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**Title**

**Quantifying the Environmental and socioeconomic  
Benefits of the DWWT**

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### **Acronyms and Abbreviations**

|                 |                                                  |
|-----------------|--------------------------------------------------|
| <b>AF :</b>     | Anaerobic Filter                                 |
| <b>BOD :</b>    | Biological Oxygen Demand                         |
| <b>CFSGAS :</b> | Continuous-Flow, Suspended-Growth Aerobic System |
| <b>COD :</b>    | Chemical Oxygen Demand                           |
| <b>DWWT :</b>   | Decentralized Wastewater Treatment Plants        |
| <b>EQA :</b>    | Environmental Quality Authority                  |
| <b>HRT :</b>    | Hydraulic Retention Time                         |
| <b>IDRC :</b>   | International Development Research Centre        |
| <b>NGO's :</b>  | Non Governmental Organizations                   |
| <b>PARC :</b>   | Palestinian Agricultural Relief Committees       |
| <b>PDS :</b>    | Palestinian Draft Standard                       |
| <b>PHG :</b>    | Palestinian Hydrology Group                      |
| <b>RSC :</b>    | Residual Sodium Carbonate                        |
| <b>S1 :</b>     | Sample number one                                |
| <b>SAR :</b>    | Sodium Adsorption Ratio                          |
| <b>SS :</b>     | Suspended Solids                                 |
| <b>ST :</b>     | Septic Tank                                      |
| <b>SWIS :</b>   | Subsurface Wastewater Infiltration System        |
| <b>Tci :</b>    | Inflow Cold Water Temperature                    |
| <b>Tco :</b>    | Outflow Cold Water Temperature                   |
| <b>TDS :</b>    | Total Dissolved Solids                           |
| <b>TKN :</b>    | Total Kjeldahl Nitrogen                          |
| <b>WHO :</b>    | World Health Organization                        |
| <b>WWTP :</b>   | Wastewater Treatment Plant                       |

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## ***Chapter One: Introduction and Background***

### **1.1. INTRODUCTION.**

In Palestine (West Bank and Gaza), wastewater represents an annual volume of 66million m<sup>3</sup>. Only 30% of this water is collected in a public sewer network and less than 7% is conducted to a water treatment plant. The virtual lack of a household wastewater collection network and hence of any pollution treatment, especially in the West Bank, forces each household to store its wastewater in cesspools holding both black waters and grey waters. These cesspools are sized to take approximately one month's household waste, which amounts to 15m<sup>3</sup> to 40m<sup>3</sup> depending on the size of the family. (ARIJ, 2006) In terms of wastewater collection, the majority of households in urban areas are already connected to wastewater collection, with connection rates of up to 90%. However, connection is significantly less in rural areas; in addition, some major cities (e.g., Jericho) remain without centralized wastewater collection. Regarding wastewater treatment, the currently existing treatment plants in the OPT are clearly inadequate to handle the amount of wastewater collected. Thus, in the West Bank, 93% (33.5 MCM/year) of produced wastewater is discharged untreated into the environment. The wastewater treatment plants located in the Gaza Strip, which only function at moderate efficiency rates (40-60%), operate above their capacity and are need of upgrade and maintenance. 4.9 MCM/year of untreated wastewater and the (partially) treated wastewater is discharged into the environment (ARIJ, 2007, p. 122). The lack of effective wastewater treatment has impacts on nature, biodiversity and groundwater quality and endangers public health (ARIJ, 2007). Assuming a standard that would correspond to the 1991 EU Urban Waste Water Treatment

Directive (CEC, 1991), an additional 5.25 million inhabitants would need to be connected to at least secondary treatment plants, which would result in additional 87.9 MCM of wastewater being treated at least at secondary level

⋮

1.1. The large number of institutions involved and the complex system of wastewater treatment and reuse require the establishment of a sound institutional framework for coordination among the stakeholders. A reuse project should be a result of coordination between the stakeholders where each stakeholder has its part of shared responsibility. Unfortunately in the developing countries the institutional arrangement is very controversial and complex. The complications could run from an overlap of responsibilities to the absence of well-defined mandates. The general role is that everybody wants the benefits but none feels responsible when work and/or expenses are necessary. The fore-mentioned obstacles are present in



lack of their enforcement could result in serious damages, of health, economic and environmental natures. In Palestine the laws and regulations for wastewater treatment and restricted reuse for agriculture and groundwater recharge are drafted, the problem lies with their enforcement due to many internal and external factors.

A reliable financial structure with cost recovery mechanisms and incentives for farmers to use the treated wastewater is lacking in Palestine. There is no comprehensive pricing policy or prices for reuse in Palestine. The farmers do not pay for reuse nor do they pay a penalty for using wastewater in irrigation.

On the ground the situation is further compounded by the existing weak institutional capacity for wastewater treatment and reuse, an incomplete legal framework, very low cost recovery and the continued political instability.

The PWA as the regulator for the water sector and in close cooperation and coordination with the stakeholders should start a carefully phased approach to treatment of wastewater, reuse, and implementing the regulatory framework that prohibits untreated wastewater use, this will significantly mitigate the environmental and public health risks associated with the practice elsewhere in the world.

Recently, a guideline to direct the reuse of reclaimed water has been given the necessary importance with regard to the associated health and environmental impact. The first draft for proposed guidelines for effective wastewater management and wastewater reuse in Palestine is prepared by Bir Zeit University through a MEDA project named efficient Management of Wastewater ( EMwater). This project is part of a regional project includes Egypt , Jordan, Tunes and other European courtiers, where Bair Zeit university was awarded to implement it at National level. To this end a steering committee from different stakeholders encompasses Ministries such as PWA, EQA, Ministry of Agriculture, in addition of Bir Zeit University and other stakeholders at community level was formed to steer the project's progress. Final draft will be available at MEDA web site after being approved by the donor and SC members. Palestine still in the stage of setting its own standard .There is A Palestinian Standards for the Treated Wastewater – PS-742-2003 - & industrial effluent discharge Standard PS-227–June 1998 which have been prepared by a special committee & accredited by the Palestinian Standards Institute However only in May 2012 the reuse guidelines was endorsed.

The main components of standard are as below:

- Field.
- Definitions (Wastewater & Reclaimed wastewater).
- General Guidelines.
- Specifications /(Quality of the treated wastewater.
- Classification of reclaimed wastewater (A, B, C, D)
- List of Restrictions or Barriers (11 barriers)
- Allowable crops for unrestricted irrigation with the following general criteria:

- The treated wastewater must meet the specified standards that vary according to the planned use.
- When treated effluent is used for irrigation of fruit trees, cooked vegetables and fodder crops, irrigation must be ceased two weeks before collecting the products. Fallen fruit should be discarded.
- The adverse effect of certain effluent quality parameters on the soil characteristics and on certain crops should be considered.
- Use of sprinkler systems for irrigation is prohibited.
- Use of treated effluent in the irrigation of crops that can be eaten raw such as tomatoes, cucumber, carrots, lettuce, radish, mint, or parsley is prohibited.
- Closed conduits or lined channels must be used for transmission of treated effluent in areas where the permeability is high, which can affect underground and surface water that could be used for potable purposes.
- Dilution of treated water effluent by mixing at the treatment site with clean water in order to achieve the requirements of this standard is prohibited.

Use of treated effluent to recharge an aquifer, which is used for irrigation water supply purposes, is prohibited. Nevertheless; (this issue is still under discussion from PWA and MoA) waiting the evaluation of a pilot projects The Palestinian wastewater and reuse sector strategy calls for adequate institutional capability to manage resources and infrastructure and to regulate wastewater sector activities. This necessarily implies substantial capacity building actions in the areas of wastewater reuse management, operation and maintenance, and development of service utilities. It is anticipated that institutional activities implemented under this management scenario will include a wide range of interventions, including planning and management, legislation and standards, environmental protection, financial and economic actions and institution building.

Some of the main current institutional bottlenecks include:

- Lack of adequately trained human resources;
- Unclear designation of responsibilities between stakeholders with a tendency of insufficient delegation;
- Low level of enforcement - due in particular to the insufficient number of inspectors, the lack of monitoring data and equipment, and conflicts in allocation of regulatory responsibilities, plus a culture of producing data without analysis. Legislative change will not have any effect if enforcement is not improved;
- Insufficient awareness of issues related to wastewater; and
- Lack of a separation of governance functions from service delivery.

## **1.2. TREATED WASTEWATER QUALITY STANDARDS**

The wastewater quality achievable in practice depends on the treatment processes provided at any particular treatment plant and it is essential to match the use of the final

water requirements with that level of quality. From the point of view of wastewater re-use in agriculture, however, additional quality characteristics important for health and agronomic reasons are necessary including bacteria, viruses, helminthes, protozoa and physico/chemical parameters such as conductivity and the sodium absorption ratio.

Primary treatment of municipal wastewater will remove primarily settled solids together with any adsorbed or entrained materials, such as heavy metals, which might be associated with the solids. The effect of primary treatment on health and agronomic parameters is of minor significance, except that there may be a high level of toxic heavy metals accumulated in the sludge. Conventional secondary treatment of sewage in biological filters or activated sludge plants is designed to remove more of the biologically degradable organic material, and typically removes up to 80–90% of the BOD<sub>5</sub> remaining after primary treatment. Again, the health and agronomic parameters are little affected by conventional secondary treatment processes.

Further upgrading of secondary effluent is possible in tertiary treatment processes but complex combinations of unit processes are required to achieve a high quality of effluent for unrestricted use in agriculture. Stabilization ponds can achieve high quality effluent standards with low cost, easily operated systems but the land take is high.

In order to meet the need for highly quality treated wastewater new technologies are being developed and studied throughout the world.

### **1.3. RISKS AND POTENTIAL CONSTRAINTS**

Because there are risks associated with the reuse of treated wastewater and sludge in agriculture, any proposed wastewater re-use scheme must be carefully planned and strictly controlled through local and national institutions.

There are several constraints to wastewater reuse: Health problems, such as water-borne diseases and skin irritations, may occur if people come into contact with reclaimed water or products that were produced with reclaimed water. In some cases, reuse of wastewater is not economically feasible because of the requirement for an additional distribution system. The reuse of reclaimed wastewater may not be culturally or religiously accepted in some societies therefore; treated wastewater standards must be achieved by the involvement of different key ministries like EQA, MOH, PCBS among others

PSI, EQA, PWA, MoH and MoA has conducted a standards draft study for treated wastewater for irrigation

The success of a wastewater re-use scheme depends on the strong commitment of the wastewater treatment organization to achieve consistent operational performance at all times. The need for a properly empowered body to control the allocation of land for irrigation with treated wastewater was seen as an urgent priority.



## ***Chapter two: History and Technologies of DWWT***

### **2.1. HISTORY OF DECENTRALIZED WASTEWATER TREATMENT SYSTEMS**

King Minos installed the first known water closet with a flushing device in the Knossos Palace in Crete in 1700 BC. In the intervening 3,700 years, societies and the governments that serve them have sought to improve both the removal of human wastes from indoor areas and the treatment of that waste to reduce threats to public health and ecological resources. The Greeks, Romans, British, and French achieved considerable progress in waste removal during the period from 800 BC to AD 1850.

But removal often meant discharge to surface waters; severe contamination of lakes, rivers, streams, and coastal areas; and frequent outbreaks of diseases like cholera and Typhoid fever (Curry. 1998). The past century has witnessed an explosion in sewage treatment technology and widespread adoption of centralized wastewater collection and treatment services throughout the world. Although broad uses of these systems have vastly improved public health and water quality in urban areas, homes and businesses without centralized collection and treatment systems often continue to depend on technologies developed more than 100 years ago. Septic tanks for primary treatment of wastewater appeared in the late 1800s, and discharge of tank effluent into gravel lined subsurface drains became common practice during the middle of the 20<sup>th</sup> century (Curry. 1998). Scientists, engineers, and manufacturers in the wastewater treatment industry have developed a wide range of alternative technologies designed to address increasing hydraulic loads and water contamination by nutrients and pathogens. These technologies can achieve significant pollutant removal rates.

### **2.2. NATURE OF DECENTRALIZED WASTEWATER TREATMENT SYSTEM**

The concept of decentralized wastewater treatment plants (DWWT) is to have a wastewater treated system as close as possible to the fresh wastewater source.

A decentralized system employs a combination of onsite and/or cluster systems and is used to treat and dispose of wastewater from houses, public buildings close to the source. Decentralized wastewater systems allow for flexibility in wastewater management, and different parts of the system may be combined into "treatment trains," or a series of processes to meet treatment goals, overcome site conditions, **and** to address environmental protection requirements. Figure (2) illustrates the concept of decentralized wastewater treatment plant . DWWT if properly designed and implemented, it will be distinguished by many properties as it is an approach rather than just a technical hardware. And as a result of many trials in various countries, it provides treatment for wastewater flows from 1-500 m<sup>3</sup>/day from both domestic and industrial resources.

It is based on a set of treatment principles of which has been determined by their reliability and tolerance towards inflow fluctuation, it also works without technical Energy and thus can't be switched off intentionally and it is the best solution where skilled and responsible operation and maintenance is Guaranteed. It doesn't require sophisticated maintenance. It is implemented with low cost and distinguished by long desludging intervals (Anaant, 2003).

