

Treated Wastewater Reuse in Palestine

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Abstract

Treated wastewater resource is an environmental, social and economical good that needs to be managed in appropriate way. Palestinian Territories, as in most of the neighboring countries in the Middle East region, acknowledges the importance of this resource in improving the water deficit by reusing the treated wastewater in agricultural production, industrial sector and recharges the aquifer. However, this resource is strictly sensitive and has adverse impacts on the public health. Both negative and positive impacts of the treated wastewater resource should be considered. Therefore, Environment Quality Authority (EQA) has prepared Environmental Law and Standards Draft for reusing the treated wastewater. Moreover, Palestinian Water Authority (PWA) prepared a National Water Plan where the treated wastewater reuse has an essential part. EQA is currently sharing a project which considers the development of tools and guidelines for the promotion of the sustainable urban wastewater treatment and reuse in the agricultural production in the Mediterranean countries. This paper presents the Palestinian practices and plans in wastewater treatment and reuse.

Keywords: Environment, Treated Wastewater, West Bank, Gaza Strip

1 Palestinian Territories

1.1 Background

The Palestinian territories consist of the West Bank with approximately 5,800 km² and the Gaza Strip with about 365 km². The West Bank area is made up of a hilly region in the West and the Jordan Valley in the East. The climate in the West Bank can be characterized as hot and dry during summer and cool and wet in winter. The Gaza Strip has a Mediterranean climate and consists mainly of coastal dune sands, being located between the coast and the Negev and Sinai Deserts.

1.2 Population

The broad population characteristics of Palestine are strongly influenced by political developments, which have played a significant role in the growth and distribution of population in the Governorates. According to Palestinian Central Bureau of Statistics, Palestine has a total population of 3,224,504 living in the two geographical areas, 64% in the West Bank including Jerusalem and 36% in Gaza Strip. Today Palestine has a very young population in comparison with other countries, 47% of the population is 14 years or younger. As much as 18% of the Palestinian citizens are 4 years or younger. In addition, Palestine has an average of nearly 6.4 persons per household.

The estimated population growth in Palestine has declined from 5.2% in 1995 to 3.1% in 2000. The total number of population is expected to reach 4,938,264 by the year 2010 assuming an average growth rate of 4.83-3.5 percent for the years 2000-2010 (MEDAWARE, 2003).

1.3 Water Resources

1.3.1 Availability

The large variations in rainfall and limited surface resources have led to widespread scarcity of the fresh water resources in the region, resulting in a heavy reliance on groundwater as the major source for various uses. The contribution of surface water to the overall water balance is limited and marginal. The sources of water in the WB are those renewable waters of the Mountain aquifer that rises and outcrops in the WB but extends across and below the territories of Israel. The groundwater recharge in the WB is the direct infiltration of rainwater through fractured, karstic rocks and porous soils. The overall balance in the West Bank is estimated to be 679 MCM/ yr, while in Gaza it is estimated at 45 MCM/ yr.

The Gaza aquifer, which is a classical coastal aquifer, represents the sole water source of the GS covering an area of 360 (km²) with a total recharge of approximately 60 mcm/ yr. The Gaza aquifer is threatened by seawater and salt ground water intrusion due to over pumping, and by pollution especially nitrates from the overuse of fertilizers and infiltration of sewage (Murad, 2004).

1.3.2 Utilization

The size of the problem for Palestinians may be best illustrated by noting that the total available groundwater in Israel and the Palestinian Territory is 1,209 million cubic meters mcm/ year out of which 1,046 mcm/year is currently being used by the Israelis, while the Palestinians are permitted to use only 259 mcm/year. The imbalance of current water use translates into an imbalance in water consumption. The Palestinian domestic per capita consumption of 35-80 l/day is far below the WHO standards, which assign a minimum of 100 l/capita/day. On the other end the Israeli per capita consumption exceeds 300 l/ day. Israel also uses about 800 mcm/ yr of the total quantities of the Jordan River water, which means that most of Israel's water comes from rivers that originate outside the border, or from disputed lands (Murad, 2004).

