feasibility Report, Amman, Jordan.

Maas (1990): Boron Tolerance Limits for Agricultural Crops. U.S. Salinity Laboratory Agricultural Research Service. http://www.ussl.ars.usda.gov/pls/caliche/BOROT46

Ministry of Water and Irrigation (1997): Jordan's Water Strategy. Amman, Jordan.

Reclaimed Water Project (2004a): Groundwater Monitoring Concept. Prepared by B. Hanauer. Amman, Jordan.

Reclaimed Water Project (2004b): Review of European Standards on Selected Fruit and Vegetables. Prepared by M. Will. Amman, Jordan.

Reclaimed Water Project (2004c): Proposal for a State Monitoring System for Fresh Fruit and Vegetables. Prepared by Interdisciplinary Working Group. Amman, Jordan.

Reclaimed Water Project (2004d): Evaluation of Irrigation and Fertilizer Practices for Main Crops on Monitored Farm Units under Irrigation with Reclaimed Water in the Jordan Valley. Prepared by D. Meerbach. Amman, Jordan.

Reclaimed Water Project (2004e): Soil Monitoring Concept. Prepared by H. Meyer-Steinbrenner. Amman, Jordan.

Reclaimed Water Project (2004f): Safety Control Guidelines for Fresh Fruit and Vegetables. Prepared by Interdisciplinary Working Group. Amman, Jordan.

Reclaimed Water Project (2005a): Effects of Reclaimed Water on Groundwater and Soils in the Middle and Southern Jordan Valley. Prepared by M. Al Kuisi. Amman, Jordan.

Reclaimed Water Project (2005b): Irrigation Water Quality Guidelines. Prepared by Interdisciplinary Working Group. Amman, Jordan.

Reclaimed Water Project (2005c): Long-term Groundwater and Soil Monitoring Concept. Prepared by B. Hanauer. Amman, Jordan.

Water Authority of Jordan (2005): Internal working report. Amman, Jordan

World Health Organisation (1989): Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture. Technical Report Series 778. Geneva, Switzerland.