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مقدمة من

سناء محمود عبدالحميد مبارك

الرقم الجامعي: 1015252

باشراف

الدكتور راشد "محمد ياسر" الساعد

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On The Sustainability of Rural

Wastewater Management Systems

in Ramallah / Al-Bireh District

By

Sana' Mubarak

Student Number: 1015252

Supervisor

Dr. Rashed Al-Sa`ed

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On The Sustainability of Rural Wastewater Management Systems in Ramallah / Al-Bireh District

By

Sana' Mubarak

This thesis was prepared under the supervision of Dr. Rashed Al-Sa'ed and has been approved by all members of the Examination Committee.

Dr. Rashed Al-Sa'ed
(Chairman of the Committee) ………………………………

Dr. Nidal Mahmoud
(Member) ………………………………

Dr. Ziad Al-Mimi
(Member) ………………………………

Date of Defense: June 28, 2004

The findings, interpretations and conclusions expressed in this study do not necessarily express the views of Birzeit University, the views of the individual members of the MSc Committee or the views of their respective employers.

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ABSTRACT

The regional scarcity of water in the Mediterranean and Middle East countries requires endorsement of sustainable wastewater management technologies. In Palestine, domestic and industrial wastewaters are collected mainly in cesspits or, to a much lesser extent, in sewerage networks. In some villages and refugee camps, black wastewater is collected in cesspits, while gray wastewater is discharged via open channels.

In rural areas water and money are not available to provide centralized conventional wastewater services. So, application of decentralized management approach within the water cycle and the use of low cost sewerage are more suited to the socio-cultural and environmental circumstances.

There is substantial need for more sophisticated management of both on-site septic systems and small community wastewater treatment and disposal systems. While these systems are fairly easy to maintain, it is clear from recent studies that these systems have not always been maintained properly. Better management should facilitate more extensive use of complex technological options. There are a number of institutional management entities that can be used depending upon the needs and desires of the county or local community.

The main goal of this research study is to develop a sustainable wastewater management for small communities in Ramallah-Albireh district. This research study is limited to those Palestinian rural communities, who have a population number of equal of less than 5000 residents.

The selection of adequate sanitation facilities, in this study, will take into account the environmental and socio-economical aspects of the residents in the small communities of Ramallah-AlBireh district. However, these aspects can be community specific and might vary from one district to another, a brief analysis of these aspects will be made for all districts. WAWTTAR software package will be used to assist in technology selection based on social and economical aspects.

The assumptions, justification and limits of this research study will be described. In addition, an overview of the research methodology applied is also presented.

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ACRONYMS AND ABBREVIATIONS

ARIJ	Applied Research Institute of Jerusalem
BOD	Biological Oxygen Demand
Dunum	0.1 Hectar
COD	Chemical Oxygen Demand
EAP	Environmental Action Plan
EPA	Environmental Protection Agency
GIS	Geographical Information System
IFI	International Financial Institution
L/c/d	Litres per capita per day
NAP	National Action Plan
NGO	Non-Governmental Organisation
OPT	Occupied Palestanian Territories
OWTS	On site Wastewater Treatment System
PARC	Palestinian Agricultural Relief Committees
PHG	Palestinian Hydrology Group
PWA	Palestinian Water Authority
SAP	Strategic Action Plan
SOP	Standard Operational Procedure
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
US EPA	United States Agency for Environmental Protection
WASH	Water and Sanitation for Health Project
WAWTTAR	Water and Waste Water Treatment Technologies Appropriate for Re-use
WB	World Bank
WHO	World Health Organization
WWTP	Waste Water Treatment Plant

CHAPTER 1

INTRODUCTION

1.1 Background

Water consumption is very low in Palestine due to the lack of adequate and regular water supply and high water rates. Wastewater is mainly of domestic origin. But since water consumption is very low, wastewater is concentrated and its strength, in some locations, is comparable to that of industrial wastewater. Light industries are prevailing in the West Bank, which means that heavy metal contamination is not probable. At present, the situation is changing, but still there is no enforcement of rules and regulations. This leads to a discharge of wastewater that has high pH value, high temperature, high content of chemicals, or high content of inert suspended solids. Complied by Al-Sa'ed (2000), Table 1-1 gives the characteristics of wastewater of some cities and rural communities in the West Bank (Mustafa, 1996; Tahboub, 2000; Nashashibi, 1995).

Table 1-1: Characteristics of raw municipal and rural domestic wastewater in the West Bank

	Municipal Urban Wastewater				Rural Domestic Wastewater	
Parameter	Ramallah	Nablus	Hebron	Al-Bireh	Gray	Black
BOD_5	525	1850	1008	522	286	282
COD	1390	2115	2886	1044	630	560
Kj-N	79	120	278	73	17	360
NH_4-N	51	104	113	27	10	370
NO_3-N	0.6	1.7	0.3	-	1	-
SO_4	132	137	267	-	53	36
PO_4	13.1	7.5	20	44	16	34
Cl^-	350	-	1155	1099	200	-
TSS	1290	-	1188	554	-	-

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

High chemical oxygen demand (COD) and high biological oxygen demand (BOD) values mean that wastewater is highly concentrated with organic matter. Hence, the treatment process might be complicated and need advanced technology to reach an effluent that is safe to discharge in the wades or reuse in agriculture. Another important parameter is the chloride concentration in wastewater. Since the chloride ions are dissolved in the wastewater, the conventional treatment processes do not remove chloride. Thus, in case treated wastewater will be used in agriculture, then salt-tolerant crops should be considered.

Wastewater management in Palestine has been a neglected issue over the past years. No comprehensive data on wastewater characteristics and amounts discharged are yet available.

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

The situation of the sewerage system is extremely critical. Approximately, 60% of households in the urban cities are connected to the sewerage system. In some urban and all semi-urban areas as well as all rural communities, collection systems are rarely used and wastewater is discharged into percolating pits or septic tanks. The septic tanks emptied by vacuum trucks and disposed of either in the treatment plant or just in the wades. In villages, no sewage network exists, and wastewater is discharged into percolating pits.

Decentralized wastewater management systems should be an integral part of any rural sanitation policy. This will ensure public health protection, reduction in aquatic environment degradation and save costs of treatment and biosolids. Furthermore, privatization might play a key role in solving some of the sanitation problems of rural communities. The advantages lay in reduction of capital investments, private sector responsibility of risk for planning, investment and operation, enhance the economical efficiency and project management. However, the experience gained in Europe on privatization of municipal services indicated that privatization was not always the best option for public owned utilities (Nisipeanu, 1998).

Key factors to success in formulating rural community wastewater management programs should include public acceptance and local political support, funding availability and reasonable costs, visibility and accountability of local leaders. Also capability and skills of local technical and field staff, availability of creative and professional advisors, clear and concise authority, regulations and enforcement mechanisms are key issues (EPA, 1994).

The powers and authorities of the PWA as a legal body for the water and sanitation sectors are still very weak as of political and technical factors. This is quite clear with regard to the power to issue and enforce regulations; the authority to plan and control how and when sanitation services will be provided, the ability to license, train, or certify persons involved in system design, installation, maintenance, and residual disposal. In sum, minimal institutional requirements for the successful implementation of community sanitation projects are; a government policy that support the project, a sectoral agency at the regional level to provide the project with technical support and a community organization, committee to provide link between users and agency. Moreover, a close cooperation between rural community councils and other national institutions with regard to community planning change in land-use and environmental management will help in a successful development of sanitation management.

1.2 Main goal and objectives

The main goal of this research study is to develop a sustainable wastewater management in small Palestinian communities of Ramallah / Al-Bireh districts with special emphasis on technical, environmental and socio-economical aspects.

The objectives are as follows:

To achieve the main goal of this study, the following objectives are envisaged to accomplish:

1. Evaluate the present status of rural sanitation in the West Bank with special emphasis on existing onsite sanitation systems in Ramallah-Al-Bireh district.
2. Assessment of available alternative options on adequate sanitation technologies
3. Development of a sustainable approach for rural wastewater management.

1.3 Methodology

To achieve the main objectives of this research study, the following research methodology will be adopted:

- Conduction of a detailed literature review, collect and analyze all available studies, technical reports and published data on rural wastewater treatment in Palestinian and international published scientific papers and reports.
- Evaluation of available technical data on design, operation and evaluate process performance of existing small rural sanitation systems
- Questionnaire development and distribution to investigate the social and economical aspects of small community wastewater treatment systems
- Application of WAWTTAR software package to develop technical guide on technology selection and provide financial assessment of alternative

WAWTTAR is an external model developed by Humboldt State University under contract to USAID. It provides solid engineering analyses of wastewater treatment plant (WWTP) alternatives, with defensible pollution removals and costs. WAWTTAR software package is developed to help planners and sanitary engineers to improve their sanitation strategies while selecting treatment technologies. This program provides feasibility assessment for alternative treatment options based on community needs, capabilities and resources. Also the appropriate technology can be selected taking into account the treatment efficiency of the selected system and wastewater reuse requirements, public health and disposal standards.

The program is not a dynamic one and does not analyze the response of a given system to variable influent conditions. Also, it does not automatically select the appropriate technology, but the user must build the treatment scheme and select the unit operations.

1.4 Thesis outline

The study is divided into four parts:

- Overview of wastewater management infrastructures in small areas (chapter two).
- Evaluation of existing rural wastewater and reuse management on Palestine especially in Ramallah / Al-Bireh district (chapter three, Annex 1, Appendices A&B).
- Social and economical aspects of onsite sanitation in Ramallah / Al-Bireh district (chapter four, Appendices C&D).
- Research methodology (chapter five)
- Results and discussion (chapters six and seven).
- Presentation of the final conclusions and recommendations in chapter eight.

CHAPTER 2

OVERVIEW OF WASTEWATER MANAGEMENT INFRASTRUCTURES IN SMALL AREAS

2.1 Guiding principles and options for sustainable development

In water stressed countries such as those of the Middle East and North Africa, every drop of water must count. Sustainable management of water resources can only be achieved if the water resources and wastewater management policies come together in addressing the water cycle in a holistic manner. Water must be used wisely and efficiently not only to control the consumptive use of water but also to reduce the wastewater flows. Wastewater flows must be managed effectively to protect the freshwaters from pollution. They must be reintegrated safely in the water cycle and accounted for in the water budget.

Several governments are now in the process of providing wastewater management services to their small towns and communities after providing these services to the main and secondary cities. Centralized sewerage systems, the preferred choice of planners and decision makers, are inappropriately provided to individual communities and wastewater is transported from several scattered communities to centralized treatment facilities.

2.2 Conventional concepts for centralized wastewater management systems

In commonly called "centralized" water/wastewater management system all the water to be distributed in the urban area is purified at one discrete location, the water works, and the wastewater collected in the area is sent to one discrete plant for treatment and discharge. Centralized wastewater management has been the norm in municipal engineering circles for more than 100 years. Based on the "Pipe it away first, then think about what comes next" philosophy, centralized management is the structure of choice in most cities and countries.

That approach may be changing. Most of small communities have found conventional systems to be hugely expensive and have begun to investigate decentralized concepts. The decentralized concept is base on a simple premise: Wastewater should be treated (and reused, if possible) as close to where it is generated as is practical.

That philosophy allows local governments to circumvent one of the major disadvantages of the conventional, centralized management system - huge investments in an extensive collection system that does nothing more than move pollution from place to place. (The phrase "decentralized management" is used here, but it is somewhat of a misnomer, because, while facilities are decentralized, management may be handled by a central entity).

In many places were faced with extending service. Its engineers determined that using decentralized treatment methods would be a far more cost-effective solution than extending the city's centralized system into the area. The elements that decentralized wastewater management systems comprise include: (1) wastewater pre-treatment, (2) wastewater collection, (3) wastewater treatment, (4) effluent reuse or disposal, and (5) biosolids and septage management. Although the components are the same as for large centralized systems, the difference is in the type of technology applied. It should also be noted that not every decentralized wastewater management system would incorporate all of above elements.

2.2.1 Consequences of centralized wastewater treatment

Discharging the wastewater from dwelling areas through a sewer system caused new problems:

- A sewer system must be financed already in the planning and building stage although it takes long years until such a system pays off.
- The costs for building and operation of a sewer system are enormous. The investments for transportation of the wastewater amount to approx. 80% of the total wastewater treatment system. Maintenance of the sewer system and cleaning of the stormwater tanks additionally causes very high operational costs.
- Centralized wastewater treatment pollutes recipients, so that downstream water users have to install expensive clarifying equipment to cover their demand for drinking water from surface waters. So one began to build sewage treatment plants, at first to remove the organic carbon and later to eliminate nitrogen. Today we are faced with the problem to remove the pathogenic germs from the enormous amounts of wastewater that sewage treatment plants discharge into the recipients, which is typically achieved by sand filtration, followed by an UV treatment or by means of an ultra filtration-membrane process.
- It is undisputed among experts that it is virtually impossible to operate a sewer system in a way that there never occur any leaks. Infiltration of ground water into the sewer, and what is even more fatal ex-filtration of wastewater through the sewer into ground water, is accepted as a fact. Sewer systems are therefore a potential source for ground water pollution.

- Another weak point of sewer systems is the unspecific mixture of all types of waste-water with storm water and infiltration water (usually groundwater), resulting in very big amounts of wastewater to be processed, which require large-area and expensive treatment plants, as main structures of a sewage treatment plants have to be designed for the hydraulic flow rate and not for the nutrient load to be eliminated.
- The sewage sludge, which serves as a collector of pollutants contained in the different types of wastewater, is usually unsuitable for agricultural land treatment so that the finitely available nutrients, especially phosphorus and potassium, are lost. The amount of nutrients produced per population equivalent would however be sufficient to fertilize an area of 200 to 400 m^2 [Otterpohl, 2002].
- The wastewater is transported from the source of production through a sewer system to central treatment where it is processed to such an extent that it can do no substantial harm to the environment. The water is not available for reuse, which is disastrous especially for arid areas since the water has caused high treatment costs but is not available anymore.

2.2.2 Decentralized systems offer flexibility

A decentralized system employs a combination of onsite and/or cluster systems and is used to treat and dispose of wastewater from dwellings and businesses 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.

Managed decentralized wastewater systems are viable, long-term alternatives to centralized wastewater treatment facilities, particularly in small and rural communities where they are often most cost-effective. These systems already serve a quarter of the population nationwide and half the population in some states. They should be considered in any evaluation of wastewater management options for small and mid-sized communities.

So, how does a community decide which management approach is right for its wastewater treatment? Community leaders first need to ask some questions and then create a management plan. What circumstances are causing a reevaluation of present wastewater treatment? Are local septic systems failing? Is residential development stifled because of a lack of adequate wastewater treatment facilities? An organized plan will help managers clearly define the problems, review the possibilities, and assess the costs associated with each potential solution.

Many options now exist for wastewater treatment and disposal in rural areas and small communities. Each technology has advantages, as well as limitations, so a treatment technology must be selected specifically to meet local conditions and treatment objectives. Similarly, every community's own financial, physical, and regulatory factors must be evaluated to find the best technology for their circumstances.

Onsite systems now include a number of alternatives that surpass conventional septic tank and drainfield systems in their ability to treat wastewater. Alternative onsite processes, such as sand filters, peat filters, aerobic treatment units, pressure distribution systems, drip irrigation, and disinfection systems, can be employed in a wide range of soil and site conditions. Alternative systems require more monitoring and maintenance, making a strong case for these systems to be managed.