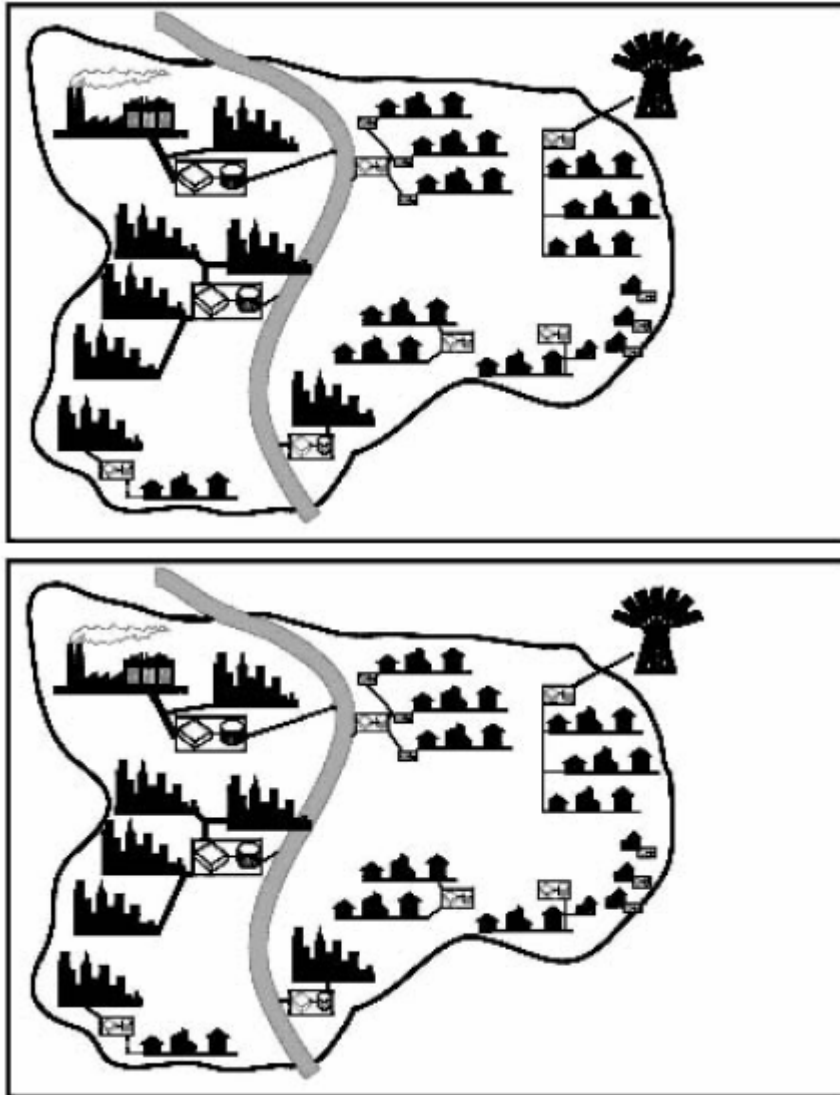


**Figure 2. Decentralized waste water treatment plant (Anaat, 2003)**

### **Common systems of DWWT**

DWWT is based on four treatment systems:

- Sedimentation and primary treatment in sedimentation ponds, septic tanks or Imhoff tanks.
- Secondary anaerobic treatment in fixed bed filters (anaerobic filters) or baffle septic tanks.
- Secondary and tertiary aerobic/anaerobic treatment in constructed wetlands (subsurface flow filters).
- Secondary and tertiary aerobic/anaerobic treatment in ponds. These systems are combined in accordance with the wastewater influent and the required effluent quality

#### **a- Conventional septic tank**

The most common of decentralized units is conventional septic tank, it is used to receive wastewater discharged from individual residences, and other non-sewer facilities, for examples; toilet water, water used from cooking or bathing. While relatively simple in construction and operation, the septic tank provides a number of important functions through a complex interaction of physical and biological processes. The essential functions of the septic tank are as follow:

- To separate solids from the wastewater flow.
  - To cause reduction and decomposition of accumulated solids.
  - To provide storage for the separated solids (sludge and scum).
  - To pass the clarified wastewater (effluent) out to a leaching field or pit.
- Septic tanks (Figure 3a and 3b) provide a relatively quiescent body of water where the wastewater is retained long enough to let the solids, oils and greases separate by both settling and flotation. This process is often called a primary treatment and results in three products: scum, accumulated sludge (or septage), and effluent. These tanks serve as combined settling and skimming tanks, unheated unmixed anaerobic digesters, and as sludge storage tanks (Crites and Tchobanoglous, 1998). In some countries, the septic tank is followed by a soil absorption system, or another post-treatment unit. The organic material retained in the bottom of the tank under goes facultative and anaerobic decomposition and is converted to more stable compounds and gases such as carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and hydrogen sulphide (H<sub>2</sub>S). The sludge that accumulates in the septic tank is composed primarily of ligneous material contained in toilet paper. While these materials will be eventually decomposed biologically, the rate is extremely slow, which accounts for the accumulation (USEPA, 1980).



(a)



(b)



(a)



(b)

**Figure 3. Typical concentration Septic Tank, concrete type and fiber glass (www.wieerconcret.com.)**

In order to improve the treatment performance, an in-tank baffle is sometimes used To divide the tank and access ports are provided to permit inspection and cleaning (Figure.4). Two compartments have been used to limit the discharge of solids in The effluent from the septic tank. Based on measurements made in both single and Double compartments, the benefit of a two-compartment tank appears to depend

More on the design of the tank. Currently, most houses in several cities of developing Countries are equipped with septic tank or other on-site systems. The use of septic tanks can be traced back to the year 1860 in France (Crites and Tchobanoglous, 1998). Septic tanks are made out of concrete, steel, red-wood or polyethylene, but the use of steel and redwood tanks is no longer accepted by most Regulatory agencies. Polyethylene tanks are inferior to concrete and fiber glass tanks because they will deform after some years in operation. Today, most of the conventional septic tanks are made out of concrete or fiber glass. Fiberglass septic tanks are rather expensive. They are usually used in areas where concrete septic tanks cannot be installed. Regardless of the material of construction, a septic tank must be watertight and must be able to withhold the wastewater loads if it is to function properly; especially where subsequent treatment units such as intermittent or re-circulating packed bed filters or pressure sewers are to be used.

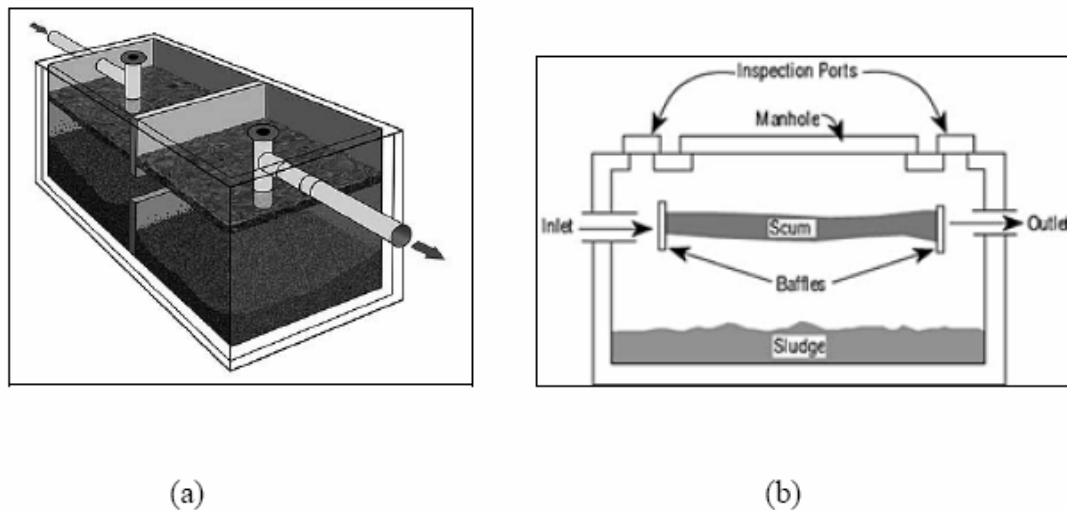


**Figure 4,schematic Septic Tank([www.septic-info-com](http://www.septic-info-com))**

### **b- Imhoff Tank**

Imhoff tanks are used for domestic or mixed wastewater flows where effluent will undergo further treatment on ground surface. The Imhoff tank is divided into an Upper settling compartment in which sedimentation of solids occurs as illustrated in Figure (5). Sludge then falls through opening at the bottom into the lower tank Where it is digested an aerobically. Methane gas is produced in the process and is Prevented from disturbing the settling process by being deflected by baffles into the gas vent channels. Effluent is odorless because the suspended and dissolved solids in The effluent do not come into contact with the active sludge causing it to become Foul. When sludge is removed, it needs to be further treated in drying beds or such for pathogen control.

Treatment efficiency in Imhoff tank is equivalent to primary treatment as it achieves

40% BOD reduction and 65% suspended solids reduction but effluents continue to be contaminated due to the poor pathogen removal.

In terms of operation and maintenance, the construction of such a system requires skilled labor with no need for electrical requirements and high area of land. To be maintained well, removal of scum and sludge has to be carried out at regular intervals.

This system has the advantages of low cost, electrical requirements, land space and operational and maintenance requirements. Therefore, it needs a skilled contractor for construction and it also doesn't meet the required reuse quality because of the existence of pathogens.

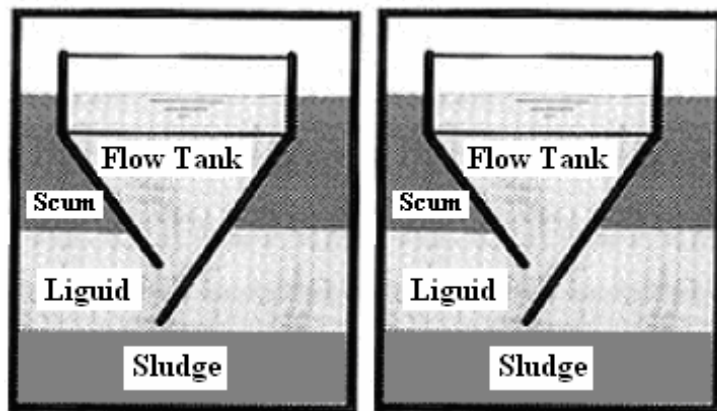


**Figure 5. cross section of IMhoff tank**

### **c- Septic Tank With Up flow Filter**

This is essentially a septic tank with an up flow filter that is incorporated directly after the second chamber of the septic tank as shown in Figure (6). Effluent after leaving the second chamber of the septic tank is directed upwards through the bottom of the filter before exiting to be disposed of either in leach fields etc. It is also mainly designed for onsite treatment of domestic sewage. In the up flow filter the effluent enters at the base and flows up through the layer of coarse aggregate, which is then discharged over a weir at the top. Anaerobic bacteria grow on the surface of the filter material and oxidize the effluent as it flows past. Disposal of the effluent may be into a stream or into soakage pits etc.

Septic Tank With Up flow Filter produce good effluent quality, it can reduce BOD up to 70 % in addition to changing the highly turbid gray water to an odorless clear light yellow effluent. This system is applicable for both gray water and black water that can be flushed through the system.

In terms of operation and maintenance, the construction of such a system requires skilled labor with no need for electrical requirements and high area of land. Filter is expected to operate without maintenance for 18-24 months, then it needs to be washed out by fresh water. Septic tank needs regular desludging.

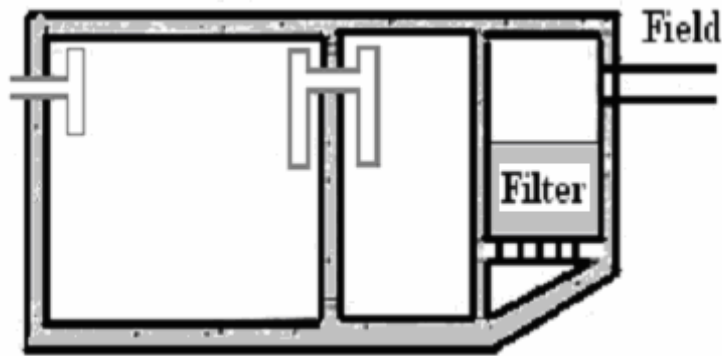


**Figure 6. Septic Tank with up flow filter section**

#### **d- Anaerobic Ponds**

Anaerobic ponds use the same biological process and same basis for loading as septic tanks but on a much larger scale. Anaerobic Ponds as the name implies operates in the absence of air. Therefore deep tanks with small surface areas operate more efficiently than shallower ponds. Before using these ponds, they should be filled with water to prevent foul conditions from occurring. After functioning of these ponds, raw sewage sludge will accumulate on the bottom of the pond and a crust will form on the surface which eliminates all odors. The wastewater type and the method of post treatment outline the role of the anaerobic ponds. Anaerobic ponds are designed for hydraulic retention times of between 1-30 days depending on strength and type of wastewater and also the desired treatment effect. Storm water could cause shock volumetric loads which may affect the performance of ponds and should be taken into account in earlier stages of pond development.

