Review

Wastewater reuse for agriculture: regional health perspective
S.S. Al Salem* and H. Abouzaid*


ABSTRACT The Eastern Mediterranean Region of the WHO is the poorest region in the world in water resources as a Region and per capita. This paper summarizes existing practices and constraints regarding wastewater treatment and reuse in the Region and describes the health impact of inappropriate practices. Appropriate treatment for agricultural use from the health point of view, and the health regulations and guidelines for wastewater reuse in the Region are outlined. The work of the WHO Regional Office to assist countries face the challenges of water scarcity and wastewater reuse are described. Finally, key suggestions that could enhance the use of reclaimed wastewater while at the same time safeguarding human health are presented.

Réutilisation des eaux usées en agriculture : perspective sanitaire régionale

RÉSUMÉ La Région OMS de la Méditerranée orientale est la région la plus pauvre du monde en ressources hydriques en tant que région et par habitant. Le présent article fait une synthèse des pratiques et contraintes existantes en ce qui concerne le traitement et la réutilisation des eaux usées dans la Région et décrit l’impact sur la santé des pratiques inadéquates. Le traitement approprié des eaux usées pour utilisation dans l’agriculture d’un point de vue sanitaire, et les règles et directives sanitaires pour la réutilisation des eaux usées dans la Région y sont exposés. L’action du Bureau régional de l’OMS pour aider les pays à faire face aux défis posés par la pénurie d’eau et la réutilisation des eaux usées y est décrite. En dernier, des suggestions clés qui permettraient de renforcer l’utilisation des eaux usées récupérées tout en préservant la santé humaine sont présentées.

*World Health Organization Regional Centre for Environmental Health Activities, Amman, Jordan
Correspondence to S.S. Al Salem: alsalems@ceha.emro.who.int.
*Supportive Environmental Health, World Health Organization Regional Office for the Eastern Mediterranean, Cairo, Egypt.
Received: 18/11/01; accepted: 22/09/04

المجلة الصحية لشرق المتوسط، منظمة الصحة العالمية، المجلد الثاني عشر، العددان 3-4، 2006
Introduction

The Eastern Mediterranean Region (EMR) of the World Health Organization is the driest region in the world. The region is poorly endowed for water; rainfall is low and poorly distributed. Drought and desert define the region. At the same time, water demand in the Region is growing fast and water availability is falling to crisis levels [1].

As the population has grown against a background of finite freshwater resources, so the water available to individuals has fallen dramatically. In 1960, the average annual per-capita availability for the region was about 3300 m³ [2]. This has fallen by 60% to about 1250 m³ today. This is the lowest in the world and it is predicted to fall by another 50% to below 650 m³ by 2025. This figure covers all human activities, domestic, industrial and agricultural. In some countries, water availability is already well below the projected regional average 30 years from now. For example, in Yemen and Palestine, the per-capita availability today is less than 180 m³ [2].

Fortunately, solutions are available which reduce water consumption and demand in an environmentally acceptable manner. A number of technologies and devices can help water users to reduce their consumption and demand without any appreciable impact on lifestyles. These include minimizing unaccounted-for water (the difference between the quantity of water supplied to a city’s network and the metered quantity of water used by the customers), adopting a demand approach, wastewater reclamation and reuse and water conservation through low-flow toilets, low-flow shower heads and faucet flow restrictors. Generally speaking, these technologies have been well received in the Region and have become steadily more popular as the cost of municipal water has risen.

Adequate sanitation could be considerably expanded and pollution reduction achieved through on-site wastewater treatment and recycling systems that permit the reuse of greywater (all wastewater except toilet wastes and food wastes derived from garbage grinders) for landscape irrigation and toilet and urinal flushing. As an example, in the typical household, approximately 34% of water consumed is used in the flushing of toilets. The remaining 66% of the water for the most part is available for on-site recovery and reuse. On-site wastewater treatment and recycling systems can be used in all types of residential and commercial buildings and most types of institutional and industrial buildings.

Further measures that could achieve significant water cutback in water consumption are the use of modern irrigation systems and the increase in plantation of high-value crops and decrease in plantation of crops that have high-water consumption but low economic value. Long-term plans in this context are likely to shift the economy from an agricultural-based to an industrial/service-based economy. Other measures to overcome the water crisis could be achieved by using industrial water conservation and economic incentives, and maximising the recycling and reusing industrial wastewater.

