

## Wastewater Reuse: Problems and Challenges in Cyprus, Turkey, Jordan and Morocco

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**Abstract:** In many situations in various countries wastewater is simply too valuable to waste. The Mediterranean countries are characterized by a severe water imbalance, mainly in the summer months, especially those located in the North Africa and Middle East region. This imbalance in water demand versus supply is due mainly to the relatively and uneven distribution of precipitation, high temperatures, increased demands for irrigation water and the impacts of tourism. To alleviate water shortages serious consideration must be given to wastewater reclamation and reuse. The sustainable wastewater treatment and reuse is a continuous challenge. MEDAWARE project funded by the Euro-Mediterranean partnership, seeks to develop a methodology for the safe wastewater reuse in the countries of this region. Through this project a methodology which deals with the main issues that are related with the problematic treatment and reuse of wastewater is being developed. This paper gives an overview of the project's methodology while at the same time provides an insight on the existing situation prevailing in various countries in relation to wastewater management and reuse.

**Key words:** urban wastewater treatment and reuse - Mediterranean countries - problems related to safe wastewater reuse.

### 1. INTRODUCTION

There has been an increasing interest in reuse of wastewater in agriculture over the last few decades due to increased demand for freshwater. Population growth, increased per capita use of water, the demands of industry and of the agricultural sector all put pressure on water resources. Treatment of wastewater provides an effluent of sufficient quality that it should be put to beneficial use and not wasted [1]. The reuse of wastewater has been successful for irrigation of a wide array of crops, and increases in crop yields from 10-30% have been reported [1]. In addition, the reuse of treated wastewater for irrigation and industrial purposes can be used as a strategy to release freshwater for domestic use, and to improve the quality of river waters used for abstraction of drinking water (by reducing disposal of effluent into rivers). Wastewater is used extensively for irrigation in certain countries e.g. 67% of total effluent of Israel, 25% in India and 24% in South Africa is reused for irrigation through direct planning, though unplanned reuse is considerably greater.

During the last decade, there has been growing concern that the world is moving towards a water crisis. There is increasing water scarcity in dry climate regions, for example, in Africa and South Asia, and there are major political implications of water scarcity in some regions e.g. Middle East [2]. Water quantity and quality issues are both of concern. Recycling of wastewater is one of the main options when looking for new sources of water in water scarce regions. The guidelines or standards required removing health risks from the use of wastewater and the amount and type of wastewater treatment needed to meet the guidelines are both contentious issues. The cost of treating

wastewater to high microbiological standards can be so prohibitive that use of untreated wastewater is allowed to occur unregulated.

## 2. EXISTING SITUATION IN VARIOUS MED COUNTRIES

In Cyprus, the total number of the main Wastewater Treatment Plants currently in operation is 25. Apart from these treatment plants, which serve the big cities some municipalities and rural communities, there are also some smaller WWTP, (around 175) located in hotels, military bases and hospitals. During the 90's, a large number (approximately 400) of private Wastewater Treatment Plants at the tourist establishments (hotels/hotel apartments) was operating. By placing the wastewater treatment plants in the big cities, this number has been reduced. Currently the needs of 45% of the urban population and 12% of rural population are covered. Nowadays, Cyprus promotes the construction of new sewerage networks and WWTP, as well as extensions at the already working systems, with reference to achieving harmonisation with European Directive 91/271/EC [3], according to which every area with over 2000 residents (municipalities and big communities), must have their own WWTP. Recycled domestic water is presently used for the watering of football fields, parks, hotel gardens, etc. (1.5 million m<sup>3</sup>/yr) and for the irrigation of permanent crops in particular (3.5 million m<sup>3</sup>/yr). It is estimated that by the year 2012 an amount of approx. 30 million m<sup>3</sup>/yr of treated sewage effluent will be available for agriculture and landscape irrigation. No environmental impacts have been observed by the reuse of wastewater due to the fact that very strict standards have been set [4].