The system can achieve 70 % reduction in term of BOD in addition to changing the highly turbid gray water to an odorless clear light yellow effluent. This system is applicable for both gray water and backwater that can be flushed through the system. In term of operation and maintenance, the construction of such system requires skilled labors with no need to electrical requirement and high area of land. Filter is expected to operate without maintenance for 18-24 months, then it needs to be washed out with fresh water. Septic tank needs to regular desludging.

It is distinguished by feasibility as it doesn't need to electrical, operation and Maintenance requirements and the system produce high effluent quality by low Loaded ponds with long HRT. Figure (.7) illustrates the anaerobic ponds system.

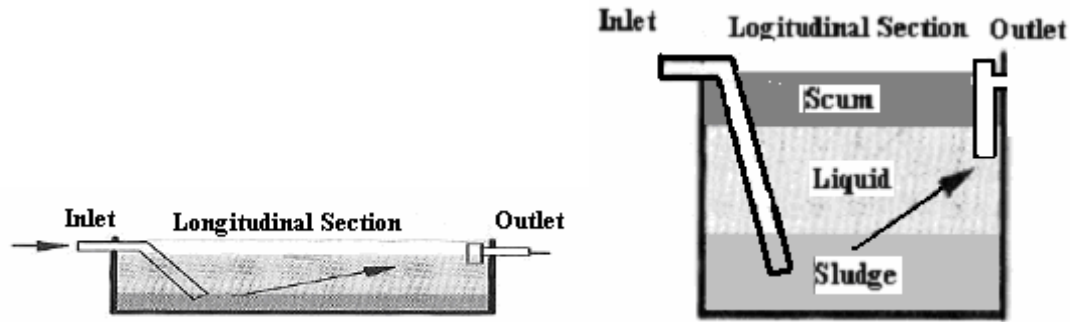


**Figure 7. low and high loaded anaerobic ponds sections**

### **e- Baffled Septic Tanks**

This process is suitable for all kinds of wastewater including domestic. The baffled Septic tank consists of an initial settler compartment and a second section of a series baffled reactors as shown in Figure (8). Sludge settles at the bottom and the active Sludge that is washed out of one chamber becomes trapped in the next. The reason For the tanks in series is to assist in the digestion of difficult degradable substances Especially towards the end part of the process. For the purpose of quicker digestion

Influent upon entering the process is mixed with active sludge present in the reactor.

Flows from bottom to top causing sludge particles to settle on the up flow of the liquid wastewater allowing contact between sludge already present with incoming flow. The settler can be used for treatment after effluent has left the tank. Hydraulic and organic shock loads have little effect on treatment efficiency.

In term of effluent quality, the system achieve moderate effluent quality as, 70-95% BOD removal and 65-95% COD removal, This system is applicable for both gray water and backwater that can be flushed through the system.

The system requires skilled labors for construction with no need to electrical power Or big area of land. Therefore, it requires moderate operation and maintenance Process as the regular removal of sludge. The system is distinguished by low cost, availability of construction materials and low land space requirements.

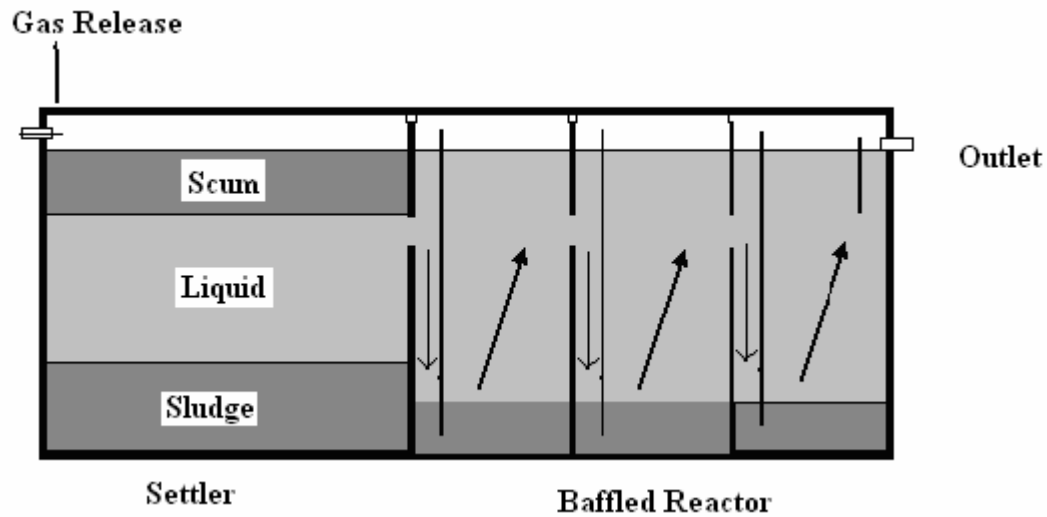


**Figure 8. Baffled Septic Tank section**

#### **f- Upstream Anaerobic Sludge Blanket (UASB)**

This process is suitable for all kinds of wastewater including domestic. The UASB Maintains a cushion of active sludge suspended on the lower part of the digester and Uses this sludge blanket directly as filter medium. The sludge blanket is kept in place By the equilibrium formed between the upstream velocity and settling speed of the sludge. After weeks of maturation, granular sludge forms that improve the stability And filter capacity of the sludge blanket. The organic load of the system is responsible for the development of new sludge. A fully controlled UASB is used for relatively strong industrial wastewaters where biogas can be utilized, with slanting baffles separating gas bubbles from solids. UASB require several months to mature i.e. to develop sufficient granular sludge for treatment. This system is applicable for both gray water and black water that can be flushed through the system.

The system requires low land space and cost. Therefore, it requires moderate operation and maintenance process, time to stabilize process and operator intervention from time to time to control and adjust treatment process. Figure (.9) illustrates the UASB system.

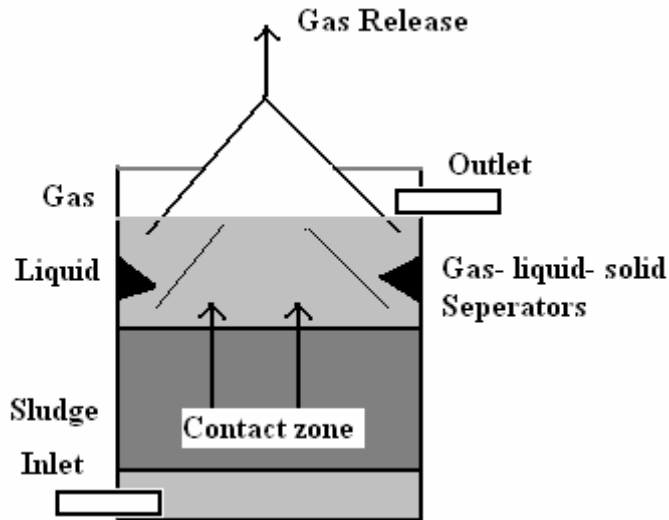


**Figure 9. Upstream anaerobic sludge section**

#### **g- Ponds/Beds/Lagoons (Reed bed systems, Horizontal Gravel Filter)**

Reed bed systems are suitable for domestic and industrial wastewater that has undergone preliminary treatment and that has a COD content not higher than 500mg/l. The reed bed system is 1m deep basin sealed with clay or some other form of lining to prevent percolation into groundwater with the basin itself being filled with soil in which reeds are then planted. Oxygen is transported through the pores of the plant down to the roots whereby the oxygen content increases the biological activity of the soil. When wastewater runs through the root zone soil organic compounds and other impurities are eliminated by microorganisms in the soil.

This system achieves good effluent quality as it gives 84% COD removal rate and 86% for BOD that are considered as high effluent quality in addition to the low requirement for operation and maintenance as only trenches are to be maintained regularly from erosion. Moderate requirement for land and costs and no requirement for electrical power.

Figure (10) illustrates the principles of horizontal gravel filter process.

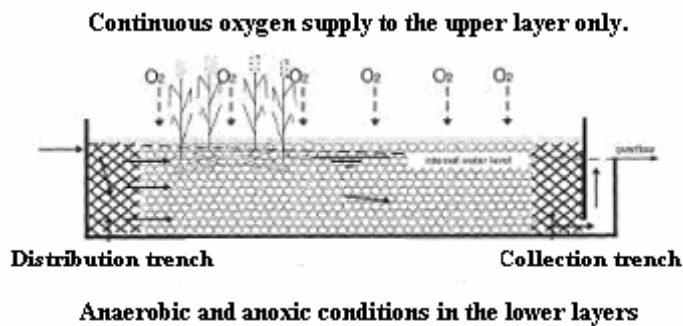


**Figure 10.Principal of Horizontal gravel filter process.**

#### **h- Ponds/Beds/Lagoons (Aerobic Stabilization Ponds/Algal Ponds/Oxidation Ponds)**

In aerobic stabilization ponds the organic matter causing pollution is consumed by Biological organisms that need oxygen in proportion to the amount of organic matter Removed. Oxygen is supplied in these ponds by a growth of algae, which is dependent on photosynthesis. If there is not enough oxygen supplied to organisms that consume organic matter then they will not function and anaerobic organisms will become active causing offensive odors and polluted effluent to be produced.

Aerobic ponds should be half-filled with water before use to prevent offensive Conditions from occurring. The treatment efficiency increases with longer retention Times. This system is produces high quality effluent as it achieves 82% BOD removal rate

That reaches 97% in multiple pond systems and 78% COD removal rate and 95% Pathogen removal. It needs high volume of water for transportation to treatment site, regular desludging in defined intervals and start up needs special arrangements and moderate requirements for land and costs. Therefore, it requires low operation and Maintenance and no electrical powers. Figure (11) illustrates the aerobic Stabilization ponds system.

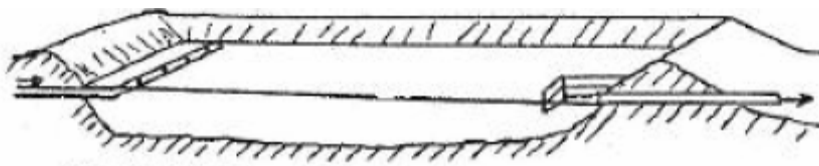


**Figure 11.aerobic Stabilization Ponds**

#### **i- Filters, Anaerobic Filters/Fixed Bed Reactor/Fixed Film reactor**

The anaerobic filter is suitable for domestic wastewater and all industrial wastewater That has a lower content of suspended solids. Anaerobic filters allow the treatment

Of none settle able and dissolved solids by bringing them into close contact with surplus active bacterial mass. The dispersed or dissolved organic matter is digested by bacteria within short retention times. Bacteria fix themselves to filter material like gravel, rocks, and cinder etc. allowing incoming wastewater to come into contact with active bacteria. Preliminary treatment may be required to remove solids of

Larger size. The system achieves 70-90% BOD removal in a well operated anaerobic filter and moderate effluent quality for other measures. It serves well when only receives liquid

Waste and not suitable where scarce or unreliable water and it is applicable for gray And black water. It requires high operation and maintenance, desludging regularly, cleaning of filter material, electrical power and high cost. Figure (12) illustrate the anaerobic filter system.

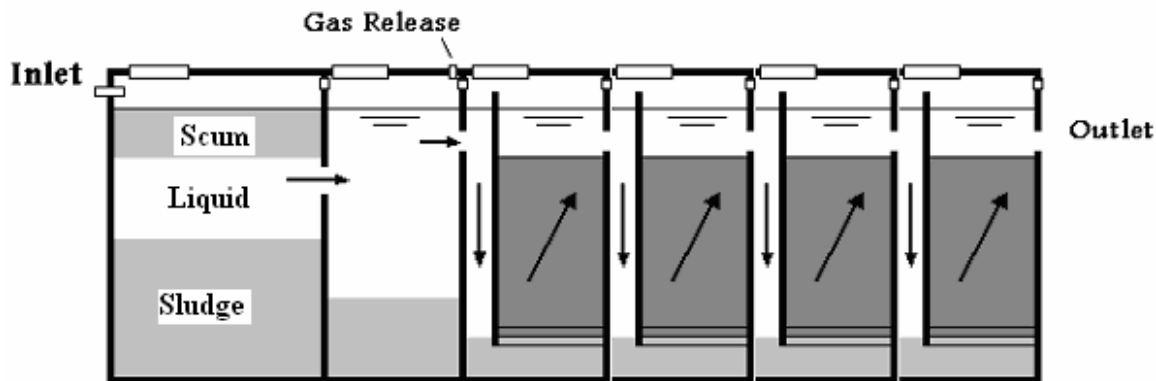


**Figure 12.anaerobic filter section**

### **2.3 LOCAL TRIALS IN DECENTRALIZED SYSTEMS.**

The decentralized wastewater treatment units were for long time existing in rural and Camps areas in a conventional form that is a cylindrical shape constructed from concrete bricks for external walls without any lining in the bottom as shown in Figure (13).

These units consist of unsanitary construction system and depend mainly on infiltration to remove the wastewater that contaminated the soil ground water in

Gaza for large extent. Another case of onsite treatment units in Palestine was adding a separation rectangular tank before the septic tank.

It is estimated that 40% of the houses in Gaza have such conventional septic tank and more than 80% before 1994 (MEnA, 2002).