1.3.3 Water Consumption.

During the recent surveys on present water consumption in Palestine (1995), the industrial consumption could not be separated from domestic water consumption, therefore it is included in the figures of domestic water consumption. Palestinian consumption from the groundwater resources (springs and wells) in the West Bank has been estimated at about 127.4 mcm for irrigation, domestic and industrial uses. The distribution of these quantities is shown in Table 1.

In Gaza, Palestinians are using about 103 mcm/yr, from groundwater. With a safe yield of only 55 mcm/yr, there is an over pumping of about 87%, and it is for this reason that groundwater quality is deteriorating. The total water consumption in Palestine was estimated at 235.45 mcm/yr. In addition to that amount, 60 mcm/yr, are used by the Israeli settlements in both Gaza and the West Bank (Barghothi, 2004).

Table 1: Summary of Water Supply and Consumption in Palestine.

Location	Water Supply to the Palestinians MCM/yr				Water Consumption MCM/yr			
	Wells	Springs	Imported	Total	Domestic and Industry	Agric	Israeli Settlement	Total
West Bank	64.7	56.6	6.1	127.4	37.5	90.0	50.0	177.5
Gaza Strip	103.0	0.0	5.0	108.0	48.0	60.0	10.0	118.0
Total	167.7	56.6	11.1	235.4	85.5	150.0	60.0	295.5

Source : Barghothi, 2004

1.3.4 Available Water Resources Alternatives

1.3.4.1 Fresh Water Resources

Apart from the water resources in the Jordan River system, the only surface water available is the runoff in the wadis, which for most wadis is intermittent. An exception is the spring fed wadis - for instance Wadi Qilt and Wadi Far'ia, but these are already heavily utilized. To a large extent, the wadis are also overloaded by raw sewerage in the headwater areas. The yet un-exploited potential safe yield available to the Palestinians in the Eastern Aquifer has not been determined accurately but may be somewhere between 50 and 100 mcm/yr. Article 40 indicated that the potential is 70 mcm/yr.

1.3.4.2 Non-Conventional Resources

The Palestinian technical and financial capacity to develop non-conventional resources is not yet adequate. However, the National Water Policy, the Water Resources Management Strategy and the Water Law that have been adopted by the Palestinian Authority all encourage conservation and call for the development of nonconventional resources. (IOB,1999)

1.3.4.3 Agriculture

Agriculture is still the most important economic sector, but its contribution to GDP has decreased from 37% at the end of the 1970s, to 22% in the end of 1980s, then it has declined to 10% at the last ten years.

The occupied Palestinian Territories can be divided into five main ecological sub-regions: the Mediterranean shoreline costal plain, the upper costal plain, the central highlands, the semi-arid eastern slope steppes and the arid semi-tropical Jordan valley. It was reported that 1,816 thousand dunums of Palestinian farmland were cultivated in the Palestinian Territory between 2000 and 2001 of which 89.9% in the West Bank and 10.1% in Gaza Strip. According to 2000-2001 results, plant production including fruit trees constituted 64.7% of the cultivated area of Palestinian Territory. Vegetables and crops produce comprised 9.6% and 25.7 of the cultivated Palestinian areas respectively. 67.5% of Gaza strip's cultivated areas rely on irrigation compared with only 7.3% of the West Banks cultivated area that relies on the same source of irrigation (MEDAWARE1, 2003).

2. Current Status of Wastewater Treatment and Reuse

Years of neglect during the occupation from 1967 to 1994 have created severe environmental problems in West Bank and Gaza. Lack of wastewater treatment plants, of sewerage systems and of

wastewater collection for recycling lead to the uncontrolled discharge of wastewater into the environment. There were insufficient financial resources within the Palestinian community to pay for new wastewater collection, disposal and treatment systems. Israel was collecting taxes from Palestinians through the Israeli Civil Administration, but they never employ the money for the infrastructure for the Palestinian communities. The situation is worsened by the discharge of untreated wastewater from Israeli colonies (MEDAWARE, 2004).

