Wastewater recycling and reuse in the Near East Region: experience and issues

M. Bazza

FAO Regional Office for the Near East. P.O. Box 2223 Dokki, Cairo, Egypt
(E-mail: *Mohamed.Bazza@fao.org*)

Abstract Wastewater in most countries of the Near East Region (NER) is being more and more recognized as of vital importance to be treated and made safe for reuse. It contributes considerably to the water budget in several countries, particularly those suffering from water scarcity. Treated wastewater is used directly in irrigation of farms or landscape green areas. Limited indirect use includes recharge of groundwater aquifers to control over-draft and salt intrusion in coastal areas. A large share of wastewater is still not treated and part of it is used in an uncontrolled manner, including for the production of uncooked food crops the consumption of which poses health risks. Expansion of treated wastewater reuse in the region is linked to a number of issues and constraints. The high cost of treatment and management of reclaimed wastewater is one of the major limitations facing the week economy of most countries. Unclear polices, institutional conflicts and lack of regulatory frameworks constitute other important constraints that hinder implementation and proper operation of wastewater reuse projects. The manpower capacity is at varying levels between countries, but additional training and capacity strengthening are generally needed throughout the region. This paper gives an overview of the existing practices of wastewater reuse in the NER and of the constraints facing it. It concludes with recommendations and policy options that are likely to lift these constraints and to make a better use of the wastewater potential.

Keywords Irrigation; Near East; quality; reuse for irrigation; wastewater treatment

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Introduction

Freshwater shortage is becoming an increasingly acute problem facing many nations in the world. In the NER (Near East Region), some 16 countries out of 29 member states are classified as water-deficit, with less than 500 m^3 per capita of the annual renewable fresh water resources (FAO, 1997a). Although the NER occupies about 14% of the world area and embraces almost 10% of the world population, it only receives 3.5% of total precipitation and only 2.2% of the annual internal renewable water resources (IRWR). The per capita figure of these IRWR is hardly 22% of the global one. The average per capita in the Region is 1,577 m^3/yr, ranging from virtually zero in Kuwait to about 10,000 m^3 in Tajikistan (Bazza, 2001). Globally, in the NER, the agricultural sector is the major water consumer, which accounts for about 91% of the total mobilized water. While other sectors such as municipal and industrial accounts for 5% and 4% respectively (FAO, 1997a). As water scarcity is echoed in the region, decision-makers and planners are considering non-traditional water resources as an attempt to reduce the gap between water supply and demand. One of these non-conventional resources is treated wastewater and its reuse for various purposes.

As a substitute for freshwater in irrigation, wastewater has an important role to play in water resources management. By releasing freshwater sources for potable water supply and other priority uses, wastewater reuse makes a contribution to water conservation and takes on an economic dimension. Moreover, wastewater use schemes, if properly planned and managed, can have positive environmental impact, besides providing increased agricultural yields. Some degree of treatment must normally be provided to raw municipal wastewater before it can be used for agriculture. The quality of treated effluent used in

agriculture has a great influence on the operation and performance of the wastewater–soil–plant system. The most appropriate wastewater treatment to be applied before effluent use in agriculture is that which will produce an effluent meeting the recommended microbiological and chemical quality guidelines, both at low cost and with minimal operational and maintenance requirements. Adopting as low a level of treatment as possible is especially desirable in the Near East countries, not only from the point of view of cost but also in acknowledgement of the difficulty of operating complex systems reliably.

Wastewater treatment and reuse: why?

Wastewater resource is very worth of control and management. Management of wastewater through treatment has two major objectives. The first is to protect the environment by reducing the pollution of fresh water resources and hence reducing the health risks. The second is to mobilize this available water resource for mitigating water scarcity and improving food production.

In most NER countries, the receiving bodies for wastewater are rivers, lakes and irrigation systems. Major environmental issues such as dissolved oxygen depletion, eutrophication, foaming, and fish kills are recorded. Therefore, uncontrolled wastewater contributes to water resources degradation, reduces agricultural production and affects public health. On the opposite, the controlled use of wastewater, through treatment and planning, leads to water resources augmentation, particularly in the countries that suffer from water scarcity conditions, in addition to environmental protection. The use of wastewater in irrigation may also improve groundwater conditions, by recharging aquifers thereby lessening overdraft and preventing seawater intrusion in coastal areas. The organic matter added through irrigation with wastewater could help improve soil conditions by increasing its fertility and water holing capacity. In arid countries, wastewater can contribute to mitigating desertification and soil degradation, through the creation of forests and green areas. Improved urban amenity, through growing green spaces for recreation (parks, sports facilities) and visual appeal (flowers, shrubs and trees adjacent to urban roads and highways), constitutes another important technical merit of wastewater reuse.

Wastewater reuse considerations for better management

Technical considerations

Treatment of wastewater and its suitability for reuse depend on the treatment technologies used. The more advanced the technology, the higher is the expected cost of wastewater reclamation. Stabilization bonds (lagoons) constitute the low cost technology that might be suitable for the countries of low-economic situation. In many cases, lagoons may not be effective to get appropriate treatment, particularly when the wind is not dominant over the year in the lagoon area. Therefore, mechanical aeration is established to improve the treatment. Other disadvantages of the lagoons include the long span of time required to achieve acceptable levels of treatment and the large areas needed to establish the lagoons. One of the largest waste stabilization pond systems in the world is located outside Amman in Jordan, with a design capacity of 68,000 m^3/d, while the actual inflow to the plant is currently estimated at 130,000 m^3/d. The excess influent had an impact on the effluent quality and restrictions to its reuse. Stabilization ponds are also used in Tunisia and Egypt. The Ismailia stabilization pond system in Egypt, with a design capacity of 90,000 m^3/d and current actual inflow of 80,000 m^3/d, showed a suitable reclaimed wastewater for reuse in irrigation of commercial trees and mulberry trees for silkworm raising. Mechanical aeration is sometimes used in these lagoons to improve the quality of treated wastewater.

Intensive wastewater treatment technologies require less land area and shorter span of time. On the other hand, higher energy and chemical inputs are required. This approach

may be suitable for countries with sound economic position. North American and European countries have developed intensive expertise in the design and operation of such high-level technologies of wastewater treatment. The Gulf countries use this high-level technology since their economic position allows. The treated wastewater is then used in irrigation of landscape areas and food crops when it is followed by tertiary treatments. Other developing countries such as Jordan, Morocco and Algeria are introducing mechanical treatment but it is not followed by tertiary treatment. Research should give attention to the use of low-cost treatment plants, such as stabilization ponds, and to the shift to decentralized small-scale treatment plants instead of large central units. The advantage of this approach is to ensure better operation and maintenance services and, consequently, better-reclaimed water that is suitable for reuse.