The idea of decentralized wastewater treatment plants (DWWT) has been used by The local community as a technology but as a tradition. Unsanitary septic tank system Was used for long time as a result of unavailable sewerage. Most of Gaza and West bank people were suffering from unavailable sanitary sewerage system due to the Ignorance of refugee camp in addition to many cities and villages from such services As an Israeli policy of deteriorating the Palestinian environment. Their policy had Been well implemented as it has deteriorated the groundwater, soil and surface water

Of Palestinian areas. Unavailable sewerage has forced the people to implement conventional septic tanks beside their dwellings to discharge wastewater from houses and other facilities.

The traditional decentralized wastewater treatment plant in Palestine was only a cylindrical septic tank constructed from concrete bricks with holes and without any isolating lining in the bottom of the septic tank. The lack of the lining system normally accelerates the infiltration of wastewater to the soil and percolation to the groundwater.

The situation has been improved since 1994 after the coming of the Palestinian Authority that got the fund from many donors to implement many sanitation projects In the Palestinian territories. However, the fund was not enough that lift many areas Without sewerage or other infrastructure that encouraged the non governmental Organizations (NGO's) to participate in the mitigation of the stress over environment. The first initiative to develop the decentralized treatment system was adapted by These organizations in the beginning of last decade to treat gray water in the rural Areas of Gaza strip because of the deficiency of irrigation water in addition to the Bad quality of existing water.

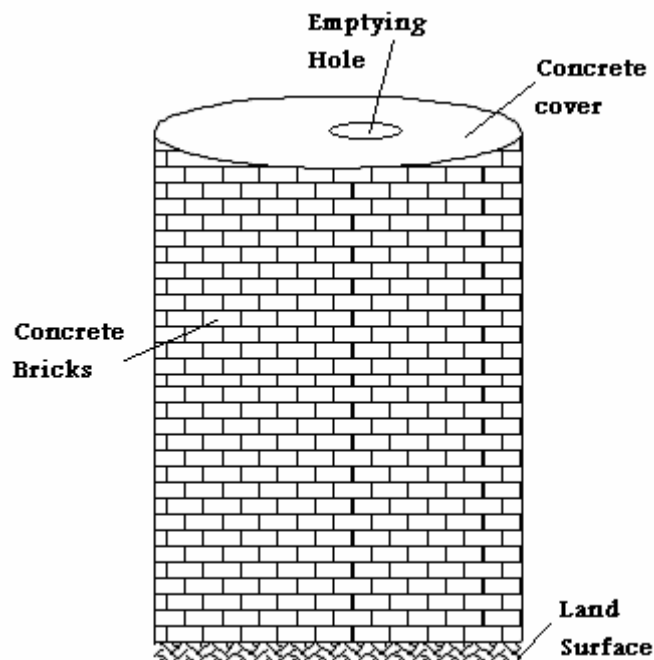


**Figure 13. Local Conventional septic tank in**

Twenty five septic tanks were implemented by the Union of Agricultural Work Committees using the same system of the traditional system but with some additional

Sanitary measures as tank ground lining and totally closed walls of tank that prevent to some extent the infiltration to the ground water but with very small fraction in treatment efficiency.

NGO's have tried to develop the idea and implemented more than 150 systems in Gaza and West Bank since 1995. The main two NGO's were the Palestinian Hydrology Group (PHG) through their Wastewater treatment and reuse in Agriculture project and Palestinian Agricultural Relief Committees (PARC).<sup>1</sup>

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<sup>1</sup> More details in the report prepared by French mission to evaluate the Palestinian experience of DWWT May 2011.

### Chapter Three: Literature Review and Local Experience

Palestine is experiencing a severe water crisis caused mainly by the lack of control Over the Palestinian Water Resources. Therefore, most houses are served from indoor Taps and depend on municipal wells for domestic use.

According to reports and studies by the Palestinian Water Authority (PWA), 95 % of Gaza residents receive service, which means that most of the population has access to an indoor tap (MEnA, 2002).

Most of the distribution systems in the municipalities operate a timetable for supplying drinking water. The use of rooftop tanks with a 1-2 m<sup>3</sup> capacity is a common practice in all houses in Gaza Strip. Such storage tanks provide at least some security in the case of any failure in the water supply system (MEnA, 2002). In term of wastewater in Gaza, access to sewerage facilities at present varies from areas where more than 80 % of the households are served by well-functioning sewerage systems, to areas where there is no sewerage system at all. On average, it is estimated that about 60 % of the population is connected to a sewerage network. Cesspits and boreholes are the other wastewater disposal systems in the area.

There are three treatment plants in Gaza Strip, at Beit Lahia, Gaza City and Rafah, but none is functioning effectively. Approximately 70-80 % of the domestic wastewater produced in Gaza is discharged into the environment without treatment, either directly, after collection in cesspits, or through leakages and overloaded treatment plants .Most wastewater is discharged into the Mediterranean. The effluent from Gaza and Rafah treatment plants is mostly discharged into the Mediterranean. In the case of the Beit Lahia treatment plant, a substantial quantity of wastewater infiltrates into the ground, contaminating soil and groundwater in the area (MEnA

Desk study, 2002). The total annual wastewater production in Gaza strip is estimated to be 30 million m<sup>3</sup>, of which 20 million m<sup>3</sup> passes into sewerage networks and the rest to cesspits or pit latrines. The Beit Lahia wastewater treatment plant is located some 1.5 km east of the city of Beit Lahia in the northern part of Gaza Strip. It was constructed in stages,

The major aim of the plant was to produce effluent of a quality suitable for direct use in irrigation. However, as a result of the poor quality of the treated wastewater, which is far below World Health Organization (WHO) guidelines for use in agriculture, plans for transporting treated wastewater to agricultural areas were never completed. A new wastewater treatment plant for the Northern Governorate is planned at another location some five kilometers from the existing plant. It is to be completed in year 2010 and provide a capacity of 40,100 m<sup>3</sup> per day. The Gaza treatment plant is located to the southwest of Gaza City and has recently been rehabilitated with an influent flow rate of 42,000 m<sup>3</sup> per day (equivalent to what is normally a population of 300,000 discharges). Nevertheless, the plant is still receiving more wastewater than it has capacity to treat (MEnA, 2002). Most of the effluent is discharged to the Mediterranean Sea.

The Rafah wastewater treatment plant was designed for a capacity of 1,800 m<sup>3</sup> per day (equivalent to what is normally a population of 21,000 discharges). At present the plant is overloaded and receives in excess of 4,000 m<sup>3</sup> per day. As a result, effluent from the plant far exceeds the recommended values. The wastewater treatment plant has

reportedly sustained recent damage as a result of the ongoing conflict. Gaza WWTP has a better quality effluent for irrigation than that for Beit Lahia or Rafah WWTPs. Special care directed to Gaza WWTP and its recent rehabilitation contributed partially to the improvement of the effluent quality. Although little improvement has been introduced to Beit Lahia WWTP, Rafah WWTP does not get any improvement

### **3.1. PALESTINIAN HYDROLOGY GROUP'S (PHG) EXPERIENCE IN GREY WWT**

PHG's history with GWWT began in 2000, PHG focused on this subject and used a septic tank up flow gravel filter followed by an aerobic filter system (see Figure 1) that was installed in households and schools. PHG implemented these projects aiming to create new sources of water to be used for irrigation in home gardens in addition to making valuable improvements to existing sanitation systems in households and schools, which are threatening fresh water sources and public health.

Grey wastewater forms about 80% of the total water used at household level. At least 60% of grey wastewater can be recovered, treated and reused. More than 150,000 liters of fresh drinking water are be annually saved per household, through implementing grey waste water treatment and reuse systems in 159 households and schools implemented by PHG. Large amounts of water are efficiently managed, treated and reused in irrigating home gardens.

The general shortage of water and the high grey wastewater generation from households requires careful consideration of solutions that can be locally applied, considering environmental elements, health issues and the socio-economic situation. Septic tank up flow gravel filter followed by aerobic filter system installed in households and schools showed enough satisfaction to these elements.

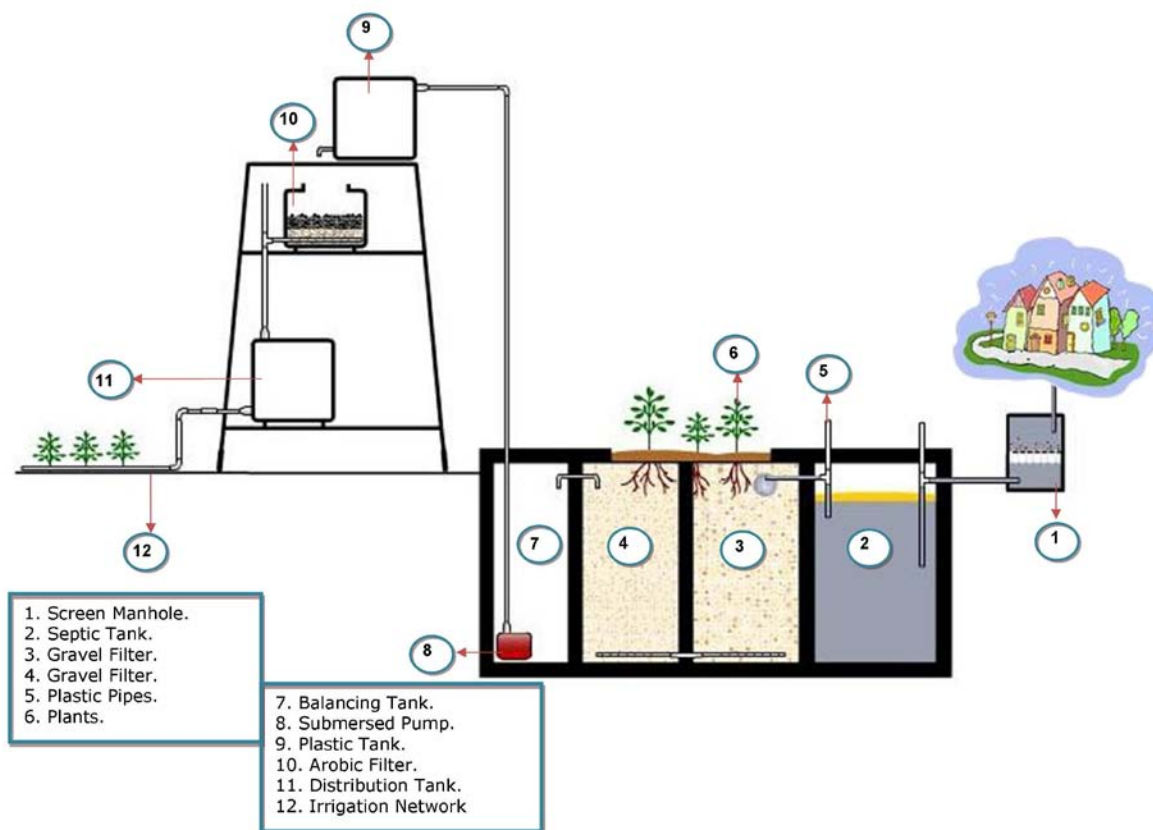


Figure 14. Grey Water treatment Plant scheme developed by PHG

### 3.2. APPLIED RESEARCH INSTITUTE (ARIJ)

ARIJ, based in Bethlehem, is the only Palestinian NGO providing an individual water treatment system that treats all raw water (greywaters + blackwaters).

#### Water treatment

##### *Principle of the process*

3-sequence micro-plant:

Sequence 1: primary decanter

Sequence 2: free culture aerated biological reactor

Sequence 3: secondary decanter

In principle, there are no particular remarks on this type of process.

## ***Product description***

The product is a single polyethylene tank with a **standard volume 3.15m<sup>3</sup>**. Grooves are molded into the tank for insertion of Plexiglas partitions separating the tank into three sections, corresponding respectively to sequences 1, 2 and 3. A set of conduits transfers the effluent to each compartment according to the steps of the process.

Volumes of the three:

- primary decanter: 0.8 m<sup>3</sup>
- aerated biological reactor: 1.6 m<sup>3</sup>
- secondary decanter: 0.75 m<sup>3</sup>

Aeration is supplied to the biological reactor by a diffuser cylinder placed horizontally in the bottom of the tank powered by a 65watt compressor.

The tank is half-buried at depth of around 2 meters (see Photo 3) on a bed of sand.

## ***Operation***

Raw waters arrive in the primary decanter, the upper part of which has a coarse screen rake. This first compartment is itself partitioned for better separation of the phases.

☞ *An air inlet hose connected to a compressor is plunged into this compartment. At the outlet of the compressor, this hose has a valve in shut position.*

Decanted effluent overflow feeds the biological reactor. The air feed line from the diffuser placed in the reactor is equipped with a valve positioned at the compressor outlet. This valve is used to set optimal airflow. A programmer in the outside control box is used to set work (aeration) and idle sequences.



**Photo 2**

***Inside view of tank. Right: primary decanter compartment; center: biological reactor compartment; left: secondary decanter compartment.***



**Photo 3**

***Tank containing the running micro-plant. The biological reactor compartment can be seen in the center.***

☞ The programmer is set for sequences of 30 minutes of aeration and 30 minutes idle for 6-person dwellings. Sequences can be programmed for 45 minutes of aeration and 15 minutes idle for more people.