Wastewater reuse is an important approach to help overcome the water scarcity problem of the Region. The objectives of this paper therefore are to summarize the existing practices of wastewater reuse and their environmental health effects and to suggest strategies to enhance the full use of reclaimed wastewater while at the same time safeguarding human health. A further objective is to list the constraints faced by the wastewater reuse sector, so that the countries of the Region can review the
problems and devise actions to overcome them.

**Wastewater reuse in the Region**

Wastewater reuse in the Region could contribute significantly to solving the problem of quality and quantity of water. However, this does depend on how it is used. In terms of costs, it is the most feasible option to augment the water resources in the Region for the coming years (Table 1). As a result, wastewater reuse will have a major impact on the agricultural economy, as well as on the well-being and the health of the society.

Wastewater reuse is already practised in the Region [5]. The total quantity of reused treated wastewater in EMR is estimated at 1200 million cubic metres (MCM) per year. The Syrian Arab Republic, Saudi Arabia and Egypt are the largest users of treated wastewater in absolute terms, accounting for almost 66% of all the wastewater reused in the Region, with the Syrian Arab Republic alone accounting for almost 31% [6]. However wastewater is not yet being used to its full potential.

At present, the Gulf Cooperation Council (GCC) countries recycle no more than 43% of their total treated wastewater, which contributes to 1.8% of their total water supply, being used mainly in landscaping, irrigation of fodder crops and some industrial uses. It is estimated that if only 50% of domestic water supplies in the GCC countries is treated and recycled in agriculture, recycled water will have the potential to meet more than 11% of their countries’ total water demand, satisfy more than 14% of the agricultural sector’s demand, and reduce fossil groundwater withdrawal by more than 15% by the year 2020 [7].

<table>
<thead>
<tr>
<th>Table 1 Cost and options for enhancing water resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option for enhancing water resources</strong></td>
</tr>
<tr>
<td>Reducing end-user demand</td>
</tr>
<tr>
<td>(recirculation, low-water use technology and leakage repair)</td>
</tr>
<tr>
<td>Rain water harvesting and cloud harvesting</td>
</tr>
<tr>
<td>Secondary treatment of wastewater for irrigation</td>
</tr>
<tr>
<td>Tertiary treatment of wastewater for irrigation</td>
</tr>
<tr>
<td>Greywater reuse for toilet flushing and landscape irrigation</td>
</tr>
<tr>
<td>Desalination of brackish water</td>
</tr>
<tr>
<td>Desalination of sea water</td>
</tr>
<tr>
<td>Water conveyance by pipelines</td>
</tr>
<tr>
<td>Transport of water by marine vessels</td>
</tr>
<tr>
<td>Transport of giant floating bags by sea, not including the costs of terminals, inland transport or purification</td>
</tr>
</tbody>
</table>

*Initial cost for combined wastewater treatment and recycling systems in larger commercial and industrial facilities/gross m² [3].

bThe price of the water itself is not included. The cost depends mainly on the distance [4].

**Appropriate treatment for agricultural use from the health point of view**

Currently, wastewater reuse in the Region is mostly haphazard and presents significant health risks, especially where untreated wastewater is used to irrigate vegetables [5]. To avoid the spread of diseases, waste-
water should be suitably treated for the type of the irrigated crop and in accordance with the health protection measures.

Most of the treatment plants in the EMR use an activated sludge process followed, in some cases, by rapid sand filtration [8]. These techniques were developed to reduce the suspended matter load and oxygen demand of the discharged reclaimed waters and to reduce water eutrophication of the water bodies. These technologies are not efficient in removing pathogenic microorganisms and are not intended to achieve high removal of excreted pathogens, while at the same time they may reduce substantially the nutrients for the soil. Their use in EMR, where excreted infections are endemic and where wastewater is mostly used for agriculture irrigation, is justifiable only in specific circumstances.

The above situation has the following environmental and health impacts to differing extents.

- Soil, surface water and groundwater pollution occurs as a result of the discharge of untreated or partially treated wastewater into the environment. This can raise the nitrate concentration in the water and subsequently affect children and pregnant women.
- Farm workers are at risk of infection as a result of direct or indirect contact with reclaimed effluent and contaminated soil.
- Direct and indirect risks to human health exist as a result of consumption of polluted crops and fish, with especial impact on vulnerable groups such as pregnant women and children.
- Contamination of the coastal seawater occurs, threatening swimmers, the fisheries, as well as the marine ecosystems.

