Wastewater Treatment and Reuse for Food and Water Security

This situation is compounded by the high urbanisation rate in MENA. It varies from 18 per cent in Egypt to 4 per cent in Palestine and 5.3 per cent in Yemen (with an overall rate for MENA of 3.2 per cent, which is higher than the rate for developing countries as a whole). With 79 per cent of the population already living in cities in Jordan, and 88 per cent in Lebanon, the average for the region as a whole is already 53 per cent (United Nations Secretariat, 2002 and Population Reference Bureau, 2002). Within the region, about 80 per cent of fresh water is used for agriculture. Even with low urban tariffs, the value of water is at least 10 times higher in urban areas than it is in agricultural areas (Gibbons, 1986). As a result, water will increasingly be taken out of agriculture and put into urban areas. This means that the region will increasingly suffer from twin and related problems of food and water insecurity.

Many countries wish to increase fresh water supplies to domestic and industrial usage, and at the same time expand irrigated agriculture. For example, Tunisia wishes to increase the area of irrigated agriculture by at least 30,000 hectares (ha), and Egypt, by 880,000 ha (World Bank, 2000). How can these seemingly contradictory objectives be reconciled? The answer is water-demand management; more efficient water use within all sectors. One specific component is to use treated domestic wastewater for industry, for some municipal purposes such as flushing toilets and irrigating green spaces, but, above all, for urban and periurban agriculture (UPA).

BENEFITS
There are several benefits in using treated wastewater. First, it preserves high quality and expensive fresh water for potable use. The cost of secondary-level treatment for domestic wastewater in MENA, an average of US $0.5/m³, is cheaper than developing new drinking water supplies in the region (World Bank, 2000). Second, collecting and treating wastewater protects existing sources of valuable fresh water, the environment, and public health. In fact, wastewater treatment and reuse (WWTR) not only protects valuable freshwater resources, but also can supplement them through aquifer recharge. If the benefits of environmental and public health protection were correctly factored into economic analyses, wastewater collection, treatment and reuse would be among the highest priorities for scarce public and development funds. Third, if managed properly, treated wastewater can sometimes be a superior source for agriculture than fresh water sources. It is a constant water source, and nitrogen and phosphorous in the wastewater may result in higher agricultural yields than freshwater irrigation, negating the need for additional fertiliser application. Research projects in Tunisia and Saudi Arabia have demonstrated that treated effluent had superior...
non-microbiological chemical characteristics than that in groundwater for irrigation. Most importantly, treated wastewater had lower salinity levels (WB, 2000).

CASE STUDIES
The countries in the region that practise wastewater treatment include Kuwait, Saudi Arabia, Oman, Syria, UAE and Egypt. However, only Israel, Tunisia and Jordan practise wastewater treatment and reuse as an integral component of their water management and environmental protection strategies.

PROBLEMS
The main problem with the use of wastewater is the threat to public health, the soil and water if reuse is not done carefully. While the main impact on health from reuse in developing countries is from diseases caused by helminths, such as roundworm, hookworm and guinea worm, microbial pathogens pose the second largest threat. The worst-case situation occurs when untreated wastewater is used to irrigate vegetables or salad crops that are then eaten raw. This practice resulted in the cholera outbreak in Amman, Jordan in 1981. Unfortunately, there are many on-going instances of raw wastewater reuse which, without doubt, result in occasional gastro-intestinal illness, but have the potential for causing widespread illnesses. For example, due to water scarcity, the irrigation of market vegetables such as eggplant and cucumber with raw wastewater flowing in the Kedron Valley, West Bank is common. Components in wastewater that are most toxic to some crops include sodium, chloride and boron.

Raw wastewater can also salinise soils, and the grease in this water can reduce soil permeability and aeration by clogging pores. Both microbial pathogens and nitrates from wastewater can contaminate shallow aquifers.

These obstacles are real, but not insurmountable. In 1989, the World Health Organisation published the Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture (WHO, 1989), to protect public health. These guidelines identify necessary treatment levels depending on whether the irrigation will be restricted (e.g. cereal, industrial, fodder crops or pastures and trees), or unrestricted (e.g. irrigation of crops likely to be eaten uncooked, sports fields and public parks). Even the most stringent treatment levels in the WHO guidelines can be met by a series of wastewater-stabilisation ponds. In addition to identifying a combination of treatment and crop restrictions, the WHO guidelines also outline safe waste application methods and control of human exposure, to protect public health.

Grey Water Reuse in Urban Agriculture in Jordan
With its low and rapidly decreasing per capita water availability of 148 m3/p/y, less fresh water will be available for agriculture in Jordan. One means of addressing this threat to food security is to treat and reuse domestic wastewater in UPA. An IDRC-supported project found that 16 per cent of the households in Amman already practice UPA, mainly for the production of fruits, vegetables and herbs. The annual value of UA in Amman is US $4 million — already 2.5 per cent of the total value of agriculture in Jordan (Government of Jordan, 2002). The problem is that only 40 per cent of wastewater in Jordan is collected and treated. The necessary rehabilitation and expansion of conventional sewerage and wastewater-treatment systems will take time and millions of dollars.

