Prospects of Efficient Wastewater Management and Water Reuse in Palestine

Country Study

Prepared within the Framework of the EMWater-Project
"Efficient Management of Wastewater, its Treatment and Reuse in the Mediterranean Countries"

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List of Abbreviations

ABP	Algae Based Ponds
ARIJ	Applied Research Institute Jerusalem
BZU	Birzeit University
CDG	Carl Duisberg Gesellschaft
DBP	Duckweed Based Ponds
DEG	Deutsche Investitions- und Entwicklungsgesellschaft
DSE	Deutsche Stiftung für internationale Entwicklung
EHP	Environmental Health Project
ELV	Environmental Limit Values
EQA	Environmental Quality Authority
EU	European Union
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
IWS	Institute for Water Studies
KfW	Kreditanstalt für Wiederaufbau
LRDP	Local Rural Development Program
mcm	million cubic meter
MEnA	Ministry of Environmental affairs
MoA	Ministry of Agriculture
MoH	Ministry of Health
MoI	Ministry of Industry
MoLG	Ministry of Local Government
MOPIC	Ministry of Planning and International Cooperation
NGO	Non-Governmental Organization
PAPP	Program of Assistance to the Palestinian People
PARC	Palestinian Agricultural Relief Committees
PE	Population Equivalents
PHG	Palestinian Hydrology Group
PNA	Palestinian National Authority
PPP	Polluter Pays Principle
PSI	Palestinian Standards Institute
PWA	Palestinian Water Authority
SCF	Save the Children Federation
UASB	Upflow Anaerobic Sludge Blanket
UNDP	United Nations Development Programme
UNRWA	United Nations Relief and Works Agency
USAID	United States Agency for International Development
WBG	West Bank and Gaza
WEDO	Water and Environmental Development Organization
WESI	Water and Environmental Studies Institute
WUS	World University Service
WWTP	Wastewater Treatment Plant

Summary

The point and non-point source pollution of scarce water resources is of great concern world-wide. Lack of pollution control in general and nitrogen emission control in particular (especially by untreated or poorly treated wastewater) might aggravate the availability of scarce water resources, especially in arid and semi-arid areas.

Water is a scarce and precious resource in the Middle East. Palestine is a typical example in which scarce water resources are being massively contaminated by non-point sources such as the excessive use of both fertilizer and manure in agriculture and by uncontrolled discharge of municipal sewage into the environment. Such practices have compromised several water sources so far and might seriously endanger future potable water supplies of the population at large. Nitrate concentrations exceeding 100 mg NO_3^-/l are reported for most of the deep wells (50-150 m) used for potable supplies; signs of nitrate pollution in some agricultural wells and freshwater springs in the West Bank were also reported.

Due to water scarcity, the reuse of reclaimed wastewater has been taking an increasing interest throughout the Middle East. The reuse of reclaimed wastewater in Palestine is a major priority, as confirmed by the Palestinian Water Policy recently adopted by the PWA (Palestinian Water Authority) and the Ministry of Agriculture.

Up to now, the agriculture sector makes up about 70 % of the total water consumption in Palestine, and it represents by far the largest water consumer (as elsewhere in the region). Other water uses include domestic (27 %) and industrial (3 %) sectors.

Therefore, agricultural reuse of treated effluents is indeed a topic of great concern in Palestine. Some applications have been realised so far (i.e. Jabaliah and Gaza City) but such implementation failed due to the lack of funds and to the rejection by local farmers.

Cultural acceptance by public opinion seems to be one of the main problems associated with the expansion of wastewater reuse in agriculture. In any case, such practice may become realistic only when effective treatment systems are realized and irrigation standards for treated effluents are accomplished.

Thus, socio-cultural and technical obstacles have to be overcome in order to promote reclaimed wastewater reuse for agriculture purposes. At the moment, in spite of the high potential of this practice, the lack of a national strategy and guidelines makes rejection of reuse most likely. It will be important to emphasize the vitality of water reuse for the Palestinian water sector since recycling the wastewater would lower the burden and pressure on the water resources.

This challenge represents the framework in which the EMWater-Project “Efficient Management of Wastewater, its Treatment and Reuse in the Mediterranean Countries” is introduced. Its main goal is to create public awareness about innovative solutions in wastewater treatment and its reuse and to support the installation of new technologies of wastewater management in the targeted countries (Jordan, Lebanon, Palestine and Turkey).

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Introduction

There have been substantial developments in (waste) water management and treatment technology worldwide during the past decades (Gijzen, 2001). In spite of that, in 1997 three billion people on earth lacked adequate sanitation. In Africa alone, 80 million people are at risk of cholera, and 16 million cases of typhoid infections each year are a result of lack of clean drinking water and adequate sanitation (WHO, 1996). According to the Kyoto summit in 2003, two billion people will not have access to safe drinking water supplies in the year 2015. The Mediterranean countries are among the most affected region in the world. Approximately 95% of the wastewater generated in the world is released into the environment without treatment (Niemczynowics, 1997). Wastewater has been identified as the main land-based point source pollutant causing contamination of the (coastal) marine environment (UNEP/GPA, 2000). The increase in population and therefore in sewage production poses a great challenge to developing and introducing sustainable sewage collection and treatment. The efforts in providing these essential services, especially for poorer regions of the world, are hindered by the shortcomings of the current concept of urban water management and financial limitations.

Water is a scarce and precious resource in the Middle East. The Mediterranean countries are among the regions of water stress in the world (Water stress < 1700 m^3/cap.year). Comparing the average international per capita minimum need according to the WHO (1993) standards (150 l/c/d) with the actual Palestinian water consumption (82 l/c/d), the deficit in water supply reached up to 41 million cubic meters (mcm). Population growth, rising living standards and urbanization increase the pressure on the resource, leading to increasing costs of water supply.

The pollution of scarce water resources by untreated or poorly treated wastewater is of great concern world-wide. Contamination of surface water induces algal blooms, fish kill, ecological imbalances and odour problems, whereas high levels of nitrate make groundwater unfit for potable supplies. Lack of pollution control in general and nitrogen emission control in particular might aggravate the availability of scarce water resources, especially in arid and semi-arid areas of the world. Palestine is a typical example where scarce water resources are being massively contaminated by excessive use of both fertilizer and manure in agriculture and by uncontrolled discharge of municipal sewage into the environment. This might seriously endanger future potable water supplies of the population at large.

In Palestine, the only substantial water resource available is groundwater. Presently, the application of wastewater treatment is limited due to high costs and the technological complexity of conventional systems. Seepage of domestic wastewater from on-site cesspits, inadequately performing off-site sewage treatment plants, together with the excessive use of fertilizer in agriculture has resulted in a dramatic increase of nitrate levels in aquifers. Nitrate concentrations in excess of 100 mg NO_3^-/l are reported for most of the deep wells (50-150 m) used for potable supplies

(Mahmoud et al., accepted). In the West Bank, signs of nitrate pollution in some agricultural wells and freshwater springs were also reported by Alawneh and Al-Sa`ed (1997).

Such a challenge represents the framework in which the **EMWater-Project** “Efficient Management of Wastewater, its Treatment and Reuse in the Mediterranean Countries” is introduced. Its main goal is to create public awareness of innovative solutions in wastewater treatment and its reuse and support the installation of new technologies of wastewater management in the targeted countries: Turkey, Jordan, Palestine and Lebanon. Additionally, the project aims at strengthening capacity building through local and regional training programs, the development of regional policy guidelines for wastewater treatment and reuse in the region. The improvement of water supply and the efficient use of wastewater in the Mediterranean countries is the best recipe for social, economic and political stability in the region and is, thus, the foremost goal of the project.

A **country study** is prepared for each participating Mediterranean partner country as a baseline document of the EMWater-Project. The objective of the studies is to analyze the present state of water and wastewater management and reuse in each country. Therefore, relevant data are collected in different fields, such as

- national institutions, policies, guidelines and standards in the water sector,
- situation of the water resources (quantity, quality, demand, consumption)
- rural and urban water distribution systems,
- wastewater quantity and composition, and disposal systems
- status of wastewater treatment and reuse, existing wastewater treatment facilities

This study provides an insight into the situation of the water and wastewater sectors in Palestine and gives an overview of possible partners and contact persons in the countries. It will be one of the baseline documents within the EMWater-Project for all further activities, like the development and construction of pilot plants, the formulation of wastewater treatment and reuse guidelines and the implementation of different training programs.

Compared to other countries in the Middle East, **Palestine** has a serious position regarding rainfall and water resources, and it is forecasted that Palestine will have to face a water deficit within the next 10-15 years due to several reasons. As the country is still suffering from Israeli occupation, the Palestinian territories face deficiencies in the water supply and wastewater sector. Sanitation and environmental problems result from the lack of funds necessary for installing the appropriate infrastructures related to wastewater treatment and integrated management. Almost half of all water produced is unaccounted for because of losses and billing deficiencies, while leaking or overflowing wastewater collection systems are affecting the environmental conditions and contaminating groundwater resources.

1 Country Profile

1.1 Geography

The Palestinian Territories include two geographical regions, Gaza and the West Bank, which are separated by Israel. Neighboring countries include Jordan and Egypt. The West Bank has a varied topography consisting of central highlands, where most of the population lives, and semi-arid rocky slopes, an arid rift valley and rich plains in the north and west. The West Bank is mostly composed of limestone hills that range in altitudes between 700 and 900 meters. Brown lithosols and loessial arid brown soils cover the eastern slopes and grasslands, with pockets of cultivation spreading over the steep slopes. Fertile soils are found in the plains. Soil cover is generally thin and rainfall is erratic. About 12% of the land is desert, eroded or saline.

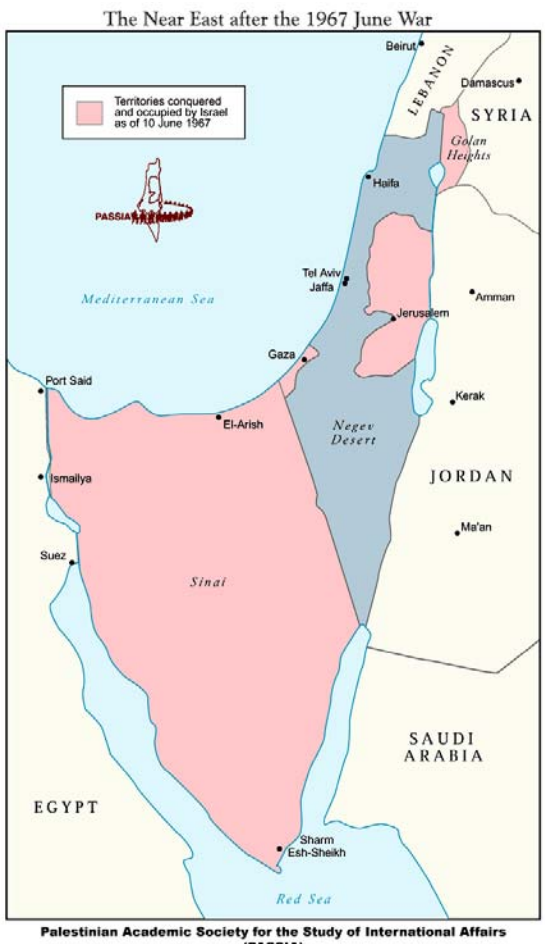


Figure 2: Geographical map illustrating the Palestinian territories and the neighboring countries

Gaza is a narrow, low-lying stretch of sand dunes along the eastern Mediterranean Sea. It forms a foreshore plain that slopes gently up to an elevation of 90 meters. The sea is warm and saline and is affected by water outflow from the Nile River.

1.2 Administration

The Palestinian Territories are divided into sixteen Governorates. Eleven of these are located in the West Bank, and five are located in Gaza. The Governorates are sub-divided into 105 municipalities of which 89 are in the West Bank and 16 in Gaza. In addition, local councils have been formed to manage all infrastructure and basic services. The Oslo Accords divide the West Bank and Gaza into three types of areas, A, B and C. Areas A are under Palestinian control, areas B are under joint Palestinian and Israeli control, and areas C are under Israeli control.

1.3 Demography

Approximately 3 million Palestinians live in the Palestinian Territories, of which over 1 million are in Gaza. About 40% of Palestinians living in the Palestinian Territories are refugees from 1948, and 4 million Palestinians are refugees in the neighboring Arab countries. Approximately 65% of the population lives in urban areas. Annual population growth in the Palestinian Territories is estimated at 4.8%. In 1970, the Israeli settler population living in the West Bank and Gaza was 1,514. It rose to 12,424 in 1980, and ten years later it was 76,000. It nearly doubled over the next five years to reach 146,207 people, and in 2000 it was 203, 067.

1.4 Climate

The climate in the Mediterranean region has four months of hot, dry summer and a short winter with rain from November to March. The climate in the West Bank can be characterized as hot and dry during the summer and cool and wet in winter. The Jordan valley is warm and very dry in the south, while the climate in Gaza, by the sea, is more temperate even though it borders the desert. The average annual precipitation is 450-500 mm, decreasing from north to south and from high to low altitude. Rain tends to fall in intense storms. The northern Gaza Strip receives 400 mm, the south 200 mm per year, and the Dead Sea less than 100 mm.

1.5 Vegetation

The Palestinian Territories can be divided into five main ecological sub-regions: the Mediterranean shoreline coastal plain, the upper coastal plain, the central highlands, the semi-arid eastern slope steppes and the arid semi-tropical Jordan valley. The dry, southern West Bank, eastern slopes and central Jordan valley are composed of Mediterranean savannah grading into land dominated by steppe brush and spiny dwarf shrubs.

On the Gaza coastal plain the original Saharo-Sindian flora has been almost completely replaced by farmland and buildings. Gaza includes six main vegetation zones: the coastal littoral zone, the stabilized dunes and blown-out dune valleys, the Kurkar, alluvial and grumosolic soils in the northern part, the loessial plains in the eastern part, and three wadi (river) areas.

1.6 Economic Situation

The outbreak of the second Intifada in September 2000 and the subsequent worsening of the crisis have had devastating effects on the economy in the Palestinian Territories. After several years of relative economic prosperity, real GDP growth in the West Bank and Gaza dropped from + 6% per annum in 1999, to - 6.5% in 2000 and - 12.5% in 2001. Unemployment reached over 40% in early 2002. There are a variety of causes for development. The main cause of economic decline in the Palestinian Territories has, however, been the policy of curfews and closure instituted by Israel in the face of the deteriorating situation. Direct impacts from these restrictions include a decline in income for workers unable to go to their workplaces, restricted access to markets for businesses and producers, and the rising cost of imports. This decline has recently brought all economic activities to a near standstill.

2 Legal and Institutional Framework

2.1 Development of the Water Laws in Palestine

So far, several laws govern water and environmental management in the Palestinian territories. These laws are listed below:

Safeguarding of Public Water Supplies Ordinance No. 17/1937.

Water Resources Testing Law No. 2/1938.

Water Control Law No. 31/1953 in West Bank Governorates.

Law No. 2/1996 regarding the establishment of the Palestinian Water Authority.

Historical background

In the Oslo II agreement 1993, water is referred to under article 40 of Annex 3 “Protocol concerning Civil Affairs”. The main issues agreed upon can be summarized as follows:

- Israel recognizes the Palestinian water rights in the West Bank. These rights will be negotiated in the permanent status negotiations and settled in the Permanent Status Agreement relating to the various water resources.
- The Israelis shall transfer authority to the Palestinians to assume powers and responsibilities in the sphere of water and sewage in the West Bank related solely to Palestinians, that are currently held by the military government and its Civil Administration, except for the issues that will be negotiated in the permanent status negotiations.
- The issue of ownership of water and sewage-related infrastructure in the West Bank will be addressed in the permanent status negotiations.
- The future needs of the Palestinians in the West Bank are estimated to be between 70 - 80 mcm/year.