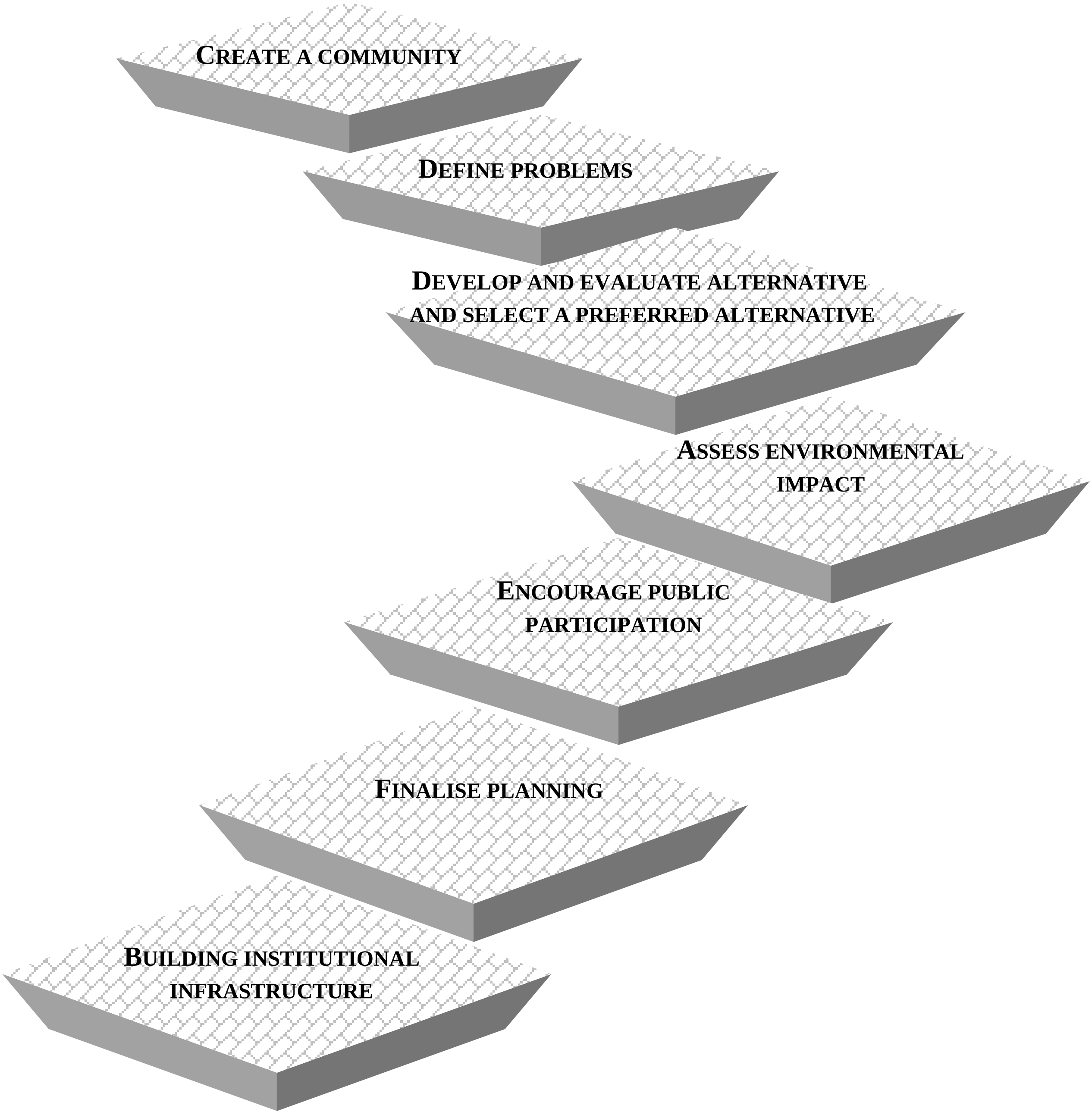
Small satellite treatment plants or soil absorption systems that have low-cost collection sewers are called cluster systems. Cluster systems treat wastewater from a group of dwellings and/or businesses and are most appropriate in moderately populated areas. These systems serve two or more dwellings (but not usually an entire community) and are located near the buildings they serve.

The wastewater from each dwelling or business flows into its own interceptor (septic) tank to settle out and allow solids to break down. From the tank, the effluent is able to travel through smaller diameter, therefore less expensive, collection pipes.

These pipes are buried at a shallower depth than full sewers and run relatively short distances to smaller, less maintenance-intensive treatment and disposal units. These units often use soil absorption fields or effluent recycling rather than discharging the treated wastewater into surface waters.

2.3 Planning issues

This section provides an overview of environmental planning fundamentals required to develop appropriate wastewater treatment facilities for Ramallah / AlBireh rural countries like many in the West Bank. A typical process for domestic wastewater management planning consists of the following steps:



2.4 Wastewater management infrastructures

2.4.1 Technology options

A large variety in conventional and non-conventional sewage treatment technologies exists, ranging from simple screening and settling operations to sophisticated biological and chemical operations. The materials removed from wastewater end up as sludge and other residual matter, which may require additional treatment before disposal. The treatment costs, energy requirements and sludge volumes generally increase with increasing pollutant removal capabilities.

A sanitation strategy should be environmentally sound, appropriate to local conditions and affordable to those that must pay for the services. Table 2-1 lists a number of key factors in the sanitation strategy and technology selection. In rural areas with low water consumption rates, human excreta can be disposed on-site through dry sanitation. As the water consumption per capita increases, sanitation will be increasingly water-based and septic tanks are introduced as a decentralized on-site treatment system. In the case of even larger water consumption rates and population densities, sewerage is required and the collected wastewater should be treated off-site in centralized systems, although recent developments seem to go back to the study of dry sanitation.

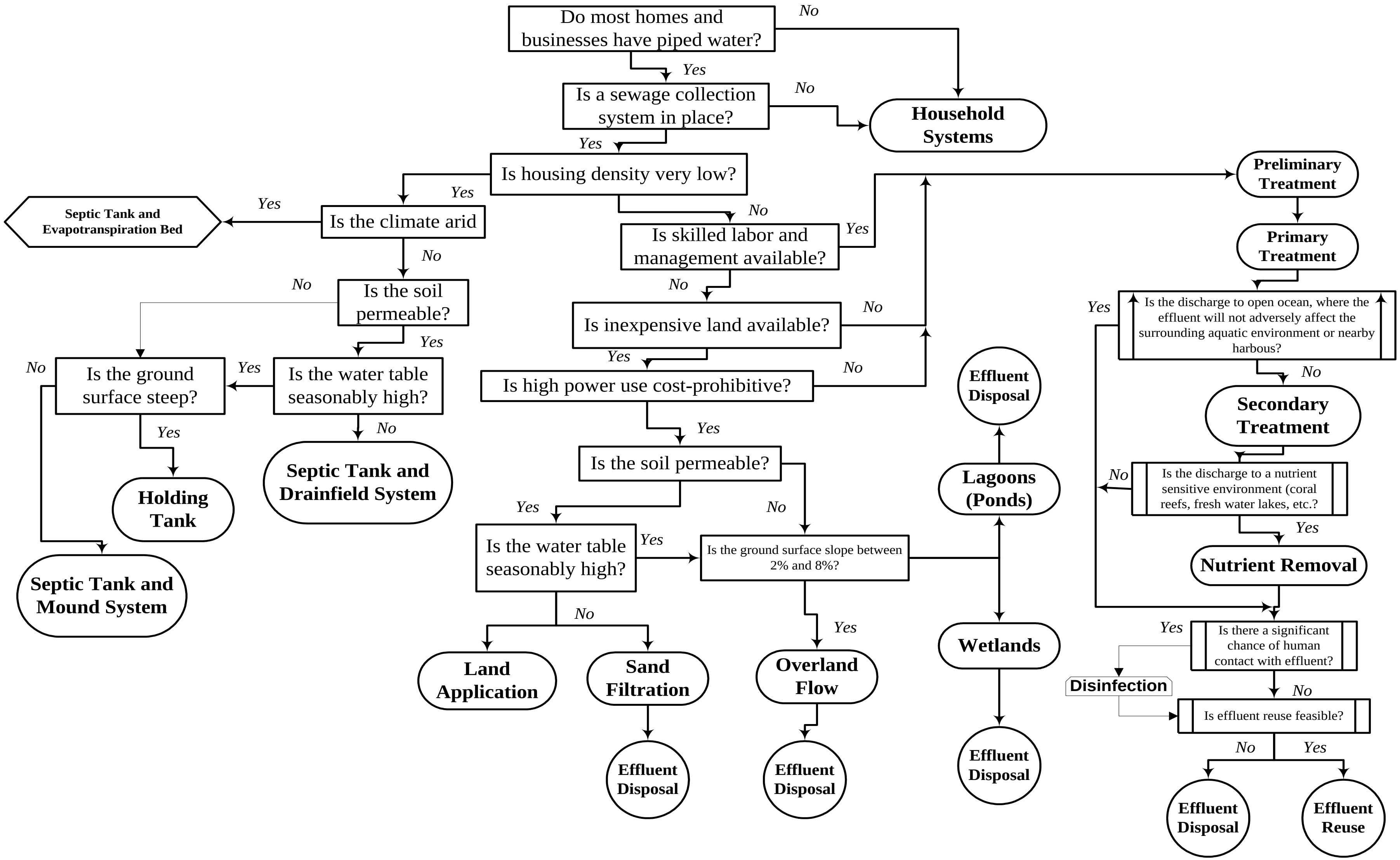
Table 2-1: Key factors in wastewater treatment technology selection (EPA, 1994)

1. Size of the community served (including industrial contributions)
2. Water availability and characteristics of the sewer system, if in place;
3. Wastewater sources (domestic, industrial, storm water), volume and composition;
4. Quality requirements of the effluent receiving water body and effluent discharge standards
5. Availability and hiring cost of local skills for design, construction, O&M
6. Availability and cost of power
7. Environmental conditions: land availability and cost, geography and climate.
8. Possibilities and need for effluent re-use

A decentralized approach through on-site sanitation leads to treatment and possible reuse of water in the direct vicinity of a settlement with accompanying savings in water supply requirements. Reuse of wastewater effluent avoids discharge of nutrients and other contaminants into receiving waters and reduces water demand by providing an alternate water source. The reuse objective determines the required treatment efficiency. In the case of centralized wastewater treatment, reuse would require an additional large distribution network for distributing the effluent to agricultural and /or recreational sites.

The selection of a wastewater treatment technology process should consider the average performance of a technology; its reliability (under variable wastewater flows and compositions and operational problems), its institutional manageability (planning, designing, construction, operation and maintaining capacity); and required investment, operation and maintenance costs. The local availability of skilled manpower is essential in the proper functioning of a wastewater treatment installation. Figure 2-1 presents a decision tree for the selection of wastewater treatment technology in rural areas, and illustrates a number of key factors in the technology selection. Different options need to be compared to establish the best available technology for a given community. A land-based alternative such as lagoons or wetlands could be initially compared to a conventional alternative, either secondary treatment or primary treatment and outfall discharge, depending on the receiving water requirements. Only after local costs (of power, land, labor and capital) have been identified, the questions in the decision tree can be answered.

Fig 2-1: A developed decision tree for the selection of wastewater treatment technology in rural areas (UNEP, 1997)



2.5 Progressive view of decentralized systems

Decentralized systems include small, medium and large flow systems using basic and advanced on-site technologies. Medium flow, on-site systems (designated here as systems with design flows between 0.5 m^3/d and 2.0 m^3/d), and large flow on-site systems (> 15m^3/d design flow) include those serving individual commercial facilities and cluster systems serving multiple homes in a community. Monitoring of the cumulative impacts of on-site systems on the ecological resources in a watershed area, as well as monitoring the performance of each individual or cluster system in the community, closes the loop for on-site systems (Figure 2-2). Once monitoring is in place these on-site systems can be repaired or upgraded as needed to protect public water supplies as well as ecological resources such as ground water resources and surface water resources including nutrient sensitive waters and shellfish harvesting waters.

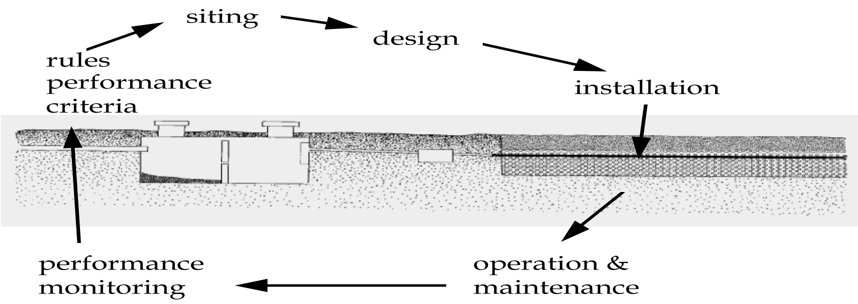


Fig 2-2: Siting and design of on-site systems with long term monitoring.

In a progressive regulatory structure, closely monitored and maintained advanced on-site systems are allowed on otherwise unsuitable soils to remediate existing failing conventional septic systems and ineffective cesspools. These advanced systems must meet specific treatment performance standards so as to:

- Protect personal family health at the site,
- Protect the public health in the surrounding community,
- Protect and preserve the environment including important ecological resources, and
- Be affordable to communities.

System performance is measured and assessed relative to the applicable treatment performance criteria. Resource impact monitoring identifies early on any potential for environmental degradation (such as eutrophication) before it happens. This facilitates upgrading the treatment performance requirements for technologies used within that subwatershed area if necessary to protect the public water supply or resources.

I. Individual (on-site) treatment systems

These service individual sections or lots (Fig 2-3), where all waste produced on-site are treated on-site. Generally the treated waste re-enters the ecosystem on site. This means the ability of the soils to absorb the treated waste will determine whether this kind of system can be used.

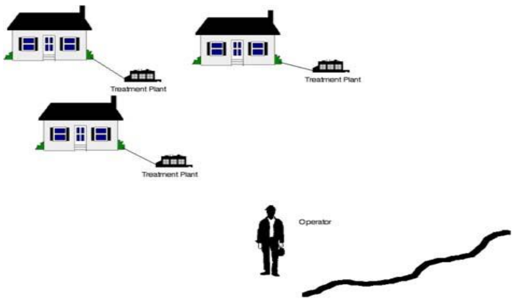


Fig 2-3: Onsite wastewater management - builds small treatment systems for each home (Graf, 1990)

The nature of your local groundwater systems, including the level of the water table in different seasons, will be important. Sometimes underground water (aquifers) can be affected by wastewater trickling though the soils and polluting the water. This water may find its way into a local stream, or bores may bring it to the surface for household use.

Some soils will not be suitable. Others may require a larger area for absorption. In many ways the absorption ability of these soils will have been a major factor in originally deciding the density of your Deciding whether or not to stick with on-site systems will be a 'crunch' soils to absorb wastes at all, or to absorb increased amounts, will be a deciding factor for the system you choose.

On-site systems use biological processes that need to be carefully managed and protected. People can find this tiresome, and some visitors to beach communities may know little about how to deal with them. There are ways the community can come together to manage the separate on-site systems. In other words, individual systems do not have to mean private management. The modern approach to managing on-site systems involving system monitoring and operation and maintenance inspections can ensure the long life of the system while protecting the investment in the system hardware. The cost of this managed approach can, when spread out on an annual basis, equate to the sort of charge that councils levy as sewerage charges in urban residential areas.

Treatment systems can also be designed to deal with different kinds of wastewater. For example, on-site systems can deal with a combination of graywater and blackwater, just graywater, or just blackwater.

II. Cluster treatment

The focus here is on relatively small treatment plants designed to service a group of houses or businesses (Fig 2-4). More than one plant may be needed to service the whole community. They provide considerable flexibility. For example, your community may decide that it wants to continue with on-site treatment and the densities of settlement that this brings. At the same time, it may be prepared to allow a one-off development of a certain size that cannot be serviced by on-site systems. Provided the development has its own cluster system, it can proceed.

On the other hand, it may be that your community is on a centralized system. To allow more growth would require a bigger system – not just the treatment plant but the pipes as well. This can be expensive. More development might be possible if a small cluster system is used. It is therefore a useful tool for allowing some growth and change to occur without shifting to a centralized system that might bring pressure for even more growth. Often a cluster treatment system utilizes land disposal. The number of dwellings serviced by the cluster system needed will determine the area of land. At the same time, a cluster system can allow a more managed land-based ecosystem re-entry because the volumes of waste treated will be relatively small.

Cluster treatment can also be linked to a centralized system. For example, some technologies allow the wastewater, by hooking up to wastewater mains pipes and removing some of the wastewater for processing. This mining can provide reclaimed water for re-use and contribute to reducing the amount of wastewater going to a centralized plant.

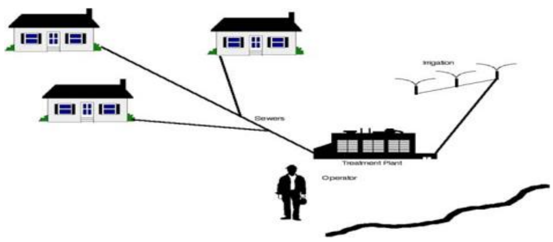


Fig 2-4: Collect wastewater and treat before reuse through irrigation (Graf, 1990)

2.6 Scenarios for sound practices

General scenarios can be sketched based on population density to illustrate integration of technology, environmental, economic and social factors. For a low population density and where land is available around dwellings, on-site systems with on-site reuse provide householders with options, which are a function of water availability, toilet type and desired reuse of blackwater and graywater. Use of a double vault composting toilet and graywater for subsurface irrigation is shown in Figure 2-5. Maintenance requirement will be emptying the vault (say, every 6 months), windrow composting the content with garden waste and diverting blackwater from a full vault to the one just emptied. Irrigation system for graywater needs to be checked weekly.

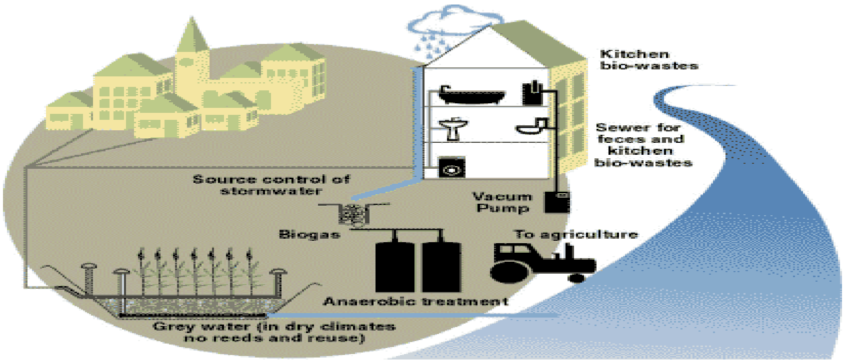


Fig 2-5: Composting toilet for blackwater and sub-surface irrigation of graywater (Otterpohl and Lange, 1997)

A system requiring less householder maintenance is a septic tank with an inverted leach drain or evapotranspiration trench. The septic tank needs to be de-sludged every 3 to 5 years. This is done by calling a sludge contractor. This service should be available in the community for this option to operate satisfactorily including the safe disposal of the sledge by the contractor.

For a high population density, community ablutions blocks with payment for use can work well. The wastewater can be conveyed to a location where land is available for land-based treatment and reuse through grazing grasses irrigated by treated wastewater. The operator of the ablutions facilities needs to ensure public health requirements for the wastewater reuse are met.