Currently in Jordan, there are 19 domestic wastewater treatment plants. These treatment plants were established in big cities that actually serve big areas surrounding these cities. All of the effluents of the existing treatments plants in Jordan are either directly used for irrigation or be stored first in a reservoirs/dams that are used for irrigation. There is no non-sustainable disposal method for the effluent in Jordan. It is considered that the use of effluent for irrigation is sustainable since it complies with the national standards for effluent reuse. In 2003, a large project for evaluating the environmental impact of the past use of King Talal Dam water (which is used to store more than 2/3 of the effluent in the country) for irrigation on the soil, plant/produce quality and water was completed. No negative impact for all variable investigated was determined except for the salt level in the soil which tended to increase in some areas that was related to salinity of the wastewater and as well as to the on-farm management. Unfortunately, no investigation has been made to evaluate the impact on health issues so far [4].

In Morocco, the number of urban wastewater treatment plants in municipalities (from which only 4 are located in cities where the population exceeds 100.000 inhabitants (i.e Agadir, Beni Mellal, Khouribga and Nador), is 49. The number of the plants operating in communities or rural centres is 23. Nowadays, approximately 31 WWTP are in function. The plants serve a population of approximately 900000 inhabitants, out of a total of 13.4 millions. Wastewater in some plants in Morocco undergoes only secondary treatment and hence treated wastewater does not comply with the standards for wastewater reuse in agriculture, [4].

In Turkey, 43 of its 81 provinces have urban wastewater treatment plants and approximately 45% of the country's population is being served. There are a total number of 129 urban wastewater treatment plants in operation according to the most recent official records (Municipalities and personal communication with the treatment plant staff, 2003). A total number of 52 plants are located in 8 of the Greater Metropolitan cities. For example in Antalya being the centre of tourism in South Anatolia, 14 urban wastewater treatment plants are in operation, followed by Istanbul Greater Metropolitan City, i.e. the most crowded city of the country, that has 13 urban wastewater treatment plants and another 6 plants in the highly industrialized province Kocaeli, i.e. the vicinity of Istanbul. A number of 62 plants distributed among Municipalities of provinces are those that are either constructed in the provinces that are not declared as Metropolitan Cities or in the towns of Metropolitan cities with a population >15000. In addition, it is estimated that over 2000 small scale package plants exist in Turkey serving for populations between 20-800 persons. The 75% of these

serve for between 50- 400 pe [5]. These units are mainly used for tourist settlements. Treated municipal effluent is mainly discharged into flowing receiving water bodies like rivers and creeks, and coastal and deep sea environment. Effluent being discharged to rivers and creeks (35 % of the total treated urban wastewater) is partly directly and/or indirectly used for irrigation purposes. Direct denotes reuse of effluents directly in agricultural irrigation, whereas “indirect” indicates reuse through a receiving body. In arid areas in which irrigation activities should be increased for crop production, direct irrigation is experienced. Sustainability of irrigation in contemporary agricultural practices is being negatively affected by some constraints in Turkey that are mainly restrictions on soil, water and energy resources, changes in economic conditions, growing environmental consciousness, and wrong decisions in irrigation system management [4].

### 3. PROBLEMS AND CONCERNS

As it can be observed from the information given above, the potential of improvement is open and the challenges must be faced successfully. Most Mediterranean countries have no well established and effective wastewater treatment plants, neither wastewater reuse standards nor criteria. Nevertheless, an increasing trend in wastewater treatment plant construction and planning is evident in almost all the countries of the Mediterranean basin. In addition, reuse water standards should be developed in a way that will clearly take into account the local conditions while reasonably safeguarding the population.

The field of wastewater treatment and reuse of the effluent for agricultural purposes has received particular attention in the recent years and it is expected that the research activities for the development and application of innovative practices for the most efficient wastewater reuse will be further encouraged in the future. In this framework, many international opportunities for the acquisition of funding exist for the Mediterranean countries. More specifically, organizations such as the European Union (EU), the United Nations, the US Agency for International Development, the World Bank and the European Investment Bank promote and support financially research projects in several areas of interest including the environmental sector and particularly the wastewater treatment and reuse.

