

The operation of Urban Wastewater Treatment Plants and the Reuse Practices in the Med Countries– The Medaware Project

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Abstract

The MEDAWARE project funded by the Euro-Mediterranean partnership aims at addressing the significant issue of sustainable urban wastewater treatment and reuse in the agricultural production through the promotion of effective technologies and safe practices. The project mainly focuses on the development of technical specifications for urban wastewater treatment technologies and systems (including innovative ones) and for urban wastewater utilization. The project aims at increasing the safe reuse of wastewater in agriculture with the overall objective of water saving, safe effluent disposal, and the protection of environment and public health from the uncontrolled reuse of raw or low quality effluent. In specific, the project aims at supporting the competent authorities and all actors involved in the field of urban wastewater treatment and reuse by providing them tools and methods for the promotion of best practices (tailored to local needs and constraints) in respect to wastewater treatment and reuse. In this paper, the methodology followed in this project is described and also the first results on the existing situation in a number of Med countries are given. In particular an evaluation of the existing situation related to the operation of urban wastewater treatment plants and the effluent disposal practices with emphasis on the reuse in the agricultural production in Cyprus, Jordan, Palestine and Turkey is provided.

1. Introduction

Rising water needs for urban areas, agriculture, industry and the environment, are creating competition over the allocation of scarce water resources. The supply of freshwater is finite and threatened by pollution. To avoid a crisis, many countries must conserve water, pollute less, manage supply and demand and reduce the impact of growing population. In these circumstances, recycled water is a valuable resource.

Appropriately treated recycled water can be reused to reduce the demand on high quality freshwater sources. Water recycling increases the availability of water supply, reduces vulnerability to droughts and enables greater human benefit with less use of fresh water. By reducing the need for fresh water and wastewater discharges, water recycling has the potential to make a substantial contribution to meeting human water needs, and lessening mankind's impact on the world's water environment.

The North African and Middle East Countries are characterized by the lowest per capita amount of water supply in the world, unequally distributed in space and time. The Mediterranean Water Chapter established in Rome in 1992, stressed the need to contribute towards the creation of new resources of water [1]. The Declaration of the Euro-Mediterranean Ministerial Conference on local water management of Turin stressed the importance of integrating water resources management into sustainable development policies [2]. Another main aspect of this declaration is the statement that water scarcity could be alleviated through mobilization of non-conventional water resources, such as reused wastewater. Another problem that these countries face is that there are no sufficient systems for the environmentally sound treatment of urban wastewater. Raw sewage is deposited into the sea, rivers, and pits or used for irrigation purposes endangering human health and environment as a whole. According to the Barcelona Declaration the Mediterranean cities that do not belong to EU and have a population of more than 100000 inhabitants must have adequate water treatment systems to treat their sewage installed by the year 2005, while those having a population of more than 50000 inhabitants must develop such systems by the year 2010 [3].

Following, an overview is made for some of the Med countries in regards to the water resources, wastewater treatment and reuse. This overview refers to Cyprus, Jordan, Palestine and Turkey. This information has been collected and elaborated in the

framework of the MEDAWARE project which 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).

2. Geographic and Demographic Information

The Mediterranean Sea is one of the rare borders in the world which separates two adjacent areas with opposite demographic characteristics and contrasted development levels. The Mediterranean region consists of three sub-regions as follows:

- the North or greater Europe: Portugal, Spain, France and Monaco, Italy, Malta, Bosnia-Herzegovina, Croatia, Slovenia, F.R. of Yugoslavia, Albania, Greece;
- the East: Turkey, Cyprus, Syria, Lebanon, Israel, Palestinian territories of Gaza and the West Bank, Jordan;
- the South: Egypt, Libya, Tunisia, Algeria, Morocco.