Toilet facilities in individual dwellings are an option with wastewater collected using simplified sewerage. This can be condominial sewers or with street connections depending on community choice. Collected wastewater is treated using a series of lagoons, with the final lagoon employed for aquaculture. Depending on land use downstream of the lagoons, wastewater can be reused further for agriculture, horticulture or tree plantation.

The requirement of planning a sewerage system within a catchment basin (to use gravity flow), the environmental requirement for reuse of wastewater nutrients (to prevent pollution), the economic requirement of balancing economy of scale of treatment and the cost of the sewer pipes, and the social requirement for community consultation point to planning for a community-scale collection, treatment and reuse of wastewater. The optimum size of the population served for a community-scale systems will depend on local conditions, which in turn are determined by local geographical (topography, climate, soil), environmental, economic and social/institutional considerations.

A useful tool that can help towards achieving integrated waste management is the waste management hierarchy. It has been used to direct waste management towards achieving environmentally sound practice. The waste management hierarchy in its most general form is shown in Table 2-2. In using this tool for waste management we systematically go down the list to see if step 1 (Prevent or reduce waste generation) can be implemented, before considering the next step (2) and so on. Only when steps (1) to (5) have been fully considered that we consider disposal of the waste (step 6).

Table 2-2: The waste management hierarchy
1. Prevent or reduce waste generation
2. Reduce the toxicity or negative impact of the waste
3. Recycle waste in its current form
4. Reuse waste after further processing
5. Treat waste before disposal
6. Dispose in an environmentally sound manner

We cannot prevent the production of human excreta or stormwater, but we can prevent other materials from being disposed with human excreta, or solid waste with stormwater. We can use less water to achieve the same purpose (e.g. flushing toilet) and hence produce less wastewater. We can avoid toxicity of wastewater by preventing toxic household or industrial wastes to be disposed with biodegradable organic wastes. A reuse example is the use of urine as a liquid fertilizer, while composting can convert human excreta into a soil conditioner. It should be recognized that all waste management practices have costs as well as benefits. The application of the waste management hierarchy therefore needs to consider economics as well as other factors (e.g. some culture may not allow reuse of human wastes).

Environmentally sound practices in wastewater and stormwater management are practices that ensure that public health and environmental quality are protected. A range of technologies exist that can achieve this objective. A summary is shown in Table 2-3. Even though this table does not cover all available technologies, they represent major technologies for situations that are likely to be encountered. The Regional Overviews include technologies that are modifications or variations of the listed technologies or represent practices or advances in the regions.

Table 2-3: Technologies for wastewater management (with relative costs, environmental impact and maintenance requirement)

Technology	Capital cost	O&M cost	Environmental impact
On-site technology			
Pit latrine	Low	Low	Pollution of groundwater
Composting toilet	Low	Low	Reuse of nutrients
Pour flush toilet	Low	Low	Pollution of groundwater
Improved on site treatment unit	Medium to high	Low to medium	Reuse of water and nutrients
Collection technology			
Conventional sewerage	High	High	Dependent on treatment
Simplified sewerage	Medium to high	Medium	Dependent on treatment
Settled sewerage	Medium	Low	Dependent on treatment
Treatment technology			
Activated sludge	High	High	Nutrients may need removal
Trickling filtration	Medium	Medium	Nutrients may need removal
Lagoons	Low to medium (dependent on cost of land)	Low	Nutrients may need removal; aquaculture can be incorporated
Land-based treatment	Low to medium (dependent on cost of land)	Low to medium	Reuse of water and nutrients
Constructed wetland	Low to medium (dependent on cost of land)	Low	Amenity value
Anaerobic treatment	Medium	Medium	Produces biogas; further aerobic treatment needed

**Cost increases from source control to regional control technology.*

Common to all sound technologies is that there is a scientific basis for the physical, chemical and biological processes for the removal of pathogens and pollutants from the water. These processes are largely akin to the purification and recycling processes taking place in nature. Properly designed, constructed, maintained and operated these technologies can achieve protection of public health and the environment, and can recycle water and nutrients, which are beneficial to sustaining ecosystems and life.

Associated with each technology hardware is a philosophical basis or approach, e.g. separation of waste components (dry conservancy), or conveying all wastes away with water (water based conveyance) minimizing capital cost, minimizing maintenance requirement; or maximizing reuse maintenance and operational requirements, which are the software associated with the technological hardware, and therefore level of skills required to operate the hardware and software, and consequently training requirements for personnel.

CHAPTER 3

RURAL WASTEWATER MANAGEMENT IN PALESTINE

3.1 Review of rural wastewater management

Palestine suffers from both water scarcity and water pollution; water supply is dependent upon annual precipitation, which replenishes the aquifers, natural springs and streams in Palestinian territories. Ground water and rainwater collected in cisterns is exposed to severe pollution especially from untreated wastewater. This problem can be more evident in rural areas where there are no sewer systems available.

The most common method for wastewater disposal in rural and semi-urban areas (represent 70% of population) is cesspits. This method of wastewater disposal has many adverse effects on public health and environment in addition to high consumption of water for flushing away human excreta from flushing toilets to the cesspits.

3.1.1 Rural wastewater management approaches

Al Sa'ed (2000) reported that many non-governmental organizations (NGOs) exist in Palestine, to provide technical and financial services to small Palestinian communities as they struggle with their drinking water and wastewater problems. These NGOs are qualified to assist small rural areas in identifying the most cost-effective solutions to their problems. One of such organizations is the Palestinian Hydrology Group (PHG), which traditionally work with many donor agencies to provide valuable technical and financial assistance to small rural communities suffering from various environmental and public health problems.

3.1.2 Onsite sewage treatment systems in rural Palestine

The sanitation system that is proposed for implementation in the village of Artas, Palestine is based on the collection of sewage by small-bore gravity sewer system and biological treatment in parallel upflow anaerobic sludge blanket (UASB) rector. During the first phase, the system will serve about 9300 population equivalents (PE) by the year 2005. The effluent of the anaerobic stage is post-treated in agricultural facultative ponds. The effluent is reused for agricultural irrigation. Septage from interceptor tanks near the houses and excess sludge from the anaerobic tanks is treated in a vertical flow wetland system. The system is designed to treat sewage of Artas village, the Salmons Pools Report, and the village of Al-Khader.

The use of small diameter gravity sewers (SDGS) is one of the introductions, for although the SDS has been suggested for the village of Taffouh in Hebron district. Artas will be the first location in the Middle East to have such a system implemented. This option requires the use interceptor tanks near the houses. The probability of having low sewage flow at least occasionally, due to low water consumption, further justifies the choice for this system. The interceptor tanks bring about certain degree of pre-treatment which is favorable to the process in the anaerobic tank. Small diameter gravity system is developed for flat areas, and so it will be the first time that SDGS system will be constructed in a mountainous environment with very steep slopes. Therefore, the project will contribute to develop and test new standards that can be used else where in similar situations. In particular, the characteristics of collected wastewater from Artas will be useful to design other decentralized rural sanitation projects.

Another first step is the use of the upflow anaerobic sludge blanket (UASB) reactor, which will be the first sort in Palestine. A similar pilot treatment plant has been built in Jordan and involved scientists are anxious to exchange performance results and other practical information to enhance the understanding and functioning of this cost effective primary treatment technique for further use in the Middle East. The UASB reactor has been designed a pre-treatment stage and to reduce the strong biological loaded wastewater to a level were it could be further treated in facultative ponds. Another aspect of this project, the constructed vertical wetlands, will also be new to this region. This project is considered as an urban sanitation one, and only the sewerage systems ha been implemented by now. The main treatment system is being modified and still not yet erected. Therefore, no practical experience can be reported.

Both PHG and PARC implemented onsite wastewater treatment systems of different types and sizes in the range between 5- and 1000 inhabitants over the last 3 years. The systems are listed in Table 3-1 and illustrated in Fig 3-1.

Table 3-1: Onsite treatment systems erected by NGOs in rural Palestine

Site	Treatment System	Units	Treatment Objective	Size
Aba	ST + Trickling Filter + Sand Filter	38	Reuse/Treated Gray WW	500 PE
Aba School	ST + TF + Sand Filter	1	Reuse/Treated Gray WW	20 PE
Beit Doggo	Anaerobic Pond + TF + Sand Filter + PP	1	Reuse/Treated Gray WW	200 PE
Jericho	ST + UF Gravel Filter + Sand Filter	1	Reuse/Treated Gray WW	30 PE
Talita Komi	Waste Stabilization Ponds + Sand Filters	1	Reuse/Treated mixed WW	1000 PE
Turmus Ayya School	ST + multilayer Trickling Filter + PP	1	Reuse/Treated mixed WW	50 PE
Al-Samu` School	ST + multilayer TF + Sand Filter + PP	1	Reuse/Treated mixed WW	50 PE
ST = two compartments septic tank; TF = trickling filter; PP = polishing pond; UF = upflow				

Initial results of onsite sewage treatment plants were found to be of the same magnitude as those for large conventional secondary treatment systems. Reported elimination rates were for COD 90 – 95 %; BOD 90 – 95 %; TKN 20 – 79%; and for TSS 90 – 99%. The technical reliability has to be shown mainly affected by the electromechanical parts used in the systems, provided proper operation and maintenance is carried out. Most failure, so far, concerns pumps, where blockage through fouling may cause breakdown of the system.

The technology applied in all these treatment systems revealed a stable one, no possibility of turbid effluent due to suspended solids, no odor complains, and low temperature impact on process stability has been recorded. By waste stabilization ponds, complains and fears were raised concerning odor emission and mosquitoes; transfer of the Blue Nile Fever. However, these problems were solved by covering all ponds and spray of insecticides in the neighborhood of the ponds (Theodory, 2000). However, the environmental impact from all systems is small to negligible.

Beside process efficiency and reliability, sludge disposal and land requirement and environmental impact, capital and operational expenditure, sustainability and process simplicity are considered as critical items in selecting a treatment option for rural areas in Palestine. Investment costs and costs for operation and maintenance were estimated for different sizes of the systems based on current experience in Palestine.

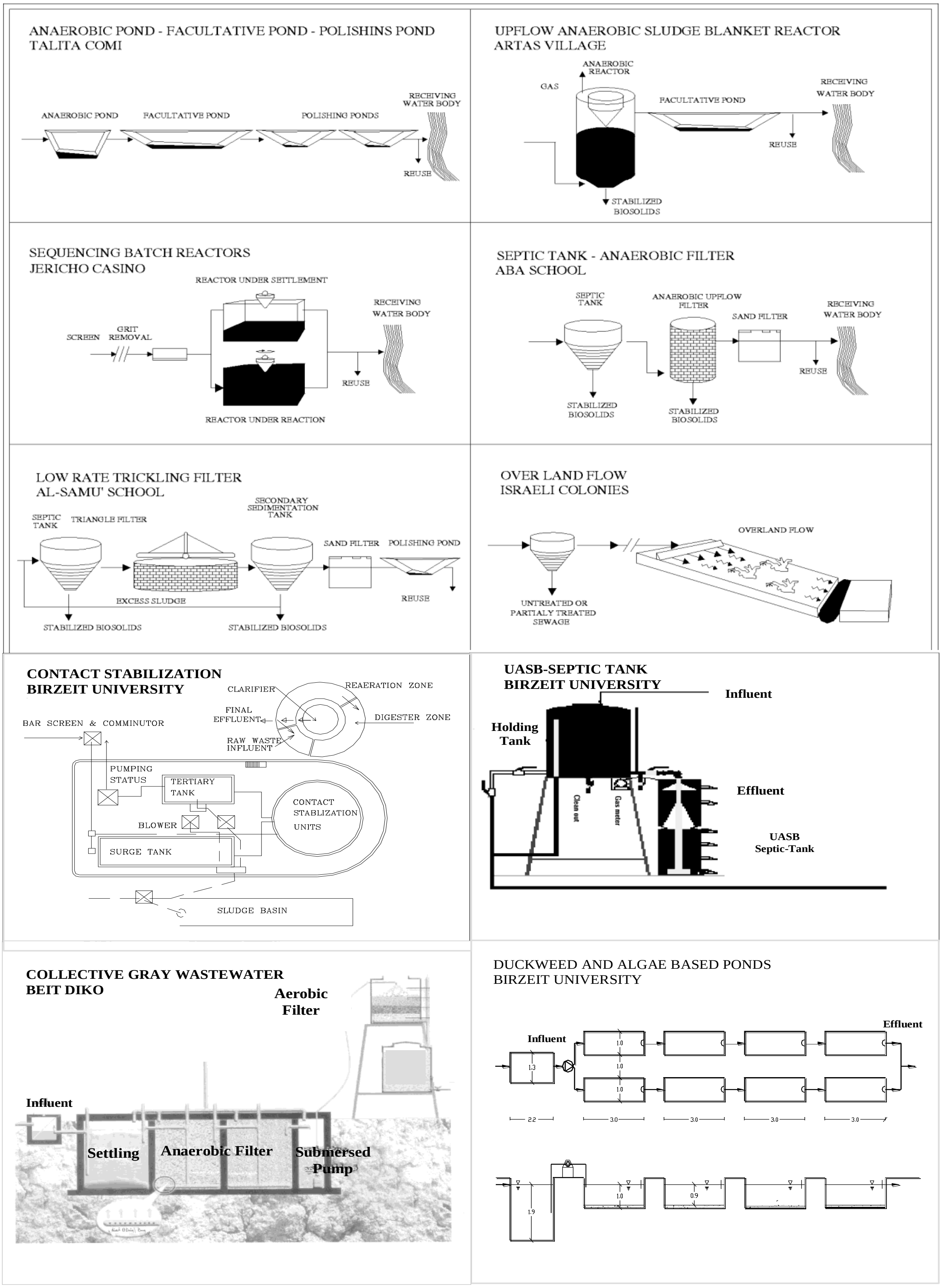


Fig 3-1: Flow sheet diagrams of onsite sewage treatment systems in rural Palestine

3.2 Treatment strategies for unsewered areas in Ramallah/Al-Bireh district

The current emergency conditions wastewater in the Palestinian rural is mostly disposed of in the house hold garden, open areas or streets for the following reasons:

(a) Necessity for emptying the overflowing cesspits,

(b) Irrigating the house garden plants since the cutoff of water supply became usual,

(c) Household food production became necessary since it became difficult to exchange or buy products between and from Palestinian districts under the current conditions.

The current practices have a serious risk on public health, soil clogging which reduces the productivity of land, and drinking water sources.

On site household gray wastewater treatment and reuse or disposal has become a pressing issue of concern for rural areas throughout Palestine. On-site treatment systems are the low cost, fast and effective possible solution for the problems of water supply shortage, and generally used overflowing cesspit.

On-site household gray wastewater treatment (Fig 3-2), reuse in irrigation or safe disposal have emerged as a potentially viable means by which individual rural households and local authorities can treat wastewater and reuse for food production beside decreasing the risk on public health and reducing the amount of produced wastewater.

The PARC concept gives costs analysis of building and operating on-site household individual gray wastewater treatment plant of different sizes. Two sizes of on-site individual household gray wastewater treatment plants are considered:

1. Small to medium families (7 to 15 persons).
2. Medium to large families (16 to 30 persons).

The characteristics of wastewater, wastewater production per person per day, weather conditions will be assumed the same for rural areas all over West Bank.

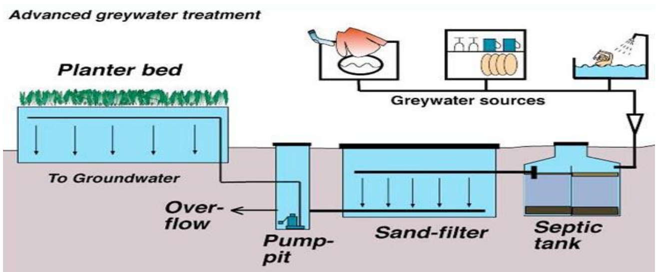


Fig 3-2: Sketch of the pilot plant used to treat graywater

I. Blackwater and gray wastewater analysis

Household wastewater derives from a number of sources (Fig 3-3). Wastewater from the toilet is termed 'blackwater'. It has a high content of solids and contributes a significant amount of nutrients (nitrogen, N and phosphorus, P). Blackwater can be further separated into faecal materials and urine. Each person on average excretes about 4 kg N and 0.4 kg P in urine, and 0.55 kg N and 0.18 kg P in faeces per year.

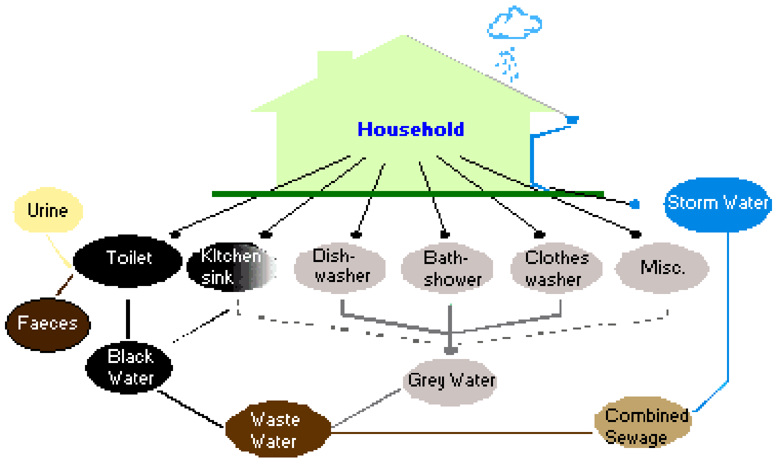


Fig 3-3: Sources of household wastewater, showing wastewater from toilet, kitchen, bathroom, laundry and others

Graywater consists of water from washing of clothes, from bathing/showering and from the kitchen. The latter may have a high content of solids and grease, and depending on its intended reuse/treatment or disposal can be combined with toilet wastes and form the blackwater. Both graywater and blackwater may contain human pathogens, though concentrations are generally higher in blackwater.