IDRC’s research partners have come up with a new approach to combat food insecurity — helping the poor to harvest water at the household level. The systems consist of minor plumbing modifications that divert water from showers and bathroom and kitchen sinks through small-scale, natural filters in each household allowing residents to recycle water for reuse in home gardens. Grey water reuse is much safer than combined wastewater reuse because greywater contains no pathogens from the toilet. Also, because most “wastewater” is simply “grey water,” diverting it from the public sewerage system can dramatically reduce the costs required for installing and expanding such systems. In this pilot project, grey water-treatment systems were installed in 25 homes in Ain Al Baida, Jordan, and households members were taught how to set up efficient gardens. Systems were also installed at the main mosque in the community, and at a girl’s school.

The project has exceeded expectations. The grey water effluent meets standards for restricted irrigation, and households are using it to irrigate eggplants, herbs and olives. Impact on poverty and water use is still being measured. However, an IDRC study on a previous untreated grey water-reuse project found that the community was able to offset food purchases and generate income by selling surplus production, and by saving or earning an average of 10 per cent of its income. Initial water savings were about 15 per cent. The economic impact of this project is likely to be much higher because the grey water recovered in the first project was only about 30 per cent of domestic water, whereas in the current project it has already reached about 60 per cent. Furthermore, previously overflowing septic tanks, that cost at least US $60/yr to pump out have not been pumped since the project began. Economic benefits certainly have been significant enough to impress the neighbours of the original beneficiaries, they are now installing the systems at their own cost, proving that households recognise that wastewater treatment can save them or make them money. The Inter-Islamic Network on Water Resources Development and Management (INWRDAM), has improved the original design developed in Palestine with innovations making the systems safer and more efficient. The media in the filters is either gravel or pieces of old irrigation piping. A simple bag filter eliminates clogging associated with previous systems. INWRDAM also developed an environmentally friendly dishwashing liquid that prevents soil salinisation arising from grey water reuse, and has begun training workshops on grey water reuse for low-income settlements in Syria and other network countries. The Jordanian Deputy Minister of Social Welfare has visited the Jordan project and is interested in the potential for the systems to alleviate poverty. Also, the Water Authority of Jordan (WAJ), a part of the Ministry of Water, is testing the effluent quality of the systems, at its own cost.
For instance, sprinkler irrigation is discouraged. Also, where fruit trees are irrigated with treated wastewater, irrigation should cease two weeks before fruit is picked, and no fruit should be picked up off the ground. Crops and soil can be protected by readily available information on what types of crops and soil are sensitive to wastewater irrigation. Groundwater and surface water can be protected by mapping sensitive areas, such as shallow aquifers used for drinking, and banning wastewater irrigation in those areas.

Given the emphasis that Islam, like other religions, places on cleanliness, there is also a persistent notion within the region that wastewater reuse is against Islam. However, as noted in Water Management in Islam, published jointly by IDRC–UNU Press (2001), wastewater reuse is permissible for all purposes, including wudu, provided that the wastewater is treated to the required level of purity for its intended use and does not result in any adverse public health effect. Wastewater reuse is being practised with the accordance of religious authorities in Oman, UAE and Saudi Arabia. The kingdom is currently reusing about 20 per cent of its treated wastewater in refineries and for irrigating forage and landscape crops (Faruqui, et al., 2001).

Another obstacle is that except for some of the richer gulf countries in MENA, mechanical treatment of wastewater has not proven sustainable in periurban areas or in smaller towns or cities, because chemical and energy costs are high and operation and maintenance is frequently not carried out. Within its Cities Feeding People programme, the IDRC is currently developing a network of decentralised, low-cost natural waste-treatment systems for reuse nearby. Pilot projects include trickling filters for grey water reuse in the low-density hilly settlements surrounding Jerusalem, aquatic wetlands using water lettuce or duckweed in the Jordan Valley, and low-mechanical content activated sludge in Egypt. See boxes.

**CREATION OF AN ENABLING ENVIRONMENT**

Based on the experiences of countries such as Israel, Tunisia and Jordan, which have successful treatment projects

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**Duckweed Wastewater Treatment and Reuse for Fodder, West Bank**

This project aims to protect the environment and improve food security by pilot-testing the use of duckweed, a floating plant, to treat wastewater in small, decentralised communities in the Jordan Valley, West Bank. In the past five years, there has been a growing recognition of the effectiveness of this tiny aquatic plant to treat wastewater at a much lower cost than mechanical treatment plants. Because duckweed is 40 per cent protein by weight and grows so quickly, it can serve as an excellent feed supplement for poultry, livestock and fish, and can even be served in salads. An integrated system can both treat wastewater and provide income and employment opportunities for local residents who sell the produce raised on duckweed. In addition to reducing biological oxygen demand (BOD) and Total Suspended Solids (TSS) levels, duckweed efficiently reduces nitrogen and phosphorous levels in wastewater. But the operation of duckweed systems is still an art rather than a science, and while plants flourish in some locations, it is difficult to grow them in others.