Other technical considerations in wastewater reuse include distribution of the treated wastewater after the plant. Wastewater that is planned for irrigation purposes often requires the provision of storage facilities to cope with the variation of water demands and availability. Treated wastewater is used as a supplementary resource in irrigation where rainfall and conventional water resources don't match the demands. Storage of reclaimed wastewater is sometimes needed prior to irrigation, to get further treatment that ensures the required quality for safe usage in irrigation. Recharge of aquifers with reclaimed wastewater is sometimes recommended to replenish over-draft and/or to prevent salt intrusion, as is practiced in the coastal areas east of Tunisia. Indirect use of treated wastewater, through mixing with fresh water in irrigation networks, is commonly practiced in many countries such as Jordan. This approach becomes the only possible alternative of reuse when pumping treated wastewater to the fringes is very costly.

Institutional issues

Wastewater reuse is characterized by the involvement of several departments and agencies, either governmental or private or both. Sanitation and agricultural departments are usually involved to a great extent in wastewater reclamation and reuse. The former is usually responsible of wastewater collection, treatment and provision to the latter, in compensation for the amounts allocated for drinking water supply. The agricultural and irrigation departments have the mandate of developing the suitable practices and promoting their adoption by farmers and end-users. Other departments play an important role in order to improve the efficiency of wastewater reuse and to ensure minimum health and environmental harms. The ministry of public health is responsible for the protection of all groups who are exposed to wastewater reuse. It develops and implements appropriate protection and prevention guidelines, in addition to ensuring the treatment of diseases. Environmental agencies have the mandate to ensure that the impact of wastewater reuse on the environment is reduced. For instance, groundwater would be affected in areas practising reclaimed wastewater, particularly when the water table is shallow. To avoid this from happening, the relevant departments should have a well established monitoring program to follow-up the impacts and changes associated with wastewater reuse.

In many countries, the water resources agency, such as the ministry of water resources or that of agriculture, is responsible of handling the reclaimed wastewater, such as building and managing storage, pumping and conveyance facilities. Other departments such as potable water agencies, industrial departments, department of energy, and water users associations are inevitably involved in the process of wastewater reclamation and reuse. The involvement of potable water agencies is needed for planning wastewater production and for supporting part or all of the treatment costs, since these agencies are the main source of wastewater production. The disposal of industrial wastes into municipal sanitation networks often results in an increase of heavy metals in wastewater that cannot be removed

during treatment stages, and consequently affect the reclaimed wastewater quality and suitability for reuse. To avoid this, industrial departments should be committed either to treat their industrial wastes before their disposal into municipal wastewater sanitation networks or to have their own collection network and treatment facilities. Industrial departments could also be encouraged to use the reclaimed wastewater for different purposes in industrial processes, such as cooling systems, and thus participate in fresh water conservation.

The large number of institutions involved and the complication of the system of wastewater production and reuse require the establishment of a sound institutional framework for coordination among the concerned agencies. A reuse project should normally be the result of joint efforts between the concerned institutions, in a way that each department has its part of responsibility. Unfortunately, the institutional arrangement in developing countries is very controversial and complex. There is a conflict among the concerned agencies on who should support treatment costs and on the ownership and allocation of the reclaimed water. The complications of institutional arrangements and framework may also exist within each department or agency. The complications could run from an overlap of responsibilities to the absence of well-defined mandates. The general rule is that each party wants the benefits but none feels responsible when work and/or expenses are necessary.

To overcome this limitation, there is a stressing need for establishing multi-institutional national committees for coordinating internal functions of the concerned departments as a part of the institutional framework. The coordination committee, consisting of representatives of the concerned departments and entities, would establish clear rules and mandates to ensure development and planning and to accommodate for the suitable usage of reclaimed water. The success of the institutional framework is achieved if the concerned agencies and departments are involved from the beginning of reuse projects, from the planning and initial stages. This approach will ensure providing the continuous support of the concerned departments and resolving the conflicts on time.

Legislative framework

The appropriate management of wastewater reuse should be under a well established legal and regulatory framework. Wastewater has potential benefits and at the same time presents hazards to people and the environment. The absence of regulations and laws or the lack of their enforcement could result in serious damage, of health, economic and environmental natures. Most countries enacted laws and standards for wastewater reuse; however, in many developing countries enforcement of these laws faces challenges and constraints. People in some places are compelled to rely on wastewater, with or without treatment, as the unique source of water for food production, disregarding quality. At times they are not even aware of the risk to which they are exposed. Some of the enacted laws and standards are too rigorous and not suitable for the country conditions, and therefore violation is expected.

Regulations are also needed to control the reuse of reclaimed water where in some cases the services of providing the reclaimed water are to be recovered. Private sector involvement is now a common approach, which entitles a sound regulatory system that ensures providing suitable wastewater for reuse. In Tunisia and Jordan, the privatization of treatment plants is underway through the BOT system. This system will involve providing water under certain quality standards at the plant outlet. Involvement of the private sector in purchasing reclaimed water for developing green areas such as golf courses is being tried in Egypt and Morocco. Such innovations in wastewater reuse are worthy of revising the existing regulatory framework to make it more adapted and comprehensive.

The regulatory framework should consider the purpose of reuse where the standards dif-

fer from one purpose to another. Unrestricted reuse of reclaimed wastewater requires higher degree of treatment where public is very likely to be exposed to wastewater. It includes irrigation of trees, fire protection, construction and street cleaning. For restricted reuse, regulations may require at least secondary treatment or biological treatment. In this case, the public exposure is controlled and hence regulations may not require a high level of treatment compared to unrestricted reuse. Irrigation of food crops, using reclaimed wastewater, is prohibited particularly those eaten uncooked, while some countries allow the irrigation of processed food. In Egypt, the regulations restrict the use of reclaimed water to growing trees and forests. Regulations for reuse of reclaimed wastewater vary from country to another depending on the circumstances of each country. Even in USA, there is a considerable variation in regulations and standards among states and cities (Crook *et al.*, 1992).

The regulatory framework is also expected to organize the handling of wastewater such as treatment level and monitoring of the plant, storage of the reclaimed water, recharge of groundwater aquifer and irrigation methods and application rate. Storage requirements are based on the demand pattern. In Arizona State, storage requires a period of five days of the average design flow while in South Dakota this period may reach 210 days. Regulations for irrigation methods using treated wastewater are also of concern that aims at reducing the risk of exposure by irrigators. Micro-irrigation systems are widely recommended in many countries such as trickle and subsurface irrigation. The application rate of wastewater needs also to be regulated and a threshold should not be exceeded in order to reduce the impact on water table quality and soil properties. Groundwater aquifers should be monitored to investigate the impact of reuse of reclaimed wastewater on groundwater quality.

Economic and financial considerations

The economic situation of the country plays a major role in wastewater reclamation and reuse. Treatment of wastewater is viewed as a must to protect the natural environment and pubic health. However, reuse of treated wastewater is also viewed as a tool to relieve some of the burdens resulting from the high costs of sanitation. Since the unrestricted reuse requires a high level of treatment, increase in the cost of treatment is expected and may not balance the gained benefits. Therefore, economic studies should be carefully carried out such as the cost effectiveness analysis, cost-benefit analysis and financial feasibility. Benefits that may be gained from reuse projects include environmental benefits, such as conservation of freshwater and reduction of saltwater intrusion, and economic benefits, such as expansion of treatment due to refunded costs.