The effluent from the biological reactor then overflows into the secondary decanter. Decanted sludge is recycled to the primary decanter by an air lift system connected to the compressor and equipped with a flow recirculation regulation valve. Treated water drains out.<sup>2</sup>

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<sup>2</sup> ☞ An elbow pipe carries the decanted effluent back to the biological reactor. The water inlet is located around 30cm below the decanter outlet. Circulation is via an air lift connected to the compressor and equipped with a valve.

For the system to run properly, the owner needs to remove sludge accumulated in the secondary decanter every six months or so using a small household pump. Once a month he or she also needs to scrape off any scum from the inlet screen of the primary decanter.

### ***Results of the analyses***

The results of analyses provided by the manufacturer are for only two outlet samples.

| Parameters (mg/l)        | Sample 1 | Sample 2 |
|--------------------------|----------|----------|
| COD                      | 232      | 241      |
| BOD                      | 23       | 32       |
| TSS                      | 58       | 52       |
| NH4                      | 5,4      | 3,8      |
| Ntk                      | 7.0      | 4.9      |
| Dissolved O <sub>2</sub> | 5.9      | 4.7      |

**Table 1. Analysis Provided by manufacture**

Without data on inlet effluent quality and values, percentages of pollution decreases cannot determine. However, we can consider that the BOD and nitrogen results present acceptable treated effluent concentrations, which would suggest that the volume of the biological reactor and the power of the compressor suffice.

On the other hand, COD results and especially TSS results lead us to conclude that the volumes of the primary and secondary decanters (compartments 1 and 3) are insufficient.<sup>3</sup>

Moreover, one might question the recirculation of the secondary decanter effluent to the biological reactor via the inlet located 30cm from the outlet, unless it is considered that this recirculation suffices to compensate for the secondary decanter's low volume and can be cleared of sludge.

### **Using reclaimed waters.**

### ***Additional equipment***

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<sup>3</sup> ☞ For this type of system (free culture micro-plant) the **known and tested** processes that ensure durable treatment performance all present much greater primary and secondary decanter volumes (never under 2m<sup>3</sup> each).

Treated water from the secondary decanter is then stored in a 1.5 m<sup>3</sup> polyethylene tank. At irrigation time, the water is pumped from the storage tank through a sand filter before distribution through a drip irrigation network (Photo 4). The sand filter serves to retain TSS which could clog the irrigation network.

Irrigation pump power is 5m<sup>3</sup>/h.

The sand filter (red cylinder in Photo 4) holds 40kg of sand and is backwashed every two to three months.



***Photo 4. The full system. In the foreground we see the sand filter. The open tank is the micro water treatment plant. On top is the control and programming unit. The closed tank stores the treated water. The compressor is in the white box behind the sand filter.***

### ***Reusing the water***

When no fecal germs are present we can consider that the quality of the treated effluent before sand filtering is between Class B and C according to Palestinian regulatory standards detailed in the appendix. The treated effluent cannot therefore be reused for irrigation unless there is a **two-barrier** cutoff. Given that the sand barrier constitutes one barrier, the reclaimed water from this process may be used to irrigate only trees bearing fruit with inedible skin or nuts with inedible shells (the skin or shell thus constituting a second barrier).

The water from an ARIJ unit is enough to irrigate a one-dunum (1/10 hectare or .25 acre) plot of trees. ARIJ is currently testing processes for disinfecting the effluent before irrigation to enhance water safety and perhaps broaden the range of crops that could be irrigated.



***Photo 5.Example of a drip irrigation system using reclaimed water from the ARIJ process***

## Costs

**Investment: total cost including installation is said by the manufacturer to be about €2,500.**

Total installation and setup times are three to four days with a four-person team.

**Operating costs: estimated at between NIS 25 and NIS 30 (€6.00) per month.** This is mostly energy cost, given a rate of €0.14/wk.

## Remarks

There are no particular remarks on the ARIJ process from a theoretical viewpoint; the process is that of a classic free culture micro-plant.

However, given the low volume of the primary and secondary decanters, the process can continue to perform reliably only if the owner strictly obeys the maintenance plan, especially removing sludge from the primary decanter every six months. Even if maintenance rules are followed, the study finds that the system could be validated only for households with no more than five people.

For households with eight to ten people (most common in Palestine) a much bigger tank is suggested, separated into three compartments of the following sizes:

- **primary decanter:**       $2\text{m}^3$
- **biological reactor:**     $1.6\text{m}^3$  (unchanged)
- **secondary decanter:**    $2\text{m}^3$

**Total tank size:  $5.66\text{m}^3$  to  $6\text{m}^3$ .**

**It would be best to cost the installation based on these dimensions.**

Moreover, we recommend pursuing the manufacturer's idea of seeking to improve the process so as to use culture fixed to a medium in the biological reactor **while remaining within the dimensions proposed above**. Such an improvement would in particular allow the user space out drain the system less often.

### **3.3. PALESTINIAN AGRICULTURAL RELIEF COMMITTEES (PARC) TREATMENT SYSTEM**

The system of PARC has been implemented in West Bank and Gaza and was funded by the International Development Research Centre (IDRC) in cooperation with agricultural committees in the rural areas to reuse treated wastewater in irrigating farms. The system was designed to treat 10 m<sup>3</sup> and serving five families with average 70 numbers. The used system consists of many parts as screening manhole, tanks, pump, trickling filter and water collection tank.

### **4.1. INTRODUCTION**

The wastewater volumes produced amount to 66 MCM/ year in 2006 (ARIJ, 2007). For the purpose of the benefit assessment and to determine the state of the environment in 2020, it was assumed that the wastewater volumes will increase proportionally with population growth. According to the EU Urban Waste Water Treatment Directive (CEC, 1991), the establishment of waste water management plants is less feasible in terms of costs and management for settlements below 2,000 inhabitants. However, as we do not have any information on the percentage of population living in settlements below 2,000 inhabitants, the following estimates are based on the total population. This can result in a slight overestimation of the benefits. Assuming a population growth rate of 2.71%, 5.5 million people will be living in the oPt by 2020. To estimate the baseline 2020, it is assumed that the proportion of treatment levels in 2006 remains the same in 2020.

#### **4.2. QUALITATIVE ASSESSMENT OF THE BENEFITS OF IMPROVING WASTE WATER TREATMENT**

The qualitative benefits of improving waste water treatment are summarized in table below

|                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Health benefits        | <p>Most health benefits are related to sewage collection, rather than treatment per se, as sewage that is not appropriately collected can cause significant health problems (such as diarrheal diseases, dysentery etc).</p> <p>These benefits are therefore assessed under the ‘sewage connection’ parameter and not here, to avoid duplication.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Environmental benefits | <p>The increased and improved treatment of wastewater is expected to reduce nutrient discharges into surface water bodies (freshwater and coastal water) and, therefore, reduce eutrophication in aquatic Ecosystems, such as the Wadis. It must be noted that nutrient removal does not just arise from tertiary treatment. Significant Removal is also achieved with secondary treatment.</p> <ul style="list-style-type: none"><li>- The danger of untreated wastewater infiltrating into the soil and damaging aquifers and river systems is significantly reduced through improved wastewater treatment.</li><li>- Further, treated wastewater can be used to substitute surface and groundwater sources for irrigation, resulting in a number of benefits which are further described under ‘water scarcity’.</li></ul> |
| Economic benefits      | <p>As many drinking water sources are derived from rivers or groundwater aquifers which are currently being damaged or could be damaged in the future, a reduction of contaminants in the abstracted waters can substantially reduce the costs of treatment for potable water.</p> <ul style="list-style-type: none"><li>- Moreover it can be anticipated that, thanks to increased/improved water treatment, surface water should be more suitable for economic uses, e.g. for</li></ul>                                                                                                                                                                                                                                                                                                                                     |

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                 | <p>industrial water uses. This will bring significant direct cost reductions to water intensive industries in particular.</p> <ul style="list-style-type: none"> <li>- Economic benefits can be further derived from the use of grey water for irrigation. For one, the production of this water is cheaper, for the other grey water can substantially contribute to increasing water Security. The benefits are further detailed under ‘water scarcity’.</li> <li>- Furthermore, the investment in environmental technology and improvement in the skills of those working in the water industry will Assist in enhancing the economic base of the country.</li> </ul> |
| Social benefits | <p>Most health benefits are related to sewage collection, rather than treatment per se), such as nuisance related to odors from direct discharge of sewage in the environment, etc.</p> <p>These benefits are therefore assessed under the ‘sewage connection’ parameter and not here, to avoid duplication.</p>                                                                                                                                                                                                                                                                                                                                                         |

**Table 2. Main components of economic, Environmental and social benefits**

#### ***4.2.1. Quantitative assessment of the benefits of improving waste water treatment***

Achieving the target of treating 100% of the wastewater at least at secondary level would Result in substantial quantitative benefits. The achievement of this target in 2020 would result in 5.25 million inhabitants being connected to at least secondary treatment plants, in addition to those already connected (i.e. total of 5.46 million people). In comparison, the hypothetical achievement of this target in the baseline year of 2006 would have necessitated the additional connection of 3.79 million inhabitants to at least secondary treatment plants. Further, the achievement of this target would result in an additional 87.9 MCM of

Wastewater being treated at least at secondary level, of which 53 MCM and 35 MCM would have remained untreated or treated at primary level only otherwise. For the hypothetical achievement of this target in the baseline year of 2006, an additional 63 MCM of wastewater would have had to be treated to at least secondary levels.

The achievement of this target in 2020 would result in an environmental improvement of 96.2%. This implies that of the total generated wastewater in 2020, 96.2% will be treated Additionally to at least secondary level, instead of remaining untreated or treated only at Primary level. Similarly the achievement of this target implies that 96.2% of the total

Population in 2020 will be connected to at least secondary treatment plants, while they would remain unconnected or connected to a primary treatment plant without the achievement of this target.

#### ***4.2.2. Monetary assessment of the benefits of improving waste water treatment***

This study has not attempted to monetize the benefits of improving waste water treatment due to the complexity of the task and the budgetary constraints of the project. However, some benefits are assessed in relation to sewage connection (see above).

#### ***4.2.3. Benefits from reducing water resource scarcity***

##### **Current state of water resource use**

In both the West Bank and the Gaza Strip, groundwater constitutes the main source of water. Rainfall is the dominant source of water, of which 68% evaporates and the remaining 32% percolate into and thus replenish the aquifers. A small amount drains off as surface runoff (Salmi, 1997). The main groundwater bodies underneath the West Bank comprise the Western Aquifer System, the North-eastern Aquifer System and the Eastern Aquifer System. This groundwater is mainly used for domestic and irrigation purposes by the communities in the West Bank and Israel. The main aquifer system in the Gaza Strip is the Coastal Aquifer, which includes the Gaza Aquifer. Around 850 MCM of renewable water are available each year in the oPt. While the Jordan River is the only perennial river in the oPt, this water is unavailable to the oPt as it merely consists of brackish water and Palestinians are denied access to it. Groundwater recharge provides a further 750 MCM of renewable water resources for the aquifers shared between Israel and the oPt. Of this, around 694 MCM/year are estimated to be internally produced in the West Bank and 46 MCM/year in the Gaza Strip.

The remaining 10 MCM/year of groundwater flow from Israel into the Gaza Strip (FAO, 2009). However, according to World Bank estimates, Palestinian abstractions only account for some 20% of the groundwater produced in the West Bank (between 138 MCM in 1999 and 113 MCM in 2007) (World Bank, 2009). No desalinated water is produced in oPt in centralized, public plants that feed into the water supply network. However, there is some private and decentralized desalination to account for the deteriorating quality and increased salinity of tap water. Around 10 MCM of treated wastewater were reused in 2005 (FAO, 2007).

According to the Palestinian Central Bureau of Statistics, in 2008, a total of 308.7 MCM of water were provided for the Palestinian population in the West Bank and Gaza from all sources (wells, springs and water purchased from the Israeli water company Mekorot). This compares to 335.4 MCM in 2007 and 319.1 MCM in 2006. In 2008, groundwater wells are the largest source of water, which provided 225.7 MCM/yr or about 73% (of which 66.3 MCM in the West Bank and 159.4 in Gaza). This was followed by the water purchased from Mekorot with a quantity of 57.8 MCM/yr, and finally the springs with annual discharge of 25.2 MCM (PCBS 2009). Out of 225.7 MCM pumped from

groundwater wells, 120.3 MCM is used for domestic use (36.1 in West Bank and 84.2 in Gaza), and 105.4MCM is used for agricultural use (30.2 in West Bank and 75.2 in Gaza) (PCBS 2009). Comparing the oPt water use of 308.7 MCM to the 850 MCM that are available indicates a water exploitation index (i.e. total freshwater abstracted as a proportion of total renewable water available) of 36% in 2007. According to international measures, this indicates severe water stress and unsustainable use of water number provides a distorted picture of the water situation: as noted above in chapter Israel abstracts substantial amounts of water from the aquifers that it shares with the oPt, well in excess of the allocations fixed in the Oslo Agreement. These abstractions clearly exacerbate the existing water scarcity problem in the oPt. With a population of 3.57 million in the oPt in 2005 (World Bank, 2010), 240 m<sup>3</sup> of water are available per capita/year. Total water use per capita is 120 m<sup>3</sup>/year, of which 60 m<sup>3</sup>/capita/year are used for municipal water use). According to FAO classifications, this indicates that the Palestinian population is living in conditions of ‘absolute water scarcity’

#### ***4.2.4 Potential environmental improvements***

Determining a water resource “no action” baseline for 2020 for any country is rather Difficult due to the multitude of complex factors influencing water supply and demand, Requiring a much more detailed assessment than what is possible in the frame of this broad, cross-cutting analysis.. The scenario 2020 assumes that the water use in the various sectors increases proportionally with population growth. The baseline estimates for 2020 assume an increase in the population from 3.94 million (2012) to 5.45 million (2020) (World Bank, 2010). Annual precipitation rates are deemed likely to fall in the eastern Mediterranean, decreasing 10% by 2020 and 20% by 2050, with an increased risk of summer which would exacerbate the problem of water scarcity (Mimi, Mason, & Zeitoun, 2009). However, as there is no regional climate modeling with a sufficient spatial resolution, and no reliable forecasts on the expected impact of decreased precipitation on water availability at this stage (SUSMAQ, 2003)<sup>4</sup>, we refrained from quantifying the impact for 2020 for the purpose of this assessment, which is not to say that such impacts are considered unlikely.