There are alternative treatment processes available that are superior and can reduce the survival of excreted pathogens and bring the load to an acceptable level so that such water will not pose an unacceptable risk [9]. There are 6 processes that can achieve complete removal of helminth eggs and pathogenic larvae and an overall excreted pathogen reduction suitable for unrestricted irrigation. These processes are:

- Waste stabilization ponds with detention time of more than 14 days for removal of nematode eggs and 21 days for inactivation of *Strongyloides stercoralis* larvae.
- Combination of treatment and effluent storage to reduce the required detention time.
- Conventional secondary sewage treatment with the effluent upgraded in polishing ponds.
- Conventional secondary treatment followed by slow sand filtration.
- Enhanced primary treatment either chemically or by using an up-flow sludge blanket reactor (site-specific further studies are needed to confirm the performance).
- Conventional secondary sewage treatment with effluent filtration using membranes.

**Health effects of inappropriate wastewater treatment and reuse in the Region**

The main constraint in wastewater reuse in the Region continues to be the control of the spread of diseases due to inappropriate treatment and uncontrolled reuse of the reclaimed water. The chemical composition of wastewater is not discussed in this paper because we have restricted our review to domestic wastewater, where the chemical concentration is usually approximate to...
drinking water quality, not industrial wastewater. Nevertheless the chemical effects of wastewater reuse and guidance are covered by manuals and guides published by the Food and Agriculture Organization.

Significant occurrence of diseases is associated with wastewater irrigation and caused by pathogens, particularly helminths, which are neither detected by the techniques used in conventional microbiological monitoring of effluent quality nor removed completely by conventional wastewater treatment processes. Thus, helminthic infections (intestinal nematodes) pose the greatest risk to farm workers as well as to consumers of farm produce.

**Prevalence and intensity of helminth infections in the Region**

Intestinal parasitic diseases are endemic and quite widespread in the most countries of the Region.

In Faizabad City, Afghanistan, it was found that the prevalence of ascariasis for male schoolchildren (7–12 years) was 96.6%, whereas the prevalence for female schoolchildren of the same age group was 79.5%. The highest prevalence was in the 7-year-old girls (87.05%) and the lowest prevalence was in 12-year-old girls (55.5%) (S. Al Salem, unpublished report, 1996).

In Morocco, a study showed that the prevalence of intestinal helminthic infections caused by 5 parasites (*Ascaris lumbricoides*, *Trichuris trichiura*, *Enterobius vermicularis*, *Hymenolepis nana* and *Taenia saginata*) in children in the areas of wastewater use was 30.8% compared to only 5.6% among children living in the control areas [10]. Children in the study sample suffered low-intensity infection with *A. lumbricoides* and *T. trichiura*. The parasite load of *Ascaris* infection, as expressed by the number of eggs per gram of faeces (epg), was much higher among children living in wastewater-exposed areas (18.3 epg) than unexposed areas (2.3 epg).

In Amman, Jordan, the enforcement of the laws on the reuse of reclaimed water and the use of appropriate technology have led to a reduction in the concentration of intestinal nematodes in stabilization ponds influent to undetectable levels (data from the Royal Scientific Society in Amman). The health records show that the average rate of intestinal nematode infections was 1.33% among schoolchildren during the period of 1995–1999 (Ministry of Health, unpublished reports, 1995–1999).

A study in Nablus, West Bank, Palestine of 6 years of accumulated data on 22 970 faecal specimens showed that the prevalence of *Ascaris* was 17.7% and *Trichuris* was 1.3% [11]. A study from Gaza Strip showed that more than 50% of the children under the age of 10 years were infected with *Ascaris* [12].