In the Mediterranean countries, wastewater, at different level of treatment (raw, secondary or tertiary) is used alone or mixed with fresh water, mostly on forage and cereals but also sometimes on fruit trees and even vegetables, depending on national legislation and its enforcement. Concern for human health and the environment are the most important constraints in the reuse of wastewater. In several cases the wastewater is not properly treated due to the fact that the construction cost of efficient treatment systems is very high, especially for small and medium size communities. Of course many alternative solutions have been developed with the scientific and technological progress during the last years. However, the selection of the appropriate treatment technique that is tailored to the needs of each community means in several cases the involvement of qualified specialists. Moreover, in several cases the outflow of the wastewater treatment systems does not have a standard quality either because standard operating procedures are not followed, or because there is no qualified personnel able to overcome usual problems and to control/monitor the whole treatment procedure.

The positive effects of wastewater irrigation are considered to be the following:

- It conserves water
- It is a low-cost method for sanitary disposal of municipal wastewater
- It reduces pollution of rivers, canals and other surface water resources
- It conserves nutrients, reducing the need for artificial fertilizer
- It increases crop yields
- It provides a reliable water supply to farmer

The potential negative effects of wastewater irrigation are considered to be the following:

- health risks for irrigators and communities with prolonged contact with untreated wastewater and consumers of vegetables irrigated with wastewater

- contamination of groundwater (nitrates)
- build-up of chemical pollutants in the soil (heavy metals)
- creation of habitats for disease vectors
- excessive growth of algae and vegetation in canals carrying wastewater (eutrophication)

In general, the main problem that can create significant obstacles in the safe reuse of the treated wastewater in agriculture is the lack of information of all the involved actors, namely:

- Governmental authorities: lack of legislation and guidelines on the reuse of treated wastewater
- Local authorities and authorities responsible in wastewater treatment: (i) lack of information on innovative cost effective technologies for wastewater treatment, (ii) difficulties in the development of technical specifications for the construction and operation of appropriate wastewater treatment systems (in terms of technology, size, quality of the outflow), (iii) difficulties in the development of specifications for the proper use of the final outflow, (iv) difficulties in finding the appropriate funds for the improvement of the wastewater treatment system
- Operators: lack of knowledge for the efficient operation, control and monitoring of the wastewater treatment system
- Farmers: lack of information on the health risks related to the use of treated wastewater and the appropriate management procedures

The efficient management of the operation of the urban wastewater treatment plants is crucial to the problems described above. Hence their operation needs to be under continuous monitoring and control by the operators themselves and the competent authorities as well. As far as the operation of treatment plants is concerned, the absence of standard methods for samplings, measurements and analyses does not allow for an unambiguous record of quantity and quality of waste that end up in natural recipients, water bodies and underground water, while at the same time unknown quality treated wastewater reuse ambushes many dangers for the environment and public health. The Competent Authorities in most of the countries concerned, at the moment, are not capable of being at any time aware of all data and information concerning the treatment plants. A prerequisite, which is at the moment absent, for the control and monitoring of all the activities taking place in relation to treatment and reuse, is the trained personnel of the authorities and the operators as well.

Concluding, the main problems that have to be dealt with are:

- The non-regulated use of treated water in agriculture
- The non-existing reuse criteria related to hygiene, public health and quality control
- The non-existing reuse criteria related to irrigation techniques, degree of wastewater treatment, and choice of areas and types of crops to be irrigated
- The lack of efficient control and monitoring of urban wastewater treatment plants
- The lack of trained personnel both in the competent authorities and the treatment plants
- The low level of awareness of the farmers and the public at large
- All the aforementioned problems together with their interconnections are given schematically in Fig. 1.