In 2002 the PWA issued the Water Law Number (3/2002). This law aims to develop and manage the water resources, increasing their capacity, improving their quality and preserving and protecting them from pollution and depletion.

2.2 National Policies in the Management of the Water and Wastewater Sector

A number of laws, decrees, and ministerial decisions govern environmental management in Palestine. Chief among them are the laws and decrees establishing the Palestinian Water Authority (PWA) and the Environmental Quality Authority (EQA), defining its mandate, and organizing the Authorities. Other legal instruments — existing or pending — define environmental policies, procedures, standards, and other requirements for specific economic sectors or environmental media.

Palestine has enacted an Environmental Law No. 7 (1999), which regulates all environmental issues; however, law enforcement has not yet been implemented. These laws include the protection of natural resources, forestry, archaeological and tourist sites, and drinking water; and the control of sewage, marine pollution, air pollution, industry, fishing, urban development, municipal and hazardous waste disposal.

3.2.1 Actions in Water and Wastewater Management

In 1996 the Palestinian Water Authority (PWA) was founded and started its responsibility as the regulatory body for water resources management for Palestine. PWA is responsible for the legislation, monitoring and human resources development. Water distribution and wastewater treatment is still under the responsibility of municipalities. As of 1996, the PWA also started a reformation in the water sector in Palestine, and the first water contract was signed for the Gaza strip whereby 26 municipalities are now served by private Water Companies. These companies have yet to provide a public report on Water, Wastewater and Solid Wastes Services performance levels supplied to the customers. Nevertheless, according to public opinion, there has been a general improvement in the quality of services provided since 1996.

This private system will be extended to other parts of Palestine (in the West Bank). A management contract with a private operator for the water utilities was initiated in Bethlehem. This policy coincides with the virtue of the newly issued water law (3/2002), which stipulates that National Water Utilities will be established based on the desire of local committees and water users associations to provide water and wastewater services. It will define the tasks, responsibilities and their compositions, management, and financial resources, dismantling, and all matters pertaining to their work in accordance with regulations that will be issued for this purpose.

Private sector involvement will grow, in part, out of recognition of the weak performance, inadequate staffing, poor resources of the regional water authorities, and the adoption of new policies advocating private sector participation.

3.2.2 Environmental Limit Values (ELV) for Wastewater

In Palestinian Territories, PWA recognizes the importance of establishing proper Environmental Limit Values (standards and guidelines) for effluent from domestic wastewater treatment plants as well as the industrial standards for wastewater to be discharged into the sewage systems. Environmental Limit Values (ELV) (Annex A1-A4) are prepared by the Palestinian Standards Institute (PSI) and the PWA (Annex 5: A5.1-

A5.9); however, these Limit Values are yet to be enforced.

Physical, chemical and biological emission limit values for different discharge options, like pH, temperature, BOD, COD, nutrients, suspended solids, AOX, detergents, bacteria and heavy metals, which are listed in Annex 1 of this study.

2.3 National Bodies Responsible for the Water and Wastewater Sector

3.3.1 The Palestinian Water Authority (PWA)

PWA has developed a strategic master plan for wastewater management, within the framework of a national strategy for sustainable development to protect the natural resources at the national, regional and global levels. The objective of the PWA's wastewater strategic plan to be implemented by 2020 is to connect 75% of the population in municipalities and 25% of the population in areas less than 5,000 PE to treatment plants. Another long-term objective is to connect about 50% of the population in rural areas to "appropriate" treatment by 2020. Comprehensive policy for waster and wastewater management has been developed to achieve these objectives.

According to By Law No. 2 (1996), PWA is responsible for wastewater treatment and reuse. Preparation of policies and strategies for management of wastewater, industrial wastewater, legal and administration are under way. PWA policy in management of the water and wastewater sectors is implemented by establishing regional utilities for large systems wherever possible, and by establishing other appropriate structures for smaller and remote areas.

3.3.1.1 PWA Industrial Wastewater Policies

Industries should be regulated by means of discharge permits from PWA and comply with other PNA regulations (e.g. municipal, Ministry of Environmental Affairs). The discharge permits should include assurances that industrial effluents must have an acceptable quality for flows being discharged into water bodies or domestic wastewater systems, and should not be discharged with contents of heavy metals or micro pollutants above given limits.

3.3.1.2 PWA Domestic Wastewater Treatment Policies

All treatment and/or reuse systems will be regulated by means of permits from PWA. The permits should ensure that the system is designed according to approved regulations, specifications, standards, and guidelines. Furthermore, the system is to fulfil wastewater flows and effluent quality for the designed period and solve identified and potential environmental and health problems.

The minimum acceptable treatment level is secondary treatment (e.g. removal of settleable and suspended solids and biodegradable organics plus disinfection). For regional utilities, this minimum treatment level is expanded to include tertiary treatment. Low cost technology is encouraged wherever it is possible.

All wastewater treatment processes should be chosen and designed to consume as little energy as feasible. Potential energy in wastewater and sludge must be utilized whenever appropriate. In addition, independent alternative energy sources should be installed, if appropriate (e.g. solar systems, battery, heating exchange pumps, etc.) and farmers should be involved in energy recovery projects thereby benefiting from wastewater sludge and farm wastes.

PWA emphasizes that treated wastewater is a valuable resource that must be utilized and agriculture is given priority for reuse. In order to encourage and promote the use of treated wastewater incentives need to be adopted.

3.3.1.3 PWA Economic, Social, and Cultural Policies

The economic policy aim is to reach a reasonable cost formula between the public, industry, re-user, and the authorities. Several strategies to implement this policy have been identified:

The general guideline to follow is that overall fees for storm water handling, wastewater collection, treatment, storage and reuse should be calculated in order to achieve full cost recovery of the system(s). The elements of these fees should be distributed using the Polluter Pays Principle (PPP). In doing so, households cannot be charged more than the defined affordability, the government should cover the gap between full cost recovery and affordability, and the farmers must contribute for making treated wastewater available for irrigation.

PWA will adopt the use economic incentives for polluting industries to decrease pollution in order to enforce the regulations and to sustain development of the sector.

PWA recognizes that wastewater treatment and reuse policies must include stakeholders' involvement throughout the policy and strategy formulation process in order to create a sense of ownership and understanding.

3.3.1.4 PWA Legal and Administration Policies

According to By Law No. 2 (1996), PWA is recognized as the Palestinian authority responsible for licensing and approving all water and wastewater projects and activities including wastewater and stormwater collection, treatment, reuse, and/or disposal. It is responsible for ensuring and overseeing the efficiency and compliance of these activities and projects initially and during operation, according to approved regulations, specifications and standards. It is also responsible for administering the construction, operation, and maintenance of wastewater and reuse systems which will be carried out by regional utilities with various levels of coordination and involvement of other PNA organizations, such as the Ministry of Environmental Affairs, Ministry of Agriculture, Ministry of Local Government, and the Palestinian Water Authority.

3.3.1.5 PWA Tariff Setting Policy

As mentioned above, PWA recognizes that the success of service utilities in Palestine depends on their ability to cover the cost of services from their users. This is only possible if all the elements of cost, whether hidden or visible, are included in the price of the services (tariff system), taking into consideration that this price does not rise above that which the majority of consumers can afford. To achieve this balance, it is necessary to reduce the cost of operation and maintenance to the lowest possible amount by using highly efficient procedures. Attempts to produce the best systems at the lowest cost through capacity building in the field of finance and financial management should be done. This intervention includes the following:

Develop a budgeting system, conduct a cost analysis and cost recovery process produce tariff systems, develop a revenue, billing and collection system, develop financial monitoring procedures, develop an accounting system, including software and establish and apply assets management plans.

According to PWA, in addition to the cost recovery, tariff policy shall fulfill social equity and economic efficiency. The already planned wastewater treatment plant (extended aeration system) for the urban areas in Palestine revealed that the tariff for wastewater treatment would be 6 NIS/ m^3 if full cost recovery will be fulfilled (this cost is 1 to 1.3 higher than the cost of 1 m^3 of drinking water). If only operation and maintenance costs are to be recovered, the tariff would be 2 NIS/ m^3.

3.3.1.6 Outlook

Despite the water shortage projected within the next couple of decades and the lack of sufficient water and wastewater management in the Palestinian Territories, many projects on water infrastructure have been initiated in recent years with the assistance of grants and loans from major donor organizations and governments (See chapter 3.5). The aim of these projects is to rehabilitate old and construct new wastewater treatment plants, pumping stations, groundwater wells, and sewage and drinking water networks. Despite the setting of the national policies for water and wastewater management, it has yet to be implemented in Palestine.

3.3.2 Environmental Quality Authority (EQA)

The mission of the EQA, formerly called the Ministry for Environmental Affairs (MEnA) is as follows: To safeguard and protect the environment, human health, control and limit the degradation of natural resources, combat desertification, prevent future pollution, enhance environmental awareness and ensure environmentally sustainable development. Palestine has enacted Environmental Law No. 7 (1999), which regulates all environmental issues and incorporates the polluter pays principles. The main responsibilities of EQA are in the fields of planning, monitoring, licensing and enforcement. The organisation’s main responsibilities are stated below (MEn A, 2000):

- Develop environmental policy, legislation and environmental planning. Developing standards, norms and guidelines for creating sustainable environment.
- Set norms to determine which projects should be subject to EIA
- Conduct environmental studies and researches
- Monitor the occurrence of environmental pollution, prepare and implement contingency plans.
- Cooperate with others concerning the supervision and coordination of environmental projects
- Enhance public awareness and the skills of its human resources through education and training in environmental management

MEnA shared the responsibility of the environment by other ministries, institutions (NGOs) and the private sector. For example, MEnA and PWA cooperate in the field of groundwater and surface water quality protection by setting groundwater and surface water quality standards, increasing public awareness in the water sector, training MEnA and PWA staff in the field of water quality protection, undertaking EIA for water projects, and setting regulations for reuse of treated wastewater.

Some other Ministries involved in the planning and management of water and environment related issues are stated below:

The Ministry of Local Government (MoLG) has a major role in solid waste management.

The Ministry of Health (MoH) is concerned with the management of medical waste.

The Ministry of Industry (MoI) is concerned with the management of hazardous waste and issues related to industrial pollution control.

The Ministry of Agriculture (MoA) is involved in the use of agrochemicals, protection of nature, biodiversity and use of treated wastewater in agriculture.

3.3.3 Municipal and Local Councils

See chapter 4.4.2

3.3.4 Environmental NGOs

NGOs active in the field of water and wastewater treatment and reuse include the Palestinian Agricultural Relief Committees (PARC), MA'AN Development Centre (MA'AN), the Palestinian Hydrology Group (PHG), the Applied Research Institute Jerusalem (ARIJ), and the Water and Environmental Development Organization (WEDO).

Examples of NGO activities include the following projects in the sector of water and waste water:

Wastewater Treatment Facilities at Al-Arroub Agricultural Secondary School

Wastewater treatment facilities at several schools and small communities

Rehabilitation of springs in rural Palestine

On-site wastewater treatment plants including separation and treatment of grey wastewater

Solid Waste Dump Site in Hebron

Ecological sanitation based on urine diversion technology (dry sanitation): A pilot project

Duckweed wastewater treatment and reuse for fodder

Laying of water distribution networks in rural areas

Conducting public awareness programs on conservation of water and protection of environment

3.3.5 Universities Research Institutions

The main objective of the Universities water and wastewater research institutions is to serve the Palestinian community's needs in terms of education, studying, monitoring, describing, controlling, and following up all issues and aspects related to the present and future state of water, wastewater and environment in Palestine. Among others, the Institute for Water studies (IWS), the Institute of Community & Public Health and the Centre for Environmental & Occupational Health Sciences at Birzeit University, the Water and Environmental Studies Institute (WESI) at An-Najah National University, and the Water Resources Center, Al-Azhar University.

2.4 International Organisations Active in the Water and Wastewater Sector

International donor agencies play an important role in financing environmental project activities. Projects cover a wide range of issues and areas of intervention, including institutional strengthening, resource management and conservation, biodiversity, and (re)building of the public infrastructure, such as water supply and wastewater treatment and energy. International organizations are working in Palestinian Territories in capacity building, project implementation and technical assistance. The most important international organizations are listed below.

3.4.1 United Nations Development Programme (UNDP)

Over the past 23 years, UNDP has operated technical cooperation programs in the Palestinian Territories with local authorities, a large network of NGOs, and civil society groups. Since the establishment of the PNA, the cooperation has been extended to several national institutions, mainly the Environmental Quality Authority (EQA) and the Palestinian Water Authority (PWA). More than $130 million (US) were invested by and/or through the UNDP (funded by major donor countries) in this field (www.papp.undp.org).

At the Community Level

- Over two hundred water supply and sanitation projects have been completed in the West Bank and Gaza. These projects included the construction of water supply and distribution networks, storage reservoirs, and house connections. In addition, water supply wells and rainwater collection cisterns were constructed and major wastewater treatment facilities and storm water drainage projects were completed particularly in the Gaza Strip. The projects were implemented in major cities and towns as well as over 150 rural communities. Together they serve a combined population of several hundred thousand people.
- 100 communities that do not have piped water supply receive regularly tankered water at reasonable prices.
- Parks and playgrounds to improve the human environment
- Community awareness of environmental issues and participation in preserving natural resources significantly increased.
- Scores of professional water engineers and planners as well as technicians were trained in integrated water resources management, leakage detection, and operation and maintenance of water supply systems.
- A large number of smaller projects have provided safe water and improved sanitation to at least 150 rural communities. Many of these have been provided

through Program of Assistance to the Palestinian People (PAPP's), Local Rural Development Program (LRDP), Engineering and Infrastructure and Environment Units.

At the Level of the Palestinian Authority

- The Palestinian Water Authority has been established to improve the planning and management of the scarce water resources of the occupied Palestinian territories.
- A number of Regional Water and Wastewater utilities have been developed to economize resources and improve management.
- The capacity of several municipal water departments was enhanced particularly in operation and maintenance of existing systems.
- The capacity of key government institutions responsible for environmental issues has been significantly strengthened in the area of policy formulation, planning and project management. The most important of these are the PNA's Environmental Quality Authority.
- Computerized information systems, management models, and monitoring mechanisms have been developed and staff trained in their use.
- A Palestinian National Water Plan, a Water Sector Strategic plan, and an Environment Action Plan have been formulated and are under implementation.
- Regional Environmental Monitoring Offices and air quality monitoring stations have been established.
- A large scale "rescue operation" has been initiated to restore the Wadi Gaza, a ravine that was once a beautiful nature reserve and is still home to many exotic species of birds, but which has been used as a dumping ground for liquid and solid waste for decades.
- In Gaza City and other towns, sidewalks have been tiled and streets repaired resulting in freer flow of traffic through an early labour intensive public works program.

3.4.2 United States Agency for International Development (USAID)

USAID/WBG has implemented a multi-year program that combines the rapid development of new water sources, improved systems for water distribution and management, and wastewater treatment.

USAID, through its $42 million (US) contracts with CH2M HILL and Contrack International, is constructing one well near Nablus and four wells, two pump stations, and 17 kilometres of pipeline in the Bethlehem/Hebron region that will add new sources of water. In the Hebron region, new transmission lines will deliver this water to more than 25 villages. An aquifer modelling tool, designed by CH2M Hill, will enable the Palestinian Water Authority (PWA) to manage these resources efficiently. In Hebron, USAID has finished the design for the Hebron Wastewater Treatment Plant, a project of $50 million (US). This plant will protect public health, clean up the environment, and provide a reuse concept for agriculture.