The volume of wastewater and concentration of pollutants produced depend on the method of anal cleaning, volume of water used and water conservation measures. Dry anal cleaning results in higher solids and fiber content. The use of dry pit latrines and the practice of water conservation produce low volume and high concentration wastewater, while use of flushing toilets results in higher wastewater volumes and lower concentrations.

The water consumption pattern and wastewater characteristics are determined by the composition of the household contributing wastewater to the pilot plants. The composition of the household is presented in Table 3-2.

Table 3-2: Household contributing of gray wastewater to the pilot plant (Mustafa, 1996)

Bathroom (shower)	One shower, 3.5 times per person per week, every shower is 30 L
Washing machine	Half automatic, 60 L per cycle, 2 to 3 cycles every time, 2 washes per week
Kitchen	Dish washer Not available, manual cleaning (15-20) liter per person per day
Sinks	Hands and face washing, ablution, shaving, tooth cleaning, 2 liters per person per day

Graywater is washwater. That is, all wastewater excepting toilet wastes and food wastes derived from garbage grinders. There are significant distinctions between graywater and toilet wastewater (called "blackwater"). These distinctions tell us how these wastewaters should be treated /managed and why, in the interests of public health and environmental protection, they should not be mixed together.

Mustafa (1997) has found that gray wastewater contains 36 % of BOD and 55 % of phosphorus, 17 % of nitrogen loads of the total pollution load of wastewater and based on this data he made a design for an onsite treatment system for the rural areas. This data match up to the data in literature that the literature shows that graywater contains about 10 % of TN and 50 – 70 % of TP of the household wastewater (NC Division of Environmental Health, 1995). The analysis also showed that graywater amounts to 60 – 65 % of the domestic wastewater generated.

II. General overview of septic tank system

The most common wastewater treatment system used in rural areas is the septic-tank soil absorption system. The septic tank removes settleable and floatable solids from the wastewater, and the soil absorption field filters and treats the clarified septic tank effluent. Removing solids from the wastewater in the septic tank protects the soil absorption system from clogging and premature failure. In addition to removing solids, the septic tank also permits digestion of a portion of the solids and stores the undigested portion.

The system is designed to provide treatment and disposal for normal domestic sewage. No non-biodegradable material should be introduced into the wastewater treatment and disposal system. Plastic and paper (except toilet paper) are examples of non-biodegradable materials that should not be placed down the drain. Normal amounts of dirt and small non-biodegradable debris (buttons, dental floss, etc.) from washing will inevitably get into the system. These solids will be retained in the septic tank until it is pumped during its normal maintenance. Oils and grease should not be placed down the drain in excess quantities. Normal washing of greasy dishes is not considered excessive. Routinely draining fat from a frying pan, deep fryer, or roasting pan down the drain would be considered excessive. A garbage disposal may be used on the system but its use should be restricted. A garbage disposal should not be used for the bulk disposal of food preparation waste.

Because septic tanks are buried and are out of sight, many homeowners forget that septic systems require periodic maintenance. Failure to pump-out the septic tank is possibly the greatest single cause of septic system failure. After several years of use, a build-up of bottom sludge and floating scum will reduce the effective capacity of the system (Fig 3-4). As mentioned earlier this means the wastewater passes through the tank too fast, and solids may eventually plug the pipes in the leach field.

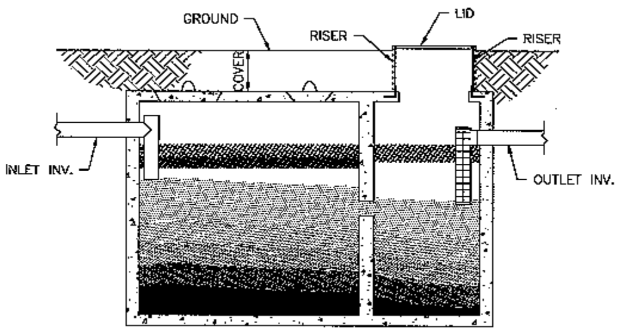


Fig 3-4: Poorly Maintained Septic Tank

To avoid leach field failures inspect the tank at regular intervals and pump when necessary. Due to many variables it is recommended that the tank be inspected every year and base pump-outs on these annual inspections. As the years pass, you should be able to see a pattern of sludge and scum accumulation. Always keep records of inspections and dates when the tank has been pumped.

Performance of septic tanks is a function of proper sizing, design, and installation, as well as use, which is in keeping with the design assumptions. For typical residential wastewater, primary treatment by septic tanks can provide for approximately 40 to 60% removal of both BOD5 and TSS if the tank is sized for a detention time of about 3 to 4 days. Some organic nitrogen removal occurs through the solids removal process.

Table 3-3 from the EPA Design Manual for Onsite Wastewater Treatment and Disposal Systems is provided on the following page, which shows typical concentrations of key parameters for effluent from residential septic tanks. A thorough site evaluation must be conducted in order to determine the appropriate level of pretreatment prior to final onsite subsurface disposal. Septic tanks can only provide for primary levels of treatment. Thus, some type of further treatment will need to be provided for if the soil and subsurface conditions at the site are such than ground or applying typical septic tank effluent may adversely impact surface water.

Table 3-3: Typical concentrations of key parameters for effluent from residential septic tanks (EPA, 1980).

Parameter	*Ref. (2) 7 sites*	*Ref. (3) 10 Tanks*	*Ref. (4) 19 Sites*	*Ref. (5) 4 Sites*	*Ref. (6) 1 Tank*
BOD5					
Mean, (mg/L)	138	138	140	240	120
No. of Samples	150	44	51	21	50
COD					
Mean, (mg/L)	327	--	--	--	200
No. of Samples	152	--	--	--	50
Suspended Solids					
Mean, (mg/L)	49	155	101	95	39
No. of Samples	148	55	51	18	47
Total Nitrogen					
Mean, (mg/L)	45	--	36	--	--
No. of Samples	99	--	51	--	--

Reference 2: Small Scale Management Project, University of Wisconsin, Madison, Management of Small Waste Flows. Municipal Environmental Research Laboratory, Cincinnati, Ohio, September 1978. 804 pp.
Reference 3: Weiber, S.R., C. P. Straub, and JR. Thoman. Studies on Household Sewage Disposal Systems. Part I. Environmental Health Center, Cincinnati, Ohio, 1949. 279 pp.
Reference 4: Salvato, J.A. Experience with Subsurface Sand Filters. Sewage and Industrial Wastes, 27(8) :909, 1955.
Reference 5: Bernhart, A.P. Wastewater from Homes. University of Toronto, Toronto, Canada, 1967.
Reference 6: Laak, R. Wastewater Disposal Systems in Unsewered Areas. Final Report to Connecticut Research Commission, Civil Engineering Department, University of Connecticut, Storrs, 1973.

III. West Bank villages installations and local acceptance

Septic tanks are the most frequently used pre-treatment unit for the final onsite treatment and disposal of residential wastewater. Septic tanks with drainage fields can be widely used throughout the West Bank.

IV. Why septic systems fail

Most septic systems will fail sometime. These systems are designed to have a lifetime of 20 to 30 years, under the best conditions. Eventually, the soil around the absorption field becomes clogged with organic material, making the system nun sable. Many other factors can cause the system to fail well before the end of its natural lifetime. Pipes blocked by roots, soils saturated by storm water, crushed tile, improper location, poor original design or poor installation can all lead to major problems.

V. Health and economic effects of a failing system

The most serious effect of a failing system is the potential for serious disease from the leaking and in improperly treated waste. These wastes can spread dysentery and hepatitis. In addition to the diseases themselves, mosquitoes and flies that spread some illnesses can breed in areas where liquid waste reaches the surlace.

Chemical or nutrient poisoning can also be a problem. Many of the synthetic products you use around the house, such as strong cleaning products, can be poisonous to humans, pets and wildlife if they travel through soil to your well or on the surface to lakes, streams or ponds. Excess nitrate levels in drinking water can pose serious health threats to iiifants.

The health of plants around your home can be seriously affected, too. The waste from failing systems can kill main species or cause increased growth of undesirable plants.

The economic costs of failure are no less important. The most obvious effect is the direct expense of replacing your septic system. This could cost $2,000 to $4,000. Also consider the indirect cost of losing the use of your house while the system isn't working and the long-term inconvenience of a system that doesn't operate properly.

The key to preventing your septic system from failing is proper maintenance. Regularly pumping the tank, being careful in what you put down the drains, and avoiding such things as planting trees over the field or covering the system with permanent patios and home additions are important to keep the system running well.

Proper initial design is another critical aspect in preventing your system from failing. Many septic systems are doomed from the start because they are put in poor locations or constructed improperly. Be sure a new system is installed in an area with proper soil conditions and at sufficient distances from your house and well (these factors are regulated by local health department codes). Also make sure the system is designed to meet your present and future needs. If, for example, you are building a small home with plans to enlarge it as your family grows, design the septic system to accommodate the largest size you expect your family to grow to. Consider asking your contractor to include such useful features as junction boxes and observation ports, which aid in assessing the condition of the system.

Water conservation was mentioned earlier as a method to keep a marginal system operating, but it is also an excellent method of preventing future problems from occurring.

A properly designed, installed, and maintained septic tank and drain field system should treat wastewater in a way that minimizes the impact on groundwater, surface water, and human health. Proper maintenance includes having the tank pumped regularly, conserving water and spreading out water usage, managing solids in wastewater, keeping potentially hazardous materials out of wastewater, not using additives, and protecting the drain field.

VI. Septic Systems and Groundwater

A few rules of thumb tell us when septic systems are most likely to function properly and minimize groundwater contamination:
Good soil facilitates treatment and disposal of septic system wastewater. Soil profiles made of sand, silt and clay work best. If there is too much clay in the soil, the waste may percolate poorly. If the soil contains too much sand and large particles, wastewater may pass through to the groundwater without being treated by soil microbes (see Figure 3-5).

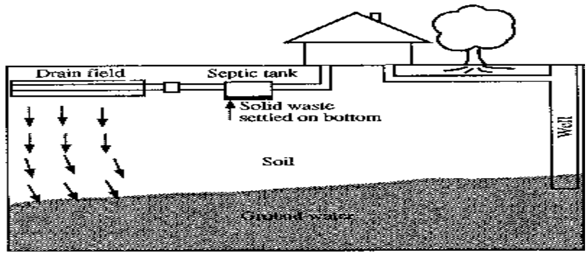


Fig 3-5: Septic systems can affect groundwater

Soil treatment occurs best when above the water table and the soil is relatively dry with oxygen present. Water at greater depths allows wastewater to remain in the unsaturated soil, where it can be treated most effectively before reaching groundwater.

Septic systems need space. Only part of the microorganisms and chemicals are removed from wastewater as it moves downward. Even properly operating systems can discharge some phosphates, nitrates and bacteria or viruses into the groundwater. To reduce loading of groundwater with effluent, install systems on lots with adequate space.

Proper design and use is important. Septic systems are designed to treat and dispose of a specific volume and type of wastewater in the conditions found at the site. The system must not be overloaded. Hazardous chemicals or large amounts of grease should not be disposed in septic systems. Kitchen grease should be placed in the garbage, not the septic tank. Water conservation extends the life of the system.

Routine maintenance is critical. Septic tanks must eventually be pumped. Sludge and scum accumulate and, if allowed to remain, will eventually cause the tank to overflow and clog the drainfield.

VII. Effluent - Bacteria and Nutrients

The liquid faction that leaves the septic tank and enters the drainfield is called the effluent. The bacterial level of the effluent is quite high, contrary to popular belief. The effluent also contains nitrates (among other nutrients), which move downward. To reduce potential for groundwater contamination by the effluent, many areas restrict building lot sizes. Larger lots reduce loading rates and help protect groundwater. Some areas with porous or sandy soils are located in groundwater recharge areas. These areas may be unsuited for septic tanks or require building lot sizes 50 to 100 percent larger than lots not in the recharge areas. Pathogens break down with soil contact and pathogen levels are reduced as the effluent percolates through the soil. Bacteria eventually die and are removed by the filtering effect of the soil, further purifying the effluent.

VIII. The Need for More Sophisticated Wastewater Management

Large regional sewage treatment plants are not economical for many rural areas. Also, some mechanical treatment plants may not meet increasingly stringent water quality limits for wastewater discharge into streams, rivers, lakes, and sounds. Therefore, rural development depends upon the proper use of septic systems.

The suitability of a building site for on-site sewage treatment and disposal depends upon soil and site conditions. Many sites that are suitable for conventional systems have already been developed, leaving less suitable sites for future use. Consequently, modified conventional and alternative septic systems may become more important for future land development.

These systems can function satisfactorily if they are used and maintained properly. Without maintenance, alternative systems failed twice as often as conventional systems. The lack of a maintenance program was a major cause of poor system performance for about 40 percent of the alternative systems studied.

Therefore, to protect the environment and public health, alternative systems such as low-pressure pipe (LPP) systems need more intensive maintenance than is currently required for conventional systems. Even a number of modified conventional systems require more maintenance than usually given to conventional systems. For instance, sediment that has accumulated in open drainage ditches must be removed periodically if artificial drainage systems are to perform as designed. Other more sophisticated on-site wastewater treatment and disposal options require even more maintenance. Sand filters, chlorinators, ultraviolet light and ozone disinfection units, home aerobic package treatment plants, and constructed wetlands could possibly be used on a regular basis in the future if adequate maintenance could be ensured. Likewise, large septic systems that serve condominiums, subdivisions, and small communities require greater oversight and maintenance than is normally given to the conventional septic system.

CHAPTER 4
SOCIAL AND ECONOMICAL ASPECTS OF ONSITE SANITATION IN RAMALLAH / AL-BIREH DISTRICT

4.1 Sustainability criteria for wastewater treatment systems

Sustainable development definitions vary according to which it is applied. Even in the evaluation of onsite wastewater treatment systems presented in this research, the relative weights for the sustainability criteria are affected by the values of the specific communities using the system (i.e., the social, economic, and environmental context). For example, environmental and climatic features, the neighborhood and other social factors, and the ability of the users to pay for the system and other economic factors affect the relative importance of each criterion.

4.2 Assessing the sustainability of small wastewater systems

The performance of a specific system depends on its construction, use, and maintenance. Whether or not this performance is sustainable from an environmental perspective depends on the sensitivity of the natural environment. Thus, it is important to realize that the outcome of an assessment of the same system for wastewater treatment might be different under different conditions, i.e., a solution leading to environmental improvements in one project may be a bad solution in another context.

Unfortunately, there are many examples of wastewater systems that do not relate to the local conditions; some of them are working despite their lack of suitability to the local environment, while other such systems fail. An example of the first can be the extension of central sewage systems into sparsely populated areas, using a lot of resources both for building and for running them, but nevertheless performing well with respect to treatment, hygienic conditions, etc. Examples of the latter are some of the so-called ecological plants that work well in a warmer climate, but without sufficient heat and sunlight they have no or very little effect, or they demand a lot of energy to work. Other examples of the latter are the projects where the users are not properly informed about the vulnerability of a plant to the contents of the wastewater. If the users flush out some chemicals they may disrupt processes within the system. In conclusion, sustainability must be assessed in a local context (Fig 4-1).

The choice of "the best solution" will have to be based on an integrated assessment of the local technical, environmental, as well as social aspects.