Figure 1: The Mediterranean Countries

The total population of the Mediterranean countries in 2000 reached 427 million people. It was 285 million in 1970, presenting an increase of 142 million, or 50%, in thirty years. The latest projected demographic figures estimated in the Blue Plan estimates the population at 523.5 million by 2025, which demonstrates a certain decrease in the population growth rate with a little under 97 million (or 22,5% increase) additional inhabitants in 25 years [4]. Presently the average rate of urbanisation is at 64.3 per cent, while it is expected to reach 72.4 per cent by 2025. This rise is mostly due to the urban growth in the southern and eastern countries. In absolute terms the urban population of all Mediterranean countries - 274.5 million in 2000 - will reach 379 million by 2025. In the same period, there will be 104.5 million additional urban dwellers, of which more than 98 million will reside in the South and East. The Blue Plan has always considered population and its physical distribution as a capital element in the Mediterranean system. Indeed, the Blue Plan's experience from the past twenty years in the Mediterranean region shows that the population dynamic is the main factor that influences the most basic needs, determining the consumption of all sorts of resources and provoking the most direct environmental pressures [4]. In general, Mediterranean countries are currently undergoing intensive demographic, social, cultural, economic and environmental changes and hence the resources consumption and the consequent environmental effects are constantly changing.

Following, the most important information is summarized in table format. Table 1 gives information on the total area of the countries under concern, the total population according to the most recent census available and the % annual population growth.

Table 1: Area and Population in Cyprus, Jordan, Palestine and Turkey

Country	Total area km ²	Total population (year of census)	% Annual Population growth
Cyprus	9251	689 565 (2001)	1.45
Jordan	89 210	5 329 000 (2002)	3.45
Palestine	6020	3 549 524 (2002)	3.1
Turkey	780 576	67 803 927 (2000)	1.83

3. The Availability and Demand of Water

As already mentioned the Mediterranean demands for water are high. Two-thirds of the Mediterranean countries currently use over 500 cubic meters per year per inhabitant – mainly because of heavy water use of irrigation. But these per capita demands are irregular and vary across a wide range – from a little over 100 to more than 1000 cubic meters per year. Table 2 provides information on the average annual rainfall, the water resources available and the water demand for the countries under examination. Table 3 gives information on the ratio between water demand and the water resources available per country. From this information it is clear that in some countries like for example Cyprus, Palestine and Jordan water shortage is already a fact. Demand is growing in the other countries but it is actually falling on a per capita basis. In other countries the demand per inhabitant is still growing – either because demand is still low (e.g. Algeria) or because water development schemes and particularly water use for irrigation are developing more rapidly than the population (e.g. Lebanon, Libya and Turkey) [5].

Table 2: Rainfall, Water Resources Available and Water Demand

Country	Average Annual Rainfall (mm)		Water resources available (surface, groundwater) MCM/yr	Water demand MCM/yr
Cyprus		465	300	265.9
Jordan	semi desert	<200	780	810
	Arid	200 - 350		
	Semi arid	350 - 500		
	Semi humid	>500		
Palestine	Mountain areas	700	295	354
	N and W	400		
	S	200		
Turkey		580 -1300	110000	42000

Table 3: Water Demand versus Water Resources Available

Country	Water Demand / Water Resources Available*
Cyprus	0.89
Jordan	1.04
Palestine	1.2
Turkey	0.38

* Surface plus groundwater resources

4. Urban Wastewater Treatment and Reuse

Table 4 illustrates the treated wastewater produced in each country and the quantity of the treated wastewater that is reused (in million of cubic meters (MCM) per year). Table 5 gives information on the total irrigated areas in each country and information on the proportion of the regions irrigated by non conventional resources, i.e. treated wastewater.

Table 4: Treated Wastewater Produced and Reused

Country	Treated wastewater produced MCM/yr	Wastewater reused MCM/yr	Treated Wastewater Reused / Treated Wastewater Produced
Cyprus	20	5	0.25
Jordan	73	73	1
Palestine	30	5.44	0.18
Turkey	1245	No data available	No data available

The total number of the main UWTPs (Urban Wastewater Treatment Plants) currently in operation in Cyprus is 25. Apart from these treatment plants, which serve the big cities some municipalities and rural communities, there are also some smaller UWTP, (around 175) located in hotels, military bases and hospitals. Centralized sewerage networks and UWTPs cover part of the broader areas of Nicosia, Limassol, Larnaca, Pafos, Agia Napa and Paralimni, serving 45% of the total urban population. The rural population represents 30% of the total island population. Centralized

sewerage networks, now serve 12% of the rural population. In the remaining rural areas the traditional methods for sewage disposal are absorption pits and septic tanks. Recycled domestic water is presently used for the watering of football fields, parks, hotel gardens, etc. (1.5 MCM/yr) and for the irrigation of permanent crops in particular (3.5 MCM/yr). It is estimated that by the year 2012 an amount of approx. 30 MCM/yr of treated sewage effluent will be available for agriculture and landscape irrigation [6].