Through USAID's Village Water and Sanitation program, a $9 million (US) activity implemented by CDM's Environmental Health Project (EHP), the construction of new water systems for under-served villages west of Hebron will begin later this year, and construction near Nablus will begin in 2004. In the meantime, USAID is providing water via tanker trucks to severely affected areas. Some of the results from the USAID projects in the West Bank and Gaza are listed below (www.usaid.gov).

- USAID wells and pipelines have nearly doubled the amount of water available for about 400,000 residents of Bethlehem and Hebron in the West Bank.
- USAID expanded a Jenin area well and provided for piped-in and cleaner drinking water for 11 villages in the Jenin area of the northern West Bank. Previously, the 40,000 people living in these villages had to rely on expensive deliveries of poor-quality water by truck.
- In early 2001, USAID financed a water distribution system for the Ein Sultan refugee camp near Jericho, bringing reliable running water to the 3,000 refugees for the first time ever.
- In Gaza, USAID built wastewater treatment capacity and sewers for about 400,000 Palestinians in Gaza City. USAID upgraded the existing treatment plant and increased its capacity to handle the city's wastes. The water treated in the plant is of high enough quality to recharge the shrinking Gaza water table.

3.4.3 European Union Financial (EU)

European Community assistance to the Palestinians began in 1971, when the first contribution was made to the regular budget of the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA). Given the prevailing political situation in the West Bank and Gaza, the EU has been unable to establish a multi-annual framework in the form of a Country Strategy Paper and National Indicative Plan. Therefore, programming of financial assistance is currently carried out on an annual basis. The MEDA program (www.europa.eu.int) is the main financial instrument through which the EU implements the Euro-Mediterranean Partnership initiated at the Barcelona Conference in November 1995. So far West Bank/Gaza has received a total of € 286.6 million under the MEDA program (€ 54 million under MEDA I (1995-1999) and € 232.6 million under MEDA II (2000-2003)). The funds have been intended among other for small and medium scale ventures, power and water supply, and waste treatment.

3.4.4 German funds

The German government has implemented several programs in water, sanitation and solid waste disposal since the establishment of the Palestinian Authority (PA). The German financial aid, including the technical and financial cooperation, contributed to to the PA up until the end of year 1999 amounted to DM 329.53 million ($165 million (US)). The German bilateral development cooperation program in Palestine can be divided into five categories:

- Infrastructure investment (water supply, sanitation and solid waste disposal; other investment projects are being implemented through Deutsche

Geseltschaft fuer Technische Zusammenarbeit (GTZ); and Kreditanstalt Fuer Wiederaufbau (KfW)).

- Technical Cooperation (support in institutional capacity-building of the PA (MOPIC, and others))

- Private Sector Development (Loan support to the Arab Palestine Investment Bank by the Deutsche Investitions- und Entwicklungs Gesellschaft (DEG), credit program through DtA to facilitate setting up Palestinian private businesses. Other small partnership programs are also funded).

- Training Programs (Various technical training programs in the areas of governmental and business administration, water, sanitation, solid waste disposal and vocational training for returnees, were carried out via Deutsche Stiftung fuer Entwicklung (DSE), Carl Duisberg Gesellschaft (CDG), World University Service (WUS).

- Some small scale self-help projects to NGO´s in the social and human rights sector were also funded.

3.4.5 Other Donors

The U.S. Government, the European Union (EU), Japan, Norway, and the World Bank are the lead donors in the West Bank and Gaza. The Arab League has also provided significant assistance to the Palestinians. Despite violence and impediments to program implementation resulting from the political situation, most donors have maintained their levels of assistance. However, there has been a shift in programming oriented towards unemployment and rising rates of poverty. The World Bank, for example, has provided $12 million (US) in immediate assistance to support emergency job creation activities, and the EU, Norway, The Netherlands, and Japan have provided support through the United Nations Relief and Works Agency.

3 Water Sector in the West Bank

3.1 Hydrology / Water Resources

Three main aquifers characterize the groundwater source in the West Bank. The western aquifer system, the largest, has an annual safe yield of 362 mcm (of which 40 mcm are brackish). Eighty percent of the recharge area of this basin is located within the West Bank boundaries, whereas 80% of the storage area is located within Israeli borders. Groundwater flow is towards the coastal plain in the west, making this a shared basin between Israelis and Palestinians. This source is mainly used for municipal supply because its water is of good quality. Israelis exploit the aquifers of this basin by means of 300 deep groundwater wells to the west of the Green Line, as well as by means of Mekorot (the Israeli water company) deep wells within the West Bank boundary. Palestinians, on the other hand, consume only about 7.5% of the Palestinian territory's safe yield. They extract their water from 138 groundwater wells tapping the

Western Aquifer System (120 for irrigation and 18 for domestic use) in Qalqilya, Tulkarm, and West Nablus. There are 34 springs with an annual discharge of about 2 mcm.

The Northeastern Aquifer System has an annual safe yield of 145 mcm (of which 70 mcm are brackish). Almost 100% of the basin is recharged by precipitation falling within the West Bank area. But the water then flows underground in a northerly direction into the Bisan (Bet She'an) and Jezreel valley. Palestinians consume about 18% of the safe yield of the aquifer by means of 86 agricultural and domestic wells in the Jenin district and East Nablus (Wadi Al Far'a, Wadi El Bathan, as well as Aqrabaniya and Nassariya) for both irrigation and domestic purposes. There are 24 springs with an annual discharge of about 1 mcm.

The Eastern Aquifer System has an annual safe yield of 172 mcm (of which 70-80 mcm are brackish). It lies entirely within the West Bank territory. The Palestinian farmers tapped their water until 1967. Subsequently, Israel expanded its control over this aquifer and began to tap its water to supply Israeli settlements implanted in the area. This aquifer is mainly drained by a group of springs. There are 56 springs that have an annual discharge of about 55.5 mcm.

This aquifer system has 122 Palestinian groundwater wells (109 for irrigation and 13 for domestic use). In several parts of the basin, wells have been over pumped thus leading to drop down in the water table and deterioration of its quality. In the past few years, the Palestinian wells at Ein Samia in Ramallah and Tequa in Bethlehem have shown drastic drops in the water table level, reaching 30 meters annually. This will lead to far-reaching consequences.

4.1.1 Precipitation

The West Bank has a Mediterranean climate classified into a wet season (winter) and a dry season (summer). The average annual precipitation in the West Bank varies between 700 mm in the mountain region and 150 mm in the Jordan Valley, and amouts to an overall annual average of 450-500 mm. This uneven distribution is due to the geomorphologic nature of the West Bank. The West Bank exhibits contrasting physiographic features and well-differentiated geomorphologic regions despite its small surface area. It was estimated that 30-40% infiltrates the groundwater aquifer, 5% discharges to the sea as surface runoff through seasonal wadis, and the remaining amount is lost via evapotranspiration (MOPIC, 1998).

4.1.2 Groundwater

The underground water resources of the West Bank are mainly related to the following formation: Hebron, Jerusalem, Bethlehem, Upper and lower Beit Kahil, Jenin and Quaternary formations. Generally all these formations are part of the three main basins, namely western, north eastern and eastern basins, and the groundwater flow direction are to the west, north and to the east, respectively (Figure 4.1).

Figure 4.1: The West Bank groundwater basins and flow directions

According to Article 40 of Oslo B agreement, the groundwater quantities available for exploitation are estimated at 362, 145, and 172 mcm per year from the three groundwater basins, respectively. However, the Palestinian consumptions from wells are only 20, 25 and 24 mcm per year and the remaining parts are the consumptions by Israel.

3.2 Water Consumption

Water use in Palestine is divided among three principal sectors: agricultural, domestic, and industrial use. As shown in Figure 4.2, agriculture, with around 70 %, is by far the largest consumer of water in Palestine (as elsewhere in the region), followed by domestic (27 %) and industrial uses (3 %).

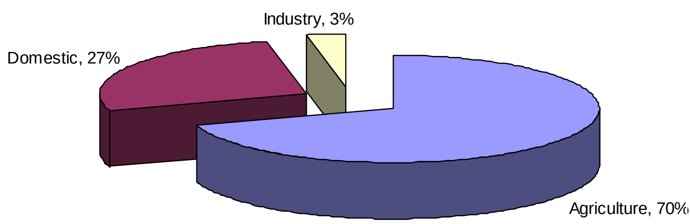


Figure 4.2: Water consumption in Palestine by sector

3.3 Sources of Domestic Water Supply

All the Governorates in the West Bank are suffering from the increasing shortage of water supply. The average **water supply rate** in the main cities in the West Bank- (excluding Jericho) is approximately 82 litres per capita per day (l/c/d), while **supply rates** may vary from 29-200 (Table 4.1). It is very difficult to determine the actual water consumption, as a large share of water in public distribution systems is lost through system leakages. The average loss in the distribution systems is 36%. In some localities, it can reach as much as 60 % (Bani N'aim, Ya'bad, Rantis, Silwad, Abud and Beituniya) of the supply.

Table 4.1: The average water supply, the required quantities, the available quantities and the average deficit for the year 2002 in the main cities of the West Bank.

Governorate	Population	Average supply (l/c/d)	Required Quantity (mcm)	Available quantities (mcm)	Deficit (mcm)
Jenin	225714	55	12.3	4.50	7.79
Tubas	41063	29	2.22	0.43	1.79
Tulkarm	149188	107	8.16	5.81	2.36
Nablus	290623	88	15.9	9.30	6.60
Qalqilia	81935	107	4.47	3.21	1.26
Salfeet	54595	71	2.98	1.41	1.58
Jericho	37066	200	2.03	2.70	-0.68
Ramallah & Jerusalem	375395	116	20.55	15.87	4.68
Bethlehem &Hebron	611714	82	33.34	18.20	15.14
Total	1867293	95	101.95	61.43	40.52

(mcm): million cubic meters; l/c/d: liter per capita per day.

In comparing the average international per capita minimum need according to the WHO (1993) standards (150 l/c/d) with the actual Palestinian water consumption (Table 4.1), the deficit in supply reached up to 41 mcm in the year 2002. With an exception of Jericho, all the governorates suffered at different ratios from the shortage of supply, with Jenin, Tubas, Salfeet and Hebron having suffered the most, and Tulkarm, Qalqilia and Ramallah the least.

Palestinian communities are supplied with domestic water by two different means: water that is owned by Palestinian sources or that which is purchased from the Israeli company (Mekerot). The owned water sources are utilized from the groundwater wells in addition to the water from springs. Table 4.1 shows the average water supply, required quantities, the available quantities and the average deficit (Figure 4.3) for the year 2002 in the main cities of the West Bank.

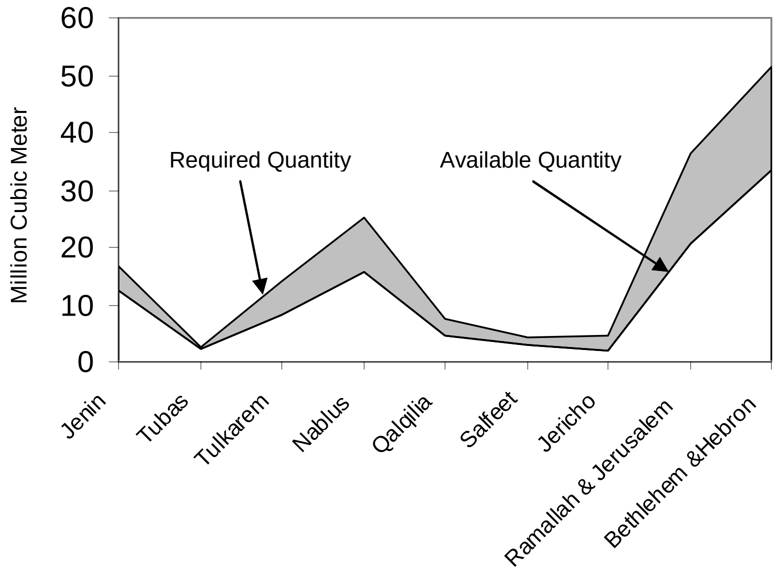


Figure 4.3: Average water deficit for the year 2002 in the main cities of the West Bank

3.4 Water Supply Management in the West Bank

The water supply management in the West Bank is performed by one of the following institutions: West Bank Water Department, Municipalities, local councils, or water institutions (Jerusalem Water Undertaken, Water and Sanitation Authority-Bethlehem). Every one of these institutions has its own water sources, some of these have there own wells or springs, and sometimes these sources are not enough to fulfil the increasing need, so these institutions buy a big portion of their water from the Israeli water company (Mekerot).

4.4.1 West Bank Water Department

The West Bank Water Department is considered the biggest water distributor and the supervisor of most of the networks in West Bank. Every year, it distributes a total of 40 mcm of water. Approximately 4 mcm is supplied to the Israeli settlements, while 4.5 mcm is allocated for agricultural purposes in the Bardala area, and the remaining quantity is supplied to 242 Palestinian communities, in addition to some private connections for industrial and agricultural purposes. This department was established in 1966 according to the Jordanian Law, and was part of the Jordanian Natural Resources Authority. After the 1967 occupation, the West Bank Water department was administered by the Israeli Civil Administration and the so-called water officer who was linked to the Israeli military governor.

After signing the Interim Agreement "Oslo II" on 1995, the Palestinian National Authority took over the responsibilities and the Palestinian Water Authority was authorized to restructure, develop, and supervise its work. The institutional structure consists of three departments (Administrative and Financial Affairs, Engineering and Planning, and Operation and Maintenance).

The responsibilities of the West Bank Water Department are as follows:

- Supervising the constructions and the O&M of the pumping stations.
- Distributing water and collecting cost.
- Distributing Chlorine.
- Supervising the Palestinian Water Authority, the municipalities, and the village councils in preparing the project proposals or documents and in fund raising.
- Preparing the water projects and forwarding them to the Joint Water Committee (Israelis and Palestinians experts) for approvals.
- Supervising the implementations of the projects.
- Coordinating and following up with Mekerot regarding the management of the purchased water in the areas of supply.

4.4.2 Municipal and Local Councils

Municipalities in the Palestinian Territories are responsible by law for building and maintaining certain infrastructure (sanitation, local roads, and sidewalks) and providing basic services (solid waste management, wastewater treatment, construction permitting, etc.).

In most of the main cities (Nablus, Qalqilia, Salfeet, Jericho, Jenin, Tulkarm and Hebron) and in some small municipalities (such as: Municpalities of Qabatia, Tubas, Anabta, Bal'a, Hala, Qaffin, Azzun, Zeita, Attil, Dir Al-Ghusun, and Local Council of Bit Imrin, Barta', Shufa, Ijnisinya, Dir Ghazala, Al-Naqura, Kufr Zeibad, Sabastiaand local councils), there are water departments and sections within the municipalities that are in charge of the management of the water supply and developing the networks and other related works. Unfortunately, most municipalities still lack the human and financial resources, environmental awareness, management capabilities, and/or political commitment necessary to discharge their mission in an environmentally sound manner. Training of municipal decision-makers and professionals will be required to improve the overall effectiveness and environmental performance of the Palestinian municipalities.

4.4.3 Non-profitable Institutions

These non-profitable Institutions, which are administratively and financially independent institutions and are owned by the municipalities, include:

- Jerusalem Water Undertaken for Ramallah and Al-Bireh Districts.
- Water and Sanitation Authority for Bethlehem, Beit Jala, and Beit Sahur.
- Joint Services Water Council for West Jenin villages.

3.5 Potable Water Quality

Municipalities and regional water authorities are responsible for procuring, treating and distributing potable water to households. The only treatment that water receives before distribution is chlorination at the source. Recently, the sources of the potable water showed an increase in chloride and nitrate concentration in some wells in the West Bank. The quality of the potable water is expected to deteriorate with time as a result of discharging untreated wastewater to wadis and heavy use of fertilizers for agriculture.