As the treatment of wastewater is a must, some financial measures should be developed to alleviate the expenses of the treatment and reuse schemes. These measures may include recovering part of capital and operation/maintenance costs through users fees, bonds, taxes, and grants. In most countries, a small portion of sanitation cost is recovered through tariffs imposed on households and industries. In these countries, the inadequate cost recovery, that does not meet the maintenance and operation requirements, results in unsuitable reclaimed wastewater for reuse. Tunisia and Jordan provide a promising example of cost recovery of operation and maintenance, and a part of capital cost of reclaimed wastewater. Reclaimed wastewater in Jordan is mostly discharged into the rivers, reservoirs, and canals to be mixed with freshwater and reused then by farmers for irrigation purposes. For this type of water farmers pay up to 45 Fils/m^3 (0.07 $). In Tunisia, the cost recovery program recovers the cost of about 66% of the treated wastewater, which includes recovering operation/maintenance and part of capital cost. It is expected to fully recover the whole costs within ten years (Sheikh, 2001).

Awareness, training and capacity building

Where the practice of wastewater reuse is not old, the public, farmers and consumers often show a great reluctance to the reuse of reclaimed wastewater, particularly for agricultural production. In other areas where water is scarce, farmers rely on reclaimed wastewater to meet the agricultural water requirements, disregarding or not knowing the health harms associated with low-level quality. In both cases, awareness campaigns and programs should be conducted to achieve two objectives: to educate and orient farmers on the precautions of wastewater reuse, and to inform the consumers about the safety of agricultural products irrigated with well managed reclaimed wastewater.

Involvement of the public in the early stages of reuse schemes, through focus group discussions and other means, would provide an effective awareness and acceptance of reuse. It will also serve in the design of the reuse schemes to meet the real needs of users. The formation of user groups, such as water users associations, contributes to reaching these objectives and to training farmers on appropriate practices when dealing with the reclaimed wastewater. The associations can play an appreciated role in orientation of irrigators and consumers, in recovering water costs, and in monitoring and resolving any issues that may arise.

Wastewater reuse in the Near East countries: an overview

Although the interest in reusing treated wastewater is comparatively recent in most Near East countries, the principle of using raw sewage effluent in agriculture is more than 2000 years old. In the outskirts of several cities such as Damascus, Marrakech, etc., untreated sewage was mixed with fresh water and used to irrigate fruit orchards and vegetables. The use of technologically treated wastewater started as early as the fifties in Kuwait, then spread later on to other countries since the sixties and seventies. FAO played an important role in supporting member countries of the region for the introduction of wastewater reuse technology and the development of national capacity to manage it.

Most countries that embarked on their own, or in cooperation with FAO and other organizations, have included treated wastewater as an important dimension of water resources in their national water strategies and action plans. Some countries, such as Kuwait, Jordan, the Gulf States, Saudi Arabia, and Cyprus, have a national policy to reuse all treated wastewater effluents and have already made considerable progress towards this end. A second category of countries are mid-way in the process and have already accomplished tremendous advances in various aspects, from policy on wastewater safe reuse to strategies and their implementation. The situation however is lagging behind in several other countries where the matter has received no attention so far, for various reasons. These countries are currently faced with the most acute problems and needs for capacity building and adoption of strategies on treatment and reuse of wastewater. These countries are at the foremost level of need from policy-makers, investors, and donors for assisting them to lift the constraints and upgrade their capacity.

It is estimated that the volume of treated wastewater in the region amounts to 2.6 to 6 billion m^3/yr, with more than half being used in agriculture. The untreated volume is estimated to be two to fifty times higher, with a mean of 25 billion m^3; the fraction used in agriculture is not known but is believed to be high. By the year 2015, the volume of municipal sewage water is expected to reach a potential of over 40 billion m^3.

The efforts undertaken over the past three to four decades, and particularly since the eighties, have achieved substantial positive results. However and as expected in view of the advanced technology involved and the limited time since its introduction, the situation is far from being perfect in most if not all countries. Several problems and constraints still persist and need to be addressed. This section presents an overview of the current and future activities on wastewater treatment and reuses in some countries of the region.

Cyprus

In Cyprus, treated wastewater and reuse is considered a realistic option as a source of water to mitigate shortage and cover part of water needs. It also has the objective of meeting wastewater disposal regulations to protect the environment and public health. From the environmental point of view, the reuse of treated wastewater in irrigation is considered as the safest, easiest and most useful disposal approach.

At present, 180 Mm^3 of water, representing 75% of the mean annual available amount, are used in agriculture. The remaining 25% (60 Mm^3) are used for domestic water supply industry and other purposes. The volume of sewage water treated at the tertiary level amounts to 6 Mm^3/yr. It is produced by 20 treatment plants and used mainly for irrigation purposes. Twelve other secondary treatment plants produce treated wastewater for other uses but not for irrigation (Photiou, 2001). The government has recently launched a program of implementation of new sewerage, wastewater treatment and reuse of treated wastewater in two major tourist areas; Limassol in the southern coast and Larnaca and Ayia Napa-Paralimni in the southeastern coast. It is expected that with the completion of these and other central collection and treatment plants in the cities and villages by the year 2012, the volume of treated wastewater will reach 30 Mm^3 and become available for use (Photiou, 2001). This will reportedly allow irrigated agriculture to be expanded by 10%, while conserving an equivalent amount of water for other use sectors.

Because of the scarcity and high cost of land, only conventional treatment plants are adopted. Treatment plants in villages are considered as a basic instrument for agricultural, social and environmental policy of the country; the government covers 75% of their cost. In cities, the cost of construction and operation of tertiary treatment plants as well as the cost of treated wastewater distribution to farmers are covered by the government.

There are three main institutions involved in the production, treatment and reuse of wastewater. The Water Development Department, which is responsible for the implementation of water policy, is body responsible of tertiary treatment as well as allocation and distribution to the farm level. The Department of Agriculture is responsible for the education of farmers in all matters related to agricultural production with the use of treated wastewater. It has also the mandate of monitoring the code of practice at farm level. The sewerage boards have the responsibility of operation and maintenance of the main sewer systems (pipes, pumping stations and treatment plants).

The problems related to current practices of wastewater reuse are multi-dimensional. They relate to the environment, health, regulatory, legal, social acceptability and public information as well as training.

Egypt

In Egypt, limited investment in wastewater collection and treatment infrastructure in the past has resulted in a significant shortfall in sanitary coverage and a growing surface water pollution problem. The discharge of raw and insufficiently treated wastes into the Nile and irrigation canals and drains threaten the environment and degradation of fresh water resources. Water pollution in the Delta tends to be higher compared to other regions. Three agricultural drainage reuse pump stations were shut down due to the high level of pollution in drainage water caused by untreated wastewater that mixes with agricultural drainage. The northern lakes are also affected by the pollution that results in fish production loss (MWRI, 2001). In rural areas, both in the Delta and the Valley, wastewater represents a major problem to agricultural drains where untreated wastewater is discharged and which are used in irrigation at some locations along the irrigation network. Therefore, the government started an ambitious program to treat the sewage water of these areas before discharging it into the drains.