The percentage of population connected to sewer networks in Palestine counts for approximately 45.8% distributed as 66.3% in Gaza Strip and 34.6% in West Bank while cesspits and septic tanks receive the rest. (MOH, 2004). There are seven main wastewater treatment facilities in the Palestinian Territories; three are located in Gaza strip while the rest in the West Bank Table 2. In addition there are six small-scale Wastewater Treatment (WWT) facilities located in the West Bank (Table 3).

2.1 Current Status of Wastewater Treatment and Reuse in Gaza Strip

The existing wastewater treatment plants` serve only Northern, Gaza and Rafah Governorates. However, not all houses in these Governorates are connected to the sewerage network. Despite that the existing three WWTPs are heavily overloaded as the actual flow far exceeds the design flow. Blocked pipes and flooded manholes are daily events in Gaza Strip . The total capacity of the existing three WWTPs is approximately 20.5 Mm³/year. The effluent of Northern Governorate plant discharges to the near sand dunes causing many environmental problems to the aquifer and to the neighboring people. Gaza WWTP recharges the aquifer with approximately 3.6 Mm³ of treated wastewater annually through the infiltration sandy basins and the remaining quantity (11.7 Mm³) is disposed into the Mediterranean sea. Rafah plant effluent is discharged into the sea. Clearly, most of wastewater effluent is wasted and causing serious environmental impact.

Future of wastewater reuse seems to be promising in the Gaza Strip. The expected amount of wastewater to be used for irrigation will progressively increased on the coming twenty years saving more than half of groundwater needed for irrigation. To distribute the reclaimed wastewater to the agricultural areas and to the proposed infiltration basins, it is suggested to construct a main reclaimed wastewater carrier that will interconnect the three proposed regional WWTPs with the agricultural areas and the infiltration basins. The amount of well treated wastewater assumed to be used for irrigation by year 2005 will be around 19 Mm³/year and this will increase to about 53 Mm³/year by year 2020 (Tubail et. al., 2003),

2.2 Current Status of Wastewater Treatment and Reuse in West Bank

Reclaiming wastewater for reuse requires collection, treatment and reuse systems. however, rural areas in the West Bank either don't have running water at all or don't have wastewater collection systems, even if they have running water. In villages, wastewater is collected in individual waste pits or cisterns where it infiltrates into the ground. Thus, there is in reality no wastewater to be reclaimed in the rural areas of the West Bank.

Table 2: General Characteristics of Municipalities Treatment Plants in Palestine

Location	Municipalities WWTP	Type of Treatment	Population Served (Capita)	Effluent Quantity m ³ /d	Effluent Disposal Method
Gaza Strip	Bait lahia	Primary Sedimentation Anaerobic lagoon	250,000	10,000	To sand dunes
	Gaza	Primary Sedimentation Anaerobic lagoon Aerobic lagoon Trickling filter Secondary Sedimentation Drying bed for sludge	300,000	50,000	Mediterranean Sea Irrigation Infiltration
	Rafah	Aerated lagoons	80,000	8,000	Mediterranean Sea
West Bank	Al-Bireh	Screening Aeration tanks disinfection by UV radiation	50,000	3200	Irrigation
	Jenin*	Aerated lagoon	20,000	1500	Valleys
	Ramallah	two aerated lagoons	47,500	1370	Wadi Bitunia
	Tulkarem	Stabilization ponds.	114,400	6742	Not available

* Jenin Wastewater Treatment plant currently is not functioning.

Source (MEDAWARE, 2004)

In urban areas, water is distributed in water networks. However, not all urban areas have collection systems for wastewater. Thus, only some urban areas can be considered for potential wastewater reuse, i.e. the ten cities with collection systems for wastewater and/or urban storm water. Thus, reclaiming wastewater in these cities will also include urban storm runoff. At times, untreated wastewater is utilized for irrigating some vegetables, in both Nablus and Bethlehem. Such utilization is causing severe health effects on the public. Treated wastewater reuse in the agriculture is mainly practiced in a small scale in case of a demonstration projects and universities (restricted irrigation), a few demonstration projects are conducted in the west bank (Beir Zeit WWTP, Al Beirah WWTP)