3.6 Water pricing

The Municipalities and regional water authorities set and collect water tariffs for domestic use. Water fees for domestic water supply vary considerably among different localities. Tariffs ranged from 0.15-0.2 US$/m^3 in Qalqiliya and Jericho to 1.0-1.2 US$/m^3 in the Dura and Ramallah area. Differences are partly due to the level of services, water availability, and distribution costs. In the Dura and Ramallah area, for example, where water tariffs are highest, water is conveyed long distances and/or pumped from deep wells. In Qalqiliya and Jericho, where water tariffs are lowest, water is available in shallow wells (Qalqiliya) and/or springs (Jericho) at low pumping costs.

Due to frequent and periodic water shortages, some localities in the North (i.e. Jenin area) purchase water from tankers; a number of areas report receiving water only a few hours per day. Such localities are paying US$ 5/m^3 of the additional purchased water. In some localities in which even no water meters are installed, the price of water will remain unaffected by actual water consumption and people will pay the same amount regardless of the quantity of water actually delivered/consumed. Users/customers have no incentives to conserve water and wastage is much more common.

3.7 Pressures Exerted on the Water Sector

The water sector in Palestine is subjected to many environmental stresses related to the agricultural, industrial, and many other sectors. In the following some of the environmental stresses and pressures on the Palestinian water sector are explained in more detail.

4.7.1 Population Expansion

The population in Palestine is expanding at an average annual growth rate of 3.5 %. This expansion of the population is exerting serious stress on the water sector since the population growth is not being coupled with parallel projects in the water sector. Thus, the expansion of the water sector has not been able to cope with the expansion of the population, which exerts pressure on the available water supply and water and wastewater services.

4.7.2 Agricultural Sector

Agriculture in Palestine is also increasingly shifting to irrigated production. Irrigation water in Palestinian agriculture is provided from springs and groundwater. In the West Bank, 93 mcm/year are used for agriculture (70% of the total water consumption of all sectors), a quantity which is not enough for current level of development in the agricultural sector. 55% of this water originates from springs which have an annual flow discharge of 52 mcm. The efficiency of the springs is low as large amounts of water are lost through seepage and evaporation. There are 316 wells used for irrigation in the West Bank (Arij, 1995). The farms that have private water wells are increasing the pumping rates rapidly to satisfy the rising need for irrigation water. Furthermore, the seasonal discrepancy between the precipitation period (winter) and the period of maximum demand for irrigation water (dry summer) has consistently led to excessive and uncontrolled withdrawal of groundwater. Uncontrolled construction of bore wells and inappropriate water abstraction from wells have led to a significant draw-down of the water table in many regions.

In 1995, approximately 30% of the total area of the West Bank was under cultivation (Arij, 1995). 97% of the total irrigated areas in the West Bank are located in two areas, namely the Jordan Valley and the North districts of Jenin, Tulkarm and Nablus. Irrigated agriculture accounts for only 6.0 % of the total cultivated land and drip irrigation is the predominant method of irrigation. The efficiency of drip irrigation method is high and could be significantly improved using optimal water and crop management schemes, however, the majority of farmers in Lebanon lack basic agricultural training and environmental awareness.

In addition, some agricultural practices have also contributed to a diminishing water quality. Excessive fertilizer utilization in Jericho has led to nitrate leakage, which has been detected in elevated concentrations in groundwater in some places. Furthermore, the uncontrolled application of pesticides is expected to contaminate springs and groundwater.

4.7.3 Industrial Sector

The pressure exerted by the industrial sector on the water sector is mainly related to pollution. The increasing number of industries and workshops that are not practicing environmentally sound procedures heavily burden the Palestinian environment. Most industries in the West Bank discharge their industrial waste into the sewer system and/or cesspits.

Presently, there are over 14,000 industries and factories in the West Bank and Gaza Strip, 70% of which are located in the West Bank alone (PCBS, 2000). Existing major industrial activities in the West Bank can be classified into two main categories: extractive industries and manufacturing industries. Extractive industries are those involving quarrying of limestone, marble stone, and crushed aggregates. Manufacturing industries include units for cutting and polishing stone, leather tanning, textile dyeing, food and beverage, textile, shoes and leather, metal processing, etc. The distribution of each type of industry is illustrated in tables 4.3. As seen from the table, the largest number of industries is located in Hebron, Nablus, and Ramallah.

Table 4.3: The distribution of each type of industry in the West Bank (Source: Palestinian Ministry of Industry)

Type of industry	Bethlehem	Hebron	Jenin	Jericho	Jerusalem	Nablus	Ramallah	Tulkarm	Total
Textile, Clothing, Shoes	95	348	89	23	85	287	143	131	1201
Metal Working	96	237	56	13	84	205	181	82	954
Wood working	123	245	67	15	91	221	158	84	1004
Food, Beverage Tobacco	109	223	88	35	83	187	207	132	1064
Non-metallic	64	107	56	10	36	86	78	71	508
Stone processing	141	134	134	—	5	140	67	85	706
Balance	23	38	21	1	4	67	77	20	251
Total	651	1332	511	97	308	1193	911	605	5688

4.1.1.1 Types of industries

The preparation of a comprehensive list of industries is needed to develop an industrial database. However, little or no data on effluent flows, concentrations, and loads are available. Some types of industries that are causing damage to the Palestinian environment are presented below:

Quarrying, stone crushing, and stone processing: These industries generate the largest amount of liquid and solid waste along with air-born pollutants. Most are located in residential and agricultural areas. Large amount of dust and particulate solids create harmful conditions for public health. The dust severely damages the agricultural land and natural ecosystem.

Charcoal: These industries are mainly located in the Jenin district (mainly in Yabad) nearby residential areas, creating adverse living conditions. The coal residue covers fertile land, destroying wheat crops and olive trees.

Leather tanning: Tanneries use large amounts of chemicals, such as arsenic, chrome, sulphuric acid and salt. Wastewater is disposed untreated in the wastewater network or disposed in open areas like wadi Al-Zomer without pre-treatment, causing possible contamination of toxic and carcinogenic compounds to groundwater.

Textile dyeing: The effluent contains high concentrations of ionic substances, organic colour and reactive dyes. High temperature and high pH values characterize the effluents from such industries. Chock loading of such waste to Ramallah wastewater treatment plant is commonly practiced.

Food and beverage: This is one of the biggest industrial sectors in Palestine. Wastewater from this industry has high concentrations of BOD (Biochemical Oxygen Demand), which creates problems for treatment units and the dairy industry is a major part of this sector.

Olive Mills: The wastewater from these factories has a high level of both BOD and acid, which disturb treatment units and pollute groundwater.

Chemicals and plastics: This includes production of pharmaceuticals, detergents, paints, adhesive, etc; quite often involving a process of mixing chemicals. Pollutants from these industries may be solid, liquid or gaseous.

Metal Processing: The most hazardous wastes are the ones from the electroplating, metal finishing, and casting industries. Some units use rubber tires and vehicle oil as furnace fuel. The particulate solid and toxic compounds emitted may contribute to serious health problems.

4.1.1.2 Main problems for efficient management of industrial wastewater

1- Industry is reluctant to control its pollution.

2- Access to sampling locations is often refused.

3- High levels of toxic materials may be discharged to the sewers.

4- Although some are in place, legislative controls are not implemented.

5- A comprehensive database of polluting industries does not exist.

Since there are no enforced laws or regulations to control industrial wastewater into the environment, this could directly deteriorate the water resources and has a detrimental effect if wastewater is discharged into domestic treatment plants without pre-treatment. Therefore, in order to have effective wastewater management in Palestine appropriate policies, regulations and enforcement of laws are compulsory. Few efforts have been made to minimize pollution loads discharged from industrial emprises. Nazer et al., (2003) developed a method whereby recycling of tannery effluent was introduced in the leather production processes. They showed that using the tannery effluent five times with slight chemical supplement had no negative impacts on the leather quality produced and reduced the environmental effects and operational costs.

4.1.1.3 Licensing of factories

In Palestine, three forms of licenses are required to be a legally registered factory: A municipal Building license, a license from the Ministry of Industry, and a license from the Ministry of Health.

1. Licenses from the municipalities for the building itself. 85% of the factories have a building license; however, this is not the license to legally run a factory. Fourteen percent of these 83 factories do not have a license to operate as a factory, while 13 factories did not respond to this question. There are 15 factories that do not have a municipal building license and are distributed as follows: 12 in rural areas, one in semi-urban areas, and two in urban areas (see Table 4.4).

The building license is usually granted by the Ministry of Local Government (Article 4, Law number 30, August 1996) or municipalities. Article 3 of Law number 30 allows the construction of residencies in industrial zones, which has led to the creation of residences in industrial zones and workshops and factories in residential zones.

Problems also arise when rented buildings with a municipal license are used for industrial purposes without obtaining permission from the Ministries of Industry and Health.

2. License from the Ministry of Industry (MOI). The MOI gives licenses based upon the industrial site having obtained the approval of the Ministry of Health's Department of Environmental Health the municipalities, the other ministries directly affected by or involved with this type of industry, and the approval of the government's Archaeology Department. Sixty-four factories and workshops have an industrial license to operate as a factory while 38 do not. Of the 38 factories that do not have a license from the MOI, six are located in urban areas, 14 in semi-urban areas, and 18 in rural areas.

3. License from the Ministry of Health, Environmental Health Department. This license is crucial as it allows inspectors from this department to check the factory for hazardous emissions, enforcing their conditions, and giving their permission if they see fit. The factories sampled in this survey are divided nearly evenly in their possession of an environmental license. Almost half of the factories have an environmental license at 44% (49), while 47 % (52) do not.

Table 4.4 also emphasizes the gap in the implementation of the existing guidelines, as some factories have one license, others have another. But as some guidelines do exist, this helps us point out a gap in the licensing implementation of the guidelines.

Table 4.4 Distribution of factories by having different licenses in the Ramallah District, 1995 (Source: MoI)

Type of License	Number of factories	% of the total factories in the survey
Do not have any license	15	13.5
Only Municipal Building License	83	74.8
Only one license from the Ministry of Health (MOH)	49	44.1
Only one license from the Ministry of Industry (MOI)	64	57.6
Having at least one license	28	25.2
Having at least two licenses	36	32.4
Having all the three licenses	32	28.8
Having two licenses from MOI and MOH	40	36.0
Having only one license from either MOI or MOH	33	29.7
Do not have neither the MOH or MOI license	38	34,2

4 Wastewater Management

4.1 Overview of (Waste) Water Management

In Palestine, groundwater is the most abundantly available and used renewable water resource. The available amount of groundwater in the West Bank is estimated at (580 – 830) mcm/year of which the Palestinians have access tday to only about 15 -20 %. In addition to water scarcity, in recent years, a ‘red line’ has been crossed, as polluted water has begun to seep into these water sources, i.e. springs and groundwater aquifers (Figure 5.1). In some places, alarming signals have been reported about groundwater pollution with high concentrations of chloride (e.g. 400 mg/l), sodium (e.g. 200 mg/l), potassium (e.g. 35 mg/l), and nitrate (e.g. up to 250 mg/l) in both the West Bank and the Gaza strip. The deteriorated environmental situation in Palestine is strongly pressing (see photo 5) and thus calls for immediate action for treating raw sewage and upgrading high loaded treatment plants (Mahmoud et al., accepted).

In Palestine, domestic and industrial wastewaters are collected mainly in cesspits or, to a much lesser extent, in sewerage networks. In some villages and refugee camps, black wastewater is collected in cesspits, while grey wastewater is discharged via open channels (see photo 1).

Rural Systems

Apart from the small international funds channelled through national and international NGOs, the rural sanitation in Palestinian areas can be considered a sector that has been neglected by donors since the establishment of the National Authority. Most communities in the rural area in the West Bank lack adequate sewage systems to dispose of their wastewater. Rural systems in Palestine are limited to cesspools and septic tanks. Moreover, in the refugee camps, grey wastewater is flowing in open drains where raw sewage is released into the environment or discharged into the sewer system of a nearby town. Inadequate disposal of wastewater pollutes the neighbourhoods and groundwater of the West Bank aquifer and poses serious risks to the health and environment of Palestinian communities. Current pressure on the environment will be worsening by the expected population growth. In recent years some projects promoting small-scale, decentralized wastewater treatment in rural areas have been implemented (for project examples see chapter 5.3).

The majority of the collected wastewater from the sewered localities is discharged into nearby wadis without any kind of treatment (see photo 2). About 65 % of the West Bank population is not served with sewerage networks, and uses mainly cesspits and occasionally septic tanks. The other 35% is served with sewerage networks, but less than 6% of the total population is served with treatment plants (Mahmoud, personal communication). The existing treatment plants in the West Bank, namely in Tulkarm, Jenin, and Ramallah, were developed in the beginning of the 1970s and consist of lagoon technology (see photo 3). All of these are not functioning well and consequently hardly achieve any treatment higher than primary. In addition to the aforementioned treatment plants, there are three others. The first system, a ponds system located in Hebron City has never been in use since its construction due to disputes between the Hebron municipality and the Israeli's authorities. The second system has been constructed since 1980 at Birzeit University and consists of a contact stabilization system serving 4,500 students and employees (see photo 4). It has been functioning in excellent condition; however, the operational cost is so high due to the cost of electricity for aeration. Treated effluent has been used for irrigation of the landscape within the University campus (Al-Sa`ed and Zimmo, 2004). The third system is a recently built extended aeration treatment plant (see photo 5) that was put into operation in February 2000 to serve 50,000 inhabitants of Al-Bireh City in the first planning phase (100,000 capita final planning phase). This wastewater treatment plant was financially funded and technically assisted by the German government.

Photo 1: Wastewater disposal in open channels/ Al-Jalazoun Palestinian Refugee Camp/ the West Bank/ Palestine (Mahmoud et al., Submitted)

Photo 2: Untreated sewage disposal / Wadi Elzomar/ the West Bank/ Palestine (Mahmoud et al., Submitted)

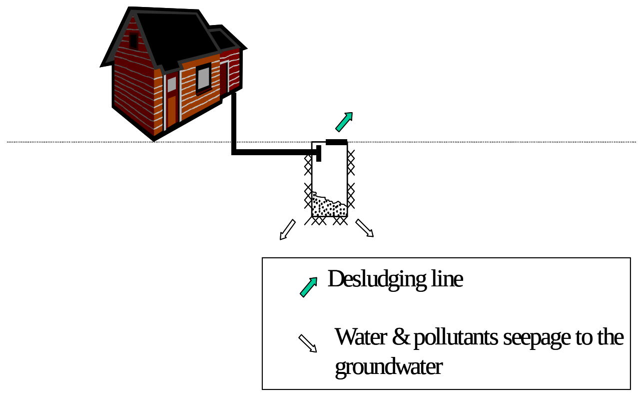
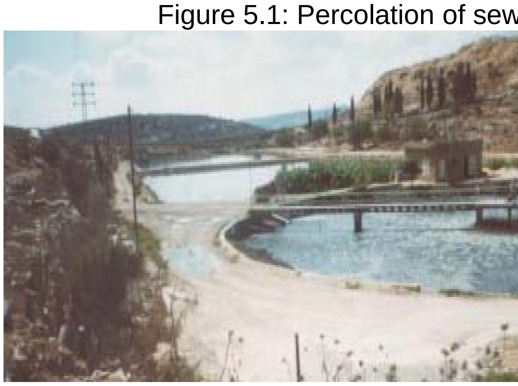


Figure 5.1: Percolation of sewage from cesspit to groundwater



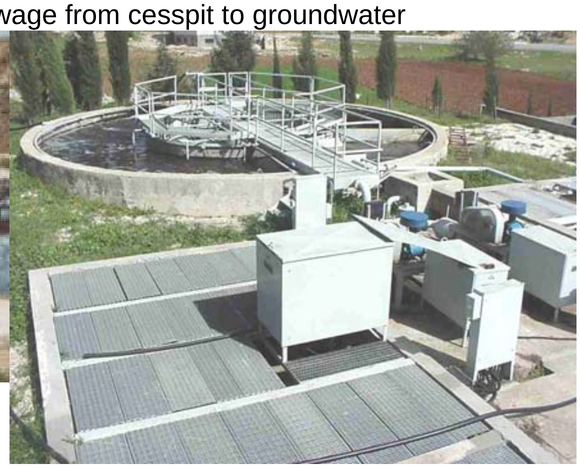


Photo 3: Wastewater treatment plant/ lagoon systems/ Ramallah City/ the West Bank / Palestine

Photo 4: Wastewater treatment plant/ contact stabilization system/ Birzeit University

Photo 5: Wastewater treatment plant/ extended aeration system/ Al-Bireh City/ the West Bank / Palestine

Photo 6: Children drinking unsafe water leaking from a broken pipe. This is due to military invasion during a period of political unrest in the Gaza Strip/ Palestine (source: Aljazeera net)

4.2 Wastewater Treatment Facilities

The existing urban sewage collection and treatment facilities are usually constrained by limited capacity, poor maintenance, process malfunction, poor maintenance practices, and lack of experienced or properly trained staff. Raw or partially treated wastewater is discharged into the wadis where it is used for irrigation purposes (MOPIC, 1998).