The Egyptian water strategy comprises the treatment and reuse of wastewater. Treatment of municipal wastewater is either primary or secondary. At present, wastewater is estimated at 4,930 Mm^3/yr, with 22 operational wastewater treatment plants, and about 150 plants under construction. The total capacity of the installed treatment plants amounts to about 1.752 billion m^3/yr (FAO, 2000).

Wastewater reuse in Egypt is an old practice. Since 1900, sewage water has been used to cultivate orchards in a sandy soil area at El-Gabal El-Asfar village, near Cairo. The area gradually increased to about 4,500 ha. According to the law, reuse of treated wastewater is not permitted for food and fiber crops. The Ministry of Agriculture advocates the restricted reuse of treated wastewater for cultivation of non-food crops such as timber trees and green belts in the desert to fix sand dunes.

The major problems and issues related to the current use of treated sewage water in Egypt are summarized below (Shaalan, 2001): (a) not enough infrastructure (treatment plants) to treat the amounts of wastewater produced, (b) only about 50% and 3% of the urban and rural populations, respectively, are connected to sewerage systems, (c) a significant volume of wastewater enters directly into water bodies without any treatment, (d) many wastewater treatment facilities are overloaded and/or not operating properly, (e) some industries still discharge their wastewater with limited or no treatment into natural water bodies, (f) municipal and industrial solid wastes are mainly deposited at uncontrolled sites and/or dumped into water bodies (especially outside Greater Cairo), (g) the quality of treated wastewater differs from one treatment station to another, depending on inflow quality, treatment level, plant operation efficiency, and other factors, and (h) negative impacts of the above problems on both health and environment.

From the institutional standpoint, seven ministries are involved in wastewater treatment and reuse in the country, with unclear delineation of responsibilities and limited coordination among them. The situation is further worsened by the absence of clear policies and action plan on wastewater management as well as standards that are practically impossible to enforce and which limit the effectiveness of pollution control abatement efforts. Dissemination of information among various organizations and to the public is limited, which substantiates the need for increased awareness and capacity strengthening regarding water quality management issues (Shaalan, 2001).

Iran

The policy of wastewater treatment and reuse in Iran is considered essentially as a means to protect water resources from degradation, but also to benefit from reclaimed water through reuse in agriculture. Currently, there are 39 treatment plants with a total capacity of 0.712 Mm^3/d (i.e. about 260 Mm^3/yr). A set of 79 treatment plants with total capacity of 1.917 Mm^3/d is under construction and expected to be operational by the year 2005. Furthermore, 112 treatment plants, with total capacity of 1.590 Mm^3/d, are being studied for completion by the year 2010. The current plan increases the volume of treated wastewater to reach 10.5 Mm^3/d (about 3,830 Mm^3/yr).

Out of the volume treated at present, 64% are from Isfahan, the first city to have a full wastewater collection system since nearly 30 years ago. Wastewater is discharged into rivers and flood ways where it is mixed and used for irrigation or infiltrates into groundwater. In some parts of the country, raw wastewater is used directly for irrigation, albeit in limited quantities, resulting in health and other problems (Mahmoudian, 2001).

In other areas, the main method for wastewater discharge is through absorption wells, through which part or all of the discharged wastewater reaches underground aquifers and is drawn and used for irrigation later on. As a result, signs of pollution are threatening the freshwater resources in some areas. For example tests have shown that nitrate content in

groundwater resources near the cities Mashad and Arak is 180 and 220 mg/L, respectively, which is many times higher than the allowed limits.

The problems related to the current practices and facing implementation of the policy of wastewater reuse in Iran are numerous and concern all aspects. There is a great gap between the pace of construction of treatment plants and the actual demand. The legal and regulatory framework is not adequate for taking action against polluting industries and the users of raw wastewater in agriculture. The rules on who should support the cost of operation and maintenance of treatment plants are not clear. From the institutional standpoint, the responsibilities are diffused within a multitude of bodies with no or limited co-ordination. In towns and areas where traditional sewerage systems have been inefficient, people are reluctant to pay wastewater connection fees. The shortage of information and awareness on wastewater risks and benefits is also evident.

Jordan

The produced wastewater in Jordan is reported to be 300 Mm^3/yr. The volume of treated wastewater, produced by 19 plants, is estimated to be 72.5 Mm^3/yr (Bataineh *et al.*, 2002). Six treatment plants out of the 19 units employ wastewater stabilization ponds. The remaining 13 plants are conventional mechanical plants that treat about 85% of the total generated wastewater. With over 95% of the country being desert, land availability for such stabilization ponds is not a significant problem. The treated wastewater is mostly discharged to watercourses and participates in water demand at a level of 13% of the total water used for irrigation. The irrigated area using direct treated sewage is estimated at 630 ha while 3,000 ha are irrigated by indirect irrigation using treated effluent in the Jordan Valley (FAO, 2001). Standards for wastewater treatment and reuse in the form of a Martial law were introduced in 1982. In 1989, a new version of the Martial law was enforced which could be considered more liberal than the previous one. No vegetables (for cooked or uncooked consumption) are allowed to be irrigated with direct treated wastewater. Like other countries of the region, problems have been reported such as the inadequate planning of the wastewater reuse scheme, insufficient medical control for the agriculture workers, inadequate training, and insufficient resources to monitor and control treated effluents.

Kuwait

Untreated sewage has been used for many years to irrigate forestry projects far from the inhabited areas of Kuwait. Effluent from the Giwan secondary sewage treatment plant was used to irrigate plantations on an experimental farm from 1956. Following extensive studies by health and scientific committees within the country and by FAO, the government of Kuwait decided to proceed about 117 Mm^3/yr (FAO, 1992). The United Agricultural Production Company, under government license, has established a farm of 850 ha in 1975 for the purpose of utilizing the treated wastewater. The directors of this close shareholding company represented the main private organizations involved in Kuwait agriculture, in particular the local dairy, poultry and livestock farming organization. In 1975, only part of the area was under cultivation, with forage (alfalfa) for the dairy industry as the main crop, using side-roll sprinkler irrigation. However, peppers, onions, and other crops were grown on an experimental basis, using semi-portable sprinklers and flood and furrow irrigation (FAO, 1992). Regulations are adopted in Kuwait to restrict the treated wastewater reuse to safe crops; the law excludes all amenity uses from the treated effluent and restricts agricultural use to safe crops. An efficient monitoring system for the treated effluent, the soil, and crops has been implemented since the experimental farm was initiated.