The houses connected to wastewater collection systems consume about 12 MCM/yr., in the West Bank. Assuming that 80% of that amount is collected into a wastewater collection system, then the

total amount of wastewater that could be utilized for reuse after constructing efficient treatment plants will be about 10 mcm/yr, or about 27% of the total water consumed in the West Bank. it was assumed that 80% of water will return to the wastewater collection system (when a house is connected to one) because most of the water usually returns to the system as minimal amounts are used in gardening (lawns are minimal in West Bank urban areas). Constructing efficient treatment plants in the nine municipalities could be done by 2010. Thus, by 2010 only 27% of water consumed in the West Bank could be utilized for wastewater reuse in agriculture (Barghothi, 2004)

2.3 Impacts of Treated Wastewater Reuse

There are major real potential health, environmental and economic impacts as a result of poor sanitation, improper disposal of treated and untreated wastewater, and use of raw or partially treated wastewater to irrigate edible crops. These impacts are described below.

2.3.1 Health Impacts:

- Irrigation with raw wastewater in the West Bank and to a limited degree in Gaza Strip presents a major health hazard to consumers of vegetables, farm workers and farm workers families.
- Undersized, poorly planned designed and poorly maintained combined/drainage collection system presents major health hazards in the urban areas of overflow and system surcharging.
- Raw and partially treated wastewater discharge to groundwater, wadis, and nearshore marine environments presents major potential health hazards. Potential hazards are through direct skin and eye contact, ingestion of water, and consumption of marine animals exposed to the effluent.

2.3.2 Economic Impacts

- A healthy community is more productive as measured directly by reduced health costs and minimal time lost on the job. It is measured indirectly, for example, in education where healthy children miss less school.
- Ability to produce exportable vegetables and fruits, which meet international standards by not using raw or partially treated wastewater.
- By not polluting the nearshore environment, the tourist industry is protected from any potentially damaging public health episode.

2.3.3 Environmental Impact

- Discharge of poorly treated effluent into the near shore and estuaries is adversely affecting the marine environment.
- Irrigation of arid lands will increase the organic content of these lands reducing erosion and increasing water retention, within the salinity limitations.
- The reclaimed water contained in the storage reservoirs and treatment ponds will attract and support migratory and resident bird populations. In the same manner these reservoirs will serve as a water source for a wide variety of terrestrial animals.

- Use of reclaimed wastewater in maintaining trees in arid regions will reduce the effect of wide erosion (desertification) (MEDAWARE, 2004).

Table 3: General Characteristics of communities' treatment plants in Palestine.

Location	Communities WWTP	Type of Treatment	Population Served (Capita)	Effluent Quantity m ³ /d	Effluent Disposal Method
West Bank	Al Aroub agriculture school	Duckweed-based pond system	Not available	12-15	The effluent is used for producing seedling in a forest-tree nursery constructed for reuse in irrigation or groundwater recharge
		Small-scale biochemical system (JOHKASOU system)			
		Aeration tank			
	Birzeit University	Screen Equalization Tank Activated sludge Sand Filters	6,000	100	Irrigation
	Deir-Samit-Hebron	Sedimentation tank bio-filters	400	40	Valleys
	Ijnsnya-Nabuls	Septic tank Anaerobic filter	250	30	Valleys
	Kharas - Hebron	Anaerobic stage Wetlands Sludge drying beds Effluent storage tank	2,000	120	Valleys
	Sarha- Nabuls	Septic tank Constructed wetland	600	40	Valleys

Source (MEDAWARE, 2004)

3. Treated Wastewater Management

3.1 Environmental Law

The Palestinian National Authority (PNA) is acting strenuously in the filed of water and wastewater management in terms of legislation, policies and strategies, seeking funds, design and

implementation of several projects. The wastewater reuse is regulated by the 1999 Environmental law (Article 29) and by one of the policies of Palestinian Water Authority (PWA). The Environmental law states: *“The Ministry(MEnA), in coordination with the competent agencies, shall set standards and norms for collecting, treating, reusing, or disposing wastewater and storm water in a sound manner, which comply with the preservation of the environment and public health”*. The policy of PWA regulates the construction of any new treatment plant to be associated with reuse project. As an enforcement of these regulations, draft of the Palestinian standard for reuse of treated wastewater (EQA, 2000) has been established. Most of the ongoing and planned treatment projects are designed for reuse of treated wastewater, such as Al Bireh, Hebron, Salfit, Nablus, and Gaza Northern Governorate treatment plants. (MEDAWARE2, 2004)