The situation of the sewerage system is extremely critical. About 73% of the households in the West Bank have cesspit sanitation and almost 3% are left without any sanitation system (MOPIC 1998; Abu Madi et al., 2000). In sparsely populated, poor, rural and semi-urban Palestinian communities, which form about 60% of the total population in the West Bank, a few small sewage treatment plants have been installed. Approximately 70% of households in the urban cities are connected to the sewerage system. In some urban and all semi-urban areas as well as all rural communities, collection systems are rarely used and wastewater is discharged into percolating pits or septic tanks. The septic tanks are emptied by vacuum trucks and disposed of either in the treatment plant or directly in the wadis.

The governmental national water institutions are under-funded. Hence, the laws and regulations are difficult to enforce. Illegal connections to the sewer system are made without permits. The financial and economic analysis forming the conceptual plan for urban sanitation in Ramallah District has indicated that about $165 million (US) should be invested to construct the sewerage facilities in the coming 20 years. Over the next 10 years, all 10 planned sewage works are to serve about 550,000 inhabitants, while more than 20% of the rural areas will still lack central sewage treatment facilities (Plancenter, 1997). Very little progress in the construction of wastewater treatment plants has taken place on the ground. To date, only one project was implemented in Al-Bireh city, while the others remain on hold (Table 5.1) and the other existing plants are overloaded.

Table 5.1: Wastewater treatment plants (WWTP) in the West Bank (status and information)

Name of T.P	Status of T.P	No. of population served by T.P * 1000 (year)	Capacity of T.P (mcm/year)	Funding Agency	Estimated cost for construction (million US$)	Technology
Nablus East Nablus West	Planning phase Approved	240 (2021) 225	9.2 9.0	Germany KfW	25 25	Extended Aeration
Salfeet	Detailed study	24 (2025)	2.3	Germany KfW	13	Extended Aeration
Jenin*	Rehabilitation is needed	13.5 (1997)	0.5	Israel		Waste stabilization ponds
Al-Bireh	Constructed	40 (2000)	1.1	Germany KfW	7	Oxidation Ditch
Tulkarm**	No study yet	223 (2030)	7.5	Germany KfW	50	Extended Aeration Process
Abu-Dees	Feasibility study	26 (2020)	1	Norway		Oxidation Ditch
Tafuh	Feasibility study	16	0.5	UNDP		Anaerobic RockFilter
Halhul	Preliminary design	42 (2020)	1.0	Not funded	5.5	Aerated Pond System
Birzeit area	Preliminary Study	28 (1994)	1.2	Not funded	4.5	Imhoff tank and trickling Filter
Hebron	Planning stage	695 (2020)	25.0	USA	45	Activated Sludge
Jericho	Preliminary Study	26 (2000)	1.2	Not funded		
Biddya	Preliminary Study	24 (2000)	1.1	Not funded	10.0	
Ramallah***	Feasability Study	40 (North) 40 (South)	1.5 1.5	Not funded	7.0 7.0	Extended Aeration
Al-Ram	Preliminary Study	86.5 (2000)	3.3	Germany KfW	11.0	Aerobic sludge Stabilization + Activated Sludge
Total		**1789**	**66.3**		**210**	

*Old and non-functioning sewage treatment plant exists. **Currently rehabilitation of the sewage treatment plant takes place. *** Currently rehabilitation of the old sewage treatment plant takes place as a partial solution.

Due to the poor design and improper operation and maintenance of the treatment plants, only low purification efficiency could be achieved. In Ramallah, Hebron, and Jenin, effluents are discharged into wadis and infiltrate into sub-soil.

In the West Banks, currently one large scale WWT plant in the Al-Bireh municipality is operating properly. It has been estimated that currently 1,500 people are working in the water sector and that 300 people are involved in wastewater treatment activities.

Most of the donor activities are mainly concentrated in the bigger cities and urban areas (e.g. Jerusalem, Hebron, Ramallah, etc.). Additionally, the focus of current planned projects in the wastewater sector is more on large scale treatment facilities (e.g. German funding for WWTP in Al-Bireh). The planned and newly erected urban sewage works were donor influenced and initiated. The PWA is currently investigating the affordability of these projects and this study will be published soon.

At present, about 24% of the total population in Palestine is served by a central public urban sewer system, and less than 5% of the municipal sewage collected is subjected to partial treatment in the existing overloaded municipal sewage works.

It was found that NGOs are active in promoting sustainable sanitation facilities in the poor rural Palestine. In many cases, traditional wastewater treatment strategies are inappropriate for the physical and economic characteristics of the small communities. Hence, non-point pollution, caused by direct discharges from rural communities can be significantly reduced by the promotion of onsite low cost treatment systems.

4.3 Existing Urban Sewage Treatment Facilities

5.3.1 Urban and Rural Wastewater Characteristics

Per capita water consumption in the West Bank is low (82 l/c/d, see chapter 4.3) due to the lack of adequate and regular water supply. Therefore, the generated domestic wastewater (separate sewer system) is concentrated and its strength is high. In most West Bank localities, light industries are prevailing, which means that heavy metal contamination is not probable. Table 5.5 gives the characteristics of wastewater of some cities and rural areas in the West Bank (Nashashibi and van Duijl, 1995; Mustafa, 1996; Tahboub, 2000; Mahmoud et al., 2003).

Wastewater is of high organic strength according to Metcalf & Eddy (1991). Hence, the treatment process might be complicated and therefore costly in order to reach an effluent that is safe to discharge in the wadis or reuse in agriculture. Another important parameter is the chloride concentration in wastewater. Since chloride ions are dissolved in the wastewater, the conventional treatment processes do not remove chloride. Thus, if treated wastewater is to be used in agriculture, then salt-tolerant crops should be considered.

Table 5.5: Characteristics of raw municipal and rural domestic wastewater in the West Bank

	Municipal Urban Wastewater				Rural Domestic Wastewater	
Parameter	Ramallah	Nablus	Hebron	Al-Bireh	Gray	Black
BOD_5	525	11850	1008	522	286	282
COD	1390	2115	2886	1044	630	560
Kj-N	79	120	278	73	17	360
NH_4-N	51	104	113	27	10	370
NO_3-N	0.6	1.7	0.3	-	1	-
SO_4	132	137	267	-	53	36
PO_4	13.1	7.5	20	44	16	34
Cl-	350	-	1155	1099	200	-
TSS	1290	-	1188	554	-	-

* All data in mg/L; - = No data were given

5.3.2 Intensive Analysis of Sewage in Some Localities

Table 5.6 presents sewage characteristics in three locations in the West Bank/Palestine. The data show that the sewage in Palestine is of high strength and thus contains a high content of suspended solids. This high sewage strength is attributed to low water consumption, industrial discharges and people's habits (Mahmoud et al., 2003).

Table 5.6: Sewage characteristics of Ramallah City, Al-Bireh City and Al – Jalazoon Refugee Camp/ the West Bank/ Palestine (Mahmoud et al., 2003)

Parameters	Ramallah	Al-Bireh	Al-Jalazoon
COD Total	2180	1586	1489
Suspended	1096	919	725
Colloidal	323	274	327
Dissolved	761	393	438
VFA as COD	187	160	123
TSS	729	736	630
VSS	584	617	480
Tww Summer	30.9	25.8	23.4
Winter		12.9	
Twth. Summer		27.1	
Winter		13.8	

All units are expressed in mg/l except temperatures (Tww & Twth) in ºC; COD: chemical oxygen demand; VFA: volatile fatty acids; TSS: total suspended solids; VSS: volatile suspended solids; Tww: sewage temperature; Twth: weather temperature

4.4 Wastewater Treatment Plants

The Jenin wastewater treatment plant consists of 3 aerated lagoons that are heavily overloaded and never desludged. In Tulkarm, the municipal sewage is partially pre-treated in two anaerobic ponds, where a nearby Israeli settlement uses the effluent, after further treatment, for irrigating industrial cotton crops. All of the old urban sewage works (Ramallah and Hebron) are almost non-functional due to overloading, misconception in planning, design, construction, and operation. The sewage treatment facilities serve about 50,000 inhabitants. A new facility was put into operation in Al-Bireh City and is the only treatment plant so far that is functioning well. The sewage treatment plants, entailing oxidation ditches and sludge management units, are working effectively. It is planned to utilize the treated effluent for agricultural purposes. In addition to the Al-Bireh sewage project, several community-based sewage treatment projects are currently taking place in different regions for the benefit of the local municipalities (Hebron, Nablus, Tulkarm and Salfeet) to overcome wastewater problems. These projects are mainly financed by international funding agencies such as the GTZ-Germany and USAID. Hence, the sanitation infrastructure has improved effectively since 1993, where the Palestinian National Authority (PNA) has taken over the civil administration.

There are few privately owned treatment plants which use the effluent for onsite irrigation purposes (see chapter 5.8). Information on Palestinian newly planned wastewater treatment projects in more detail can be found in tables 5.7 and 5.8.

Table 5.7: General information for the newly planned wastewater treatment plants

Municipality	Population In thousand (year 2003)	Connected with Sewerage Work (year 2003)	Wastewater Flows (m3/day) (year 2003)
Nablus	120	103	6400
Salfeet	10	7	800
Tulkarm	85	35	4505
Hebron	291	170	15000

Table 5.8: Technologies adopted for the newly planned wastewater treatment plants

Municipality	Alternative 1	Alternative 2	Alternative 3	Selected Alternative
Nablus	Extended aeration	Activated sludge with digesters	SBR	Extended aeration
Salfeet	Stabilization ponds	Aerated lagoons	Extended aeration	Extended aeration
Tulkarm	Extended aeration	Activated sludge		Not selected till now
Hebron	Aerated lagoons systems	Conventional activated sludge		Biological nitrogen removal Activated sludge process

Figure 5.2 illustrates the already planned wastewater treatment plant in the West Bank, which will be implemented as soon as permits from the Israelis are approved.

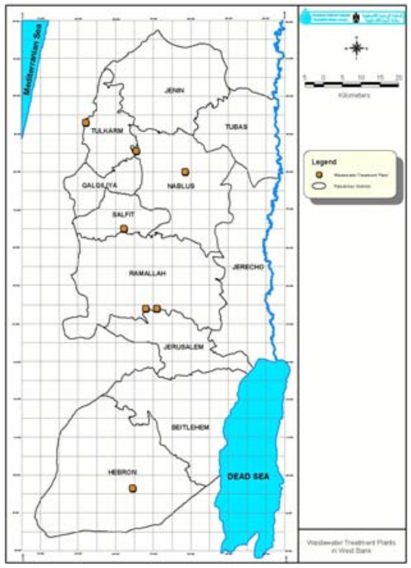


Figure 5.2: The already planned wastewater treatment plant in the West Bank is awaiting construction (Al-Bireh is already constructed while Ramallah is under rehabilitation).

4.5 Future Capital Investment in Sewage Treatment Facilities

Within the coming 10 years, the PNA will be investing about $320 million (US) through the technical and financial assistance of some donor agencies involved in the water and sanitation sector in urban areas, like USAID/USA and KfW/Germany. This money will be allocated for large urban municipal wastewater treatment facilities including collection, treatment, disposal, and municipal staff training.

Since the beginning of the peace process, the international community mainly, Germany and USAID, have committed $230 million (US) for sewage treatment projects in Palestinian cities. Since these huge funds are going to be invested in Palestinian communities, proper strategic concepts in treatment consideration and planning is needed in order to avoid technical and managerial problems encountered in the urban sanitation projects.

In addition to the proper strategic planning for wastewater treatment, the management of the wastewater sector would be improved tremendously if the PWA and ministries involved in the water and environmental sector in Palestine would enforce standards for design of wastewater treatment and set the criteria and regulations for the improvements of technical and managerial skills of professionals working in the field.

4.6 Rural Wastewater Management

In Palestine, many non-governmental organizations (NGOs) provide technical and financial services to small Palestinian communities by means of small national and international funds. These NGOs assist rural areas in identifying and implementing cost-effective solutions to their problems. Some mismanagement in the wastewater sector can be found in the following textbox.

Shortcoming of wastewater management

Lots of money was wasted in the past on unsustainable treatment plants built during the period of the Israeli occupation. Most of the treatment plants were WSPs which were constructed to serve the Israeli environmental policy during the period of the Israeli occupation without real strategic plans for wastewater management. Because of the complicated political situation in the West Bank, experience gained from recently implemented urban sewage projects indicated that about 10 years of planning is needed (Al-bireh case). Newly constructed wastewater treatment plants and/or those under design adopted activated sludge systems in urban areas. Activated sludge systems are able to reduce organic and nitrogen levels in municipal sewage. However, investment and operational cost in such systems is high. It is questionable whether sufficient financial resources can be made available for such technology, which aims to remove organic matters and to enhance biological nitrification and de-nitrification in order to strip nitrogen from the water and convert it into atmospheric N_2 gas. In addition to the treatment efficiency and reliability, several other aspects should be considered i.e. sludge disposal, land requirement, environmental impact, capital and operational cost, sustainability and process simplicity.

4.7 Description of the Proposed Rural Sanitation Systems

Rural sanitation systems, as proposed for some villages like Artas, are based on the collection of sewage by small-bore gravity sewer systems and biological treatment in parallel upflow anaerobic sludge blanket (UASB) reactor. During the first phase, the system will serve about 9,300 population equivalents (PE) by the year 2005. The effluent of the anaerobic stage is proceeded by facultative ponds. The effluent will be reused for irrigation. A certain degree of pre-treatment is achieved in the interceptor tanks. Septage from interceptor tanks near the houses and excess sludge from the anaerobic tanks is treated in a vertical flow wetland system. The low sewage flow due to low water consumption justifies the choice of this system.

The use of the upflow anaerobic sludge blanket (UASB) reactor will enhance the use of low cost high rate anaerobic treatment systems in Palestine. A similar pilot treatment plant has been built in Ginebra-Colombia and Jordan. The construction of this system will enhance the understanding and functioning of this cost-effective pretreatment technique for further use in the Middle East. The UASB reactor will reduce the organic load dramatically and post treatment will be required to reduce faecal and nutrient loads. Another important aspect of this project will be the use of constructed wetlands (in particular VF SS – CW, Vertical Flow SubSurface Constructed Wetland). The main treatment system has been modified and is still yet to be implemented. Therefore, no practical experience can be reported.