Morocco

Most Moroccan towns are equipped with sewerage networks, collecting also industrial effluent. Collected volumes of wastewater were estimated at 546 Mm^3/yr in 1999, and are expected to reach 900 Mm^3 in 2020. About 58% of the currently generated wastewater is discharged to the Mediterranean and Atlantic coasts and the other 42% are discharged to rivers and flood paths. Treated wastewater is considered as a source of water but its contribution to the national water balance will not exceed 4.2% (El Atiri and Rezgui, 2002). Moreover, this potential of wastewater cannot be totally mobilized since most of it is produced by plants located along the coasts of the Mediterranean Sea and the Atlantic Ocean, away from agricultural lands. The high cost of transferring treated wastewater to irrigated areas constitutes another constraint of wastewater reuse (Jemmali and Abdel-Majid, 2002).

At present, there is an area of about 7,000 ha directly irrigated with raw wastewater discharged by towns (about 70 Mm^3/yr) with no precautionary measures. This practice is tolerated although it contradicts the regulations that prohibit the cultivation of market crops that put the farmer and the consumer at health risk. The lack of wastewater treatment, prior to its reuse in inland cities, results in adverse health impacts and a high incidence of waterborne diseases. Major improvements are needed urgently because of the strong migration of the rural population towards the towns and the very fast demographic expansion.

Improvement in wastewater reuse methods and the quality of reused water for irrigation is recognized as essential. The country does not have yet any specific wastewater reuse regulations, but reference is usually made to the WHO recommendations. A number of controlled, pilot wastewater reuse–irrigation schemes are currently in place in Morocco.

Saudi Arabia

The Kingdom's policy is to use all available treated municipal wastewater particularly for agriculture. Reclaimed wastewater can help meet increasing demands for agriculture and landscape irrigation, for industrial abstraction, and for possible recharging of aquifers. At present, about 674 Mm^3/yr of reclaimed wastewater is available in Saudi Arabia. Only 36% of the treated wastewater is used in irrigation while the remaining is discharged to land (34%), disposed to sea (18%), and about 12% is reused for industrial purposes, groundwater recharge and landscape (Al-Morgin, 2001).

Until recently, there were no national standards or regulations for the wastewater reuse or even for the disposal of it. However, guidelines were issued by different governmental agencies that all require secondary and tertiary levels of treatment for unrestricted irrigation (Papadopoulos, 1995). Efforts are currently underway to develop national standards through consulting interrelated ministries and departments and technical assistance from FAO.

Syria

The average annual precipitation in Syria is 252 mm or 46,000 million m^3/yr. The total renewable resources are 26,260 million m^3/yr, whereas, the availability and dependency ratio are 1791 m^3/inh.yr and 80.3%, respectively.

The total volume of industrial and municipal wastewater effluent is estimated at 400, 700 and 1,600 million m^3/yr for 1990, 2000, 2025 years, respectively. The discharge of these wastes in a non-treated form into watercourses and rivers led to the degradation of surface water quality to the point where it became unsuitable for direct use for drinking purposes. The most important results of this noticeable pollution of rivers and other water bodies were the disappearance of living organisms because of the lack of oxygen, the appearance of undesirable plants and weeds that clog water canals in certain regions, hateful odours resulting from decomposition of organic materials and the abundance of

insects and rodents. The health conditions of the population living in the areas of intensive use of untreated wastewater also degraded. Diseases such as typhoid and hepatitis spread at a much greater rate in these regions. Animals were also subjected to several waterborne diseases such as tapeworm and tuberculosis and other infectious diseases. The total area irrigated with wastewater is estimated at around 40000ha, with 20000 in Aleppo (Zulita and Abboud, 2001).

Several WWTP have been already implemented, such as Damascus (Adra), Aleppo, Homs, Salamyeh, Ras El Ein, and Haramil Awamid. The treated wastewater potentially available for reuse is estimated in 400 million m^3/yr by which an agricultural area more than 40,000 ha could be irrigated. Several other WWTP are under planning or construction such as Tartus, As Sweida Idleb, Al Raqqua, Al Nabik and Dar'a. Thus, the treated wastewater is expected to increase substantially in the near future.

To face this alarming situation and at the same time secure treated water for use in agriculture, the Syrian government launched a programme for constructing several treatments plants two of which are already operational in Damascus and Aleppo. The Damascus plant currently treats 300 m^3/d using activated sludge method. The total area irrigated by treated and untreated water is 18,000 ha located in the outskirts of the city. With the exception of a large share of wastewater produced in Damascus and Aleppo, the collected raw sewage from the cities, villages and other residential areas is used without any treatment, either for direct irrigation of agricultural crops or disposed to the sea or water bodies that are used for unrestricted irrigation. The use of wastewater is restricted to fodder, industrial crops and fruit trees on smaller areas, but it is uncommon that it is used for other crops as well. The situation is expected to improve when several treatment plants under construction in all large cities of the country are co-ordinated. In towns and areas where traditional sewerage systems have been inefficient, people are reluctant to pay wastewater connection fees. The shortage of information and awareness on wastewater risks and benefits is also evident.

Tunisia

Tunisia has paid extensive attention to wastewater treatment, mainly to protect the environment, since the mid-1960s. Treatment plants were concentrated on the coastal areas where the big cities are located along the coast of the Mediterranean Sea. The treated wastewater volume rose from 12 million m^3/yr in 1975 to 140 Mm^3/yr in 2001, which represents about 58% of the total collected sewage water.

Of 240 Mm^3 of wastewater discharged annually, 140 Mm^3 (58%) are treated in 61 treatment plants around 41 of which have a daily capacity less than 3,500 m^3 and 10 are above 10,000 m^3. Municipal wastewater is mainly domestic (about 88%) and processed biologically up to a secondary treatment stage. Industry is forced to comply with the Tunisian standards to discharge wastewater into the sewerage system. So, preliminary treatment plants to fulfil the discharge requirements stated in the regulations are required and subsidies are provided to equip industrial units with pre-treatment processes (Bahri, 1998). The treatment processes vary from plant to plant depending on wastewater origin and on local conditions. Out of 61 treatment plants, 44 are based on activated sludge (medium or low rate), 3 on trickling filters, 14 on facultative or aerated ponds. Sanitation master plans have been designed for several towns. The annual volume of reclaimed water is expected to reach 290 Mm? in the year 2020. The expected amount of reclaimed water will then be approximately equal to 18% of the available groundwater resources and could be used to replace groundwater currently being used for irrigation in areas where excessive groundwater mining is causing salt-water intrusion in coastal aquifers (Bahri, 2001).

Irrigation with treated wastewater is well established in Tunisia. The current irrigated

area on treated sewage is about 6,600 ha using only about 20% of the treated sewage. The latter is available to farmers but not suitable for crops that are economically profitable; in addition it is considered as a source of health risks. Future plans for using treated wastewater in agriculture includes an additional area of 2,000 ha. A big project is also being studied to irrigate an area of 6,000 ha. In the future, the total area irrigated with treated wastewater is planned to reach a level of 20,000 ha when the capacity of treatment reaches 215 Mm^3/yr.