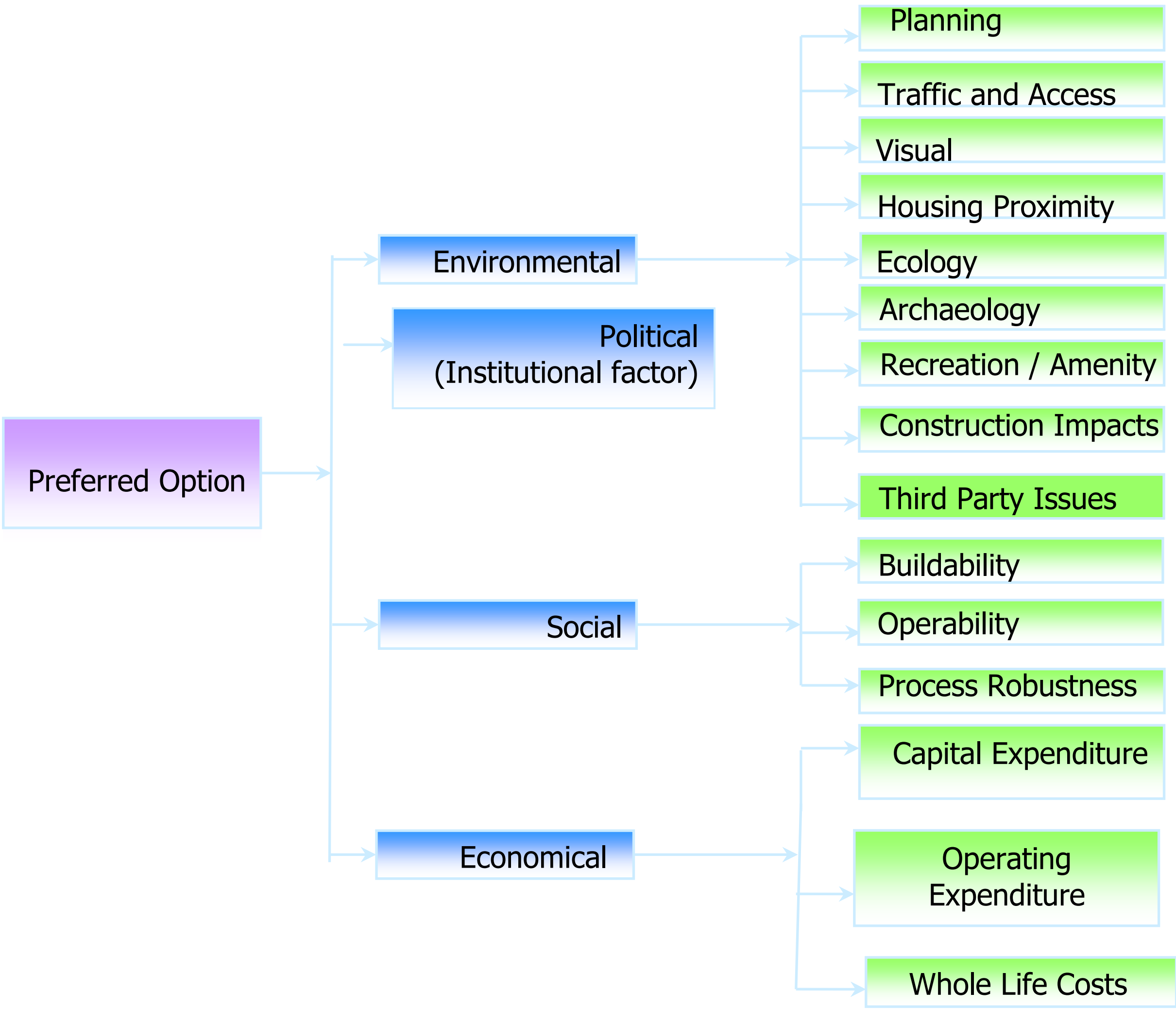


Fig 4-1: The flow sheet for a sustainability principle (Technical and Institutional factors)

4.3 Social impact and criteria selection

4.3.1 Background and approach

Sustainable development must be environmentally friendly, socially acceptable and financially viable. It is widely agreed that progress towards sustainable services requires the integration of these three elements into the decision making process. Multi-criteria analysis is different from multi-objective decision making, as the former has a single objective, which includes several criteria. There is a need to improve the quality of decisions. The adoption of transparent and stakeholder sensitive decision making processes will be crucial for future changes to water service provision. Decision makers insist they take sustainability into account but it is not so in reality, because it is difficult to consider all the aspects.

The research study aimed at examination of onsite sanitation systems from the perspective of the community with special emphasis on social and economical aspects, which might have an equal status of technical and financial assessment.

The main aspects of the research study were focusing on the following main aspects:

- Is the sanitation system socially and culturally acceptable to the community?
- Is the system affordable with respect to investment costs and ongoing annual capital and operation and maintenance costs?
- Which type of waste management is it preferable centralized or decentralized?
- Would you have benefits of wastewater separation between gray and black?
- Would you be willing to buy vegetables irrigated with treated effluent?
- Is it safe for you to have onsite sanitation?

CHAPTER 5
RESEARCH METHODOLOGY

5.1 Social feasibility and Public Participation

Village selection for this study was based on the following criteria:

- Number and distribution of sewerage system type,
- Utilization and enforcement of sound on-site wastewater system construction practices,
- Qualifications and turnover among county professional staff,
- Existence of electronically retrievable records regarding site evaluation and soil testing, system design, as-built construction, and repair/replacement construction,

Villages were selected randomly within Ramallah and Al-Bireh Districts on the basis of population (less than 5,000 persons) and existence of on site treatment system. People were selected randomly from these villages.

Site visits were arranged in November 2003 to some rural areas in Ramallah / AlBireh districts. Facilities were chosen in four countries: Billein, Rammun, Kober and Ni'llin. Billein was taken as on-site treatment systems installed there. This visits showed that household status as measured by income, education and occupation, affected water consumption. Households of higher status tended to use more water than households of lower status.

The research includes people of all ages, who are inhabitants of rural areas. The selection procedure of the random sample was made in two steps. At first, by means of systematic selection, an average of 50 households for each village were drawn. Then, in second step, a one person from households is chosen, with which I provided an interview.

The average population for each village is shown in Table 5-1, the families have around 10 person per household. Large family size may be related to general trends in poverty levels and fertility, and to proximity of the villages to each other.

Table 5-1: Village and people distribution

Villages Name	Average Population	Average Family Size
Billein	1631	14.8
Rammun	2983	9.2
Kober	3411	10.1
Ni'lin	4414	8.5

Fig 5-1: Age Distribution in rural areas

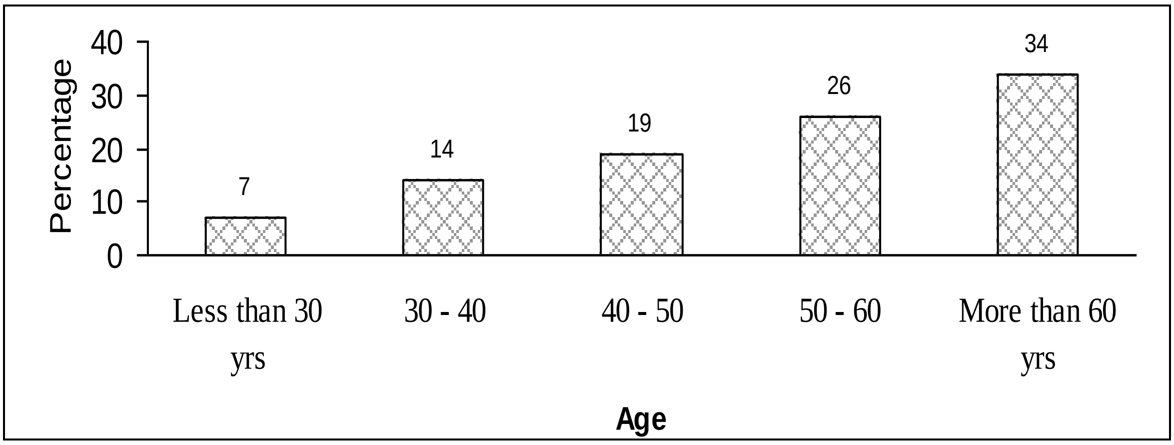
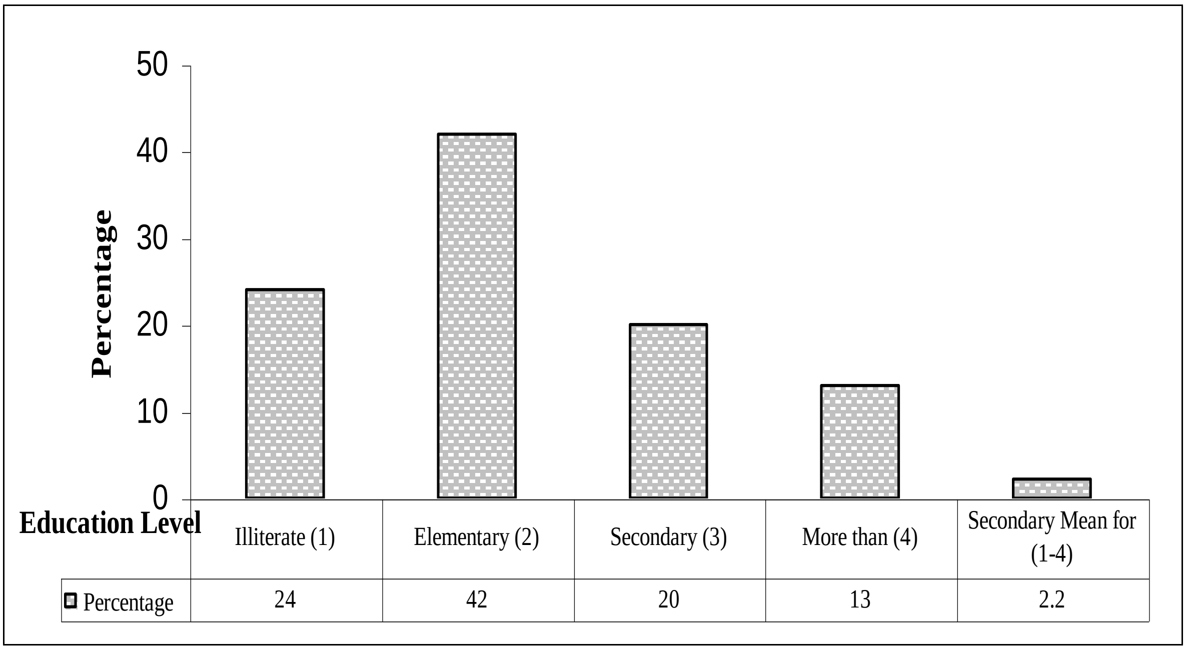


Fig. 5-2: Education Level Distribution



**The percentage of the population, which is illiterate, increases.

The data gathered was analyzed qualitatively and quantitatively (All the results are shown in Appendix D). From the analysis it is clear that the level of knowledge regarding hygiene is high in all the communities covered during the research. However, this knowledge is not practiced for a number of reasons:

- The major reason is the lack of financial means to ensure a more hygienic life style. The people in rural areas do not have the money to buy disinfectant and fridges, or to build toilets.
- The people in these communities do not have enough water to bathe daily or provide hand-washing facilities at the few toilets available.
- The respondents was that cultural taboo=s exist regarding the use of toilets by men and women, e.g. a daughter-in-law is not allowed to use the same toilet as her father-in-law.
- The lack of knowledge regarding the cause, transmission and prevention of waterborne and faeces-related diseases. The level of knowledge regarding the treatment of these diseases is high because the incidences of these diseases are high. The knowledge regarding the treatment of these diseases was obtained mostly from clinic and hospital personnel.

It can be concluded that the development and implementation of a workshop dealing with the general concept of hygiene, the cause, transmission and prevention of water-related and faeces-related diseases, and action planning to improve the hygiene in a community, would have a very positive impact.

Hygiene awareness and education are not about coercion, but bringing about change in the behavior patterns of people, to make them aware of the diseases related to unhygienic practices, poor water supply and improper sanitation. A definition of hygiene awareness and education that emphasizes activities aimed at changing attitudes and behaviors must recognize that behavioral changes cannot be effected from outside the communities. The individuals in the community must want to change and it is only they who can effect sustainable change. The role of the external agent can only be that of a catalyst and providing (or broadening) awareness. Secondly, the role of women cannot be overemphasized. Women are the latent force for change in communities; thus their empowerment and involvement is the prerequisite to the success of any community-based health or hygiene awareness and education programme or campaign or strategy.

Table 5-2 present peoples' responses to a set of ten statements people sometimes make about water. Consideration for the inclusion of these statements in the survey included teasing apart the distinctions among beliefs, attitudes and behavior and how these are affected by socio-economic factors. For example, results indicate that for all socioeconomic predictors, people believe water to be an inalienable human right but they also acknowledge that they use more water than they need (Table 5-2). The role of technology in enhancing supply, such as wastewater treatment and government, in rationing water use, were also considered in the selection of the statements. Both were considered unpopular (Table 5-2).

The statements also reflect a series of themes considered relevant to public receptivity towards the issue of water use and scarcity (Jeffrey, unpublished manuscript).

These are: individual water knowledge profile, the extent to which people are aware of a problem; perception of water quality and perceived health risks; recycling of water; economics, especially pricing and trust, whether in the government, community or infrastructure. In terms of scarcity, trust can be considered as the degree to which a problem exists.

Table 5-2**:** Ratings of agreement to statements intended to assess peoples' attitudes and perceptions toward water use in the rural areas

Statement	*Mean*	*Std. Deviation*
People should have the right to use as much water as they wish	2.60	1.22
Most families use more water than they need	1.20	0.88
The government should place restrictions on how much water a family can use	3.40	1.15
The water supply is sufficient to meet the needs of the community for many years to come	2.73	1.02
It is important that lawns be kept healthy, even if it means paying a lot for water	2.84	1.20
There will always be enough water in the Middle East to meet the needs of the people	3.53	1.15
Water quality is a serious problem	2.56	1.31
The amount you pay for water is relatively low	3.46	1.02
It would be difficult to reduce the amount of water used in your household	2.81	1.15
Treated sewage water that is proven to be safe for human consumption would be an acceptable source of drinking water for your family	3.57	1.22

Note: Responses based on a 5-point rating scale: 1=strongly agree; 5=strongly disagree; 3=neutral.

5.2 Economical aspects

Cost is an important consideration in the selection of technology. Decision makers need to know about the relative costs of technologies, so that a decision to select a particular technology can be based on sound financial and economic considerations. Cost alone should, however, not be the sole determining factor in the selection of technology. Environmental impact of the technologies, such as contamination of groundwater, should also be considered. Appropriateness of the technology in the context of the availability of skilled personnel to operate and maintain it, as well as other social and cultural factors need to be taken into account.

The costs of managing onsite wastewater treatment systems are mostly determined by the local soil conditions and the corresponding types of wastewater treatment technologies used. In areas with deep, permeable soils, septic tank-soil absorption systems can be used. In areas with shallow soils to a limiting condition, very slowly permeable soils, or very highly permeable soils (such as sand), more complicated onsite systems will be required. The cost of management is directly related to soil limitations and the complexity of the necessary treatment technology. Most of the costs come from the salary and benefits provided for the operator. All systems will require periodic septic tank pumping and for some systems worn out pumps and other parts must be repaired or replaced.

CHAPTER 6
RESEARCH RESULTS

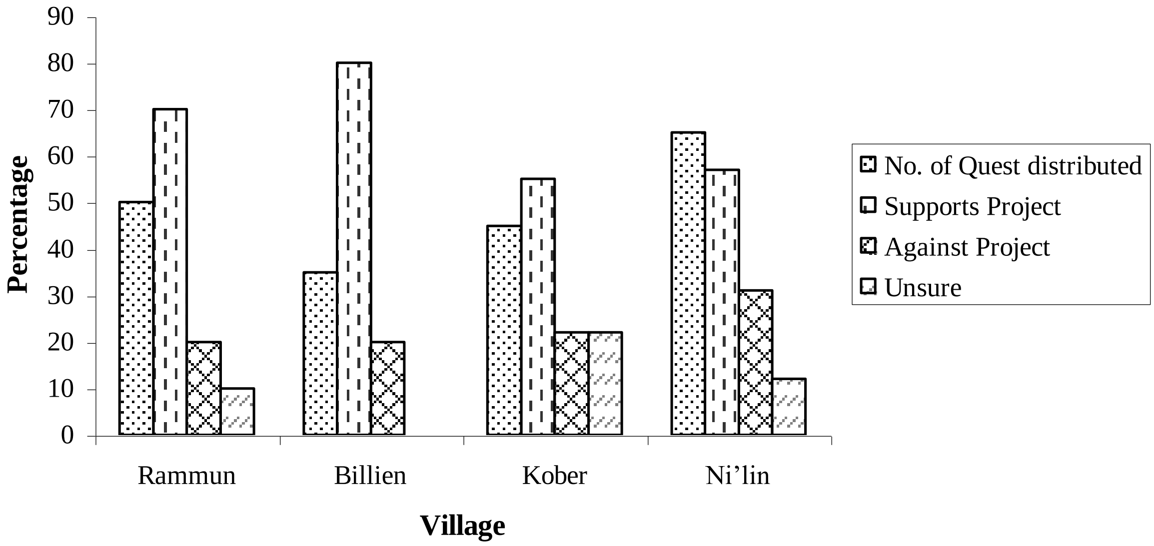
6.1 Questionnaire analysis

The basic information obtained from the questionnaire includes the following:

Table 6-1: Summary of public opinion towards wastewater reuse for agriculture:

Village	No. of questionnaires distributed	Supports project		Against project		Unsure	
		NO.	%	NO.	%	NO.	%
Rammun	50	35	70	10	20	5	10
Billien	35	28	80	7	20	-	0
Kober	45	25	55	10	22	10	22
Ni'lin	65	37	57	20	31	8	12

Fig 6-1: Public opinion towards wastewater reuse for agriculture



With regard to willingness to pay, the survey shows that willingness to pay only extends to what users see as a benefit or priority and that this is usually not sufficient to pay the full cost of the systems, including trunk sewers and treatment. Complementary financing will always be necessary to ensure the sustainability of the services. This may be done through a variety of taxes. However, tax collection in many developing countries is not efficient or effective and, moreover, a large part of the population does not pay taxes that can be used for sewage management (those living in low-income urban areas).