3.2 Palestinian Standards

Wastewater treatment and reuse criteria differ from one country to another and even within a given country. Some of the main discrepancies in the criteria are, in part, due to differences in approaches to public health and environmental protection. For example, some countries have taken the approach of minimising any risk and have elaborated regulations close to the California's Title 22 effluent reuse criteria, whereas the approach of other countries is essentially a reasonable anticipation of adverse effects resulting in the adoption of a set of water quality criteria based on the WHO (1989) guidelines. This has led to substantial differences in the criteria adopted by Mediterranean countries.

For a long time, Palestine did not have any specific wastewater regulation, references were usually made to the WHO recommendations or to the neighbored country's standard (ex. Egypt, Jordan). Recently, the Environment Quality Authority with coordination of Palestinian ministries and universities have established specific wastewater reuse regulations. The draft of Palestinian legislation for reuse of treated wastewater is still under study in the Palestinian Standard institute.

The draft Palestinian standard principles mainly envisage; a) Sanitary, b) Environmental and c) Agrotechnical quality requirements. a) Sanitary requirements centred upon the pathogens potentially present in wastewater, namely bacteria and intestinal nematodes (*Ascaris* and *Trichuris* species and hookworms). Where its recommended less than 1 intestinal nematode per liter and 200 to 1000 fecal coliforms per 100 ml of wastewater depending on the reuse conditions, b) From the environmental viewpoint concentration of various heavy metals (particularly cadmium, copper, zinc), salt, nutrients (N and P) and malodors have taken into consideration, c) Agrotechnical requirements firstly include total salt and several anion (Cl, SO₄, HCO₃), cation (Ca, Mg, Na) and boron concentrations which determine traditional irrigation water quality standards depending on the plant species, soil physical and chemical properties, climate and irrigation methods.

Most of the reuse projects in Gaza Strip and West Bank are using treated wastewater for irrigation according to WHO and FAO guidelines. The WHO guidelines are strict in respect of the requirements to keep the number of eggs (*ascaris* and hookworms) in effluent below one egg per liter whether the effluent is used for restricted or unrestricted irrigation using surface and sprinkler irrigation. This is not applicable in case of restricted irrigation where exposure of workers and public does not occur.

On the other hand these guidelines are relaxed in the case of faecal coliforms, as no standard is recommended for these pathogens in the case of restricted irrigation and 1000 or less per 100 ml in the case of unrestricted irrigation. This is based on the assumption that the treatment that results in effluent of having less than one egg per liter of intestinal will be practically safe in case of virus and bacteria.

In addition to the microbiological quality requirement of effluent used for irrigation attention also is given to quality parameters of importance in respect of ground water contamination and of soil structure and crop productivity. These include the nutrients content of the effluent (mainly nitrate), total dissolved solids, and sodium adsorption ratio and toxic elements (boron and heavy metals), which is available at FAO guidelines.

Despite meeting the regulation and guidelines, the reuse of wastewater is not entirely a risk-free. Continued research will result in developing new technologies or improving the existent methodologies used for assessment of health risk associated with trace contaminants, evaluation of microbial quality, treatment systems, and evaluation of the fate of microbial, chemical and organic contaminants (MEDAWARE, 2005).

3.4 Treated Wastewater Reuse Pilots

3.4.1 Gaza Strip

A French program called “Strategy of agricultural water management in the Middle East”, is a good demonstration example for the Palestinian practice of treated wastewater reuse in agricultural production. Two areas were chosen for the implementation of this project in the Palestinian Territories which only initiated at the beginning of 2003: Gaza Strip and Al Bathan Al Farah valley in the West Bank (MoA et al., 2004). The program is coordinated by a Steering Committee (MoA, PWA, French Consulate, MREA) chaired by a MoA representative in Ramallah and each pilot project is managed by a technical committee (MoA, PWA, PHG, French Consulate, MREA). EQA participated as a regulatory and evaluating the progress of the project and its environmental impacts during the site visits and inspections. Moreover, EQA contributes in reviewing the technical reports of the project prepared by the French Consultant MREA.