#### **4. A METHODOLOGY THAT MAY LEAD TO SOLUTIONS**

According to the opinion of the authors, the overall strategy that has to be followed in order to deal with the problems described above consists of three main sub-strategies, namely:

- (i) Sustainable and Controlled Treatment Strategy: Technical support of authorities for the implementation of the appropriate technologies for treatment, (including evaluation of existing situation in respect to wastewater treatment, development of specifications for innovative urban wastewater treatment technologies and systems tailored to local needs) and technical support of authorities for the control and monitoring of the wastewater treatment plants (including guidelines, methodologies and tools)
- (ii) Sustainable Wastewater Reuse Strategy: Technical support of authorities for the orthodological utilization of treated wastewater in the agricultural production and for the

maximum utilization in a safe way of the treated effluents, development of guidelines for the safe reuse (for operators and farmers), etc.

- (iii) Best Practices and Effective Policies Promotion Strategy: Acquisition of knowledge and experience of scientifically sound and effective practices on urban wastewater treatment and reuse implemented in countries facing the similar problems and having similar characteristics, through compilation of useful material in a report and also through selected site visits. In addition effective socio-economic and legislative instruments applied elsewhere will be examined and success stories will be promoted.
- (iv) Education/Awareness Strategy: Training/Educating support of all actors involved in the wastewater treatment and reuse cycle (including training workshops, a discussion forum, conference, a guiding support software tool, brochures, leaflets, etc)