4.8 Small Scale Wastewater Treatment Plants in Rural Areas

Strategic planning and appropriate policy for wastewater management in rural areas is non-existent despite the larger population in these areas which lack adequate sanitation. About 73% of the households in the West Bank have cesspit sanitation and almost 3%, mainly in rural areas, have no sanitation facilities (Abu Madi et al., 2000). Several small scale wastewater treatment plants have been constructed in the unsewerd rural areas of the West Bank. In addition, some applied research studies of biological treatment systems for small rural communities were recently installed and studied (Mustafa, 1996; PHG, 1999; Zimmo et al., 2002). Most of the rural sanitation facilities recently installed entail trickling filters and natural treatment systems preceded by septic tanks. Small rural sewage treatment plants showed good removal rates of organic matter and suspended solids but operated poorly in nitrogen removal (Mustafa, 1996).

Municipal wastewater is more than twice as strong as gray wastewater. PARC have constructed about 300 household treatment plants and six collective treatment plants receiving 0.5 to 20 m^3/d of gray wastewater. BOD and COD removal efficiencies of 76-88% were achieved. The household gray wastewater treatment plants consist of septic tanks followed by upflow gravel filters. The collective gray wastewater treatment plants consist of anaerobic pond, gravel filter, sand filter, and the polishing pond. Each system connected approximately 20 houses with about 180 inhabitants.

Palestinian NGOs with international funds are the only organisations involved in the construction of wastewater treatment plants in the rural areas in the West Bank. Both the Palestinian hydrology group (PHG) and Palestinian Agricultural Relief Committees (PARC) implemented onsite wastewater treatment systems of different types and sizes in the range between 5 and 1,000 inhabitants over the last 3 years. The systems are illustrated in Figure 5.3. All systems are now under evaluation and monitoring to obtain a more objective comparison under field conditions. The following represent examples of these systems.

5.8.1 Trickling filter system

A trickling filter for the treatment of gray wastewater from one house with 13 persons has been built (Mustafa, 1996) in rural areas. The effluent from the plant is used in the garden. It was found that gray wastewater contains COD and nitrogen concentrations which are sufficient for biological growth in the trickling filter.

In places where this system was constructed, the house installation was changed to separate the gray wastewater from the black wastewater. The black wastewater is discharged into the existing cesspit, while the gray wastewater is treated in the pilot plant. The trickling filter has been designed as a low loaded system. The newly constructed treatment plants have been modified to serve about 20 people by including an aerobic multi-layer filter. More details on system design can be seen in Mustafa

(1996). An advantage experienced during plant operation concerns the emptying of the cesspit; there was no need to empty the cesspit during the past 6 months and about 15 m^3 of the treated gray wastewater per month is used for irrigation.

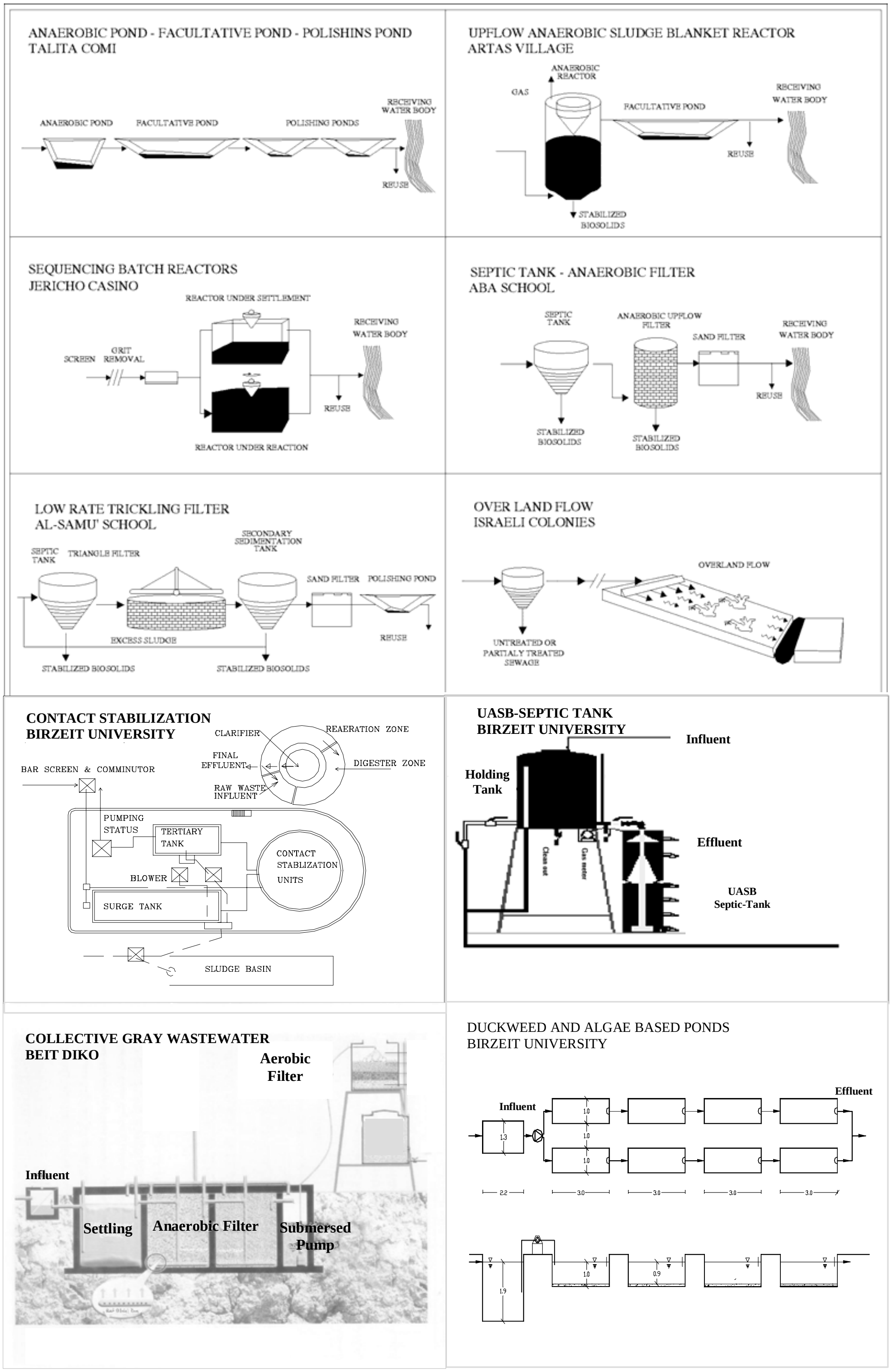


Figure 5.3: Flow sheet diagrams of onsite sewage treatment systems in rural Palestine

5.8.2 Birzeit University Wastewater Treatment Plant

Domestic wastewater from all buildings including the main restaurants and cafeterias as well as various laboratories of the Birzeit University campus is collected by means of a central sewerage network. At present, Birzeit University has almost 4,000 students including staff members. The amount of sewage collected and treated is bout 60-80 m^3 per day.

The treatment system at Birzeit University campus is called a contact stabilization system. Preaeration of wastewater influent is accomplished in the holding tank to freshen the sewage and control odour problems. A schematic flow diagram of the contact stabilization units is illustrated in Figure 5.3. From the holding tank the influent is pumped to the aeration basin with F/M ratio of 0.2 d^{-1} and sludge age of 20 days.

The purification capacity of the treatment system was studied over the last four years. COD removal was 85% and the effluent COD concentration was less than 110 mg/L (average value was 88 mg/l). Suspended solids were removed with equal efficiency. Aerobic stabilization of organic solids was efficient and excess sludge had to be removed on a sludge drying bed once to twice a year. High nitrification (70% of the influent nitrogen were nitrified) could be maintained at 15 $^{\circ}$C, and 42% of the oxidized nitrogen was denitrified. The specific oxygenation capacity of the treatment system is relatively high and reached about 5 kWh/kg COD (Al-Sa`ed and Zimmo, 2004). The actual specific wastewater treatment cost is about 0.52 US$/$m^3$ or about 58 US$ per population equivalent per year. According to Al-Sa`ed and Zimmo (2004), these high specific costs are not technology specific, but rather operational mode related, which can be reduced through regulation of the aeration process and instalment of pre-de-nitrification stage.

5.8.3 Algae-Based and Duckweed-Based Waste Stabilization Ponds at Birzeit University

A pilot plant experiment was carried out to assess treatment performance in two systems for wastewater treatment: algae-based ponds (ABPs) and duckweed-based (*Lemna gibba*) ponds (DBPs). Each system consisted of a sequence of 4 equal ponds in series and was fed with a constant flow rate of 0.38 m^3 of wastewater from Birzeit University pumped daily from the holding tank of 1 day retention time. Physical-chemical parameters and the removal of organic matter, nutrients and faecal coliforms (FC) were monitored within each treatment system over a period of 12 months. The results show clear differences in the environmental conditions. In ABPs, significantly ($P>0.05$) higher pH and DO values were observed than in DBPs. DBPs were more efficient in removal of organic matter (BOD and TSS) than ABPs. The FC reduction was higher in ABPs. However, the quality of the effluent from the third and fourth duckweed pond (total retention time of 21 and 28 days) did not exceed the WHO criteria for unrestricted irrigation during both the summer and winter period, respectively (Zimmo et al., 2000). During the summer period, the average total nitrogen was reduced more in

ABPs (80%) than in DBPs (55%). Lower values were measured during the winter period. Seasonal nitrogen reductions of the two systems were significantly different (P>0.05). In DBPs, 33% and 15% of the total nitrogen was recovered into biomass and removed from the system via duckweed harvesting during the summer and winter period, respectively (Zimmo, 2003).

5.8.4 Biet Diko Wastewater Treatment Plant

Plant site: The site is located south of Biet-Diko village with an area of 150 m^2. This site is sufficient for construction of the treatment plant facilities up to a capacity of 15 m^3/d. The treatment plant would serve a sewered population of approximately 300 persons at per capita sewage flows of 50 l/c/d. The topography of the site has a natural slope, which was adapted for the treatment units.

Wastewater from the sewer flows by gravity into the treatment plant through bar screens that is manually cleaned. Flow passing through the manual screen enters the anaerobic pond, where the solids settle down, the grease and foam settle up on the surface. The wastewater takes routes that make its retention time in this pond at least two days. According to the design, settled solids are to be removed every two years (it was noticed that the level of accumulated solids is low). The water from this pond flows to a balancing pond where a submerged pump is installed. Treatment by gravel filter follows. In the gravel filter, pre-treated wastewater is pumped from the anaerobic pond to the balancing pond to a tank where it is controlled over the bottom of the filter bed media, acting as an upflow anaerobic filter. The water from the gravel filter drops from the top of the filter touching the ambient air, going through a collecting basin to the sand filter. Then, an intermittent fine sand filter receives water from the gravel filter basin and removes the suspended solid. The sand filter surface area is 2 m^2 and its depth is 0.6 m; it is divided into four compartments. The water flows into a polishing pond that has three days storage capacity and a depth of 1.5 m; the pond surface is subjected to ambient air. The purpose of this pond is to kill the living bacteria by sunlight and it further acts as a storage tank for recirculation and irrigation. A recirculation submerged pump is installed on the polishing pond with the purpose of maintaining the water level in the balancing pond at a certain level in order to provide a minimum organic load for the bacteria in the gravel filter when the sewer system goes dry at night. A standby pump for irrigation is installed on this polishing pond. All pumps are controlled by electrical floats.

Similar on-site treatment units to the one constructed in Biet-Diko village were built in several locations in the Ramallah district (table 5.10). Almost all treatment units (household or collective) showed a sufficient reduction in organic matter so as to allow the reuse of the treated wastewater for unrestricted irrigation. However, PARC restricted the reuse of treated grey wastewater, by means of the drip irrigation method, to irrigate trees and plants that are cooked before eaten.

Table 5.10: Overview of the On-site Treatment systems for grey wastewater treatment constructed in Ramallah district since 2000

No.	Out put	Beneficiaries No:	Location	Description
1	0.5m^3/day	6	Hai-Alakbat	Gray,1house
2	1m^3/day	9	Bido	Gray,1house
3	1m^3/day	9	Bido	Gray,1house
4	1m^3/day	12	Bido	Gray,1house
5	2 m^3/day	15	Bilien	Gray,1house
6	1 m^3/day	11	Bilien	Gray,1house
7	1 m^3/day	7	Bilien	Gray,1house
8	2 m^3 day	12	Bilien	Gray,1house
10	1 m^3/day	7	Bitunya	Gray,1house
11	2m^3/day	20	Silwad	Gray,1house

5.8.5 UASB-septic tank system

Research has been conducted on UASB septic tanks at Birzeit University within the framework of an international collaboration project. The design parameters and the results for the this system as suggested by Al-Juaidy et al., (2003) and Ali et al., (2003) are presented in tables 5.11 and 5.12, repectively.

Table 5.11: Design parameters for the UASB septic tank system as suggested by Al-Juaidy et al., (2003) and Ali et al., (2003)

Value	Unit	Design Parameter
15-20	Hr	Hydraulic Retention Time
12	Kg COD/m^3.d	Organic loading
Not exceeding 0.15	m/hr	Up-flow velocity

Table 5.12: Results from the UASB reactors (all units in mg/l, otherwise stated)

Parameter	UASB-In	UASB-Out	UASB Efficiency (%)
COD_t black wastewater	1013	246	76
COD_t domestic wastewater	522	78	79
TSS black wastewater	715	301	58
TSS domestic wastewater	500	300	40
VSS black wastewater	401	158	53
VSS domestic wastewater	300	200	33
BOD black wastewater	458	190	59
BOD domestic wastewater	200	61	69
pH [-] black wastewater	8	7.5	(---)
pH [-]domestic wastewater	7.7	7.6	(---)

Compared to aerobic treatment, anaerobic treatment is a preferable option, since it does not require any oxygen input. Moreover, it enables energy recovery from organic matter as it theoretically yields about 350 l of methane per kg of COD digested. For a Palestinian with a specific COD production of 180 g COD/c.d and an anaerobic biodegradability of 50%, this translates into about 15% (0.35 kwh/c.d) of the average household electricity consumption (2.75 kwh/c.d) (Mahmoud et al., 2004).

4.9 Technical, Socio-Economic and Cultural Assessment of Applied Wastewater Treatment Technologies

During the past decades, the Palestinian people have faced a real challenge due to the political and economic situation, and the Palestinian Authority was not able to establish and operate adequate national organizations, which are supposed to satisfy the demand for Palestinian sanitation needs. Investigating the technical, economic and socio-cultural aspects of Palestinian rural and urban sanitation facilities, Al-sa`ed (2003) found that major sanitation problems are due to the weak economy and low income, low level of technical operating expertise, inadequate wastewater policies, and lack of institutional arrangements. The applications of conventional aerobic wastewater treatment systems, which are too complicated and too expensive, are not expected to provide a sustainable solution, because of the high tariff for sewage treatment in Palestine (Mahmoud et al., 2002). The development of sustainable and affordable wastewater treatment systems will have a positive influence on the Palestinian economy through a direct positive impact on poverty alleviation in addition to environmental protection.

A research study (Corotech Project) aimed at the examination of onsite sanitation systems from the perspective of the community with special emphasis on social and economical aspects were conducted in 2002 in the three Palestinian rural areas located in the Ramallah-Al-Bireh district. These areas were Birzeit, Jifna, Ein Sinya, and Jalazoun camp. Besides the latter, all other towns have septic tanks but no sewerage system. In this study, the evaluation of the existing sanitation systems, instalment alternative at low cost, decentralized treatment technology, willingness to participate, pay and utilize the treated effluent in agriculture are evaluated in a questionnaire.