The project has selected two areas in the Gaza Strip: 1. Beit Lahia area where the treated wastewater coming from the Beit Lahia WWTP was available in unlimited quantities and a new experimental irrigated area could be developed in large empty sandy dunes areas available around the village and 2. CAMP area (Coastal Aquifer Management Programme) area where TWW from the Gaza city WWTP could be used to irrigate existing citrus farms.

The farmers in Beit Lahia area are basically interested in alfalfa, considered the highest quality fodder. A “modern” variety called Hijazi was proposed by the MoA technicians. The excellent results of Jordanian farmers with a combination of Sudan Grass in summer and Rye grass in winter in their TWW irrigated areas (Madaba, Hashmieh) suggested these two crops could be tested too. Local farmers made limited experiments with maize, sorghum, plants of Olive trees, of a high and thin variety (supposed not to expand over irrigated fodders area) were given by the MoA and were planted in marginal locations (close to the fences).

An initial attempt of vegetables production had been done in a greenhouse inside the Northern WWTP but it was later abandoned due to the resistance of the consumers. Due to the good quality of water, the production of flowers (carnation) was initially considered but the Ministry of Agriculture decided not to use waste water for this production because of the hypothetical risks on export, especially for the Israeli market. The existence of an important Bedouin village with many animals and big areas of unoccupied sandy dunes has oriented the project to a demonstration of fodder production. The main observations in this pilot regarding the water quality were (MoA et al., 2004):

- The sanitarian quality of the lake water was surprisingly good (The fecal coliforms are especially low for a treated waste water:
 - less than 50 counted coliforms / 100 ml, and have been decreasing during the period).
 - No salmonellas encountered
- The salinity of the water is medium (1,8 to 1,9 deciSiemens/m) and TDS 1300 ppm
- The chloride concentration is relatively high (300 ppm).
- SAR is around 5 which is not worrying for a 1,9 mS/cm water.
- The performance WWTP's operation, considering the effect of the lake, is acceptable (BOD less than 80 and COD less than 200)
- The quantities of Boron is relatively small (0,37 ppm)
- The heavy metals were in very limited concentration
- Total Nitrogen (Kheladi) is 30 ppm and nitrate (NO₃) is around 15 ppm.
- Phosphate (P) concentration is less than 3 ppm.
- Potassium (K) concentration is 30 to 35 ppm.

3.4.2 West Bank

Al-Bireh reuse demonstration project conducted the different aspects of reclaimed water use in irrigation by developing a set of different effluent polishing and irrigation techniques on crops. The primary goals of the project were to build the initial institutional relationships, raise the profile of wastewater reuse and compost use, and to develop the first stage of on-the-ground experience and capacity in the field of wastewater reuse (CH2 MHILL, 2003b). The demonstration project was recommended by a detailed feasibility study that conducted to assess the use of the reclaimed water on the agricultural lands adjacent to the Hebron proposed WWTP.

Al Bireh WWTP is located in Wadi Al-Ein (south of Al-Bireh city) over 2.2 ha area; it was constructed in 2000 with a total cost of € 7 million. The connected population to sewers system in Al-Bireh city is about 60%, which amount to 50,000 inhabitants and designed to serve more than 100,000 inhabitants. The treatment system is extended aeration with mechanical solids handling. The plant was designed to treat 5750 m³/day with an overall retention time of 20 days (the present total inflow is 3200 m³/day) (MEDAWARE, 2005).

Ornamental crops like roses, flowers, bougainvillea and hedgerows were planted for site beautification. On an area of 5 dunum, 2 to 4 year old orchard trees were planted, including different varieties of olives, date palms, stone fruits, citrus, cherries, mango, avocado, guava, pomegranate, figs and grapes. On an area of 3 dunum indigenous Palestinian trees were irrigated,

including nut trees like pistachio, walnut, pecan, macadama, pinenuts, asacia, pines and carob. A parcel of 0.7 dunum was planted with sweet corn. Pre-sowing irrigation of corn was by sprinkler, and after emergency by alternate row drip irrigation. Nitrogen application through the reclaimed wastewater was 7 kg/dunum. No fertilizer was applied in addition to the nutrients presents in the reclaimed wastewater.