A study of parasitic infestation and the use of untreated sewage for irrigation of vegetables in the Syrian Arab Republic showed that the domestic sewage of Aleppo contained 3340 *Ascaris* eggs/L, which represents an *Ascaris* infestation rate of 42% of the total Aleppo population excreting an average of 800 000 eggs daily per person [13]. The correlation between the number of parasites in Aleppo and the irrigation of vegetables with sewage is that irrigation completes the cycle by returning the parasites to the community. On the other hand, a sample of untreated sewage from the Syrian coastal town of Lattakia contained 460 *Ascaris* eggs/L. Untreated sewage is not used for irrigation in Lattakia and this is reflected in the lower parasite count of Lattakia sewage. A study carried out in 1999 showed that in the Barada river basin, which contains treated wastewater, 11.4% of the people were infected with *Ascaris* worms [14].
A survey of the prevalence of some diseases related to wastewater from records of the health offices in Helwan, Egypt during the years 1994–1995 showed that 0.55% of the population in the area were infected with *Ascaris* in 1994 and 3% in 1995; 0.7% of the people were infected with *Taenia* in 1994 and 0.3% in 1995. The concentration of viable *Ascaris* eggs at the inlet of raw wastewater at the Helwan wastewater treatment plant (activated sludge) was 70 eggs/L while at the outlet (secondary effluent followed by chlorination for Helwan wastewater treatment plants) the viable *Ascaris* eggs were 15 eggs/L and the concentration of *Ascaris* eggs in the River Nile water at Faroque corner was 60 eggs/L. The result of clinical examination for Helwan sewage plant workers and some of the sewage farm workers showed that 38.2% had parasitic infections (*Ascaris*, *Entamoeba histolytica* and *Giardia*) [15].

In South Batinah Region, Oman an epidemiological study of intestinal parasitic infestation among schoolchildren showed that 19% of the children examined were infected with *H. nana*. The frequency of *A. lumbricoides* infection was relatively low (0.1%) and the infestation of *Strongyloides* was 5 per 1000 of the examined schoolchildren (S. Al Salem, unpublished report, 1998).

**Wastewater reuse constraints in the EMR**

The Region’s low coverage in adequate sanitation and high infestation in sanitation-based diseases can be attributed to the following factors.

- Institutional inefficiency is one of the major constraints in managing the sector. There is an insufficient number of national professionals in the field of wastewater treatment design, operation, and reuse; a lack of bylaws or their enforcement; political domination of the decision-making; short-term rather than long-term planning; and seepage of brackish or saline groundwater into the sewer system, which limits the reuse of wastewater.

- Donor agencies tend to impose unsustainable/unaffordable technologies and projects, which are not within the long-term integrated planning or within the affordability of the community.

- Trustworthy, valid, and reliable data and information are lacking in most of the countries in the Region. Information is scarce regarding quality, coverage, use and cost. The inadequacy and insufficiency of the information can lead to incorrect planning and decisions. This situation does not permit correct decision-making either for the politicians or for the professionals.

- There is inadequate and/or insufficient research into the situation at the regional and local level. The Region is reliant on research generated from Europe and North America. There are few surveys or investigations carried out in the Region addressing the Region’s problems. There are Region-specific problems that need to be thoroughly investigated by the resource institutions and universities located in the Region. More funds need to be allocated for the research and development in the field of wastewater treatment and reuse.

- Inadequate financing exists in most countries of the Region. There is a need to reform the wastewater reuse sector and its operations, striking a balance between the capability of the sector to sustain itself and the health and social benefits of the people.
• There is a lack of participation of the beneficiaries themselves in decision-making and an absence of consideration of the ability of communities to contribute to the sector’s planning and investment. The cultural and spiritual beliefs in the Region do not oppose the use of reclaimed wastewater for agriculture use, but for direct or indirect human consumption or body contact activities there will be social resistance for such reuse.

• The coverage of adequate sanitation is low in the Region and the technology used for wastewater treatment is inadequate and is not usually designed to be compatible with the end use, or the end discharge point.

• The laws and regulations governing wastewater reuse in the Region are generally weakly enforced or inadequate.

• The primary measure for protection of health in wastewater reuse is the treatment used. In the Region, this is usually an expensive method or an unreliable one and is associated with the wrongly selected technology.

• Reclaimed water and greywater are not used to their full potential in the Region and the resources are often reused to irrigate low-value agricultural crops.

• The costs of serving one household with a conventional sewer system are high due to the unusual terrain and topography of the Region, and the construction of sewers which predominantly takes place after urbanization. All of these factors contribute to limiting the expansion of wastewater collection systems which consequently limits the wastewater available for reuse.

Health regulations and guidelines for wastewater reuse in EMR

Most of the standards and government regulations in the Region are set as country effluent standards to control the quality of discharge. However, the fact is that the application of uniform effluent standards may be uneconomical and inappropriate [5]. Moreover, the effluent standard is usually too stringent and environmentally unjustified. This is due to the great variation in the end uses covered by one uniform standard.