#### ***4.2.5. Benefits of using decentralized Grey Water***

The quality of the treated water, free in principle from fecal germs and close to Quality A, should allow the water to reuse on a wide range of crops, provided that drip irrigation is used. Nevertheless, Palestinian regulatory standards, based on those of the World Health Organization do not actually mention reusing reclaimed waters for irrigation of vegetables. This lack of stipulation is interpreted differently by PHG and other organizations.

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<sup>4</sup> SUSMAQ : Sustainable management of aquifers :project funded by British Government was implemented between 2004-2007 by PWA

PHG foresees using reclaimed grey waters solely for arboriculture and fodder crops, although during the study it was in fact observed that on his own plot, an owner might irrigate vegetables on climbing plants (eg tomatoes, cucumbers, peas).

Palestinian Waste Water engineers Group PWEG,<sup>5</sup> considers that the quality of the reclaimed water permits reutilization for all types of crops including vegetables on climbing plants as long as the vegetable itself is not in direct contact with the drip. The installation they propose in fact includes creation of a standard 88m<sup>2</sup> greenhouse, the Palestinian Ministry of Agriculture informed us that vegetables were in fact excluded from the list of irrigable crops.

- The first point concerns determining reuse of water according to its quality and *source*. The standards in the Appendix for reclaimed wastewater presumably refer to *raw* water (greywaters + backwaters). In the case of greywaters one could simply specify the physico-chemical qualities required and protective barriers needed to authorize use for a given type of crop.<sup>6</sup>
- The second point concerns information that could be added to Table 18. The table lacks data on a large number of crops such as tubers (eg potatoes and carrots), whereas it devotes a specific line to artichokes. It is difficult to distinguish between omissions and actual prohibitions which leave considerable latitude of interpretation.

With the aim of equipping homes that won't be connected to the collective network with individual water treatment systems and therefore of convincing families to invest in such equipment, these two points must be clarified, because one of the advantages of using reclaimed water is the economic bonus, and obviously this will depend on which crops are authorized.

Depending on crop type and family size, the irrigable area would be between 100 and 500m<sup>2</sup>.

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<sup>5</sup> -local NGO

<sup>6</sup> ☞ *This point is particularly important because farmers can be seen using non-treated waters from wadis, wells or other sources, the quality of which, by definition, including fecal germs, is obviously far poorer than water treated by the above processes.*

#### **4.3. ECONOMIC REVIEW OF DIFFERENT PROCESS**

The investment required to install an individual water treatment system needs to be examined in a wider economic context including how expensive septic tank drainage is for families and the benefits that families can reap from reusing treated water.

The economic review presented here is based on the following assumptions (which in fact can be frequently verified in Palestine):

- water consumption per inhabitant per day: 80 liters , i.e. around 29m<sup>3</sup> per year
- proportion of grey water: 75%
- cost /m<sup>3</sup> of drinking water: NIS 4 (€0,80)
- cost of draining 1m<sup>3</sup> of waste water: NIS 10 (€2.00)
- Savings on fertilizer: €0.3/m<sup>3</sup> reused (figure taken from the brochure entitled “Gray Wastewater treatment and reuse system” reporting on a project conducted by UAWC, ASPO and PWEg with special Italian support in Yatta, in the Hebron area).<sup>7</sup>

For a family, the overall benefits include:

- money saved on drainage
- money saved on drinking water that would have had to be purchased to irrigate the same crops with the same acreage
- Money saved on purchasing fertilizer, as treated waters provide plants with needed levels of nitrogen, for example.

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<sup>7</sup> For the sake of consistency, we preferred to cost drinking water savings corresponding to the volumes of water that would have been required to irrigate the same type of crops, rather than costing revenues generated by this reutilization. Actually, this revenue varies considerably according to type of crop irrigated and could have been obtained with drinking water had it been available. For purposes of illustration, one could nonetheless estimate revenue obtained from crops irrigated with reclaimed waters to be between €100 and €500 per month, with greenhouse crops such as early peas

From the broader perspective of the community, we can consider not only these cost savings, but also the **benefits for the environment**. These benefits are of course hard to measure, so we have used the only value we have for the time being, i.e. the cost of treating 1m<sup>3</sup> of wastewater at a collective water treatment facility. We are in fact judging that this cost represents the price to pay to “repair” the pollution of 1m<sup>3</sup> of household wastewater. We have estimated this cost at NIS 2.4 (€0.48) per m<sup>3</sup>, as calculated in the water treatment pre-feasibility study for the Tubas-Tayasser area financed by the Adour-Garonne Water Agency.

On the basis of these assumptions the table below summarizes our findings.

#### 4.3.1. Economic review of the process

| En €                                                 | PROCEDE ARIJ<br>(pour 5 personnes)<br>(1) |            | PROCEDE PWEG<br>(pour 10 personnes)<br>(2) |            | PROCEDE PHG<br>(pour 10 personnes)<br>(2) |            |
|------------------------------------------------------|-------------------------------------------|------------|--------------------------------------------|------------|-------------------------------------------|------------|
| <b>Installation Cost<br/>(a)</b>                     | <b>2,500</b>                              |            | <b>3,000 (3)</b>                           |            | <b>3,000 (3)</b>                          |            |
| Drainage<br>savings/yr<br>(b)                        |                                           | 290        |                                            | 435        |                                           | 435        |
| Drinking water<br>savings/yr<br>(c)                  |                                           | 116        |                                            | 174        |                                           | 174        |
| Fertilizer<br>savings/yr<br>(d)                      |                                           | 43         |                                            | 65         |                                           | 65         |
| <b>Total's family<br/>savings / yr<br/>(e)=b+c+d</b> |                                           | <b>449</b> |                                            | <b>674</b> |                                           | <b>674</b> |
| Environmental<br>benefits/yr<br>(f)                  |                                           | 69         |                                            | 104        |                                           | 104        |

**Table 3. Economic Review of the Process**

- (1) On the basis of our observations, the ARIJ process in its current configuration cannot be recommended for a household of more than five people.
- (2) The PHG and PWEG processes in their current configuration are sized to treat up to 12 people, subject to certain reservations expressed in our study. With regard to greywaters, the volume used to calculate savings is 75% of water consumed.
- (3) The installation cost indicated includes greywater treatment (€2,000) plus blackwater treatment (€1,000). Even though PHG has not presented a particular

blackwater solution, we'd have hypothetically aligned the cost of blackwater storage with the cost of the PWEG process.

**Conclusion: For a family that presently drains their septic tank regularly, the cost of installing one of the systems studied here would pay off in around five years.<sup>8</sup>**

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<sup>8</sup> In addition to this economic benefit, there are also **the environmental benefits.**



***Photo 10 Inside a greenhouse irrigated with reclaimed greywater (PWEG)***

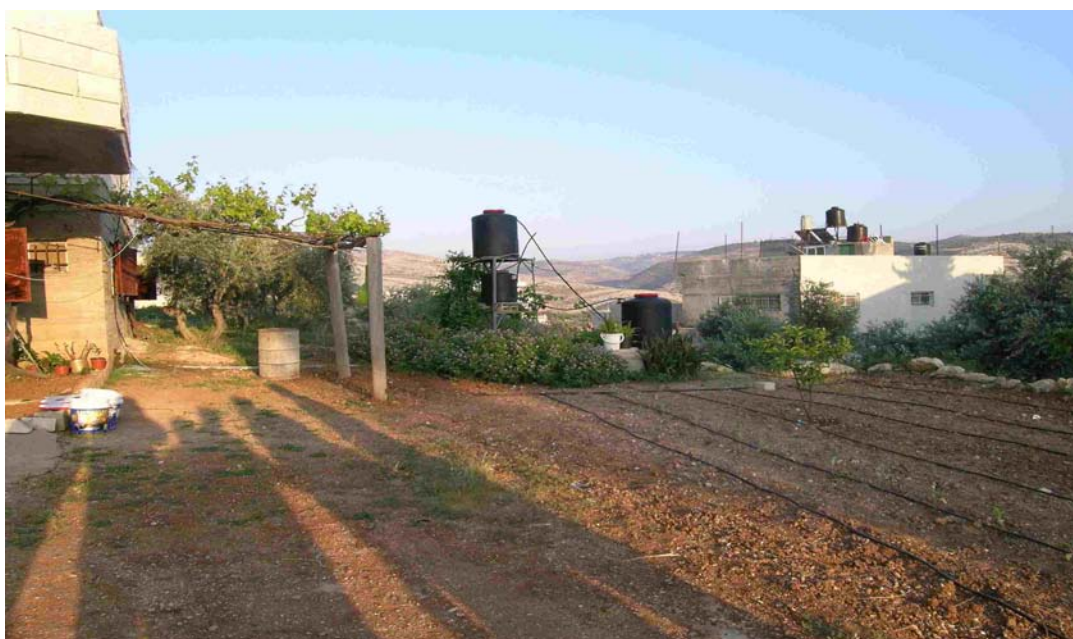


***Photo 11 irrigating a field with reclaimed greywaters***

### ***Costs of Grey water treatment***

The costs announced by PHG and PWEГ are practically identical if we consider the same expenses: engineering, works, equipment and installation. We can therefore estimate the complete greywater installation as presented above at a total of approximately €2,000. Operating costs have not yet been worked out but they are relatively low given that there is just the energy required for pumping between the anaerobic and filtration sequences.

Of course, these costs do not include blackwater treatment, which we will consider further on in this report. Nor do they include expenses for development of the network or various irrigation equipment.<sup>9</sup>

### ***Remarks***

#### On the anaerobic sequence:

There were no particular remarks on the general design (process and dimensions of the unit and its components).

We did however observe the following:

- The caliber of the filling gravel in compartments 2 and 3 of the system are often larger than manufacturer recommendations, which raises the question of the useful contact surface of the effluent with the medium; it is advisable to respect the recommended sizes (respectively 3cm and 0.7cm) to provide sufficient surface contact.
- On certain sites, odors were noticed coming from the first compartment of the system. This compartment in fact acts like a septic tank, with the formation of H<sub>2</sub>S gas produced degradation of proteins containing sulfur whereas the manhole covers are not designed to be perfectly tight. (The start of corrosion was in fact observed on these covers.). For this reason, **we recommend equipping this compartment with a vent with a “four winds” cover.**

#### On the aeration-filtration sequence

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<sup>9</sup> ☞ Thus, in PWEГ's offer, for example, they provide an 88m<sup>2</sup> greenhouse for €1,200 extra.

There are no significant remarks on running an aeration filtration sequence after the anaerobic sequence.

On the other hand, doubts may rise on the effectiveness of aeration in the second tank. The supply method (drip feed), the surface areas and the volumes of the different layers do not appear sufficient to ensure a complete changeover from anaerobic to aerobic. To remedy this, the following is suggested:

- feed the tank with a sprinkler for better distribution of the effluent over the entire available surface
- feed the tank sequentially to better oxygenate the filtering media via convection
- increase the surface area and height of the gravel packing by using a larger tank
- reinforce aeration capacity by laying a 20 to 30cm pebble bed at the bottom of the tank and inserting the collection pipe feeding the lower effluent storage tank; at the tank's outlet, this tube should extend upwards so as to continue aerating the filtering media during the non-feeding phases; moreover, in the event that the lower storage tank is closed, this system provides safety by acting as a bypass during loading of the storage tank; for this reason the upward tube must not extend further than 1/3 of the height of the tank.

Under these conditions, we would recommend filling the aeration-filtration tank from top to bottom as follows:

- upper level of 10cm stones: 20 cm
- activated carbon layer: 15-20 cm
- gravel layer (1 to 3cm): 70cm
- screen
- large stones (10-20cm) with collection tube

#### Possible upgrades:

The robustness of the product, given the size of the pit and the possibility of easily expanding it, suggest that a concrete pit module could be used as a **raw water treatment micro-plant**. The unit could be partitioned so as to have the following sequences: primary decantation, aeration (fixed or free culture), filtration, and storage of treated water for irrigation. This would of course imply an energy cost for the aeration sequence (around €60 to €80 per year).