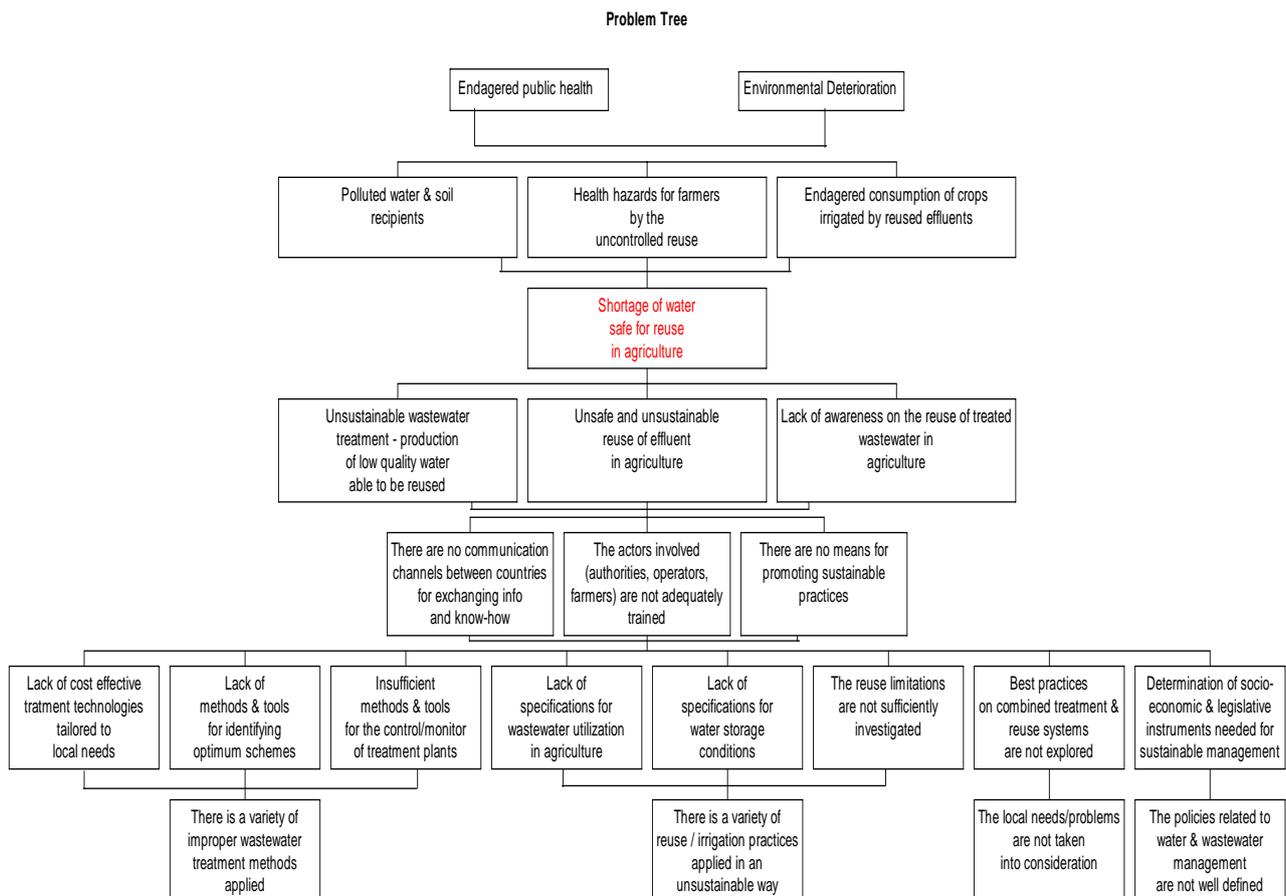


Figure 1: The Problems related to the efficient treatment and reuse of wastewater

The MEDAWARE project is a project funded by the Euro-Mediterranean partnership and more specifically by its Regional Program for Local Water Management. The countries that participate in the project are Cyprus (Agriculture Research Institute), Jordan (Jordan University of Sciences and Technology), Lebanon (American University of Beirut), Morocco (Chouaib Doukkali University), Palestinian Authority (Ministry of Environmental Affairs), Turkey (Istanbul Technical University and Middle East Technical University), Spain (CARTIF Technology Center) and Greece (National Technical University of Athens and Prospect Systems). The main objectives of this project are to deal with all the aforementioned problems and in particular:

- The identification of the (i) existing situation prevailed in the participating countries in regards to water and wastewater management policy, (ii) the existing situation related to the operation of the urban wastewater plants and the effluent disposal methods and practices applied, (iii) the potential negative impacts caused by the non orthodox operation of the wastewater

- treatment and disposal methods applied with emphasis given to wastewater reuse in agriculture
- The development of specifications for the urban wastewater treatment technologies and systems and also for the wastewater agricultural reuse methods, the aim being the presentation of those, including innovative ones, where the effluent can be safely reused and easily adapted in the regional context.
  - The development of the appropriate tools and a database for the effective control and monitoring of the operation of the wastewater treatment plants and to develop relevant guidelines to ensure the safe operation of the wastewater treatment plants.
  - The development of a multi-criteria analysis user friendly software that will guide the responsible authorities to the most efficient solutions in terms of health and safety for the agricultural reuse of the produced effluent as well as in terms of sustainable operation of the treatment unit
  - Organization of a series of training workshops, conferences, pilot studies, etc., aiming at capacity building, information and know-how transfer and raise of awareness
  - Establishment of a network between the authorities of the Med. Countries for the exchange of information and intra regional transfer of experience

## 5. CONCLUSIONS

Water reuse has been dubbed the "greatest challenge of the next century" as water supplies remain the same and water demands increase because of increasing populations. Use of municipal wastewater (sewage effluent) ranges from non potable purposes such as agricultural and urban irrigation, power plant cooling and other industrial purposes, and environmental uses (wetlands, wildlife refuges, riparian habitats), to potable uses. Reuse accomplishes two functions: (1) the effluent is used as a water resource for beneficial purposes, and (2) keeping the effluent out of streams and lakes reduces pollution of surface water. The main concerns in water reuse are proper treatment of the effluent so that it meets the quality requirements of the intended reuse, and public acceptance of potable reuse. Wastewater is a valuable resource, however without a properly developed framework policy, safe and efficient management of this resource can not be achieved.

The highest priority in the wastewater management sector in every country that for the time being is facing problems has to be given to setting up an effective wastewater management system which will include:

- Maximization of collection of wastewater
- Upgrading the existing wastewater collection systems.
- Rehabilitation or upgrading of existing wastewater treatment plants or the construction of new treatment plants
- Establishment of proper standards for influent and effluent wastewater quality
- Education of the farmers

Therefore there is still a lot to be done in the field of wastewater management in the Mediterranean countries. Medaware project is good opportunity through which the existing situation prevailing in some of the Med countries will be examined and through the findings it will be able to set up goals and objectives.

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