It is suggested that standard discharge to stream be imposed only in the case of indirect reuse and to be based on using the total assimilative capacity of the rivers or watercourses and on the water quality level for the predominant water reuse downstream. Ultimately, water reuse standards must protect public health and the environment and must match with end reuse objectives and the methods of application. Most of the EMR standards are based either on United States Environmental Protection Agency (USEPA) or WHO guidelines regardless of the end use or the country’s disease profile. But most of the time these standards are not reinforced. Some countries with a high prevalence of sanitation-based diseases lack the proper standards for reuse of wastewater. A consultation was convened in CEHA/WHO for professionals in the field of wastewater treatment and reuse in the Region in October 2003; guidance criteria were suggested at this meeting for health aspects of wastewater reuse which reflect the health map of the Region (Table 2) [16].

المجلة الصحية لشرق المتوسط، منظمة الصحة العالمية، المجلد الثاني عشر، العددان 3-4، 2006
Table 2: Recommended revised microbiological guidelines for treated wastewater use in agriculture [17]*

<table>
<thead>
<tr>
<th>Category/reuse conditions</th>
<th>Exposed group</th>
<th>Irrigation technique</th>
<th>Intestinal nematodes* (arithmetic mean no. of eggs/L*)</th>
<th>Faecal coliforms (geometric mean no./100 mL*)</th>
<th>Wastewater treatment expected to achieve required microbiological quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Unrestricted irrigation</td>
<td>Workers, consumers, the public</td>
<td>Any</td>
<td>&lt; detection</td>
<td>≤ 10³</td>
<td>Waste stabilization ponds with a retention time of 21 days or secondary treatment followed by equivalent storage or slow sand filtration or equivalent</td>
</tr>
<tr>
<td>For vegetable and salad crops eaten uncooked, sports fields, public parks*</td>
<td>Workers, consumers, the public</td>
<td>Any</td>
<td>&lt; detection</td>
<td>≤ 10³</td>
<td>Waste stabilization ponds with a retention time of 21 days or secondary treatment followed by equivalent storage or slow sand filtration or equivalent</td>
</tr>
<tr>
<td>B. Restricted irrigation</td>
<td>Workers, nearby communities</td>
<td>Spray or sprinkler</td>
<td>&lt; detection</td>
<td>≤ 10³</td>
<td>As for category A</td>
</tr>
<tr>
<td>Cereal crops, industrial crops, fodder crops, pasture and trees*</td>
<td>Workers, nearby communities</td>
<td>Flood/furrow</td>
<td>&lt; detection</td>
<td>≤ 10³</td>
<td>As for category A</td>
</tr>
<tr>
<td>C. Localized irrigation of crops in category B if exposure of workers and the public does not occur</td>
<td>None</td>
<td>Trickle, drip or bubbler</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Pre-treatment as required by the irrigation technology, but not less than primary sedimentation</td>
</tr>
</tbody>
</table>

*In specific cases, local epidemiological, sociocultural and environmental factors should be taken into account and the guidelines modified accordingly.

*b For *Ascaris* and *Trichuris* species and hookworms, the guideline limit is also intended to protect against risks from parasitic protozoa.

*c Guideline values are given for design purposes. They should be achieved during the planning and design stages for effluent reuse projects, and not used as a standard specification for monitoring effluent quality and sample collection.

*d A more stringent guideline limit (≤ 200 faecal coliforms/100 mL) is appropriate for public lawns, such as hotel lawns, with which the public may come into direct contact.

*e In the case of fruit trees, irrigation should stop 2 weeks before the fruit is picked, and no fruit should be picked off the ground. Spray/sprinkler irrigation should not be used.

*f In cases where the treatment method fails to achieve the guideline limit, use faecal coliforms < 10³, provided that precautions are taken such as protective clothes, crop restriction and providing a buffer zone between the irrigated area and nearby communities.
Specific health issues

In 1989, WHO published new guidelines for wastewater use in agriculture and aquaculture [9]. The guidelines included a new dimension, which had not been considered in the previous WHO reports on reuse [17]. The new guidelines set microbiological quality criteria for wastewater use in the irrigation of: crops to be eaten cooked or eaten raw, sports fields, public parks, cereal crops, industrial crops, fodder crops and trees. The new dimension in the guidelines required that treated wastewater should contain less than 1 nematode egg/L. In addition to nematode eggs, the faecal coliform criteria have been revised and state that treated wastewater should contain less than 1000 faecal coliforms per 100 mL for vegetables eaten raw.