Other uses of treated wastewater include irrigation of golf courses, hotel gardens and green areas, industrial usage, and groundwater recharge. There are eight golf courses, covering an area of 600 ha, irrigated with 4 million m^3 of treated wastewater annually, which accounts for about 4% of the total treated wastewater. Most of these golf courses are operated by the private sector, which provides high profits since it is used in tourism activities. There also are about 100 ha of irrigated gardens, such as hotel gardens and green areas (roadsides and airports), using treated sewage. A groundwater recharge project was initiated in 1986 in Nabeul to protect groundwater from seawater intrusion and over-drafting. The recharged volume of treated wastewater ranges from 60,000 to 200,000 m^3/yr. Different problems and constraints have been reported such as the inadequate planning of wastewater reuse projects, the insufficient resources to monitor and control treated effluents and products, insufficient medical care for agriculture workers, some equipment and management problems, and the inadequate education and training for farmers and extension services.

Yemen

Major cities in Yemen such as Sana'a and Taiz are desperately short of water, including for drinking purposes. With progressive coverage of urban water supply and sewerage services, increasing quantities of wastewaters are being produced (Angelakis, 1997). Currently, nine wastewater treatment plants are installed in Yemen and produce about 33.5 Mm^3/yr, which represents only 69% of their capacity. It is expected to reach the total design capacity of these plants by the year 2005 (Qahtan, 2001). An additional three stations of the stabilization pond type, with a total design capacity of 70 m^3/d, are under construction and should be operational soon. It is also estimated that some 74 Mm^3/yr of effluent will be potentially available for reuse in the near future, and that up to 15,000 ha of land will be irrigated with treated wastewater. However, most wastewater treatment plants in Yemen are suffering from lack of maintenance and operational control (Sorour, 1999).

The practice of wastewater reuse is encouraged by officials in the Ministry of Agriculture and Irrigation particularly to build green belts in the coastal plain cities and for sand dunes fixation. But because of the very high demand for water, particularly for irrigation, farmers throughout the country use both treated and untreated wastewater freely for irrigation, without any concern about quality. Such use, which is mainly for growing corn, wheat, sorghum and barley, is currently taking place in an increased rate in Taiz and Aden. The growing of sensitive crops is not uncommon. The consequences of these practices on health and the environment are as expected (FAO, 1997b). Like many other developing countries, Yemen is lacking almost everything needed for appropriate use of wastewater. Efforts to invest in treatment plants is a good sign but they still needs to be followed by the rest of measures and actions.

Issues and the way forward

Unclear policies on wastewater reuse

Nearly all Near East countries recognize the importance of wastewater and have adopted its treatment for health control and environmental protection as well as its reuse as a potential source of water for agriculture and other purposes. However, clear policies and comprehen-

sive planning to optimize the use of this resource and to reduce its environmental risks and health risks are still lacking. The largest share of the current wastewater potential is not treated and continues to be a threat to health and the environment, particularly fresh waters. Considerable amounts of the treated amounts are discharged to the sea or lakes without reuse. Unplanned use of raw wastewater is also a common practice in many areas.

More systematic approaches in wastewater treatment and reuse need to be adopted, including planning and involvement of concerned departments – governmental or private – in the process. This would allow identification of the potential of reuse according to quality, of the required storage and distribution facilities, and of the optimal management tools and practices. Treated wastewater represents an alternative source of water in all areas, especially those suffering from water deficit. Reclaimed water is a reliable source with less or even no seasonal fluctuations when compared to conventional water sources.

Technology and cost of wastewater treatment

All treatment levels are currently adopted in the region, depending on the expected quality of the effluent: primary, secondary and tertiary. Specific processes that reduce nitrates and phosphates and remove remaining bacteria are also used in certain limited situations. As the mechanical process of treatment increases the cost, most countries prefer implementing the low-cost models of wastewater reclamation. However, these approaches depend totally on natural aeration ponds, which require relatively large areas. Due to the existence of communities on high-value land, land acquisition for construction of low-cost treatment models is a conflicting matter. This problem is faced for instance in Egypt, in the Nile valley and Delta governorates, except Cairo, where treatment plants are constructed on agricultural lands. As these areas are productive and difficult to be subjected to expropriation, a mixed system of treatment that consists of natural and mechanical aeration is being used, and this raises the cost of treatment. In other cases, activated sludge system is also used, as the available land for the plant is small, which puts an additional cost to the wastewater reclamation process. In addition to the availability of land, the type of treatment model is also determined by climatic conditions, particularly wind speed as a major factor for natural aeration. In areas with relatively low wind speed, such as those located in depressions or behind physical barriers, mechanical processes have to be included.

Mechanical approaches for wastewater treatment are very common for large-scale wastewater treatment of communities with high population. The cost of capital investment is not the only constraint since that of operation and maintenance is also high. Deficiencies in maintenance, often resulting from financial constraints that do not comply with the required equipment and supply of spare parts, often lead to low quality of treated wastewater.

The high cost of wastewater treatment can be offset when considering the incurred benefits on health and the environment, in addition to the value added in irrigation and the equivalent of fresh water released for other uses. In Egypt, trees such as African Mahogany grown using treated wastewater showed high economic value. The cost of mobilized reclaimed wastewater for use in agriculture can be less than that of conventional water when considering the construction of a new dam for instance. In Tunisia, reclaimed wastewater can currently compete with groundwater and shows less cost paid by users particularly when reclaimed wastewater is reused in areas near the treatment plant. Transmission of reclaimed wastewater to farther areas will add other costs to reuse scheme that might reduce the benefit/cost ratio. Treatment facilities are also a major factor in the cost side. In countries where natural treatment is not possible, costs will increases due to use of mechanical methods that require considerable energy.

Reclaimed wastewater could be a competitive source in the water markets. Investigation

of potential markets for reuse of reclaimed water should be considered in planning. The high cost may result from the lack of economic feasibility studies and the subsequent selection of inadequate treatment models. Unfortunately the absence of comprehensive economic feasibility studies is common in the NER.

Restrictions on use

The policy of restricted reuse of treated wastewater cannot be put in parallel with that of recovering the cost of treatment from the end-users. The treatment cost is often much higher than the value added from using treated water for irrigation, particularly since the crops allowed to be grown are not high value cash crops. The consumers of drinking water are the polluters and should support the largest share of treatment, and this is actually the policy in the region.

There a paradox between crop restrictions and what is actually practiced by farmers in the field. While standards and regulations are very stringent, the level of their implementation is extremely week. Vegetables and other sensitive crops are normally excluded from irrigation with treated wastewater in most countries, but in practice the rule is not respected, including with raw wastewater, because these crops are the most profitable to farmers. The latter are generally not aware of the limitations imposed by the laws. The regulations can be considered only as a safeguard in the first phase of the process, but there should be a gradual build-up of knowledge, through training and extension. As quality of treated water and the knowledge of farmers and technicians improve, restrictions should also be lifted gradually. This will in turn increase demand for wastewater.

Sprinkler and localized irrigation systems are recommended for use with wastewater, but their use is constrained when treatment level is not adequate (clogging problems).