Table 6-2: Full set of data and results collected from questionnaire (See Appendix D)

No.	ITEM	MEAN	Std. Dev.
I.	***Open-ended questions***		
1.	Age	37.6	11.2
2.	Gender*	73% is Female	0.46
3.	Education **	62.5%	1.34
4.	Children (under 18 years old)	4.28 per family	2.60
5.	No. of rooms per household	3.90	0.92
6.	Income	1,800 NIS	337.1
7.	Empty Cost ****	35 NIS/one tank	15.0

** Gender: Male I, female O.*
*** Education: consists of 5 classes, from illiterate to university graduate.*
***** Cost of emptying the seepage pit.*

No.	ITEM	PERCENTAGE
II.	***AWARENESS (PEOPLE CONCERN ABOUT THE PROJECT)***	
1.	People agreed completely to use treated wastewater	25%
3.	People rejected completely to use treated wastewater	75%
4.	Accepting decentralized system	75% accepted
5.	Accepted on site sanitation with reservations	40% accepted
III.	***SOCIAL CRITERIA***	
1.	Interference with customs	75% interfere
2.	Contradiction with cultural tradition	65% contradict
3.	Participation in new on site sanitation	55% refused
4.	Separation black and domestic	63% agreed
5.	Wastewater irrigation	75% with wastewater irrigation
IV.	***ECONOMIC CRITERIA***	
1.	Readiness to pay for construction	82% not ready
2.	Pay for construction only	75% refused
3.	Sewerage network construction	85% agree
4.	Safe disposal to valleys	65% agree

6.2 Cost-effective technologies

Developing country cities are beginning to recognise that poor urban residents cannot afford, nor do they necessarily want or need, costly conventional sewerage. Beyond the dense urban centres, the average household cost of conventional sewerage may range from US$ 300-1,000. This is clearly too expensive for many households with annual incomes well below US$ 300. Fortunately, a broad range of cost-effective technological options are available to respond to the demands of urban consumers beyond the urban centre, with the potential to reduce costs to the order of US$ 100 per household. The UNDP/World Bank, Water and Sanitation Program has worked with many countries over the past decade to develop, demonstrate, document and replicate many of these low-cost sanitation options. The examples illustrate many of the options available to households (e.g. ventilated improved pit (VIP) latrines in Lesotho, Sulabh pour-flush latrines in India, condominial sewers in Brazil and simplified sewerage in Pakistan), as well as the supporting institutional and financial systems that make possible the wide-scale application of these options. In Palestine there is a need to these programs especially to the rural areas which lack of a sewerage system.

Information on capital cost and the cost for operation and maintenance for a wide range of technologies that can't be available in Palestine can be derived from experience in a limited number of countries. Extrapolation of the data to other locations is fraught with difficulty.

Relative costs may be sufficient to narrow the choice of technology, although it must be borne in mind that the relative values may change from location to location dependent of specific local conditions. Cost of land and of labor in particular can vary considerably. The information provided here should therefore be used only as a guide of relative costs. Actual costs for a particular location and community should be ascertained from suppliers of equipment, materials and labor.

A septic tank system and separation of wastewater can be studied relative to cost value and compared to choose the best alternative. For this purpose table 6-3 show different types of wastewater treatment systems that can be used in Palestine and cost analysis were done to these sytems in the following section.

Table 6-3: Basic and advanced on-site systems evaluated are:

SN	Code	Treatment System
1	A	Septic tank
2	B	Blackwater to Holding Tank and Graywater to Septic Tank
3	C	Blackwater to Composting Toilet and Graywater to Septic Tank
4	D	Blackwater to Incinerating Toilet and Graywater to Septic Tank
5	E	Aerated Tanks (Aerobic Units)
6	F	Septic Tank to Intermittent Sand Filter
7	G	Septic Tank to Recirculating Intermittent Sand Filter
8	H	Septic Tank to Subsurface Wetland System
9	I	Septic Tank to Anaerobic Filter to Intermittent Sand filter with Recirculation to Anaerobic Filter
10	J	Septic Tank to Trickling Filter with Recirculation to Septic Tank
11	K	Septic Tank to Rotating Biological Contactor with Recirculation to Septic Tank
12	L	Septic Tank to Anaerobic filter to Trickling Filter with Recirculation to Anaerobic Filter
13	M	Separated Gray and Blackwater Denitrification Systems
14	N	Textile Filter Pressure Dosed Dispersal System
15	O	Septic Tank to Sequencing Batch Reactor (SBR)
16	P	Septic Tank/Wetland/Trickling Filter
17	Q	Septic Tank/Wetland/Mound System

Table 6-4: Estimated cost of wastewater treatment systems in table 6-3:

SN	System	Capital Cost		O&M Cost		20-year NPW
1	Septic tank	($5\ m^3$) installed	$1000	Pumped once every 3-1/2 yrs	$2.08/month	**$1,249.27**
2	Blackwater to Holding Tank and Graywater to Septic Tank	Septic Tank (5 m3) installed	$1000	Septic Tank pumped once every 3-1/2 yrs	$2.08/month	
		Holding Tank, installed, ($5\ m^3$)	$2000	Holding Tank pumped approximately once every five weeks,	$78.21/month	**$9,350.34**
3	Blackwater to Composting Toilet and Graywater to Septic Tank	Septic Tank (5 m3) installed	$1000	Septic Tank pumped once every 3-1/2 yrs	$2.08/month	
		Composting Toilet Units (2, each with a daily design capacity of 2 persons),	$2500	Residuals removed from composting toilet units 3 times annually (@ $100 by licensed transporter), on the average,	$12.5/month	
				Estimated maintenance/repair/replacement costs for composting toilet units (assuming that a $300 repair is required for each of the units ever five years, and the units are replaced, @ $2,000 after 10 years),	$31.75/month	
				Composting toilet energy use (estimated at 1,825 KWH/year),	$12.17/month	**$11,988.95**
4	Blackwater to Incinerating Toilet and Graywater to Septic Tank	Septic Tank (5 m3) installed	$1000	Septic Tank pumped once every 3-1/2 yrs	$2.08/month	
		Incinerating Toilet Units, installed, (2, each with a daily design capacity of 2 persons),	$3500	Estimated maintenance/repair/replacement costs for incinerating toilet units (assuming that a $300 repair is required for each of the units every five years, and the two units are replaced , @ $3,000 after 10 years, and including paper liners),	$42.80/month	
				Incinerating toilet energy use (estimated at 5,650 KWH/year),	$37.67/month	**$14,619.08**

SN	System	Capital Cost		O&M Cost		20-year NPW
5	Aerated Tanks (Aerobic Units)	Estimated initial aerobic unit costs, installed, and including septic tank pretreatment unit,	$3000	Equipment repair/replacement costs, estimated at $50/year	$4.17/month	
				O&M, with a maintenance contract of $360/year (est. 12 hrs. @ $15/hour * 2.0, including taxes, overhead, and profit),	$30/month	
				Septage and sludge pumping once annually (it is assumed that the septic tank is pumped simultaneously, as needed, so as to eliminate separate costs for that),	$14.58/month	
				Energy costs (using 6 KWH/day energy use),	$14.60/month	**$10,324.49**
6	Septic Tank to Intermittent Sand Filter	Estimated initial intermittent sand filter unit costs, installed, and including septic tank for pretreatment, pump, pump tank, control and alarm,	$3250	Equipment (pump) repair/replacement costs, estimated at $60/year),	$5/month	**$6,725.22**
				O&M (assumes buried intermittent sand filter), with a maintenance contract of $240/year (est. two 180-day filter runs, with system checks and maintenance twice annually) 8 hrs. @ $15/hour * 2.0, including taxes, overhead, profit, and including pump/controls servicing,	$20/month	
				Septage and sludge pumping once every 2 to 5 years	$4.17/month	
				Energy costs (using 0.051 KWH/day energy use),	$0.124/month	
7	Septic Tank to Recirculating Intermittent Sand Filter	Estimated initial Intermittent sand filter unit costs, installed, and including septic tank for pretreatment, pump, pump tank, control and alarm, and valves,	$3,500	Equipment repair/replacement costs, estimated at $60/year (pump repair/replacement),	$5/month	**$7,002.22**

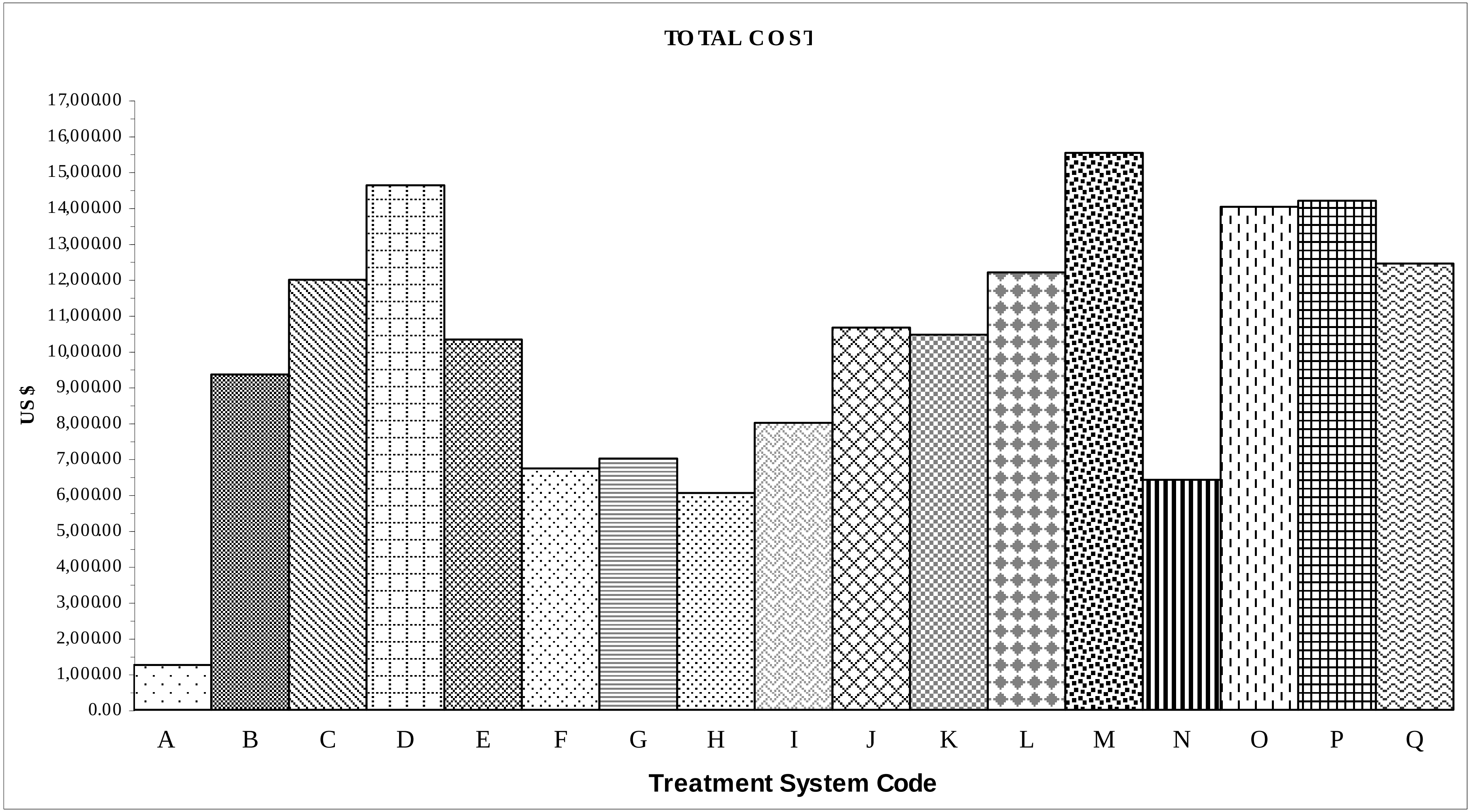
SN	System	Capital Cost		O&M Cost		20-year NPW
				O&M (does not include periodic sand removal/replacement and disposal if/as needed), with a maintenance contract of $240/year (est. two 180-day filter runs with system checks and maintenance performed twice annually) 8 hrs. @ $15/hour * 2.0, including taxes, overhead, profit, and including pump/controls servicing,	$20/month	
				Septage and sludge pumping once every 2 to 5 years,	$4.17/month.	
				Energy costs (using 0.051 KWH/day energy use),	$0.124/month	
8	Septic Tank to Subsurface Wetland System	Wetland unit, installed, and including septic tank for pretreatment,	$4,000	Septage and sludge pumping estimated at once every 3-1/2 years,	$2.08/month	
				O&M, with a maintenance contract of $180/year (est. 6 hrs. @ $15/hour * 2.0, including taxes, overhead, and profit),	$15/month	**$6,042.59**
	Septic Tank to Anaerobic Filter to Intermittent Sand filter with Recirculation to Anaerobic Filter	Estimated initial intermittent (recirc.) sand filter unit costs, installed, and including septic tank for pretreatment, pump, pump tank, control and alarm, and valves,	$3,500	Equipment repair/replacement costs, estimated at $60/year (pump repair/replacement),	$5/month	**$8,002.22**
		Upflow rock filter tank, installed,	$1,000	O&M (does not include periodic sand removal/replacement and disposal if/as needed), with a maintenance contract of $240/year (est. two 180-day filter runs, with system checks and maintenance performed twice annually) 24hrs. @ $15/hour * 2.0, including taxes, overhead, profit, and including pump/controls servicing,	$20/month	
				Septage and sludge pumping once every 2 to 5 years	$4.17/month	

SN	System	Capital Cost		O&M Cost		20-year NPW
				Energy costs (using 0.051 KWH/day energy use),	$0.124/month	
9	Septic Tank to Trickling Filter with Recirculation to Septic Tank	Estimated costs for trickling filter, installed, and including septic tank for pretreatment, pump, control and alarm, valves, and piping	$4250	Trickling filter/pump components repair and replacement costs, estimated at $80/year,	$6.67/month	
				Septic tank pumped once every year,	$14.58/month	
				Maintenance contract of $300/yr. (est. 10 hrs. @ $15/hr. * 2.0, including taxes, overhead, and profit),	$25/month	
				Energy costs (using 3 KWH/day),	$7.30/month	**$10,652.13**
10	Septic Tank to Rotating Biological Contactor with Recirculation to Septic Tank	RBC unit, installed, and including septic tank (1,000 gallons) for pretreatment,	$4250	RBC mechanical components repair and replacement costs, estimated at $60/year,	$5/month	
				Tank pumped once every year,	$14.58/month	
				Maintenance contract of $300/yr. (est. 10hrs. @ $15/hr. *2.0, including taxes, overhead, and profit),	$25/month	
				Energy costs (using 3 KWH/day energy use),	$7.30/month	**$10,452.48**
11	Septic Tank to Anaerobic filter to Trickling Filter with Recirculation to Anaerobic Filter	Estimated costs for trickling filter, installed, and including septic tank for pretreatment, pump, control and alarm, valves, and piping,	$4,500	Equipment repair/replacement costs, estimated at $80/year (estimated pump and controls repairs/replacement),	$6.67/month	
		Upflow rock filter tank, installed,	$1,000	O&M, with a maintenance contract of 10 hrs. @ $15/hour * 2.0, including taxes, overhead, profit, and including pump/controls and servicing,	$25/month	
				Septage and sludge pumping estimated once every year,	$14.58/month	
				Energy costs (using 4 KWH/day energy use),	$9.73/month	**$12,192.65**

SN	System	Capital Cost		O&M Cost		20-year NPW
12	Separated Gray and Blackwater Denitrification Systems	Blackwater septic tank (5 m3), and intermittent sand filter unit costs, installed, and including pump, pump tank, control and alarm, and valves,	$3,250	Equipment repair/replacement costs, estimated at $60/year (pump repair/replacement),	$5/month	
		Upflow rock filter unit, installed	$1,000	O&M, with a maintenance contract of $720/year (est. four 90-day filter runs, with sand removal/replacement twice annually, and raking performed twice annually) 24 hrs. @ $15/hour * 2.0, including taxes, overhead, profit, and including pump/controls servicing,	$60/month	
		Graywater septic tank, installed,	$1,000	Septage and sludge pumping once every 2 to 5 years, and sand/biosolids mixture transported and disposed of twice annually (@ $100 per haul, incl. landfilling fee)	$20.83/month	
				Energy costs (using 0.051 KWH/day energy use),	$0.124/month	**$15,526.17**
13	Textile Filter Pressure Dosed Dispersal System	Estimated initial lined costs, installed, and including septic tank for pretreatment, pump, pump tank, control and alarm,	$3,500	Equipment (pump repair/replacement costs, estimated at $60/year),	$5/month	
		Replacement of peat bed after 7 and 14 years intervals (NPW for future costs of $4,000 each time bed replaced),	$1,800	Septage and sludge pumping once every 3-1/2 years,	$4.17/month	
				Energy costs (using 0.051 KWH/day energy use),	$0.124/month	**$6,411.14**
14	Septic Tank to Sequencing Batch Reactor (SBR)	Estimated initial SBR unit costs, installed, and including septic tank pretreatment unit (single home system),	$5,250	Equipment repair/replacement costs, estimated at $80/year	$6.67/month	
				O&M, with a maintenance contract of $450/year (est. 15 hrs. @ $15/hour * 2.0, including taxes, overhead, and profit),	437.50/month	**$14,019.31**

SN	System	Capital Cost		O&M Cost		20-year NPW
				Septage and sludge pumping once annually (it is assumed that the septic tank is pumped simultaneously, as needed, so as to eliminate separate costs for that),	$14.58/month	
				Energy costs (using 6 KWH/day energy use),	$14.60/month	
15	Septic Tank/Wetland/Trickling Filter	Estimated costs for trickling filter, installed, and including septic tank for pretreatment, pump, control and alarm, valves, and piping,	$4,500	Equipment repair/replacement costs, estimated at $80/year (estimated pump, fan and controls repairs/replacement),	$6.67/month	
		Wetland unit, installed	$3,000	O&M, with a maintenance contract of 10 hrs. @ $15/hour * 2.0, including taxes, overhead, profit, and including pump/controls and servicing,	$25/month	
				Septage and sludge pumping estimated at once every year,	$14.58/month	
				Energy costs (using 4 KWH/day energy use),	$9.73/month	**$14,192.65**
16	Septic Tank/Wetland/Mound System	Estimated mound system costs, installed, including septic tank for pretreatment, pump, pump tank, control and alarm,	$6,750	Equipment (pump) repair/replacement costs, estimate at $50/year	$4.17/month	
		Wetland unit, installed,	$3,000	O&M, with a maintenance contract of $180/year (est. 6 hrs. @ $15/hour * 2.0, including taxes, overhead, and profit),	$15.00/month	
				Energy costs (using 0.5 KWH/day energy use),	$1.22/month	
				Septic tank pumped once every 3-1/2 years,	$2.08/month	**$12,436.43**

Fig 6-2: Estimated cost of wastewater treatment systems described above in table 6-3:



6.3 Sustainability evaluation of the onsite treatment and disposal systems

The performance of the least cost systems was compared for every criterion. Each system was assigned a score, with five being the most desirable and one the least desirable. For this analysis, experience and judgment were used to establish the performance score. In other applications, more formalized practices can be used to assess performance. The final score per asset was normalized by dividing the score per asset by the number of assets. The performance and scores are provided in Table 6-5. The overall sustainability score for the conventional septic systems was 11.42 and 12.55 for the textile filter pressure-dosed dispersal system. These scores are relative to each other and are not meant to suggest an overall sustainability score for either of these systems as compared to some absolute score for sustainability (which does not exist), or as compared to other onsite systems or centralized collection and treatment systems.