#### **Environmental consequences**

Then situation described above has several consequences:

The lack of water treatment works for the wastewater collected by the drainage companies means causes the latter to dump waste matter directly into the environment: into a wadi, a

ditch, or a karstic infiltration area. Untreated household waste is thus spilled massively into the natural environment causing heavy infiltration polluting springs and ground water.

Because draining septic tanks and cesspits is so expensive for Palestinian families, they do so as little as possible, resulting in overflow onto public streets or neighboring land. Such overflows are obviously problematic both for public health and neighbor relations.

The effects of these overflows combine with those of chronic infiltration of wastewater directed to cesspits or poorly-maintained septic tanks that are often cracked. The impact of these combined effects is infiltration that contaminates drinking water tanks also buried under the dwellings, as well as springs and ground water.

This benefit assessment report intends to help the country to evaluate the benefits of addressing environmental challenges it is facing and, where possible and appropriate, estimate their economic value – hence making benefits comparable and understandable to A wide audience. The assessment provides “order of magnitude” results, in order to communicate the scale and significance of the potential benefits of taking action.

This benefit assessment report aims to assist policymakers by providing new evidence and

Values on:

- key environmental issues affecting their country, i.e., the issues that could result in the greatest benefits if tackled appropriately;
- impacts of these issues on society – i.e., in terms of social (e.g., health), economic
- (e.g., additional social costs) and environmental (e.g., biodiversity loss) impacts; and
- benefits (health, environmental, economic and social) that accrue to society from Taking actions to protect the environment

## ***Chapter five: analysis of the Case Study***

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### **5.1. INTRODUCTION**

The Palestinian rural areas experience a high level of drinking water shortage. There is a lack of water resources for all purposes (industrial, agricultural, and residential uses), and the existing sources of water are controlled by the Israeli occupation. The quantities of available water for the Palestinian people are limited and less than the minimum recommended by World Health Organization (WHO) standards, where the average consumption of the Palestinian per capita is 76 L/day (water for life 2006, PHG).

The Palestinian communities experience a great weakness in their water and sanitary systems infrastructures where most of the water networks experience to deterioration and devastation, and most of the Palestinian communities are not connected to sanitary network and treatment plants.

A high percentage of Palestinian families in the villages especially the far-off ones live in poverty and low incomes. Most of these families depend on farming to ensure their basic needs of life. Because of the lack of water many use untreated grey wastewater to irrigate their farms and gardens without taking into consideration health and environmental risks especially to the children and women who are the direct user of this kind of water in addition to the social problems with neighbors because of the foul odors and insects, which ultimately affects the social bonds.

Grey wastewater treatment and reuse in the irrigation of gardens and farms is acceptable by the Palestinian families which helps ensure a good and durable source of water for agricultural use ensuring their basic needs from vegetables which are planted in the house garden with an area of 150 to 200 square meter, in addition to the reduction in pollution and sanitary problems caused by untreated grey wastewater.

As earlier mentioned in this paper the Palestinian Hydrology Groups has implemented many grey wastewater treatment units in the Palestinian communities in addition to reclaim house gardens through providing the Palestinian families with irrigation networks and vegetable plants which can be irrigated with this kind of water according to the Palestinian and international standards. This helps in improving the healthy livelihood and conditions for poor Palestinian families.

However, reuse in Palestine remains to be very primitive and requires development mainly due to the lack of large scale infrastructure, social obstacles and public unacceptability. Farmers and households must be fully aware of the importance of reuse and how they can benefit from the treated wastewater by increasing the production and saving the costs that would in other case be spent on fertilizers and fresh water.

Within the SMART project framework PHG carried out a field survey which is included 75 decentralized grey water treatment plants in order to assess the socioeconomic and environmental benefits of the system and to understand the social perceptions towards the systems.

## **5.2. GWWT PROJECTS IMPLEMENTED BY PHG.**

PHG implemented a number of GWWT projects in different places in Palestine, which all had the main goal of introducing a new source of water for the irrigation of home gardens safely and preserving a safe environment. The following projects were implemented by PHG:



Figure (2): GWWTPs projects implemented by PHG in Gaza Strip.

1. Southern part of the West Bank: Funded by European Commission Humanitarian Aid Office(ECHO) and in cooperation with Civil Volunteers Group (GVC) association, in the year 2010 PHG's branch in Hebron implemented a project that included the construction of 10 grey water treatment units and the reuse of the treated grey water for agricultural purposes in schools in Hebron Governorate. In 2011 and through the Polish Humanitarian Organization (PHO) PHG's

branch in Hebron also implemented a project that included the construction of 3 grey water treatment units and the reuse of the treated grey water for agricultural purposes in schools in Bethlehem Governorate.

5. Northern part of the West Bank: In 2002, PHG's branch in Nablus implemented a project that included the construction of a centralized grey water treatment plant and the reuse of the treated grey water for agricultural purposes in the village of Ijnisinya which has a population of 600 residents. This project served more than 70 families, and had the main goal of reducing pollution resulting from leaking wastewater cesspits to the main and only source of water which is the spring that supplies the community with drinking water. In addition to that, Nablus Branch implemented in 2002, 60 grey water treatment units in Seir, Meselyia, Al-Jdayidah, Tayaseer and Rabah, and 57 units in Sanour/Jenin District, where 117 families have benefited from that. Moreover, 14 units for grey water were in 14 schools; Aqqaba, Jenin, Kafr Thulth, Awarta, Jamal Abdel Naser (Nablus City), Sabastya, Tallouza and Al-Badhan.
6. Ramallah Governorate: In the years 2002 and 2006 PHG's branch in Ramallah implemented a project that included the construction of 12 grey water treatment units and the reuse of the treated grey water for agricultural purposes in Bil'in, Ras Karkar, Deir Ibzea and Kharbatha Al Mousbah communities.



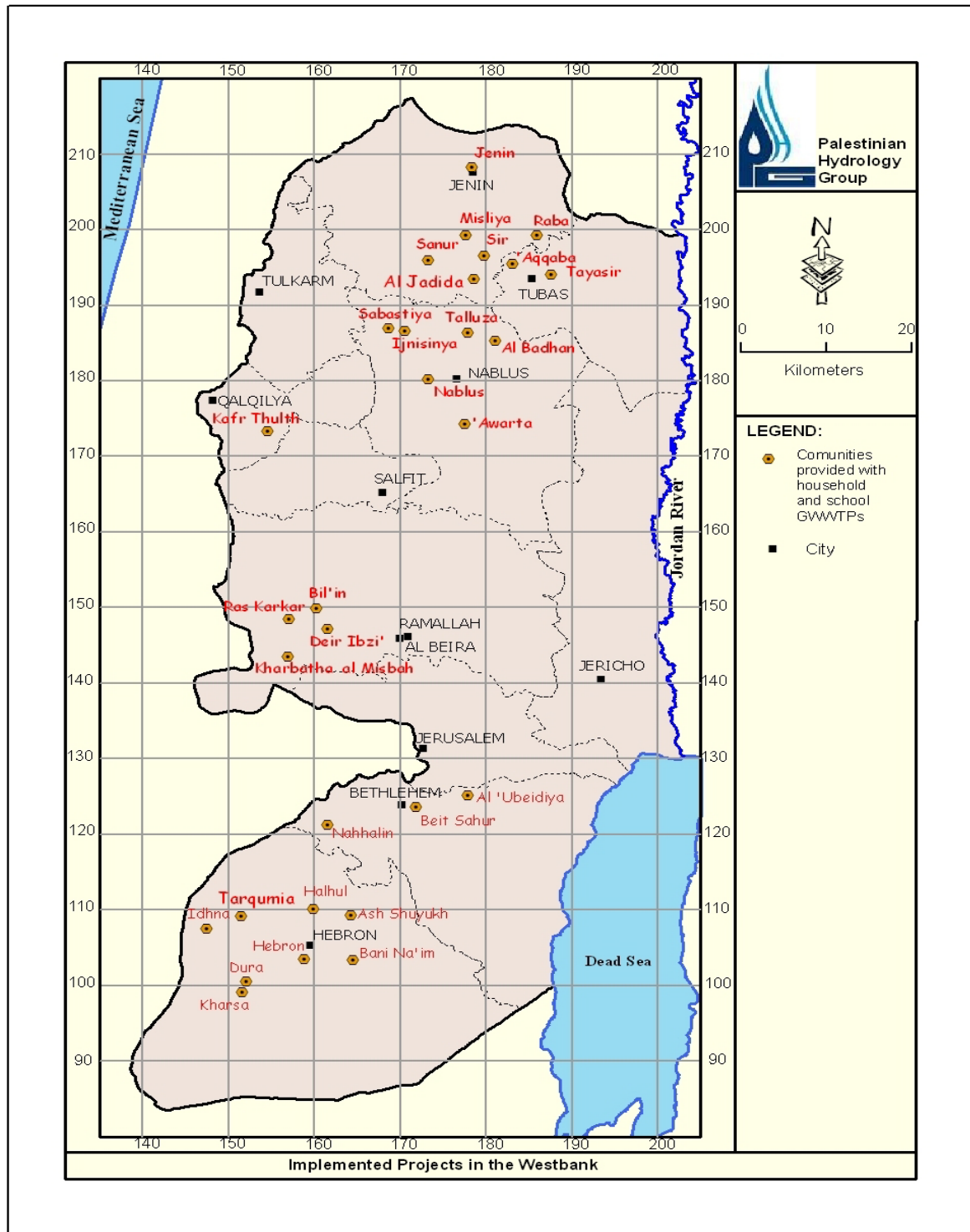


Figure (4): Implemented projects in the West Bank.

### 5.3. METHODOLOGY

The research adapted different methods to collect , manage abd to analyze the data

a. **The Contingent Valuation Method (CVM):** CVM relies on hypothetical assessment. For example, the respondent is asked to value the good in question by expressing his/her WTP for an improved quantity or quality. The positive feature of this method is that it is utility based but the drawback is that it is hypothetical. McFaden and Leonard (1993) assert that two conditions must be met for the CVM to be valid: (1) there must be reliable survey methods for eliciting stated consumer preferences, and (2) the consumer's stated preferences are the same as his/her true preferences. Because of these issues, the following biases may arise<sup>i</sup>:

- Strategic bias: this refers to the free riding behavior, which refers to respondent's strategic behavior of understating his/her true WTP, thinking that it might lead to actual lower tariffs.
- Starting point bias: the starting point can potentially influence the respondents' WTP if taken as a reference point.
- Vehicle bias: this occurs if the respondent misperceives the payment vehicle (method of finance).
- Information or questions order bias: the order in which questions are asked could lead to bias in WTP.
- Hypothetical bias: this is due to the nature of CVM as the respondent is not making real payments.
- Interviewer bias: in this case the respondent does not reveal his/her true response to please the interviewer.
- The existence of most of these biases is testable; in case they exist, remedial measures can be devised to correct the problem.

b. Focus Group Meetings

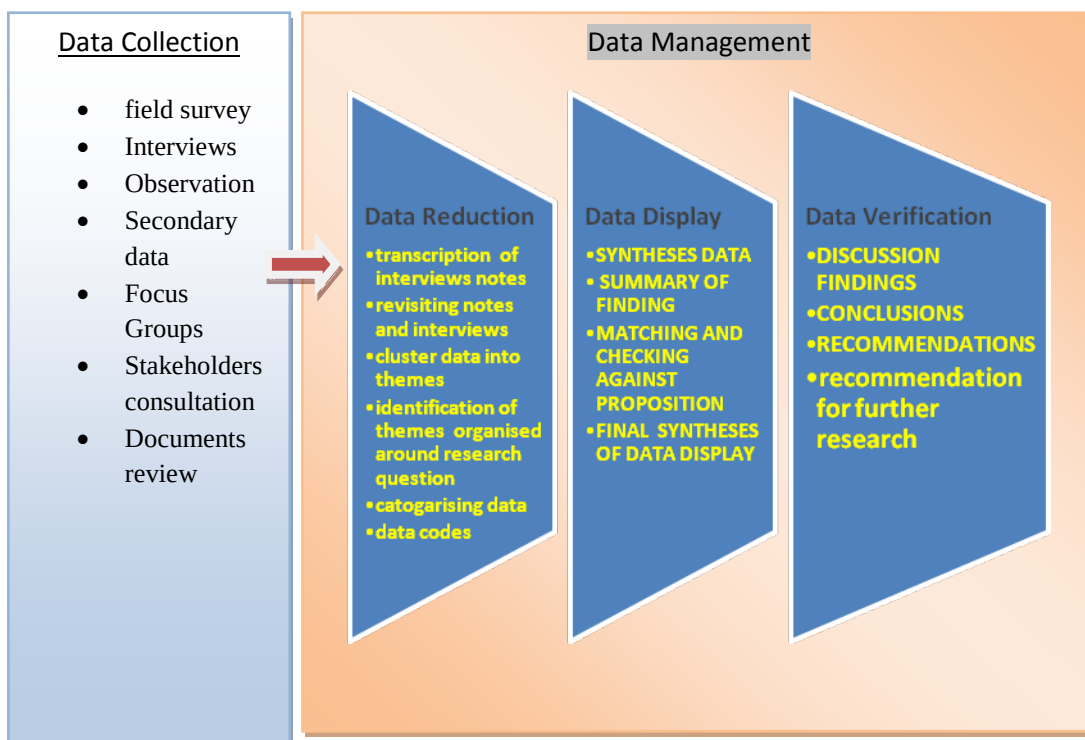
The methodology used in the meetings was the participatory rapid appraisal (PRA). The PRA method allows people to go beyond the quantitative aspects that are covered by the questionnaire. It also attempted to promote open group discussion on the value placed on water. In addition, different tools such as the matrix mapping and pie chart were used during the meetings. The meetings were organized in Nablus, Hebron and Ramallah areas.