Impact on groundwater

Treated wastewater is normally used directly for irrigation or stored in reservoirs for use when needed at later times. When the construction of storage reservoirs is not feasible, an alternate solution is recharge of groundwater aquifers. In areas where water table is high and/or the aquifer layers are of low permeability, recharge of groundwater using treated sewage may not be recommended. It is well recognized in the Near East that reclaimed water could be used for compensation of over-drafted aquifers, with reliable recharge depending on the level of treatment. The recharge option is not favored in many countries, particularly in areas where groundwater is used for potable water supply. It is however widely practiced in some countries such as Iran.

In Tunisia, there is a pilot scheme for seasonal recharge of shallow groundwater below sandy soils, using secondary treated sewage. The practice resulted in an increase during summer of the volume of water extracted by farmers to irrigate citrus and orchards. The rise in water table also reduced the cost of pumping (Bahri, 2001). The high concentration of some species such as nitrogen, boron, sodium, and chloride may result in deterioration of groundwater quality. Some countries, particularly those located along the coast, developed strategies for using reclaimed water to recharge salt-effected aquifers along the coast.

The high cost of recharge may represent a constraint to the reuse of reclaimed water. Often recharge schemes seem to be cost effective, but economic feasibility studies are needed to substantiate the economic opportunity each time a scheme is planned.

Monitoring programs, information systems and database

Monitoring in the field of treated wastewater is essential to assess treatment performance and ensure protection of public health and the environment. In practice however, monitor-

ing programs are limited to the effluent, with no concern to the utilization areas. Monitoring of treated wastewater before its reuse is important to assess its suitability for irrigation, but it should also be extended to crops, soils and groundwater, as a measure of controlling hazards and achieving protection measures for consumers and farmers. Most Near East countries lack comprehensive wastewater monitoring programs that ensure appropriate treatment and reuse of wastewater.

The monitoring data and all information related to the treatment and reuse systems should normally be kept in a database to serve for evaluation purposes and to investigate any shortcomings in operation, such as changes in influent and effluent water properties. Results of evaluation constitute valuable information when establishing new reuse schemes.

Institutional issues and conflicts among organizations

One of the major constraints of wastewater reuse in NER countries is the institutional framework. Wastewater management responsibilities are usually distributed among different governmental departments with no or little coordination. The heavy investment in wastewater treatment needs cooperation between all concerned departments to utilize the produced reclaimed water in a manner that achieves benefits. In most countries, there are usually at least five ministries involved in the management of wastewater resources. The department in charge of treatment, the ministry of water resources and/or irrigation for planning and allocation, the ministry of agricultural responsible of use at the field level, the ministry of health for health protection and the ministry of environment. Other units may also be concerned one way or another, such as municipalities, the private sector and farmers organizations. The lack of cooperation between these bodies often result in inefficient use and a wide range of problems. Monitoring is also not clearly defined among these institutions. Tunisia has achieved a high level of inter-ministerial collaboration for water reuse, partly through an inter-ministerial committee that defines the linkage and respective responsibilities of the concerned institutions.

A solution to the inter-ministerial conflict is the involvement of the private sector through the BOT system to produce suitable treated wastewater and sell it to farmers. Fees of such water will be determined based on its quality. The BOT system is now underway in Tunisia and Jordan. Involvement of the private sector could be extended to purchase and reuse the reclaimed water through BOT system to grow forest, golf courses and other type of reuse such as in Morocco and Egypt.

Lack of legislation and standards: illegal use of untreated sewage

The legal framework of wastewater reuse is to protect the field workers, the general public who might be exposed to the reclaimed water and the consumers who eat the food irrigated with the reclaimed water. The legal framework concerns developing and enforcing suitable regulations and standards, but this is usually constrained by inter-ministerial conflicts. Several countries have set standards for treatment and reuse of wastewater and regulations for implementing them. The regulatory framework is either not comprehensive or incompatible with the conditions and capacity of the country to enforce it.

Each country may have local standards compatible with its economy, its social demand and its environmental and other conditions. These standards may not initially comply with the world standards, such as WHO or the European Community standards, but would improve with time as the capacity of the country is improved. Revision of water laws and regulations are being conducted in some of the Near East countries to eliminate the conflicts and ensure a higher degree of implementation. Comprehensive laws are expected to be the output of the on-going efforts.

Social acceptance and reluctance

Where the use of sewage water is not a common practice from past times, reclaimed water has been less desirable by farmers and other users, when compared to fresh water. Therefore, selling reclaimed water, even at a considerable subsidy level, may need campaigning to convince water users to accept treated wastewater. Water users, particularly farmers, may be right to be reluctant to use treated wastewater as it affects the selling of their products. Saudi Arabia, for example, has banned importing Jordanian crops grown with inadequately treated wastewater effluent (Sheikh, 2001). This may need to establish a focused educational activity to counter misunderstanding and misapprehensions by consumers. The government, through a well established control system for wastewater reuse, should support and protect the marketing of agricultural products grown using reclaimed water.

Lack of awareness and training

The lack of awareness on the suitability of reclaimed water in recycling uses such as irrigation may constraint its reuse. In the Near East countries, awareness activities usually are not included in the projects on reuse of reclaimed water. Religion could also be considered in awareness campaigns. In 1979, the Islamic Council of Research and Consultation in Saudi Arabia issued a statement, after consultation with technical and health experts, indicating that properly treated wastewater can be considered clean if it poses no health hazards (Al-Mogrin, 2001). The United Emirates issued a similar statement (Fatwa) stating that wastewater could be reused whenever it returns to its natural form free from impurities.

In most countries, the lack of awareness on the health hazards of non-reclaimed wastewater constitutes a major problem. It is recorded that farmers use treated wastewater, or even non-treated, to grow restricted and non-restricted crops. Training and awareness to build skills and knowledge on using the reclaimed water should be considered in the planning process of reuse projects so as to protect all groups under risk. The training programs should also focus on technical aspects, in addition to health and environmental aspects, for reuse such as introducing micro irrigation techniques to reduce exposure of farmers to reclaimed water. Awareness and educational training programs should also be extended to include schools curricula.

Health aspects and issues

One of the major issues that constrain the reuse of reclaimed water is the health hazard associated with reuse schemes. These hazards depend on the degree of treatment and on the safety and protection measures adopted. The lack of health care and protection measures for farmers, workers and consumers is reported in nearly all countries of the region. Consequently, the spread of diseases associated with wastewater reuse is common in many places where such reuse is practiced with as well as without treatment.

Need for cooperation framework: regional network on reuse of wastewater

The need for establishing a regional network on wastewater treatment and reuse in the NER has been demonstrated during an "Expert Consultation on Low-Quality Water Reuse for Sustainable Agriculture", co-organized by FAO the World Health Oorgainzation (WHO) in Amman, Jordan, in 1997. The forum was the result of joint collaboration efforts of the Regional Inter-Agency Task Force on Land and Water Resources (IATF) which comprised most international and regional organizations active at the time in wastewater treatment and reuse in the NER. In order to strengthen regional co-operation in the field of treatment of wastewater and its use for irrigation, three alternatives were considered: (a) strengthening the existing relevant institutions; (b) formation of a regional network; and

(c) establishment of a specialized centre. After considering these alternatives, the Consultation concluded that the first step for strengthening co-operation among the countries of the region is to establish a "Regional Network on Wastewater Reuse".