A detailed comparison of the two options suggests that a principal trade-off between the two systems is that the textile filter system increases initial installation and operations and maintenance costs, while producing a higher quality effluent that can be reused for subsurface landscape irrigation. Reuse of the effluent, in turn, produces the environmental benefits of reducing the discharge of pollutants (especially nutrients) to surface water and reusing the nutrients in the wastewater for the growth of landscape plants. Additionally, reuse of the effluent reduces the demand for water extractions from surface and ground water.

For this particular example, the highest weighted social criteria are for protection of human health (weighted score of 10) and preservation of cultural traditions, ways of life, and physical heritage (weighted score of 9). Based on the analysis summarized in Table 6-5, it is easy to see that the application of the various criteria could result in tradeoffs when selecting a real system. However, that is a typical dilemma for treatment technologies and environmental infrastructure. The value of this type of decision making is that it is based on a balanced approach, providing equal importance to the three types of community capital. Given the long-lasting effects of environmental infrastructure, the sustainability analysis provides a basis for making credible tradeoffs.

Table 6-5a Sustainability Evaluation of the Septic System and Textile Filter-Drip Dispersal System

Criteria	Crit.Weight		Performance		Performance	
Social Criteria	**Rel.**	**Norm**	**Septic System**	**Score**	**Textile Filter-Pressure-Dosed Dispersal**	**Score**
The treatment system protects public health.	10	0.21	Under circumstances where coliform do not enter ground water used for consumption and if the septic tank is operating well and the leach field is not blinded, septic systems provide excellent treatment. Risk for non-performance may be high but is frequently unknown.	3.5	Textile filters produce much higher effluent quality and less likelihood of blinding the dispersal field. Risk is associated with reliance on homeowner to maintain the system.	4
Promotes societal virtues such as the public trust	6	0.13	The consumer generally has little understanding of how the system works and is not supported by health agencies or others for assurance of long-term performance.	3	Consumer understanding generally low and is not supported by health agencies or others for assurance of long-term performance.	3
Preserves cultural traditions, ways of life, and physical heritage	9	0.19	Allows for dispersed human settlement and opportunities for rural lifestyles and livelihoods. Promotes traditional dispersed land use pattern.	5	Allows dispersed human settlement, opportunities for rural lifestyles and livelihoods. But allowable smaller lot sizes may erode traditional way of life.	2.5
Community makes informed decisions. Actions reflect local values through a public process in which the public has a sense of ownership over the decision making.	7	0.15	The consumer is the manager of the septic system and therefore has greatest sense of ownership for this type of treatment system. However, limits on allowable treatment systems and reuse of the treated effluent create limits act as limits to the sense of ownership.	4	The consumer is the manager of the textile system and therefore has greatest sense of ownership for this type of treatment system. Increased siting flexibility and reuse potential promote a sense of ownership.	5
Preserves aesthetically-valued environments (beauty, open space, recreation, wildlife viewing pleasure). No olfactory or audible degradation	8	0.17	Septic systems generally promote large lots and more open space. Unsuitable soils with high rainfall will produce odors. Degradation of aquatic environments may reduce aesthetic quality	4	Does not require as large a disposal area if the subsurface assimilative capacity is adequate. There is less likelihood that unsuitable soils with high rainfall will produce odors or degrade aesthetic quality of aquatic environment Increased housing	4

					density may reduce visual aesthetics.	
Ability of all community members to attain highest potential as appropriate natural resource-based development	8	0.17	Traditional septic system promotes low density and rural lifestyles but cannot support high density development. System does not provide opportunities to reuse water for added advantage.	3	Textile systems promote low density and rural lifestyles, but can support higher density development. System provides reuse opportunities for landscaping.	4.5
			Overall weighted score	**3.87**	**Overall weighted score**	**3.9**

Table 6-5b Sustainability Evaluation of the Septic System and Textile Filter-Drip Dispersal System

Criteria	Crit.Weight		Performance		Performance	
Economic Criteria	**Rel.**	**Norm**	**Septic System**	**Score**	**Textile Filter-Pressure-Dosed Dispersal**	**Score**
Ability of most community members to fund the costs for implementing the system.	8	0.19	Conventional on-site systems are widely used, widely available, and of modest cost. Most cost goes to trenching and equipment installation.	5	Modest cost but more than conventional systems; higher costs for design & equipment are somewhat offset by lower trenching costs.	4
The capacity of the community to finance the necessary capital improvement, considering initial and final population served.	10	0.24	Conventional on-site systems are widely used, widely available, and of modest cost. Since individual systems are installed for each housing unit, no up-front capital investment in advance of population growth is required.	5	Textile systems are not used widely, because they have only been introduced over the past three years. Textile systems are of modest cost. With individual systems installed at each housing unit, no up-front capital investment in advance of population growth is required.	5
The capacity of the community to finance the necessary system operation and maintenance, Considering initial and final population and time varying demands.	9	0.21	Principal operation is automatic, not requiring the resident's involvement. Principal maintenance activity is to pump septic tank. Septic tank pumpers are generally in business in most localities. Principal challenge is septage disposal, which is either by discharge to a centralized wastewater treatment plant or to the land. In this case, septage is pumped and discharged to the centralized treatment plant.	4	Principal operation is automatic, not requiring the resident's involvement. Principal maintenance activity is to annually rinse the biotube filter and to periodically pump the contents of the septic tank. In the event of a pump failure, alarm will sound and pump must be maintained, usually by a qualified repairman. Principal challenge is septage disposal, which in this case, septage is	3.5

					pumped and discharged to the centralized treatment plant.	
The capacity of the community to finance the necessary long-term repair and replacement of the system.	7	0.17	Long-term repair /replacement is responsibility of home owner. Typical home owner does not plan for the expenditures, often has the financial resources. This cost usually associated with blinded disposal field or leaking tank.	3	Long-term repair/ replacement is the responsibility of the home owner. Typical home owners do not plan for such expenditures, but often has the financial resources. Blinding of disposal field is less likely so this cost would occur less often.	4.5
The system supports the explicitly stated community economic development objectives.	8	0.19	Septic systems are generally modest cost, but they produce no recreational or water resource benefits	2.5	Textile systems are generally modest cost, producing several potential financial benefits if water reused: (1) landscape improvements enhance property value, (2) reduce water bill, (3) irrigation of food crops offset food costs, and (4), irrigation of crops for economic gain.	5
			Overall weighted score	**3.98**	**Overall weighted score**	**4.41**

Table 6-5c Sustainability Evaluation of the Septic System and Textile Filter-Drip Dispersal System

Criteria	**Crit.Weight**		**Performance**		**Performance**	
Environmental Criteria	**Rel.**	**Norm.**	**Septic System**	**Score**	**Textile Filter-Pressure-Dosed Dispersal System**	**Score**
Surface water quality and quantity	9	0.16	Assumed adequate distance from surface water to attenuate water quality impacts, and the septic system works well. The septic system does not promote conservation and the permit conditions essentially eliminate reuse.	3	When limited distance to attenuate water quality impacts, the textile system works well because of the added treatment provided by the textile filter. The system promotes conservation through root-zone reuse in the shallow trenches.	5
Ground water quality and quantity	8	0.14	With adequate distance to ground water to attenuate water quality impacts, the septic system works well. The septic system promotes recharge of ground water.	4.5	Works well to attenuate water quality impacts. Promotes groundwater recharge, promotes water resource conservation through root-zone reuse.	5
Aquatic	10	0.18	With adequate distance from surface water, septic	3.5	With adequate distance from surface water,	4.5

ecosystems			systems adequately protect aquatic ecosystems. However, septic systems typically do not promote conservation and the permits do not allow reuse, both of which would reduce impacts by water withdrawals.		system provides significant protection of aquatic ecosystems. Textile systems promote conservation and reuse. Subsurface reuse is feasible within most permits	
Land-based ecosystems	10	0.18	Typically, systems do not promote conservation, permits do not allow reuse, both of which would reduce impacts by water withdrawals. Systems allow for urban development, may promote urban sprawl.	1.5	Textile systems promote conservation through reuse which will reduce impacts by water withdrawals. Textile systems allow for urban development, which may promote urban sprawl.	3
Soil quality	7	0.13	Septic systems may promote salt accumulation soil. Leach lines may clog with bioslimes over time but the problem is localized. The pH is normally not altered unless graywater only is dispersed in the leach lines.	3.5	May promote accumulation of salts in soil. If drip lines used, salt buildup is less; treated effluent is dispersed over larger area. Drip lines may clog with bioslimes but can be designed to be self cleaning.	3.5
Air quality	6	0.11	Under normal operating conditions, septic systems do not cause odors. Absence of aerators and exposure to the atmosphere mean that toxic emissions and biosols are negligible.	5	Under normal operating conditions, textile systems do not cause odors. A fan is operated in the textile filter box but the low velocity and enclosed box provide little opportunity for biosol emissions. Some emissions of household toxics may occur intermittently and probably at low-risk levels.	5
Energy use	6	0.11	Normally no energy use except gravity.	5	Textile filter fan, pump consume energy.	3.5
			Overall weighted score	**3.57**	**Overall weighted score**	**4.24**

Overall, advanced onsite wastewater systems, such as the textile filter with pressure-dosed disposal, offer a higher level of sustainability to users, the community, and the environment. At the same time, reductions in sustainability may occur because such systems will allow for higher housing densities in rural settings.

CHAPTER 7

DISCUSSION

7.1 Selection of technology

Procedures to consider economic and environmental factors in a systematic way have been developed. These range from a single decision-making flow sheet to a computer software package.

7.1.1 Selecting appropriate technology for rural areas

Ramallah / Al-Bireh rural areas has over 67 small communities without municipal sewage treatment. Often these communities have small lots, each with their own well, and an old septic system often connected to stormwater drainage. On-site systems are normally thought of as intended for large, rural lots, but on-site systems are being used heavily in counties with rapidly growing suburban populations. A high density of individual on-site systems and private drinking water wells provides little margin for malfunction. Sanitarians regularly report encountering failing systems, tile drained systems, and systems discharging to surface water. Community municipal sewer projects to eliminate these failing individual systems are rare because the cost of building a conventional sewage treatment plant and large diameter gravity sewers frequently exceeds the assessed value of property in the community. Many residents are on fixed small incomes and cannot afford the sewer bill. Attempts to build alternative or experimental systems are often met with resistance from regulatory agencies and established engineering firms.

The decentralized wastewater management approach discussed in this research utilizes innovative on-site technologies and sophisticated management to solve these wastewater problems without sewering. In the study area, these new management efforts have arisen out of a need for flexibility in remediating existing situations and less so in allowing new systems for new development. However, one potential side effect of allowing the broad use of managed on-site technologies could be a slow changing in the character of a locality. This is particularly likely to occur in areas where septic system rules have been used as *de facto* land use controls to limit growth and development. This is true for many towns in the districts where soil limitations have made it impossible to use poorly maintained conventional septic systems on a broad scale. As a result these communities have not developed true land use controls that would specify the allowable development density in different areas of the towns.

Therefore, communities should enact strong land use controls well before adopting the wastewater management infrastructures described here. Communities that wish to continue to maintain the overall rural character of the area will need to establish true land use controls such as zoning and development density restrictions. It is clear from many studies of advanced on-site technologies that there is no scientific basis for extreme development limitations imposed due to the "the lands inability to handle septic systems". With proper management, advanced on-site technologies can be used within an extremely broad range of soil conditions in most watersheds without substantial environmental impact.

Conventional systems use no electricity or mechanical devices. Besides periodic pumping of accumulated solids, conventional systems operate by natural processes. Gravity provides all the power needed for the water and wastes to flow through the system. Natural physical, chemical and biological processes accomplish treatment of the wastewater in the treatment unit and soil absorption system. If adequate site and soil conditions are available, conventional systems can provide adequate treatment and disposal of sewage for many years when properly constructed and maintained.

The most typical onsite system studied is the septic tank followed by a drainage field or absorption pit. In many areas soil drainage systems are inappropriate for onsite wastewater disposal because of poor soil permeability or high ground water. Alternative systems for wastewater disposal in these circumstances include mound and evapotranspiration systems. Other more mechanized systems for on-site treatment are available besides septic tanks including rotating biological contactors, re-circulating gravel filters, intermittent filters and other systems, which aim to treat water for discharge to surface water.

7.2 Rural domestic wastewater treatment options

Many technical manuals are available to assist in the evaluation and selection of a wastewater management system that is suited to the needs of a particular rural community (EPA, 1992; EPA, 1997; CEP, 1998). Based on a large-scale research carried out by Graaf *et al.,* (1990) on onsite wastewater treatment systems, different types of systems were compared. The comparison involved technological, economical and environmental features. It was found that infiltration systems have the best features for onsite treatment up to 100 PE, while for larger rural areas the rotating biological contactors were the best solution because of the lower costs.

Low cost anaerobic treatment technologies such as UASB have shown considerable promise recently as advanced pre-treatment option. The UASB technology is feasible in an urban and rural communities in developing world and industrialized counties because of its high organic removal efficiency, simplicity, low cost, low capital and maintenance costs and low land requirements (Lettinga and Halshoff Pol, 1991). The ability of anaerobic treatment systems, such as this described, suggest that they may be suitable for increased use in the urban environment. These systems are capable of attain high levels of wastewater treatment, produce minimal sludge that is, itself, high in N-P and are capable for producing biogas energy that can be recovered and reused.

Waste stabilization ponds (WSPs) are large, man-made basin into which wastewater flows and from which high quality treated effluent can be produced after a retention time of days-as opposed to hours in conventional treatment processes (Mara and Pearson, 1998). Wastewater stabilization ponds offer a low-cost method for the treatment of domestic wastewater. They represent an immediate irrigation resource for semi-arid regions and are characterized as simple to operate low-cost, high efficiency and are, therefore, technologies of choice for many developing world situations (WHO, 1987; Mara and Pearson, 1998).

WSPs function through natural forces (sun, wind, gravity, and biological activity) acting on the treatment process, allowing low-cost treatment and providing a much greater removal of pathogens than most conventional treatment processes (Mara and Cairncross, 1989; Bartone, 1991) attribute coliform reduction in WSPs to high wastewater pH and ultraviolet radiation, making them especially attractive for Mediterranean regions where these resources are abundant. WSPs are not energy or capital intensive and allow for a high degree removal of pathogenic organisms.

The disadvantages of the WSPs are that large land areas are required and that their construction may only be feasible when land values are low. WSP lose their comparative cost advantage over mechanized treatment systems when prices are greater than US$ 15-20/m^2 (IBRD, workshop, 1993). However, Mara and Pearson (1998) contend that even at high land costs WSPs are often the cheapest option.

Waste stabilization ponds often have high concentrations of TSS in the effluent, which may not be desirable depending on the irrigation method. Several polishing options are feasible to upgrade pond effluents, thereby increasing the options for effluent reuse. Rock filters, when used in conjunction with WSPs, have been shown to upgrade WSP effluent. Research at a pilot-scale rock filter demonstration conducted at the Assamra WSP in Jordan showed that effluent content reductions could be reduced greatly. TSS and BOD were reduced by 60%, total feacal coliform count by a maximum of 94% and Total-P by 46% at a loading rate of 0.33-0.44 kg TSS/m^3 (Saidam *et al.,* 1995). In a pilot plant study on differences in nitrogen removal in algae-based (ABP) and duckweed-based ponds (DBP), Zimmo *et al.,* (2000) found that both systems were efficient in nitrogen pollution control. However, DBP were efficient in inhibiting algal growth by preventing sunlight from reaching the water column.