Four meetings were held in each of Ramallah and Hebron for women and two held in Nablus area, one for women and one for men (Head of village councils – stakeholders). The purpose of the meetings that targeted women was to get a clear perception of women on water issues. However, the purpose of the meeting that targeted men was to define the stakeholder perception about water and to assess their water related gender perception especially their perception on women involvement in the management of water resources at the village council and at centralized levels.

### c. Meeting with Stakeholders

Several meetings, consisting of oral discussions and questionnaires, were held in order to have an idea about the future vision of the water policy in general and the approach of water pricing. The main stakeholders of the water sector are the donors, ministries, NGOs, local governments, municipalities, water administration authority (the PWA, and the National Water Council. It is important to see the vision of main donors such as the World Bank and GTZ, since these donors are the main drivers of the water sector in Palestine and work closely with decision makers.

### d. Data Management



#### 5.4. RESULTS AND ANALYSIS

In order to use the CVM special questionnaire has been prepared, 75 questioners were filled and analyzed, and the following table shows the major socioeconomic and environmental indicators

| Indicators                                                               | results      | Remarks                                                               |
|--------------------------------------------------------------------------|--------------|-----------------------------------------------------------------------|
| Amount of water saved for agriculture (m <sup>3</sup> /household /year)  | <b>19.17</b> | Treated grey water used for home garden                               |
| Reduction of fresh water use for home garden (m <sup>3</sup> /household  | <b>14</b>    | The no more use the fresh water for irrigation                        |
| Average income increased by production from the home garden \$/household | <b>220</b>   | Usually their production are fruits and olive                         |
| Average money saved from evacuation the septic tank (\$/household /year  | 450          | The cost of Evacuation very high and all this money saved             |
| Social conflict on cesspits overflow reduction                           | Very high    | Social conflict is unremarkable after the use of grey water treatment |
| Reduction of odor                                                        | No odor      | Cesspits used to have very bad odor before using the treatment        |

**Table 4. Qunatitative socioeconomic benefits of the case study**

**The other study done in cooperation with Birzeit showed that: Benefits of GWTS:** The major direct benefit of using GWTS is the saving in water bill. The indirect benefit at national level is the reduction in groundwater pollution and need for expensive sewerage and treatment plants. The results of the study show that the households' average expenditure on water supply is about 28.6 US\$/month (4.2 US\$/person/month) and 38.9 US\$/month (7.2 US\$/person/month) in the cases of GWTS and cesspits, respectively

(Table 3). The average share of the water supply expenditure as percentage of the households' income is about 6.5% and 8.5% in the GWTS and cesspit cases, respectively. The results also show that the average share of sanitation expenditure as percentage of the households' income is about 0.5% and 2.3% in the cases of GWTS and cesspits, respectively. The results for households with GWTS can be considered high when compared with the international affordability level (4% of annual income) for water supply and wastewater services (DANCEE, 2002). Nevertheless, the GWTS results (about 7%) can be considered satisfactory when compared with that of cesspits (about 11%).

| N                                     | Minimum | Maximum | Mean  | Std. Deviation |       |
|---------------------------------------|---------|---------|-------|----------------|-------|
| GWTS:                                 |         |         |       |                |       |
| Water expenditure (US\$/month)        | 30      | 11.63   | 58.14 | 28.64          | 12.73 |
| Water expenditure (US\$/person/month) | 30      | 1.94    | 11.63 | 4.22           | 2.17  |
| Water expenditure (% of income)       | 30      | 1.25    | 18.00 | 6.48           | 3.90  |
| Wastewater expenditure (% of income)  | 30      | 0.14    | 1.33  | 0.54           | 0.32  |
| Cesspits:                             |         |         |       |                |       |
| Water expenditure (US\$/month)        | 100     | 11.63   | 93.02 | 38.86          | 23.19 |
| Water expenditure (US\$/person/month) | 100     | 1.45    | 23.26 | 7.24           | 5.39  |
| Water expenditure (% of income)       | 100     | 1.14    | 35.00 | 8.47           | 6.94  |
| Wastewater expenditure (% of income)  |         | 37*     |       | 0.33           |       |

**Table 5. Impact of GWTS and cesspits on households' expenditure on water and waste water (abu madi. 2010)**

#### **5.5. PUBLIC PERCEPTIONS ABOUT SOCIOECONOMIC BENEFITS.**

Despite their high cost, cesspits are often constructed at each rural household with own funding devoid of affordability complaints. On the contrary, the available GWTS are mainly constructed with external funding, except for very few cases. Therefore, one of the study objectives was to better understand this phenomenon by eliciting the perceptions of public towards having GWTS with and without external funding. The results show that about 72% of the surveyed households

. Are willing to implement GWTS with external funding against 17% with own funding. These results are in harmony with the findings of other research studies in the same study area. A study by Al-Sa'ed (2004) conducted on the socio-economical aspects of decentralized sanitation in small Palestinian communities revealed that about 85% of the people accepted the idea while about 60% refused small onsite sanitation systems. The major reason behind these findings is that most (80%) of the respondents did not show willingness to pay or participate in construction costs. Another study by Al-Sa'ed and Mubarak (2006) showed that more than 50% of the respondents in Ramallah and Al-Bireh district were against having new onsite treatment systems and favored centralized wastewater treatment options, while only 18% showed willingness to participate partially in construction costs. All these results reflect the overriding culture of Palestinian reliance on donor funding for infrastructural projects.

The major two reasons behind public rejection to have and self-finance GWTS at their households (n=83) are:

- (i) 54% refuse to restructure their internal piping systems in order to separate black and graywater,
- (ii) 33% refuse to use the reclaimed graywater for garden irrigation,
- (iii) 21% believe in availability of externally funding for such type of projects, and
- (iv) 17% cannot afford the high construction costs.

The percentage of households that refuse to have GWTS even with external funding is about 28%. The reasons standing behind their rejection (n =28) are:

- (i) 90% are satisfied with the existing cesspits that require no emptying,
- (ii) 86% refuse to use reclaimed grey water for garden irrigation, and
- (iii) 63% refuse to restructure their internal piping systems in order to separate black and grey water.

These results reveal that the construction of GWTS has more chances of success in houses under construction coupled with appropriate awareness and promotion campaigns. Therefore, more effort is needed by the local and international concerned institutions to raise the public awareness on the advantages and merits of GWTS against the prevailing cesspits.

The direct benefits of using GWTS overweigh those of cesspits even without considering the indirect ones associated with preventing groundwater pollution, safeguarding public health in the target communities, and rich-nutrient content that replace artificial fertilizers. Literature reviews shows that the GWTS associated indirect costs and externalities -such as negative health impacts and soil contamination) are minimal. Literature widely reports that there is no recorded case of anyone falling ill as a result of household recycling of graywater (Marshall 1996; Baker and Jean, 2000).

However the PHG Surveyed showed the following results

- About 77 per cent of those surveyed believe decentralized water will help to solve water shortage at household level and will secure water for household agriculture.
- Although 73 per cent who have piped water systems, believe the decentralized WWT will reduce the public health problems
- Almost all the respondents (85 per cent) believe that reusing waste-water is one option for coping with the shortage of irrigation water.
- Over half of those surveyed (55 per cent) believe that wastewater is no longer simply waste, but a usable water source.
- More than 78 per cent believe that there is an acute need to reuse DWWT at household level.

- Over 80 per cent said they believe the social and economic benefits of DWWT
- About 50 per cent felt that the reuse should be to irrigate crops that can be exported while the other 50 per cent said the irrigated crops should be marketed locally.
- Nearly 80 per cent had no knowledge of how to deal with wastewater, and 94 per cent said it was necessary to take precautions when dealing with wastewater.
- About 87 per cent said they would accept having wastewater treatment plants in their house or to share it with cluster of houses
- Nearly 60 per cent think that drip irrigation is the most appropriate method for irrigation with treated wastewater.
- About 65 per cent of respondents said that diarrhea was the most prevalent disease in their towns. And they believe the DWWT will reduce it
- Over 66 per cent said their family income was less than two thousand new Israeli shekels per month (US\$1 = NIS4.1), and they believe the DWWT will improve their income
- Almost all the respondents believed that wastewater use is allowed by Islam under conditions that prevent harm to the users.

### **Farmers**

A random sample of 45 farmers from the villages surveyed expressed their opinion as the following

- Most of the respondents said they are happy with the economical benefits of the DWWT.
- Almost all believed that it is technically and economically possible to safely reuse wastewater to address irrigation water shortages.
- Many respondents said that the main obstacle they faced was the lack of sufficient water and the high cost of fertilizer.
- Most of the farmers said that wastewater has an advantage over freshwater for irrigation because it contains most of the nutrients required by plants.
- The farmers are ready to accept the reuse of wastewater for irrigation on their farms if the effluent quality is assured, and the law allows it, and they do not have to change their cropping patterns.

- Almost 60 per cent of the farmers said they did not know enough about sludge from sewage treatment plants, but that they were willing to use it as a fertilizer if it is safe and not contaminated with pathogens.

## ***Chapter Six: Conclusions & lessons learned:***

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### **6.1. CONCLUSIONS**

- 1) DWWT can be a very significant water source for home gardens.
- 2) Treated grey wastewater is more acceptable for re-use than other kinds of treated water, due to religious and cultural beliefs.
- 3) DWWT treatment can contribute to improving the socio-economic conditions of poor families in rural areas by saving a considerable portion of their income spent on water supply and wastewater disposal.
- 4) Using treated grey water for agricultural activities protects the public from the risk of being infected with water borne diseases.
- 5) Grey water treatment also contributes in preserving the food security of these families by providing a reliable water source to produce a vegetable basket for the household.
- 6) Due to the poor condition of the sanitation infrastructure, the political situation and the deteriorating economical condition, PHG strongly believes that grey water treatment can be an effective solution to the wastewater management problem especially in the marginalized rural areas.
- 7) Through its experience, and that on a regional level, PHG has concluded that the up flow gravel filter is an acceptable technology that is low cost and easy to operate and maintain.
- 8) The COD removal efficiency of the constructed grey wastewater treatment plants ranges from 31% to 90% as a result of using different models in addition to problems related to poor maintenance.
- 9) The concrete chambers developed by PHG are better than infiltrations ponds and parallel barrels previously used since:
  1. They are easier to control.
  2. They are more durable (have a longer life).
  3. More efficient since the volume is not limited.
  4. Environmentally friendly.
- 10) The mixed system consisting both aerobic and anaerobic processes overcomes many of the problems encountered in the previously implemented units especially due to the generated odors.

## 6.2. RECOMMENDATIONS:

*It is recommended that:*

1. Grey and black wastewaters are separated for the purpose of on-site treatment and reuse of grey waste water. On-site treatment through a septic tank and up flow gravel filter system (the system used by PHG) is provided for the reuse of grey wastewater for gardening
2. Further evaluation for the Pilot projects technical performance is needed
3. The DWWT is the only option for improving the household public health situation in the scattered houses case.
4. Economically and environmentally benefits highly depends on the performance of the DWWT, in order to increase the benefits, regular maintenance and proper management is needed.
5. Official monitoring and inspections program is needed.
6. Public awareness campaigns is recommended in order to increase The DWWT promotion
7. Specialized unit in PWA to monitor the DWWT and proper institutional arrangements need to be done.

## 6.3. POTENTIAL USERS OF AND TARGET AUDIENCE FOR THIS BENEFIT ASSESSMENT REPORT

The potential users of and the target audience for this benefit assessment report include:

- **Governmental institutions**, responsible for a sector that will directly benefit from environmental improvements, such as the ministries responsible for environment, water, energy, land use, agriculture, fisheries, health, social affairs and tourism. This report provides evidence of the benefits of environmental improvements that can support their arguments for funding environmental actions and for environmental policy integration<sup>5</sup>.
- **Regional and local authorities**, for similar reasons as the above mentioned Governmental institutions.
- **Finance ministries**, which often play an important role in deciding the funding levels for each other ministry, are also a potential user of benefit assessments. This is important, as it is the perceived benefits that drive policy decisions to allocate public resources to maintain and to improve the quality of the environment.
- **Parliament**: this report can help legislators responsible for environmental matters to make the case for better environmental protection and conservation legislation.

- **Ministry of Justice**) and environmental inspectorates/enforcement
- **Agencies.** This report provides evidence that supports their arguments for enforcing environmental legislation.
- **Communities:** this report can help communities that depend for their livelihood on natural resources (e.g., forestry, fisheries) to demonstrate the value of the resource and the importance of preserving them, community management of community resources.
- **The private sector, civil society and the development partner community,** which jointly work on the common challenge of the transition to a resource efficient, effective, green and equitable economy. This report can help them to set priorities for action and provides evidence when advocating for enhanced environmental protection.

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