The findings and results derived from the questionnaire revealed that people don't accept paying for on-site sanitation or handling their own wastewater. They also reject the idea of reusing wastewater even in agriculture.

The basic information obtained from the questionnaire includes the following:

- People don't have money for construction equipment and those who do are not ready to pay.
- Customs and tradition interfere with the treatment and usage of sewage especially in handling sewage and sludge.

- Social and cultural traditions don't allow or accept persons who work on monitoring reactors to enter their homes.
- Some people (85%) accepted the idea of having a decentralized sanitation system but they wanted technical and financial support from the local community.
- People who have special cesspits think that they don't need to participate in new on-site sanitation facilities.
- The majority of people (90%) using the treated wastewater to irrigate indoor plants and some people also refuse to buy any vegetable or fruits that were irrigated with treated wastewater.
- A few people (20%) want to pay only for the construction part but refused to pay for the ongoing monitoring and maintenance costs.
- The on-site area is an unpleasant view for people. In addition, houses are not designed to consider on-site sanitation systems; especially source separation of wastewater.
- During the survey it was observed that the majority of people (80%) prefer to construct central sewerage networks and construct an off-site treatment facility rather than on-site sanitation systems.
- Many people believe in a safe wastewater disposal with less pollutant to valleys instead of discharging sewage without treatment.
- All people didn't accept the separation of black and domestic wastewater. They prefer collecting the wastewater from kitchen and toilet together.
- Some people (40%) accepted the onsite sanitation system with reservation; unless they are sure it will not cause waterborne diseases or harbour/transmit harmful insects.

5 Reuse of Reclaimed Wastewater

The reuse of reclaimed wastewater in Palestine is a major priority confirmed in the Palestinian Water Policy adopted by the PWA and the Ministry of Agriculture. Agricultural use of treated effluents was initially intended in Jabaliah and Gaza City. However, implementation failed due to the lack of funds and rejection by local farmers because there is no cultural acceptance. Reuse of treated effluent may become realistic only if effective treatment systems are installed that provide effluents that comply with irrigation standards.

<u>This does not seem to be the case with any of the existing treatment plants in Palestine except for Al-Bireh wastewater treatment plant.</u>

Various wastewater reuse projects are planned. Until now, only a few demonstration projects exist. Reasons for failing to promote reclaimed wastewater reuse in agricultural purposes have socio-cultural and technical origins. Lack of a national strategy and guidelines makes reuse most likely to be rejected. Nevertheless, wastewater in Palestine has a high reuse potential. New recycling techniques should be employed to make use of the wastewater discharged. It is important to emphasise the vitality of water reuse to the Palestinian water sector since recycling the wastewater will lower the burden and pressure on the water resources.

Recent results based on a small-scale questionnaire on buying agricultural crops that were irrigated by reclaimed wastewater conducted by Birzeit University indicated that most of the participants were willing to buy these products if they are hygienically free of contaminants. The Palestinian Hydrology Group (PHG) has also conducted a field survey in the form of a Questionnaire for Western Bany Zaid Municipality (Bieit Reema and Deir Ghassaneh). The survey conducted showed farmers' readiness to use treated wastewater for irrigation. It has been found that 74% of the farmers agree to reuse treated wastewater for irrigation as a substitute for fresh water. It has also been found that 60% of the farmers accept cultivating new crops rather than irrigating olive trees with treated wastewater.

Despite these findings, farmers still hesitate using the reclaimed wastewater, mostly due to the lack of a proper demonstration site. Therefore, there is an urgent need for public awareness, training programs, and a demonstration site for wastewater reuse. Good extension and public awareness materials need to be prepared and combined with on-farm training. Within the wastewater reuse capacity building program, PHG is currently developing these materials. The following section conveys the national and regional experience in reuse projects.

5.1 Birzeit University (BZU) Reuse of Reclaimed Wastewater

BZU is a leading University in the application of wastewater reuse for irrigation. Irrigation of tree plantations is the practice option at Birzeit, but the impact on groundwater has to be assessed and the water has to be disinfected to ensure the absence of pathogens. BZU also envisaged the importance of reuse via previous and on-going projects within the framework of a Dutch-funded program carried out by the IWS. Furthermore, PhD research on the reuse of treated wastewater for agricultural purposes in the Middle East and North Africa region based on an in-depth study in Jordan and Tunisia is in its final stage.

5.2 Al-Bireh biosolids Composting and Reuse of Reclaimed Wastewater

Within the framework of the USAID project for the Hebron Wastewater Treatment Plant, a demonstration reuse project has been conducted at the site of Al-Bireh wastewater treatment plant. Reuse of both biosolids and treated wastewater is being practiced in partnership with the Palestinian Water Authority, the Municipality Al-Bireh, and the CH2M Hill West Bank Water Resources Program, and is funded by the USAID. It was intended as a demonstration project for the Palestinian institutions who will be involved in future wastewater treatment and residuals management projects (see photo 6 to 9).

The objectives of the composting demonstration project are to demonstrate the role of reuse and the potential agricultural value of biosolids, to demonstrate a sustainable alternative for landfill disposal of biosolids, and to demonstrate the management of a biosolids composting system. The main activity of the demonstration project is the composting of biosolids generated at the Al-Bireh Wastewater Treatment Plant (WWTP) in a windrow system and its subsequent reuse in agriculture. The aim is to generate compost that complies with the strictest standards under Israeli and USEPA regulations for unrestricted land application of the composted sludge. This means that the composted biosolids obtain the required low level of pathogens and heavy metals.

The composting process occurs in an optimal environment of porosity and moisture content and in the presence of a carbon source. In this process temperature rises to 55°C, pathogens are eliminated and organic matter and odours decrease.

The project established this environment by shredding a carbon source and bulking agent (cardboard), mixing and testing compost feedstocks of biosolids and a shredded bulking agent, stacking the composting windrows, monitoring temperature, pH and moisture content and re-stacking and watering the composting piles.

The objectives of the reuse of reclaimed water demonstration project are to demonstrate the important role of reclaimed water use for agriculture, to demonstrate a range of crops and irrigation equipment suitable for reclaimed water use, and to demonstrate appropriate management and monitoring procedures.

The main activity of the demonstration project is the construction and management of a 6 dunum reclaimed water drip irrigation system at the site of the AI-Bireh Wastewater Treatment Plant (WWTP). The irrigation system operates according to Israeli and USEPA regulations for reclaimed water use. The high quality reclaimed water of the WWTP is used to irrigate a range of common Palestinian crops: orchard and ornamental trees, grape stocks, processed vegetable and flowers, and ornamental shrubs. Very high quality reclaimed water is used to irrigate a 600 m^2 greenhouse with cultivation of cooked vegetables (not for commercial purposes) and commercial nursery crops (Nursery producing 23,000 seedlings/year). The greenhouse is operated under a public-private partnership with a Palestinian nursery.

5.3 Regional Experience in Water Reuse

Water reuse in agriculture is common throughout the Middle East and North Africa. Water reuse can be planned through specifically designed projects to treat, store, convey, and distribute treated wastewater for irrigation. Examples of planned reuse can be found in Israel and Tunisia. Indirect reuse can also be planned as in Jordan and Morocco, where treated wastewater is discharged into open watercourses. In most countries of the region, wastewater treatment plants are not operated and maintained adequately, making wastewater unsuitable for unrestricted irrigation even where it has passed through a treatment plant. Wherever available, farmers prefer to rely on freshwater, which is usually very cheap and socially acceptable. But if no other source of water is available, especially in arid and semiarid regions such as the case in the Middle East, farmers throughout the region would be encouraged to use wastewater for irrigation.

Photo 6: Composting demonstration project-Al-Bireh

Photo 7: Irrigation system for the reuse project (Head controls (disk filter, irrigation controller and pressure valves, fertilizer injection valve and pressure tank) -Al-Bireh

Photo 8: Reuse demonstration project (Very high quality effluent) -Al-Bireh

Photo 9: Greenhouse reuse demonstration project (Very high quality effluent) -Al-Bireh

6 Public Awareness Program for Proper Water, Wastewater Management and Reuse in Palestine

6.1 Assessment of Institutional, Political and Societal Framework

After the establishment of the Palestinian National Authority (PNA) in 1993, wastewater treatment projects and awareness programs have been increased substantially. Positive public attitudes towards wastewater treatment and reuse have been increased. The involved municipalities, the PWA, the Environmental Quality Authority, the MOPIC, and NGOs encourage and support any effort being invested to increase the familiarity of the public in issues of proper management of wastewater. It was recognized and agreed that without public acceptance, it would be difficult for any municipality to site, finance, construct, and operate wastewater treatment plants. It was well known that many of the valuable water resources are depleted and the quality is deteriorated due to the lack of proper wastewater management studies.

6.2 PWA Public Awareness and Involvement

Because of the current political conditions in Palestine, the main objectives of the public awareness program are to enhance the public understanding regarding Palestinian water resources and water rights and to update the public on water emergency procedures.

The PWA organized the World Water Day 2003, 2004 and 2005 whose theme was Water for the Future and Water for Life, and called on one and all to observe sustainable approaches to water use for the benefit of future generations. The PWA has implemented an interactive awareness process to transfer important messages and information to the public. The awareness program also helps to foster positive attitudes regarding water services. The PWA is utilizing modern communication approaches in its Public Awareness program such as:

Mass media

The media plays a crucial role in disseminating environmental information and promoting awareness. Although it has become more involved and proactive in recent years, environmental programming continues to lack sufficient technical and funding support.

Radio: Radio Stations have experienced a similar rise in environmental programs and host regular talk shows on various green issues. This is a remarkable shift compared to the situation only 10 years ago, when the environment was rarely seen as a priority or as material for readers and viewers. Public awareness slogans have been used to promote efficient use water seminars to acquaint the public with water sector issues.

Television: Television is airing more and more environmental programs. Several stations run regular documentaries and live debates on environmental issues. High-level officials and senior staff working in the field, prominent individuals and lawyers, and environmental associations are frequently hosted by TV shows. Public service announcements of creative water utilization and public health spots are broadcasted. A documentary describing the water reality in Palestine has been produced.

Newspapers, Magazines and leaflets: Monthly Environment magazines have been issued in Palestine. The magazine is a combination of current environmental topics, global issues, nature and environmental lobbying. PWA issued leaflets on water conservation contests and press releases on the water situation in Palestine.

Direct communication with the public

Seminars and lectures in schools to encourage water protection and efficient utilization of scarce water resources were conducted. Workshops were initiated in coordination with municipalities and local councils to improve water and sanitary services. Participation in international conferences and workshops, where the Palestinian water reality and the role of the PWA was presented.

Indirect Communication with the Public

Posters: Stressing the value of water and public health issues

Brochures: Brochures emphasized the demonstration of efficient water utilization in homes such as the importance of rain water harvesting wells. It also addressed farmers on water pumping from wells and the use of pesticides. Explaining methods for efficient use of water and contamination, school schedules including water-related slogans and posters, school activities and competitions addressing the cycle and the value of water as a public health issue were stated.

6.3 Status of Ongoing NGO Activities Dealing with Public Awareness

The NGOs in Palestine involved in activities dealing with environmental issues were contacted. Most of the NGOs clarified that they were not directly involved with the wastewater management problems. Some did have activities during the implementation of small scale community water and wastewater service projects. Below are some examples of NGO involvement in public awareness programs:

Save the Children Federation (SCF) public awareness and involvement

More than 40 communities in the West Bank and Gaza benefited from the public awareness project implemented by SCF, which was funded by the Dutch government over the last three years. 1,200 children became active participants in the development of their communities through the child to child programs. In all project areas in both Gaza and the West Bank, infrastructure works were done in conjunction with active community participation and education on environmental health topics, as well as water and sewage network maintenance. Through a comprehensive public awareness campaign on environmental health issues, the project included the following activities:

- Child-to-Child activities;
- Environmental health awareness days;
- Community activities that focus on water conservation;
- Assistance to local organizations to increase their capacity for environmentally sound programs; and
- Capacity building training for municipalities and village councils for operations and maintenance as well as sustainable management of new systems.

Palestinian Hydrology Group (PHG) public awareness and involvement

PHG organized series of workshops which aimed at creation of environmental committees. The following issues were covered:

A. Environment of Palestine

- Introduction and Definition for the environment
- Environment elements, links and relations / environmental system
- Palestinian surrounding environment and effects on human
- Human effects on environment: increasing of population, traditions and habits, wrong practices
- Deterioration of environment (pollution), pollution definition, sources of pollution in our home, pollution types (desertification, wastewater and air pollution)

B. Solid Wastes

- Definition and solid waste types
- Contents of solid wastes and effects on environment
- Solid Waste Disposal Methods
- Production of organic fertilizer

C. Waste water resources in Palestine

- Water cycle in the nature and the importance of water, distribution on the sphere
- Scarcity of fresh water
- Results for water shortage in the poor countries
- People Utilization for their water resources
- Water resources in Palestine
- Israeli occupation effects on water shortage
- Water pollution and effects on human

D. Wastewater

- Domestic wastewater types (black and gray)
- Quantities and contents and relation with communities (culture, religion, traditions and habits) population, environment…)
- Some basic principles in wastewater treatment
- Best practices for wastewater disposal in Palestine
- Reuse of treated wastewater in agriculture

E. Industrial Wastewater

- Definition, types and effects of industrial wastewater on the environment

F. The biodigester

- Definition and principle of indigested function
- Advantages of produced biogas

- Factors affecting biodigester in Palestine
- Fertilizer

Furthermore, in 2003 PHG conducted a campaign with the slogan "Clean your country" in Al Rihiyyeh village located to the south of Hebron. The four day campaign included cleaning the accumulated garbage in the streets in addition to an environmental awareness program for 600 women from the village who attended the campaign. The program dealt with several issues including cleanliness in general, water consumption conservation and preservation, how to deal with the polluted water especially in cisterns, and the diseases that result from pollution. Brochures and different detergents were distributed to the women. The Ministry of Health also participated in distributing medicines, insecticides and chlorine tablets for purifying polluted water. The campaign was conducted in cooperation with the Ministry of Health (environmental health department), local community, Doura Municipality and other private companies.

7 Pilot Plant Study

7.1 Site Selection

In Al-Jalazoun camp, the domestic wastewater flows in an old sewer system that consists of septic tanks or cesspits and open trenches. Wastewater from the Al-Jalazoun Refugee camp discharges into the Jifna area causing serious problems for the people and the environment. The geological area is described as carstic, where groundwater and freshwater springs are vulnerable for pollution with septic tanks seepage and via unsanitary wild disposal of septage by vacuum trucks into wadi beds. To solve the problem in Jifna, a sewer line was constructed to transport wastewater away from Jifna, thus creating a pollution problem down stream at the Ein Sinia village. Because of the nuisance effect and potential, environmental and groundwater pollution resulted from the transmission of the sewage from the Al-Jalalzoun refugee camp to the village of Ein Sinia. PWA now proposes to complement those sewerage activities and eliminate pollution in the areas by addressing the sewage collection and treatment.

With previous ANERA grants, a detailed study was conducted to serve all villages (Birzeit, Jifna, Ein Sinya and Jalazoun) with comprehensive sewage collection systems and central treatment plants with a total budget of $4.5 million (US). At this stage, implementation and testing of a pilot wastewater treatment plant before construction of a full scale treatment plant is recommended. The construction of the pilot plant will solve the problems created by the sewage generated from Al-Jalazoun. In addition to enhancing the environmental health awareness activities, the pilot wastewater treatment plant will also achieve capacity building and active public participation. The project activities will be implemented in the rural areas of the West Bank where a real environmental problem is evident.