Table 5: Total Irrigated Areas and Area of the Regions Irrigated by Non Conventional Water Resources

Country	Irrigated areas (ha)	Area irrigated by non conventional water resources / Total irrigated area (%)
Cyprus	38200	0.5
Jordan	10820.8	No data available
Palestine	24418	No data available
Turkey	1471000	No data available*

*Particularly in the inner parts of Turkey urban wastewater treatment plants discharge their effluent to rivers and irrigation channels. However, the amount of discharged effluent is not exactly known (therefore: no data available) and at the same time this water amount is relatively low compared to conventional irrigation sources (irrigation water).

Some problems concerning the reuse of water are the following:

- The demand for water exists only during the summer, thus the Sewerage Boards faces problems with the storage and or disposal of water during winter.
- There is no systematic monitoring of the water use: as a result in some cases the recycled water irrespective of its analysis is used for irrigation of crops including leafy vegetables.
- There is a problem of disposal of treated water at the smaller UWTPs of villages. The farmers in these areas refuse to irrigate with the recycled water their cultivations, due mainly to psychological reasons. The problem is aggravated due to the fact that these treatment plants are located in the mountain area of the island.

Currently in Jordan, there are 19 domestic UWTPs. These treatment plants are located in big cities and they actually serve big areas surrounding these cities. By far the largest plant is the Al Samra plant that serves, besides the capital Amman,

several more relatively big cities which altogether are called Greater Amman. However, Jordan is currently planning to establish several new treatment plants that will serve the rest of the areas which can be classified as communities. It is estimated that about 63% of the total population of Jordan has access to sewage collection and treatment systems. All of the effluents of the existing treatments plants in Jordan are either directly used for irrigation or are stored first in reservoirs/dams and are used for irrigation at a later stage. 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 [6].

In Palestine, due to the chronic political unrest in the Palestinian Territories, wastewater sector has been suffering from the weak financing, the inadequate planning and management, etc. Accordingly, there is a serious need for concerted efforts to improve the wastewater status in Palestine. In spite of the hard circumstances that the Palestinians are living, some significant achievements in wastewater issue has been accomplished since the establishment of the Palestinian National Authority.

The situation of the sewerage system is extremely critical. Both the West Bank and Gaza are facing a series of wastewater and sanitation related problems. These are: large scale discharge of untreated wastewater, leaking of collected wastewater from sewer systems and cesspits, water treatment plants that are badly functioning and uncontrolled reuse of untreated wastewater by the irrigation sector. There is a strong need for appropriate management, for establishing sanitation infrastructures in rural communities and effective wastewater treatment plants and for the promotion of the sustainable practices the aim being the protection of the environment and public health.

Three treatment plants are located in the Gaza Strip namely, Beit-Lahia, Gaza City and Rafah. The effluents of the treatment plants are mostly discharged to the Mediterranean Sea and to the ambient environment. The total annual wastewater production in the area is estimated to be about 40 MCM, from which 22 MCM are disposed into the sewers and 18 MCM into cesspits or pit latrines. At present, about 25% of the total wastewater produced daily from the Gaza Wastewater Treatment Plant (GWTP) is used to replenish the groundwater through water infiltration. The treated wastewater is mainly discharged into infiltration basins at Gaza central wastewater treatment plant and some local farmers adjacent to the treatment plant

use part of the treated effluent to irrigate fodder crops without any training on how to use the treated wastewater [7].

In the area of the West Bank only 30-35 % of the population is connected to sewerage networks. The majority of the population uses individual or communal cesspits for temporary storage of wastewater. Cesspits are emptied by vacuum tankers, which usually dump their contents into open ground, into wadis, sewerage networks, irrigation channels, and solid waste disposal sites. On the other hand, in refugee camps sewage flows through open drains originally constructed to convey rainwater. Most villages have no sewerage system and wastewater is discharged into soak-away (infiltration) pits. The existing wastewater treatment plants in the West Bank are inadequate to serve the volume of wastewater being discharged [8]. There are 5 public plants in the West Bank (Jenin, Tulkarem, Ramallah, Al Bireh and Hebron).