The 1989 WHO health guidelines for the use of wastewater in agriculture and aquaculture state that: “The presence of free-living nematode larval stages, sometimes in large numbers, in stabilization pond effluents IS OF NO PUBLIC HEALTH SIGNIFICANCE because they are not pathogenic to human beings” (emphasis added) [9]. This statement is valid for all helminthic pathogens excreted in faeces except for Strongyloides stercoralis (threadworm) and Enterobius vermicularis (pinworm), since their eggs are NOT normally excreted in faeces. The pinworm is of minor public health importance because it is an infection that does not commonly cause serious illness. Strongyloides is potentially serious, particularly in malnourished or immune-suppressed individuals. When the body’s immune responses are deficient, disseminated strongyloidiasis may occur, with larvae attaching to most organs of the body; such cases are usually fatal [18].

The mode of transmission of Strongyloides infective filariform larvae, which develop in most soils contaminated with faeces, is by penetrating the skin (usually through the foot), entering the venous circulation and being carried to the lungs. They hatch and liberate non-infective, rhabditiform larvae, which migrate into the lumen of the intestine, leaving the host in the faeces and developing either into infective filariform larvae, which may infect the same or a new host, or into free-living adults after reaching the soil [19]. The eggs are ovoid and measure 50–60 by 30–35 μm but are seldom seen because larvae hatch out and are passed in the faeces. S. stercoralis exists in night soil and sludge as a delicate larva, not as a robust egg. A new infection can be initiated by the penetration of a single larva. Since Strongyloides represent a high actual risk, it is recommended to eliminate or remove 100% of its concentration. This would mean having zero S. stercoralis larvae/L, because infection can be initiated by skin penetration of a single S. stercoralis larva. The period of communicability is as long as there are living worms in the intestine, which may extend up to 35 years [19].

Concerning inactivation of Strongyloides in sewage treatment processes, there are no studies reported [18]. However, it is suggested that sludge pasteurization, as currently applied in Switzerland and Germany at 70 °C for 30 minutes may offer considerable safety. Pathogens may be reduced in rapid sand filtration but not substantially and probably insufficiently to justify investment in this filtration method by the health benefits it yields, and most helminth eggs will be totally unharmed by effluent chlorination [18]. This was confirmed by a study carried out in Jordan and by the performance of the Bahrain tertiary treatment plant operating on dual media filtration, chlorination and ozonation (S. Al Salem, unpublished report, 1992).
So far, there is no guaranteed feasible method of inactivation of *S. stercoralis* larvae either in sewage or sludge treatment processes. It is recommended to take protection measures by a high dose of chlorination for the final effluent, wearing shoes and gloves, burying the sludge at least 0.5 m below ground surface, and stopping irrigation of crops at least 3 weeks before harvesting (S. Al Salem, unpublished report, 1992).

It is worth mentioning here that WHO/HQ is currently updating the 1989 health guidelines for the use of wastewater in agriculture and aquaculture.

**Work of the WHO/EMRO in facing the challenges**

WHO/EMRO through the Centre for Environmental Health Activities (CEHA) is working with Member States to address the challenges of water scarcity and wastewater reuse, to find solutions and to ensure sufficient and safe water for the people of the Region. The following activities and projects have been carried out by the Regional Office in relation to wastewater reuse.

- Training is a vital activity and the following courses have been organized by the Regional Office.
  - In order to disseminate the appropriate technology transfer in wastewater treatment and reuse in EMR, 19 training courses in various aspects of wastewater reuse and treatment were carried out from September 1999 until April 2004 for professionals in several countries, namely Egypt, Iraq, Jordan, Kuwait, Oman, Saudi Arabia, Syrian Arab Republic, Tunisia and Yemen.
  - A regional training course was held in 1999 for 12 professionals from 10 countries, the main objectives of which were to:
    - disseminate knowledge on the regionally recommended procedure for the testing of nematodes eggs (*Ascaris* and *Trichuris* species and hookworms) in raw sludge and treated wastewater and to introduce periodic programmes regarding the frequency of sampling, times, days, and numbers of samples to ensure better safety and foster community health during wastewater reuse in agriculture;
    - disseminate knowledge on the monitoring and surveillance of reclaimed water and sludge for agriculture.
- A course on treatment of sewage and agriculture use of treated effluent, sponsored and co-organized by WHO/CEHA, was held at Jordan University, Amman, 2–20 April 2000.
- Recognizing the importance of information, guides and manuals, the Regional Office has commissioned the preparation of several publications in Arabic and in English.
- A manual in Arabic on the operation and maintenance of wastewater treatment plants written for wastewater superintendents.
- *Guidance for design, operation, and maintenance of wastewater treatment plants* (in Arabic) written for a wider audience than the manual above.
- *Integrated guide to sanitary parasitology*. The guide is the first of its kind dealing with nematodes eggs screening and enumeration in the wastewater, final effluent, and sludge. It is available in Arabic and English.
- *A regional overview of wastewater management in the Eastern Mediterra-
This publication is intended to delineate the status of wastewater management and reuse in the EMR.