The goals and objectives of the pilot project are to introduce a low-cost and appropriate community wastewater treatment system to solve uncontrolled sewage disposal in rural communities in the West Bank. This will lead to the improvement in the physical health status of poor rural communities, while introducing hygiene education and public awareness activities through training programs.

In order to construct the pilot plant, first a conveyance sewer line (2 Km) will be constructed in Ein Sinia. Funds from the ministry of the local government have been made available to construct this line and it is expected to be completed on April 2004. Therefore, the construction of the pilot scale wastewater treatment plant in Ein Sinia could be implemented.

7.2 Population and Growth Rates

The PCBS census of 1997 was used. The population in Jalazoun camp was estimated at 7,500 people and is not expected to increase as the built up area could not be expanded.

7.3 Sewage Production

The Al-Jalazoun refugee camp was selected as a site to construct the pilot wastewater treatment plant because it has a collection system for wastewater. The wastewater production is approximately 80% of water consumption. Assuming a peaking factor of 2 (1.8-2.1) for maximum and 0.7 for minimum flows. The average, peak and minimum flows are presented in table 8.1.

Table 8.1: Present wastewater production for the Jalazoun refugee camp

Population	Average daily flow (m^3/d) DWF	Maximum daily flow (m^3/d) DWF	Minimum daily flow (m^3/d) DWF
7,500	450	900	315

7.4 Draft Design of Sewage Treatment Plant

The proposed treatment location assures the gravity flow from the existing residential area (Jalzoun, Jifna, Ein Sinia and Birzeit) and the availability of agricultural land in order to use the effluent of the pilot plant for irrigation. The proposed site for the treatment plant lies within Ein Sinia property outside the residential area of the village. The site will be possessed by the village council upon the project initiation. The nearest residence to the site lies within 2 km distance.

7.5 Possible Treatment options for the Pilot Plant

Wastewater treatment systems based on anaerobic biological processes have traditionally been adopted to stabilize both primary and secondary waste sludge as this application is well suited to the main requirements of anaerobic systems. These include:

- good removal ability of the biodegradable substrates;
- efficiency levels that are not excessively high;

- high biogas production;
- and low running costs, mainly due to the lack of a forced aeration system.

However, over the last few years, the search for “sustainable” treatment systems capable of minimizing energy consumption has encouraged the use of anaerobic biological systems even for intensive and high-loaded wastewater treatment, where the main goal is to eliminate the biodegradable dissolved fraction in carbonaceous substrates.

High-rate anaerobic biological systems may be classified into three broad groups, depending on the mechanism used to achieve biomass detention. These are: fixed film, suspended growth, and hybrid systems.

The full-scale systems that have found a wider application are those based on the Upflow Anaerobic Sludge Blanket (UASB), which is a suspended growth system that was developed in The Netherlands in the early 1980s. When anaerobic biological systems are arranged in series, they are called ABRs (Anaerobic Baffled Reactors).

Innovative anaerobic biological systems guarantee a fairly good removal of carbonaceous matter (which may even reach high efficiency levels in the case of rapidly biodegradable substrates), but are markedly inadequate in removing nitrogen and phosphorus compounds. Consequently, the use of anaerobic systems alone cannot guarantee compliance with legal standards, a goal that could be reached by using the so-called integrated systems, in which anaerobic biological systems constitute only one of the stages in the treatment flow-sheet.

The integrated systems developed over the last few years differ according to the various treatment systems and the substrates that they eliminate.

The above considerations have been taken into account for the definition of a suitable treatment scheme to be applied for the wastewater produced by rural areas and characterized by medium-high organic concentration in temperate climate countries.

The proposed treatment scheme is described in the following and is intended as a two-stage biological integrated system.

The first stage shall consist of an anaerobic reactor (UASB or ABR depending on further discussion about the efficiency removal requests, the hydraulic configuration, and on the organic load to be applied).

The second stage shall be fed by the effluent from the first and it shall consist of an aerobic reactor to be chosen between several types, e.g. Activated Sludge System (Continuous or Batch fed) Aerobic Bio-filter, Vertical Flow Sub-Surface Constructed Wetland, Attached Growth Reactor (Trickling Filters), Rotating Biological Contactor, etc.

In the first biological stage (anaerobic reactor), the following processes primarily take place: ammonification of organic nitrogen; separation and hydrolysis of suspended organic solids; degradation of a part of the dissolved carbonaceous substance through the combined action of acid-forming and methane-forming micro-organisms; reduction of sulphates to sulphides through the action of sulphate reducing bacteria (SRB). The lower the COD content and the ratio between COD and sulphate concentration in the incoming wastewater, means the greater the efficiency of the sulphate reduction process.

In the second biological stage (aerobic), oxidation of the residual carbonaceous fraction, ammonia nitrogen and sulphides occurs.

De-nitrification, if requested, shall take place in an anoxic section to be realized according to one of the following options (the most reasonable are listed):

1. Recycling of a portion of the clarified effluent from the second aerobic stage (containing Nitrates produced by the nitrification process) in an anoxic section to be realized within the first stage. The anaerobic effluent will supply the C source requested by the de-nitrification process with an obvious advantage for the following aerobic treatment.
2. The de-nitrification process can occur within the second aerobic stage which consists of an SBR system. The time cycle process will foresee, in the same tank, an anoxic phase after the oxidation/nitrification processes.

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9 Annexes

Environmental Limit Values (ELV) for Wastewater

Palestinian standards

A1: Recommended Guidelines by the Palestinian Standards Institute for Treated Wastewater Characteristics according to different applications

Quality Parameter (mg/l except otherwise indicated)	Fodder Irrigation		Gardens, Playgrounds, Recreational	Industrial Crops	Groundwater Recharge	Seawater Outfall	Land-scapes	Trees	
	Dry	Wet						Citrus	Olive
BOD_5	60	45	40	60	40	60	60	45	45
COD	200	150	150	200	150	200	200	150	150
DO	> 0.5	> 0.5	> 0.5	> 0.5	> 1.0	> 1.0	> 0.5	> 0.5	> 0.5
TDS	1500	1500	1200	1500	1500	-	1500	1500	500
TSS	50	40	30	50	50	60	50	40	40
pH	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9
Color (PCU)	Free	Free	Free	Free	Free of colored matter	Free of colored matter	Free	Free	Free
FOG	5	5	5	5	0	10	5	5	5
Phenol	0.002	0.002	0.002	0.002	0.002	1	0.002	0.002	0.002
MBAS	15	15	15	15	5	25	15	15	15
NO_3-N	50	50	50	50	15	25	50	50	50
NH_4-N	-	-	50	-	10	5	-	-	-
O.Kj-N	50	50	50	50	10	10	50	50	50
PO_4-P	30	30	30	30	15	5	30	30	30
Cl	500	500	350	500	600	-	500	400	400
SO_4	500	500	500	500	1000	1000	500	500	500
Na	200	200	200	200	230	-	200	200	200
Mg	60	60	60	60	150	-	60	60	60
Ca	400	400	400	400	400	-	400	400	400
SAR	9	9	10	9	9	-	9	9	9
Residual Cl_2	-	-	-	-	-	-	-	-	-

A1: Recommended Guidelines by the Palestinian Standards Institute for Treated Wastewater Characteristics according to different applications "continue"

Quality Parameter (mg/l except otherwise indicated)	Fodder Irrigation		Gardens, Playgrounds, Recreational	Industrial Crops	Groundwater Recharge	Seawater Outfall	Landscapes	Trees	
	Dry	Wet						Citrus	Olive
Al	5	5	5	5	1	5	5	5	5
Ar	0.1	0.1	0.1	0.1	0.05	0.05	0.01	0.01	0.01
Cu	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
F	1	1	1	1	1.5	-	1	1	1
Fe	5	5	5	5	2	2	5	5	5
Mn	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ni	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Pb	1	1	0.1	1	0.1	0.1	1	1	1
Se	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cd	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zn	2.0	2.0	2.0	2.0	5.0	5.0	2.0	2.0	2.0
CN	0.05	0.05	0.05	0.05	0.1	0.1	0.05	0.05	0.05
Cr	0.1	0.1	0.1	0.1	0.05	0.5	0.1	0.1	0.1
Hg	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.05	0.05	0.05	0.05	0.05	1.0	0.05	0.05	0.05
B	0.7	0.7	0.7	0.7	1.0	2.0	0.7	0.7	0.7
FC (CFU/100 ml)	1000	1000	200	1000	1000	50000	1000	1000	1000
Pathogens	Free	Free	Free	Free	Free	Free	Free	Free	Free
Amoeba & Gardia (Cyst/L)	-	-	Free	-	Free	Free	-	-	-
Nematodes (Eggs/L)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

(-) Undefined

A2: Recommended Guidelines for Constituents Requirements

A2.1: Toxic Substances

Matter	Maximum Allowable Limit (mg/l)[1]			
	Reuse for Irrigation purposes[2]	Groundwater Recharge	Discharge to:	
			Seawater	Streams, rivers, wadis, water bodies
Pb	1.0	0.1	0.1	0.1
Sc	0.02	0.05	0.02	0.02
Ar	0.1	0.05	0.01	0.05
Total Cr	0.1	0.05	0.3	0.1
CN	0.1	0.1	1.0	0.1
Cd	0.1	0.02	0.07	0.01
Hg	0.001	0.001	0.001	0.001
Ni	0.2	0.1	0.02	0.2

[1] Unit: mg/l / monthly average is not valid because of the severe toxicity of such elements
[2] Depending on crops type, productivity, irrigation method, soil type, weather, and groundwater in that area

A2.2: Substances with special effects on health water characteristics for specific use

Matter	Maximum Allowable Limit (mg/l)[3]			
	Reuse for Irrigation purposes[4]	Groundwater Recharge	Discharge to:	
			Seawater	Streams, rivers, wadis, water bodies
COD	–[5]	150	200	150
DO[6]	1	1	5	1
TDS	2000[7]	1500	-	3000
TSS	100	-	-	50
FOG	5	-	10	15
Phenol	0.002	0.002	1	0.002
MBAS	-	15	-	25
NO_3-N	50[8]	12	-	12
NH_4-N	5	5	12	5
O.Kj-N	50	-	125	-
PO_4-P	-	-	-	15
Cl	300	500	-	500
F	-	1.5	-	1.5
Na	-	400	-	-
Mg	-	-	-	-
Ca	-	-	-	-
SAR	9	-	-	-
HCO_3	500	-	-	-
SO_4	400	500	-	500
Al	5	0.3	-	5
B	1	1	-	1
Cu	0.2	2	0.1	2
Fe	5	1	2	1
Mn	0.2	0.2	0.2	0.2

[3] Unit: mg/l / monthly average
[4] Depending on crops type, productivity, irrigation method, soil type, weather, and groundwater in that area
[5] Undefined value, depends on general requirements and results for samples analysis for industrial wastewater
[6] Minimum value
[7] Allowable value depends on TDS concentration for factory's water supply source and the effected groundwater basin
[8] Allowable value depends on used irrigation system (drip, surface or sprinkler)

A3: Physical Characteristics

Characteristics	Maximum Allowable Limit (mg/l)			
	Reuse for Irrigation purposes[9]	Groundwater Recharge	Discharge to:	
			Seawater	Streams, rivers, wadis, water bodies
pH	6.5 – 8.4	6.5 – 9.0	5.5 – 9.0	6.5 – 9.0
Color	-	15	75	15
Temperature variation	-	-	± 4	± 4

A4: Microbiological Requirements

Characteristics	Maximum Allowable Limit (mg/l)			
	Reuse for Irrigation purposes	Groundwater Recharge	Discharge to:	
			Seawater	Streams, rivers, wadis, water bodies
Total Coliform MPN/100 ml	-	-	500	-
Fecal Coliform MPN/100 ml	1000[10]	500[2]	-	1000[2]
Intestinal nematodes Egg/l	< 1	-	-	< 1
BOD	-	20	-	20

[9] Depending on crops type, productivity, irrigation method, soil type, weather, and groundwater in that area
[10] Taking into account the concerned authorities instructions

A5 Recommended Guidelines Proposed by PWA for Treated Wastewater Characteristics according to different applications

A5.1: General effluent demand, average annual values

Treatment method	< 500 PE		500 – 2000 PE		2000 – 5000 PE		> 5000 PE	
	BOD	SS	BOD	SS	BOD	SS	BOD	SS
Biological	40	30	30	25	25	20	15	15
Soil	30	20	30	20	25	20	15	15
Chemical	100	40	10	30	100	20	100	15
Tertiary plant	–	–	–	–	30	20	30	15

A5.2: Treated wastewater, maximum concentrations as median and 95%

Parameter Average/Max	BOD		SS		Fecal bacteria		worms	
	Average	Max	Average	Max	Average	Max	Average	Max
> 5000 PE	30	50	20	35	100	200	< 1	< 5
500 – 5000 PE	40	70	30	50	800	1000	–	–
< 500 PE	50	80	40	70	800	1000	–	–

A5.3: Annual sampling frequency

Treatment method	< 500 PE		500 – 2000 PE		2000 – 5000 PE		> 5000 PE	
	BOD	SS	BOD	SS	BOD	SS	BOD	SS
Biological	6	6	12	12	24	12	24	24
Soil	6	6	12	12	24	12	24	24
Chemical	6	6	12	12	24	12	24	24
Tertiary plant	–	–	–	–	–	–	24	24

A5.4: Demands connected to irrigation method

Reuse method	BOD	Salinity	SS	N	Bacteria
Wadi discharge interim	35		30	30	1000
Surface water discharge	20		30	30	200
Agricultural reuse	15		15	50	100
Groundwater recharge	10			40	
Wadi discharge, sensitive area					
Industrial areas					
Dual supply system					
Washing of streets or civic areas					
Reuse in parks and forests					

A5.5: Threshold values for heavy metals in sludge used as a resource

Heavy metal	Agriculture	Parks, etc	Soil
Cadmium (Cd)	2	5	1
Lead (Pb)	80	200	50
Mercury (Hg)	3	5	1
Nickel (Ni)	50	80	30
Zinc (Zn)	800	1500	150
Copper (Cu)	650	1000	50
Chromium (Cr)	100	150	100

All Values are in mg/kg dry matter. “Soil” indicates the maximum concentration in the soil for sludge to be used

A5.6: Minimum monitoring internal program

Parameter	Frequency
pH	Continually
Conductivity	Continually
Nitrate	As nitrogen
Phosphorous	As nitrogen
Nitrogen	As BOD
Heavy metals	Special program
Salinity	As nitrogen

A5.7. Non-organic matters, threshold values (mg/l)

Parameter	Formula	Max. value	Comments
Cadmium	Cd	0.005	
Lead	Pb	1/0.05	Lowest for sludge protection
Mercury	Hg	0.002	
Chromium (3^+)	Cr^{3+}	2/0.05	Lowest for sludge protection
Chromium (6^+)	Cr^{6+}	2/0.05	Sum of 3 and 6
Iron	Fe	50	
Copper	Cu	1/0.2	Lowest for sludge protection
Cobalt	Co	1/0.005	Lowest for sludge protection
Barium	Ba	100	
Boron	B	10	
Cyanide	CN	0.5	
Fluoride	F	10	
Chloride	Cl	2.500	
Magnesium	Mg	300	Concrete corrosion
Manganese	Mn	100.2	Lowest for sludge protection
Sulphide	$S + H_2S$	5	Concrete corrosion
Tin	Sn	1	
Zinc	Zn	1/0.5	Lowest for sludge protection
Ammonium/Ammonia	NH_3/NH_4	30	Concrete corrosion

A5.8. Organic compounds

Parameter	Formula	Max. value	Comments
PAH			
PCB			

A5.9. Others

Parameter	Formula	Max. value	Comments
pH		6.0 – 9.0	Min. and Max. limits
Fat/grease		50	
Oil		50	