In Turkey, all of its 81 provinces have urban wastewater treatment plants. There are 129 UWWTPs in operation according to the recent official records [6]. 28 plants are located in the 12 of the Greater Metropolitan cities. For example, Istanbul Greater Metropolitan City, being the most crowded city of the country, has 13 urban wastewater treatment plants followed by 3 plants in the highly industrialized province Kocaeli, in the vicinity of Istanbul. Estimations concerning the population served by treatment plants fluctuate between 35-45%. Treated municipal effluent is mainly discharged into flowing receiving water bodies like rivers, creeks, and coastal and deep sea environment. Those discharged to rivers and creeks are 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.

5. 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.

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.

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 Figure 2.

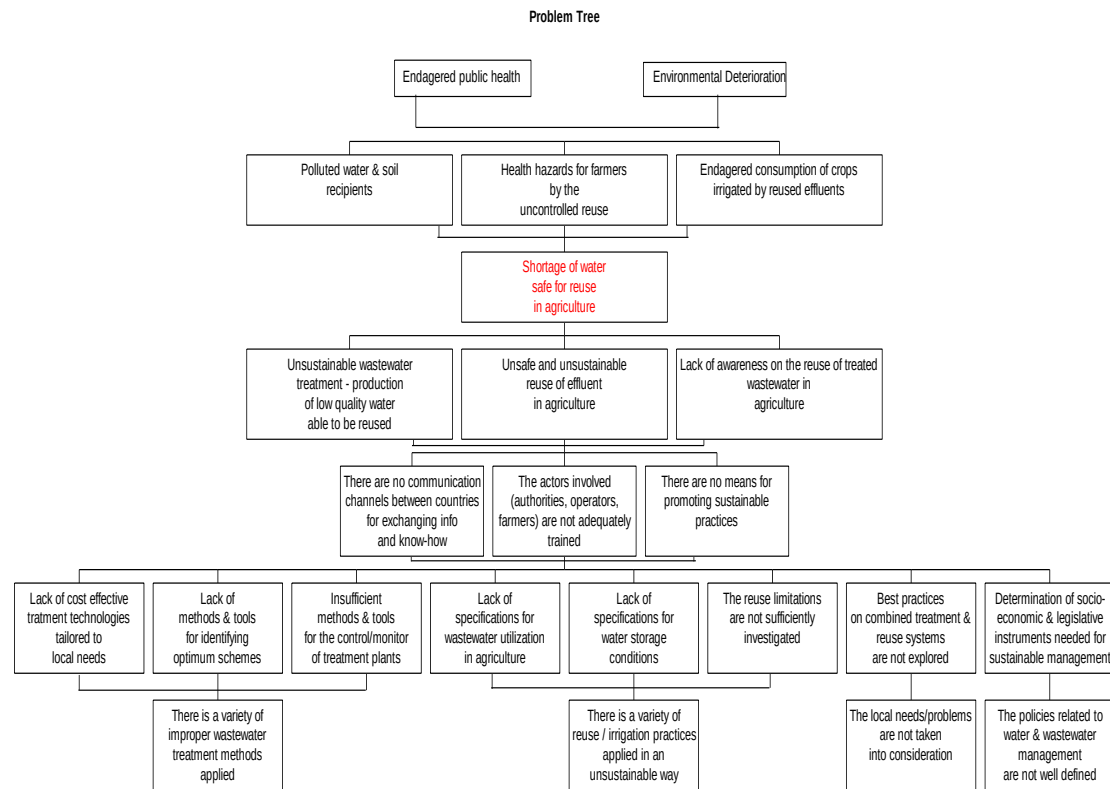


Figure 2: The Problems related to the efficient treatment and reuse of wastewater

6. A Methodology that may lead to Solutions (The MEDAWARE Project)

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, which constitute the main components of the MEDAWARE project. These are:

- (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)

The main objectives of the MEDAWARE 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 orthodological 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

7. 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.

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.

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