A nursery of 600 m² for annual cultivation of 80,000 seedlings of indigenous trees and cooked vegetables is installed. The nursery irrigation system consisted of micro-drippers with a low discharge of 0.2 l/h, thus keeping the overall system flow below the design flow of 0.8 m³/h. The eggplants were trellised to ensure a safe distance of 50 cm from the drip lines.

Four automatic irrigation head controls were installed, including fertilizer injection points, pressure control and filtration devices. A disinfection system was installed to treat 0.8 m³ of treated wastewater. It was consisted of gravel media filtration for turbidity reduction, a chlorine-dosing unit calibrated to inject chlorine at a rate of 2 mg/l and 400 l vessel that retained the chlorinated water for 30 minutes.

Two different types of effluent were identified for reuse. High effluent quality and very high quality effluent. Effluents applied on many different types of agriculture crops and trees. Subsurface drip was used for high quality effluent and the drip irrigation system was used for very high quality effluent. Table 4 summarizes the adopted regulations, applications and achievements of Al-Bireh WWTP reclaimed water use.

Table 4: Summary of Al-Bireh WWTP reclaimed water use achievements

Effluent Type	Regulation	Application	Achievements
High quality	BOD/TSS<20/30 mg/l F.C* <1,000 MPN/100 ml	Orchard, olives, Ornamentals Grape stocks Processed vegetables Restricted area landscaping	High growth High yield
Very high quality	F.C* non-detectable Effluent polishing**	Cooked vegetables Nursery (eggplants)	High yield No contamination

* F.C: Fecal Coliform ** Gravel media filtration and chlorination used

Regular basis of the reclaimed water, soil and microbiological quality were tested. The test results show that the tertiary treatment generates reclaimed water suitable for unrestricted agriculture reuse application according to Israeli and US EPA guidelines (Table 5). Crop quality tests showed that eggplants irrigated with reclaimed water were not contaminated with fecal coliform and intestinal viruses. In the nursery, seedling germination rates were high (>90%) and seedlings irrigated with the reclaimed water showed high vegetative growth.

Table 5: An overview of secondary, tertiary effluent and soil characteristics of Al-Bireh reclaimed wastewater reuse demonstration project

No.	Item	Sampling Dates	Parameter	Results
1	Secondary treated water	Continuously	BOD	25-15 mg/l
			TSS	35-25 mg/l
			EC	1.7-1.5 DS/m
			pH	7.5-7
			N	40-30 mg/l
2	Tertiary treated water	01 June, July, August, 2003	Residual chlorine	1.0-0.5 mg/l
			Turbidity	1-2 NTU
		24 June, 2003	Fecal Coliform	0 CFU/100 ml
3	Soil	07 July, 2003	pH	7.5
			ECe	0.5 dS/m
			Na	1.0 meq/l
			Ca	63.4 mg/l
			Mg	13.2 mg/l
			Cl	48 mg/l
			HCO ₃	195 mg/l
			SO ₄	43 mg/l
			NO ₃	6.2 mg/kg
			NH ₄	35 mg/kg
			P-Olsen	3.0 mg/kg
			K	6.1 mg/l
			Mn	39.2 mg/kg
			Zn	1.6 mg/kg
			B	0.08 mg/l
			CaCO ₃	6.4 %
			Sand	16 %
			Silty	49 %
			Clay	35 %
			Saturation	64 %

Source: CH2 MHILL, 2003a

3.5 MEDAWARE Project

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

The expected results will be the intra-regional transfer of knowledge, the increase of awareness and education level on relevant problems and opportunities, reinforcement of capacity building to promote active involvement of all actors concerned in water planning and wastewater management, dissemination of information on the role and the effectiveness of training in spreading awareness in respect to opportunities for wastewater reuse, sustainable operation of wastewater treatment plants, environmental advantages and the training of all project target groups e.g workers, farmers, operators and competent authorities on the wastewater sustainable management and safe reuse. The project consists of 8 tasks and one that concerns the project management.