Recognizing the role of such a network in enhancing regional consultation and exchange of experience, member countries during several forums held in the late nineties requested FAO and WHO to take the lead in establishing it, in close cooperation with the other relevant organizations. FAO/RNE prepared an assessment report on the status of wastewater treatment and reuse in the region, by country, then elaborated jointly with WHO a framework for the Network. The latter was launched through an Expert Consultation organized by FAO and WHO in Amman, Jordan, in November 2001. It was attended by designated focal points from most countries of the region that have developed wastewater treatment programmes, by regional and international organizations member of IATF and by representatives of bilateral cooperation from several countries. It is believed that the Network will promote regional cooperation and exchange of experience both within and outside the region. The first activity of the Network is already underway and concerns updating of the status of wastewater and its reuse in agriculture in the region, in preparation of a forum to held in the year 2002.

Conclusions

Treatment of wastewater and its suitability for reuse depend on the treatment technologies used. Waste stabilization ponds (lagoons) constitute low cost technology that might be suitable for the countries of low-economic situation. High-level technology, such as conventional (mechanical) treatment, is adopted essentially by strong economies. The high cost of wastewater treatment is offset when considering the incurred benefits on health and the environment, in addition to the value added in irrigation and the equivalent of fresh water released for other uses.

One of the major constraints of wastewater effluent reuse in the Near East countries is the institutional framework. Diffuse responsibilities and the lack of cooperation between the concerned governmental bodies often result in an inefficient use and a wide range of problems, a fact that necessitates the establishment of multi-institutional national committees to coordinate the internal functions of all concerned departments.

An overview on wastewater effluent reuse in the Near East Region indicates that some countries have a national policy to reuse all treated wastewaters and have already made considerable progress in the field. A second category of countries are mid-way in the process and are accomplishing encouraging advances. The situation however is lagging behind in several other countries where the matter has received no attention, and which are in the need from policy-makers, investors, and donors for assisting them to lift the constraints and to upgrade their capacity. In most countries, the lack of awareness on potential health hazards of using not properly treated wastewater constitutes a major issue. These countries need, in addition to clear policies on the subject, training programs that focus on technical aspects, in addition to health and environmental aspects, such as introducing adapted modern irrigation techniques to reduce exposure of farmers to recycled water.

In order to enhance the exchange of experience and regional co-operation in wastewater treatment and reuse for irrigation, some Near East countries have initiated the establishment of a regional network on the reuse of treated wastewater, with assistance from FAO and WHO. The Network constitute a framework that could contribute to addressing the current problems facing wastewater reuse in the region.

References

Al-Morgin, S. (2001). Status of water and wastewater reuse in Saudi Arabia. *Joint FAO/WHO Consultation for Launching the Regional Network on Wastewater Reuse*. Amman, Jordan.

Angelakis, A.N. (1997). Wastewater Reclamation and Reuse Practices for Urban Areas of Yemen. *FAO Report*. UTF/YEM/024. Rome, Italy.

Bahri, A. (2001). Water reclamation and reuse in Tunisia. *Joint FAO/WHO Consultation for Launching the Regional Network on Wastewater Reuse*. Amman, Jordan.

Bahri, A. (1998). Wastewater reclamation and reuse in Tunisia. *Wastewater Reclamation and Reuse*, T. Asano (Ed.). Water Quality Management Library. Vol. 10, Technomic Publishing Company, Inc.

Bataineh, F., Najjar, M. and Malkawi, S. (2002). Wastewater reuse: the case of Jordan. *The First WDM Forum on Wastewater Reuse*, IDRC, Rabat, Morocco, 26–27 March.

Bazza, M. (2001). Experience of FAO on Wastewater Reuse in the NER. *Regional Workshop on Water Reuse in the Middle East and North Africa*, World Bank Middle East and North Africa Region. Cairo, Egypt, 2–5 July.

Crook, J., Ammerman, D., Okun, D. and Matthews, R. (1992). *Guidelines for Wastewater Reuse*. Camp Sresser and Mckee, Cambridge.

El Atiri, R. and Rezgui, F. (2002). Wastewater reuse: the case of Tunisia. *First WDM Forum on Wastewater Reuse*, IDRC. Rabat, Morocco, 26–27 March.

FAO (1992). Wastewater Treatment and Use in Agriculture. *FAO Irrigation and Drainage Paper No. 47*. Rome, Italy.

FAO (1997a). Irrigation in the Near East in figures: *Water Reports No. 9*, Rome, Italy.

FAO (1997b). Watershed Management and Wastewater Reuse in Peri-Urban Areas of Yemen. *Project Document* GCP/YEM/026/NET, Rome, Italy.

FAO (2000). Water Quality Management and Pollution Control in the Near East: An Overview. Regional Workshop on Water Quality Management and Pollution Control in the Near East. Cairo, Egypt.

FAO (2001). Strengthening Capacity for the Reuse of Treated Wastewater in Irrigation. *Draft Project Document for Syria*. FAO Regional Office for the Near East, Cairo, Egypt.

Jemmali, A. and Abdel-Majid, K. (2002). Wastewater Reuse: the Case of Morocco. *First WDM Forum on Wastewater Reuse*, IDRC, Rabat, Morocco, 26–27 March.

Mahmoudian, S. (2001). Water from Water: A Review of Wastewater Reuse in Iran. *Joint FAO/WHO Consultation for Launching the Regional Network on Wastewater Reuse*. Amman, Jordan.

MWRI (2001). Application of Policies and Procedures for Improved urban Wastewater Discharge and Reuse. *Report No. 34 Agricultural Policy Reform Program*. Cairo, Egypt.

Papadopoulos, I. (1995). *Wastewater Management for Agricultural Production and Environmental Protection in the NER*. FAO Regional Office for the Near East, Cairo, Egypt.

Photiou, C. (2001). Status of Water and Wastewater Reuse in Cyprus. *Joint FAO/WHO Consultation for Launching the Regional Network on Wastewater Reuse*. Amman, Jordan.

Qahtan, Y.A. (2001). Yemen's Water Resources and Treated Wastewater. *Joint FAO/WHO Consultation for Launching the Regional Network on Wastewater Reuse*. Amman, Jordan.

Shaalan, N.S. (2001). *Egypt Country Paper on Wastewater Reuse*. Joint FAO/WHO Consultation for launching the Regional Network on Wastewater Reuse. Amman, Jordan.

Sheikh, B. (2001). *Water Reuse Issues in the Middle East and North Africa Region. Draft Report*. The World Bank.

Sorour, M.T. (1999). *Mission Report*. GCP/YEM/026/NET Watershed Management and Wastewater Reuse in Peri-urban Areas of Yemen. Cairo, Egypt.

Zulita, A. and Abboud, G. (2001). The Uses of Non-Conventional Water Resources (Treated Wastewater and Industrial Water) in Agriculture. *Joint FAO/WHO Consultation for Launching the Regional Network on Wastewater Reuse*. Amman, Jordan.