- Grey water reuse in the Eastern Mediterranean Region (in Arabic). This pamphlet will be produced in English in the near future. It defines greywater and the health aspects of its reuse in the EMR. It summarizes the existing experiences in the Region.

- Overview of health aspects of greywater reuse (in Arabic and English). The purpose of this overview is to provide guidance for local government officers, homeowners, site and soil evaluators, designers, installers and service technicians on the impact of greywater reuse on human health, plants, animals and the environment.

- Country profiles on wastewater management and reuse for: Egypt, Jordan, Morocco, Oman, Saudi Arabia, Sudan, Syrian Arab Republic, Tunisia, and Yemen. The following profiles are being prepared: Lebanon, Libyan Arab Jamahiriya, Kuwait, Palestine and United Arab Emirates.

- The Regional Office has also commissioned the translation of useful documents into Arabic. These include:
  - The first volume of the USEPA publication *Operation and maintenance of wastewater collection systems.*
  - A series of research projects were carried out during 2002–2003 to assess the efficiency of wastewater treatment plants in the removal of helminth eggs and to find the most viable methods for removal or inactivation of helminth eggs from reclaimed wastewater. It was found that conventional wastewater treatment used in the Region is not effective in removing nematode eggs. The slow sand filtration and lagoon system could remove eggs, and chemically enhanced treatment and the up-flow sludge blanket could partially remove eggs.

- The following countries of the Region were provided in 2002–2004 with the laboratory equipment necessary to identify and enumerate nematode eggs in wastewater and sludge: Egypt, Iraq, Kuwait, Morocco, Sudan, Syrian Arab Republic, Tunisia and Yemen.

- The following conferences were convened:
  - WHO/AFESD Regional Consultation to Review National Priorities and Action Plans for Wastewater Reuse and Management, Amman, Jordan, 20–22 October [16]. In this consultation, suggested guidance for health aspects of wastewater reuse and greywater reuse in the EMR were agreed upon.

**Key suggestions to achieve full use of reclaimed wastewater and safeguard human health**

- Policy-makers and high-ranking professionals in each country need to review the current constraints on wastewater reuse related to their country and to decide how to overcome them.

- It should be planned to treat all generated wastewater and to use the whole amount in appropriate contexts.
• Only high-value agriculture products should be irrigated and water should be allocated to uses that have the highest-value and prevent pollution.
• Incentives for conservation should be provided and sanctions/penalties for irrational use should be imposed. Consumers should meet the cost for the economic water value; this will help prevent uneconomical use/reuse of water.
• Water use activities should be coordinated and water plans, strategies and investments for the long-term should be set according to the priorities to be decided with the participation of beneficiaries.

Reclaimed water should not be discharged into the sea as it is a waste of this valuable water resource.

Wastewater reuse guidelines should be updated to match newly gained knowledge and a comprehensive approach should be used for health protection measures not depending on the treatment measure as the sole method for health protection.

Wastewater reuse/greywater projects should be designed as an integral part of the wastewater network and water resources plans.

References

1. Al Salem SS. Environmental consideration for wastewater reuse in agriculture. 


7. Al-Zubari WK. Towards the establishment of total cycle management and re-use program in the GCC countries. Presented at the 7th Regional Meeting of the Arab International Hydrological Programme Committee, 8–12 September 1997, Rabat, Morocco.


10. Habbari K et al. Heminthic infections associated with the use of raw wastewater

المجلة الصحية لشرق المتوسط، منظمة الصحة العالمية، المجلد الثاني عشر، العددان 3-4، 2006