4. Conclusions

Treated wastewater is now being considered as a new source of water that can be used for different purposes such as agricultural and aquaculture production, industrial uses, recreational purposes and artificial recharge. Using wastewater for agriculture production will help in alleviating food shortages and reduce the gap between supply and demand. The interest in the reuse of treated effluent has accelerated significantly in the Palestinian Territories for many reasons;

- Depletion of groundwater resources
- Expansion of sewerage system networks
- Production of large quantities of wastewater which makes its use for agriculture a viable alternative.

- Wastewater is a rich source of nutrient and can reduce the use of fertilizers.
- The reuse is a safe disposal of wastewater which will reduce the environment and health risks, and
- The treatment of wastewater to be used for irrigation is cheaper than that needed for protection of the Environment,
- Wastewater treatment is the most economically and environmentally sound option for augmenting water supplies. The major obstacles issues for making wastewater treatment effective include maintaining a regional standard of treated water quality and building and renovating sufficient sewage infrastructure on the West Bank and in the Gaza Strip.
- Coordination between all related institutions such EQA, PWA, MOA, ...etc. should continue to finalize the concerned standards. They should also fully cooperate to implement the needed wastewater treatment and reuse projects in Both West Bank and Gaza Strip.

References

Barghothi, I. (2004) Water Scarcity in the Middle East: Regional Cooperation on International Relations, House Committee on International Relations. Available from: www.house.gov/international_relations/108/bar050504.pdf.

CH2M HILL, Inc. (2003a). Demonstration projects of reclaimed wastewater and biosolids composting and reuse. Final Report, CH2M HILL, Ramallah, West Bank, Palestine.

CH2M HILL, Inc. (2003b). Detailed feasibility study of Hebron Regional Wastewater Treatment Plant reclaimed wastewater and residual management. CH2M HILL, Ramallah, West Bank, Palestine.

MEDAWARE Project. (2003) Development of tools and guidelines for the promotion of the sustainable urban wastewater treatment and reuse in the agricultural production in the Mediterranean basin, Task 1: Determination of the Countries Profile, Palestinian Territories. European Commission, Euro-Mediterranean Partnership.

MEDAWARE Project. (2004) Development of tools and guidelines for the promotion of the sustainable urban wastewater treatment and reuse in the agricultural production in the Mediterranean basin, Task 2: Evaluation of the existing situation related to the operation of urban wastewater treatment plants and the effluent disposal practices, Palestinian Territories. European Commission, Euro-Mediterranean Partnership.

MEDAWARE Project. (2005) Development of tools and guidelines for the promotion of the sustainable urban wastewater treatment and reuse in the agricultural production in the Mediterranean basin, Task 5: Development of Specifications for Urban Wastewater Utilization. European Commission, Euro-Mediterranean Partnership.

MoA, PWA and Palestinian Hydrology Group (2004). Technical Report and Partial results for the 2003 season of Agricultural Monitoring Development Support Program (*Beit Lahia Site*). The program is developed by the Palestinian Ministry of Agriculture and the French cooperation

MOH-PHIC, (2004) Executive Summary. Health Status in Palestine 2003, July 2004.

Murad, F. (2004) Water Resources in Palestine , A Fact Sheet and Basic Analysis of the Legal Status, International Water Law Research Institute, Dundee University, Scotland. Available from: <http://www.miftah.org/Display.cfm?DocId=6719&CategoryId=4>.

The Netherlands Ministry of foreign affaires, IOB policy and operations evaluation department, (1999) IOB Evaluations No. 282: Review of the Netherlands Development Programme for the Palestinian Territories. Available from: <http://www.euforic.org/iob/publ/keysheets/282e-keysheets.html>.

Tubail, K. M., Jamal Y. Al-Dadah and Maged M. Yassin (2003), Present and Prospect Situation of Wastewater and its Possible Reuse in the Gaza Strip. Available from: http://www.med-reunet.com/05ginfo/05_case.asp.