This project will optimise various operating parameters for an integrated duckweed wastewater-treatment system at the Agricultural Development Society (ADS) training farm outside of Jericho, in the West Bank, a few hundred metres from the Jordan River and the Dead Sea.

Despite the political obstacles that have slowed down the Palestinian research team — their office was blown up, they have been shot at, they have endured long delays at checkpoints, and sometimes cannot reach the project site — it has still made some valuable preliminary findings:

Duckweed thrives between 25-30 degrees Celsius — previous systems in Amman and Hebron did not function because of the cold in winter at these high altitude locations. On the other hand, in the summer, when temperatures exceed 40 degrees Celsius in the Jordan Valley, the duckweed will have to be shaded with trellises. The duckweed is growing well — even in water with salinity as high as 3,000 ppm, and is being harvested twice a week. The effluent from the duckweed pond meets the standard for restricted irrigation. The dried feed has already been tested on chickens as a feed supplement with very good results — the average weight of the chickens fed by duckfeed was 17 per cent higher than for chickens that were not fed fodder. Furthermore, the chickens have whiter meat that increases their marketability for farmers. These factors, plus the savings in fodder cost of about 15 per cent, have led to an enthusiastic response by farmers in the area.

This case indicates that when decentralised wastewater treatment leads to opportunities for periurban farmers to generate income, they are willing to contribute to its costs. The Palestinian Researchers have visited duckweed ponds in Bangladesh, which has resulted in an important south-south transfer of knowledge. The Palestinian Ministry of Agriculture, the National Agriculture Centre, and the Palestinian Agricultural Relief Committee all have visited the project and are following the results closely.
relative to other countries in the region, governments in MENA need to do the following to create an enabling environment to encourage safe wastewater treatment. First, treatment must form part of an integrated water-management strategy at the basin level, with multi-disciplinary linkages between different sectors such as environment, health, industry, agriculture and municipal affairs. For instance, the main producer of wastewater — municipalities — must interact with the main user, urban agriculture. Urban/rural planning must be integrated so that industries are not situated in locations where their effluent, often high in dangerous constituents such as heavy metals, will contaminate water meant for the biggest user, agriculture.

Second, it is the duty of governments to facilitate the participation of stakeholders in wastewater-treatment projects, including supporting NGOs working in institution building at the local level. Safe and sustainable decentralised projects will never be established without the willing participation of the beneficiaries.

Third, there is a need to disseminate existing knowledge about the danger of raw wastewater reuse, safe reuse guidelines and the position of Islam on wastewater reuse. Knowledge of cost-effective treatment technologies and crop and soil protection must also be disseminated and site-specific research carried out to fill missing gaps. Perhaps most importantly, the economic benefits of successful decentralised wastewater-treatment projects must be disseminated to periurban households and farmers, who will only then be willing to contribute to the costs of WWTR.

Finally, to ensure the protection of public health and the environment, governments must regulate and monitor quality of effluent, reuse practices, public health, crop-water quality, and soil and groundwater quality.

CONCLUSIONS
Domestic wastewater treatment is one tool to address the food and water insecurity facing many countries in MENA. In the coming years, in most MENA countries valuable fresh water will have to be preserved solely for drinking, for high value industrial purposes, and for high value fresh vegetables and salad crops consumed raw. Where feasible, most other crops in arid countries will have to be grown increasingly, and eventually solely, with treated wastewater.

And this wastewater will be reused in urban and periurban city gardens and farms, close to where it is generated. Reuse of wastewater in UPA allows city dwellers, particularly the poor, to produce crops valued in MENA such as onions, eggplants and olives, to generate income and feed themselves. Urban agriculture is growing in MENA — for instance, 16 per cent of the households in Amman already have urban gardens, and annual value of UA in the city is estimated at US $4million, which is already 2.5 per cent of the value of agriculture in Jordan as a whole. IDRC-supported projects in MENA are demonstrating that it is possible to develop decentralised wastewater-treatment systems that meet the standards for restricted irrigation for reuse in urban agriculture. For instance, a grey water reuse project in Jordan allowed a community to offset food purchases and make money by selling surplus production, saving or earning an average of 10 per cent of its income. A project in Palestine has helped periurban farmers save 15 per cent on fodder costs and raise healthier, higher-value chickens, by supplementing their feed with duckweed from a community wastewater treatment plant. Furthermore, in both projects, it is clear that periurban households or farmers are willing to contribute up to the full costs of wastewater treatment if it can be demonstrated that they will generate income or save money as a result.

The economic, social and environmental benefits of WWTR in UA are clear. To help the gradual and coherent introduction of such a policy, which protects the environment and public health, governments shall have to adapt an integrated water-management approach, facilitate public participation, disseminate existing knowledge, generate new knowledge, and monitor and enforce standards.

In the coming years, fresh water will have to be preserved solely for drinking

An average household saves or generates 10 per cent of its income

REFERENCES

(1) In this paper, the MENA region includes the following countries where IDRC supports projects: Algeria, Egypt, Jordan, Lebanon, Morocco, Palestine, Sudan, Syria, Tunisia and Yemen.