Table 7-1: Typical treatment process removal capabilities as effluent concentration (mg/L) or removal efficiency (UNEP, 1998) (adapted)

	BOD	**Suspended solids**	**Ammonia**	**Phosphorous**	**Faecal coliform**
Septic tank	60%	40-70 mg/L	40-60 mg/L	6-7 mg/L	1-2 Log removal
Septic tank + soil	0-10 mg/L	0-10 mg/L	0-40 mg/L	0-2 mg/L	6-7 Log removal
Lagoons	20-30 mg/L	30-80 mg/L	20-30 mg/L	5-7 mg/L	3-5 Log removal
Wetlands	5-30 mg/L	5-20 mg/L	5-15 mg/L	0-10 mg/L	1-3 Log removal
Preliminary treatment	0% removal	0-10% removal	0% removal	0% removal	0 Log removal
Primary treatment	25-40 % removal	40-70 % removal	0-10 % removal	0-10 % removal	0-1 Log removal
Primary treatment chem. enhanced	45-65% removal	60-82% removal			
Secondary treatment	5-40 mg/L 86-98%	5-40 mg/L 89-97%	1-10 mg/L	5-10 mg/L	1-2 Log removal
Nutrient removal	5-30 mg/L	5-30 mg/L	0.1-5 mg/L	0.1-1 mg/L	0-1 Log removal

Palestine is one of the developing countries with limited financial, technical and natural resources. Despite recent capital investments the water and sanitation services in both urban and rural communities are still poor. To date significant national and foreign funds have been invested, but more have to be spent.

7.3 Institutional and management structure

Institutional, administrative and managerial factors should be taken seriously into account when planning water and sanitation policies. This is particularly important in developing countries.

7.3.1 Municipal and regional water utilities

In the West Bank there are several municipalities and one major utility that provide water services in the urban areas. In the rural areas, village councils and water committees provide these services. These institutions are characterised by limited quantity of available water supplies and a high percentage of unaccounted water. It was clear that many (although not all) of these water institutions are weak for many reasons, but particularly due to their lack of autonomy, inadequate performance incentives, no access to capital, insufficient dedicated revenues and human resource constraints.

Some municipal water departments and utilities have had master plans prepared several years ago. However, these plans have rarely been implemented, again for many of the reasons given above, and also due to failure to obtain permits to increase the water supply. Tariff and financial management studies are rare and tariffs are generally inappropriately structured. The staff involved with municipal services lack motivation and have little opportunity to improve their skills. Co-ordination among the municipal departments, and between the water utilities themselves, is poor.

7.3.2 Non-Governmental Organisations (National)

Several NGOs, are involved in executing water projects and research. Water projects include rainwater harvesting, spring development. irrigation systems, water quality analysis, land use management, public awareness campaigns and sanitation. Most water projects are small in scale and usually in rural areas. The main NGOs include the Palestinian Hydrology Croup (PHG), the Applied Research Institute Jerusalem (ARIJ), the Environmental Protection Centre (EPC) and Birzeit, Bethlehem, Al-Najah Universities. Other NGOs are involved to a lesser extent. In addition, there are a number of individual researchers and small private companies active in the sector, particularly in the field of water and sanitation.

7.3.3 The current situation

With the existing setting, it is difficult to differentiate between agencies responsible for planning, policy formulation, regulatory and monitoring aspects and those responsible for water delivery, operation and management of water supply and distribution projects. Therefore, restructuring is needed to separate between the roles of the different institutions, according to the following criteria:

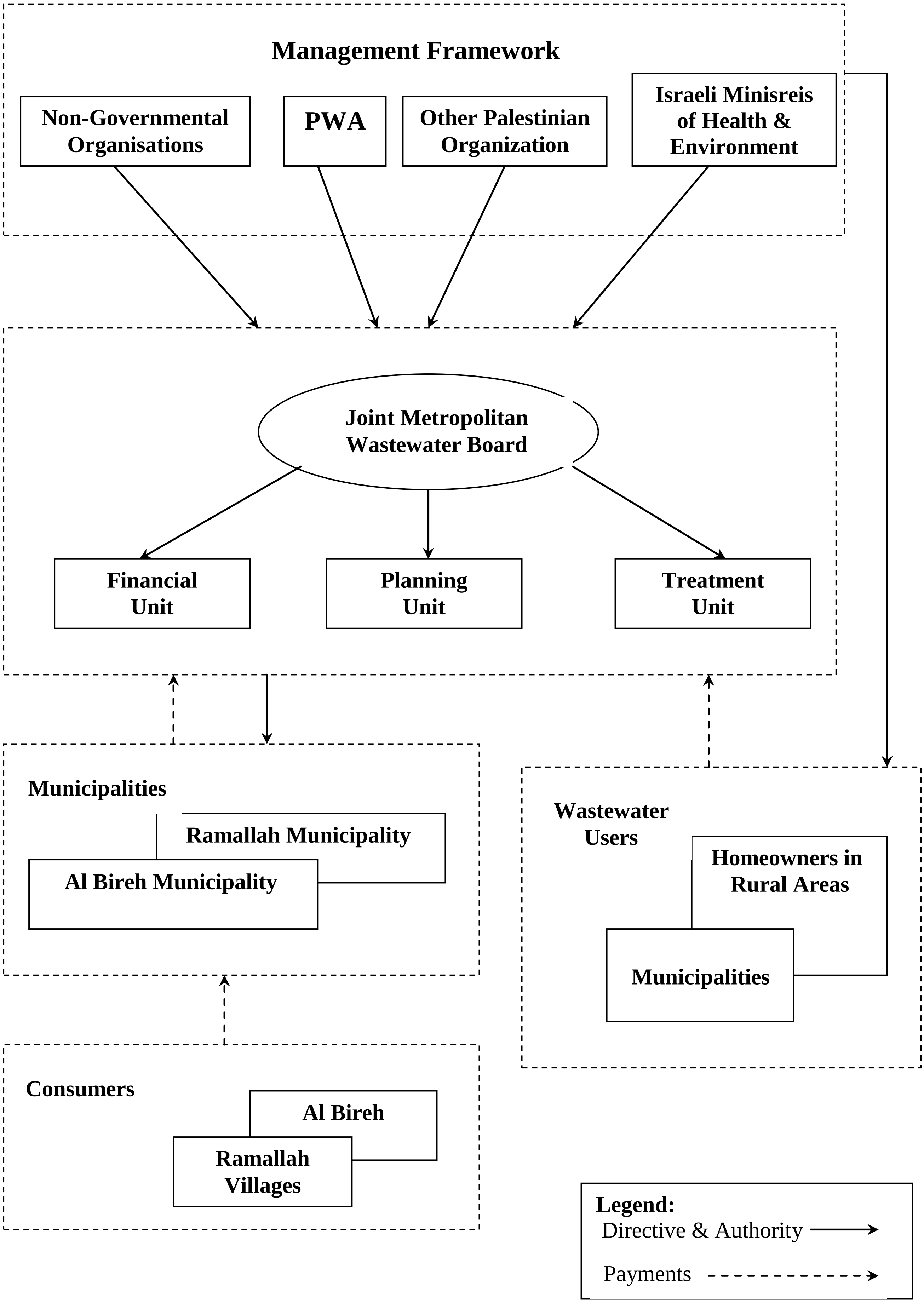
- Agency responsible for planning and policy formulation.
- Agency responsible for water supply projects.
- Agency responsible for operation and management of irrigation projects.
- Agency responsible for operation and management of domestic water and wastewater networks.

7.4 Management Options

The options for management structures are clearly related to the treatment and re-use options. However, this relationship need not be singular. These options focus on the operation of the treatment facilities. One option is putting all wastewater treatment issues under the jurisdiction of a single joint body, a metropolitan wastewater authority. This authority will be responsible for providing treatment services to all jurisdictions within the metropolitan area, regardless of nationality. It will sell the treated wastewater to farmers, municipalities, utilities, industry and recreation use, again regardless of the nationality of user. It will allow thus for a cost effective treatment system and reuse.

A possible administrative structure for such an authority is described in figure 6-1. Policies of the wastewater authority will be determined by a board, composed of representatives from Palestinian National Authority It is also possible that representatives of the municipalities or users, of both parties, will also be included in this board. The authority itself will include professional planning, financial and technical units. This last unit will operate the treatment plants.

Fig 7-1 : A management framework for proposed wastewater authority



Although wastewater treatment regulations have been imposed by the different agencies and NGOs in West Bank, it appears that in rural areas there has been little concern within the institutional and administrative structures to support the necessary changes. The traditional bureaucratic services have proved inadequate, both in terms of supervision efectiveness and the lack of experience of the existing personnel. The technical shortfalls are only one side of the problem. The willingness of the institutional structure to implement new nationwide policies is perhaps the major concern. Thus, for such policies to be efective and viable there must be concomitant changes at the institutional level. These changes should be continuously monitored and evaluated.

The evaluation of the performance of onsite treatment systems shows that those supervised by specialised agencies were in better condition and were operating well. The use of non-technical and non-specialised agencies has led to many onsite treatment systems becoming problematic and performing poorly. Most of the time the causes of problems were non-technical and the majority of them could have been alleviated by better administration of construction and operation. When diferent agencies supervise the construction and operation, the result is worse performance.

It is proposed that a single national authority should be in charge of the water sector (centrally and regionally) to provide more efective control and to promote wastewater treatment and to avoid a con ict of roles and overlapping responsibilities. In addition, inter-municipal enterprises for water supply and sewerage should be established between nearby municipalities in water basins within the water regions. Planning for this should be based on geographical, hydrogeological and social criteria.

7.5 Educations, Inspection, and Certification

Success of the increasingly complex systems often depends upon contractor understanding and proper system installation. This raises the issue of engineer, installer, and operator training. Contractors must understand not only the basis of how to design a system, but they should also understand the reasons behind the design theory. A learning curve should be expected when any new technology is introduced. However in the long term, failure due to uninformed contractors can and should be prevented. Institutions a model program for training improve designs, greater compliance, and better field implementation throughout the country. Additionally, innovative or alternative on-site systems require increasingly rigorous inspections. Functioning of all system components should be verified at installation and repair for homeowner protection.

Certification of all on-site system service providers should be considered. Site evaluations by soil scientists are the foundation of subsequent on-site system design and installation. An inaccurate soil evaluation can negate all other attempts to construct and maintain an effective treatment system. Certification should also be considered for individuals who provide for the operation and maintenance of the on-site systems. The more complex systems will require that the operator be well versed in the biological, as well as the mechanical, aspects of system performance for each type of system.

Certification will not overcome all of Palestinian's problems, but it does provide evidence that on-site professionals meet a minimum level of expertise. It also serves as an avenue to inform and train personnel. Many counties have already recognized this need and require certification of on-site system contractors and soil scientists. This may be done more effectively on a statewide basis.

7.6 Operations and Maintenance

Proper operation and maintenance of onsite systems are essential to avoiding system failures. For certain types of onsite systems with electrical or mechanical components, maintenance is often regulated through operating permits. These permits need to be renewed periodically with maintenance as a condition of renewal. In some cases, homeowners can perform system maintenance, but health officials or other qualified professionals usually must perform inspections.

Maintenance of conventional septic systems is not specified in great detail in most regulations, and although it is in homeowners' best interests to operate and maintain systems correctly, many do not know how to maintain their systems, where their systems are located, or even what types of systems they have. Yet, homeowners can be held liable for systems that pose a threat to public health and the environment.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS FOR RURAL AREAS

8.1 Conclusions

Sustainable development incorporates social, economic, and environmental factors into the evaluation and selection of wastewater management options. An assessment approach was developed and applied to evaluate two systems using these factors. The approach can be applied in other settings by adjusting the weighting of the evaluation criteria to fit local conditions. The following are specific conclusions regarding the Socioeconomic and Environmental Issues:

Socioeconomic status

- Poverty remained very high and has increased in the West Bank. Fewer household members are fully employed, and the ability or willingness to pay for piped water and electricity dropped from 31% at baseline to 24%.
- Water appears to be less affordable for many households, as evidenced by a 23% reduction in consumption.

I. Social factors

Concerning the presence of the problem of absence of sewerage, it was found that all the respondents were well aware of the problem and its impacts. Furthermore, all respondents suggested that they, and their families, suffered from the absence of sewerage services in the area.

The major concerns of the public surveyed were as follows:

- Fear that the pollution problems will adversely affect their health and safety;
- Worry about the effects of the project on their agricultural activities;
- Fear or concern that environmental control measures proposed for the project will not be implemented; and
- Questions about liability aspects, such as who is responsible for the management after the project contract expires or if the project fails after implementation.

The findings and results obtained from the questionnaire reviled that people don't accept to pay for on-site sanitation or handling their own wastewater.

II. Economical factors:

An analysis of the net economic benefits of the investments concluded that benefits exceeded costs for all projects. Cost recovery was not assured with a fixed tariff. Willingness to pay for some households was less than the per household cost necessary for cost recovery. Cost recovery was also sensitive to whether tariffs were set for individual services or charged for a combined package of services.

III. Environmental factors:

It can be suggested that from the outcome, that all respondents were quite aware of the absence of sanitary sewerage problems and its impacts. Accordingly, the vast majority of them over 95% have expressed their willingness to contribute towards the construction of a sanitary network for the area.

Sustainable development

- The sustainability of various wastewater management options can be compared when criteria are identified and weighted and performance measures selected that fit the specific conditions.
- The criteria used to assess sustainability are unique to the specific application. A site-specific definition must be developed for each application. The site-specific definition for a particular application is achieved by adjusting the weighting factors for the individual criteria.
- As new and improved onsite wastewater treatment technologies are developed, more wastewater management options will offer greater sustainability. These management options will improve the sustainability of onsite systems even further through increased reliability and flexibility.
- Overall, advanced onsite wastewater systems, such as the textile filter with pressure-dosed disposal, offer a higher level of sustainability to users in Ramallah / Al-Bireh rural areas, the community, and the environment. At the same time, reductions in sustainability may occur because such systems will allow for higher housing densities in rural settings.

8.2 Recommendations

From the data viewed in this study, the following statements regarding treatment technologies can be made:

1. It is apparent that a variety of treatment technologies are feasible for implementation in Palestine, and even more likely that many low-technology alternatives can be combined and arranged for very high efficiencies. Trickling filters preceded by septic tanks have the best feature for onsite treatment in rural areas. However, utmost care should be taken towards nitrogen pollution control. Monitoring efficiency of existing rural sanitation facilities and experimental verification of the international research findings is suggested.

2. There is increasing momentum developing behind the idea that cycling that loops, from point of generation (e.g. household) to point of treatment and reclamation must be differentiated by means of separation of total wastewater into black wastewater and gray wastewater. Reclamation of gray wastewater is more acceptable in rural Palestine as far as the socio-cultural aspects are concerned.

4. More demonstration projects on reuse of treated wastewater and stabilized sludge in/nearby the neighborhood should be introduced. Further epidemiological studies must be undertaken regarding the potential for heavy metals to accumulate in and contaminate food products that are produced from the reclaimed wastewater.

5. To promote best practice in sanitation and environmental health in rural areas, emphasis should be placed on developing sanitation projects that will validate low-technological innovations that are powered by natural processes. These pilots should include a cost benefit analysis component resulting in data that can support decision-making process and educate planners and municipal-level officials regarding the potential benefits of low technology and naturally based treatment and recovery systems.

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Annex No. 1: Projected Population for Ramallah & Al Bireh Governorat by Locality 1997- 2009 (PCBS, 1997)

Locality Name	Locality Code	Population												
		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Qarawat Bani Zeid	301455	1,932	2,019	2,110	2,208	2,320	2,444	2,572	2,701	2,834	2,968	3,105	3,244	3,385
Mazari' an Nubani	301460	1,753	1,831	1,914	2,003	2,104	2,217	2,333	2,450	2,570	2,693	2,817	2,943	3,070
Kafr 'Ein	301470	1,272	1,329	1,389	1,454	1,527	1,609	1,693	1,778	1,865	1,954	2,044	2,136	2,229
'Arura	301475	2,072	2,164	2,262	2,367	2,487	2,620	2,757	2,896	3,038	3,182	3,329	3,478	3,629
Bani Zeid	301480	4,298	4,490	4,694	4,911	5,160	5,437	5,720	6,008	6,303	6,602	6,907	7,216	7,529
'Abwein	301485	2,399	2,506	2,620	2,742	2,880	3,035	3,193	3,354	3,518	3,686	3,855	4,028	4,203
Turmus'ayya	301490	3,106	3,244	3,392	3,549	3,729	3,929	4,133	4,342	4,554	4,771	4,991	5,214	5,441
Al Lubban al Gharbi	301495	1,054	1,101	1,151	1,204	1,265	1,333	1,403	1,473	1,546	1,619	1,694	1,770	1,846
Sinjil	301500	3,883	4,056	4,240	4,436	4,661	4,911	5,167	5,428	5,693	5,964	6,239	6,518	6,801
Deir as Sudan	301505	1,521	1,589	1,661	1,738	1,826	1,924	2,024	2,126	2,230	2,336	2,444	2,553	2,664
Rantis	301515	2,020	2,110	2,206	2,308	2,425	2,555	2,688	2,824	2,962	3,103	3,246	3,392	3,539
Jilijliya	301520	714	745	779	815	857	903	950	997	1,046	1,096	1,147	1,198	1,250
'Ajjul	301525	1,013	1,058	1,106	1,157	1,216	1,281	1,348	1,416	1,485	1,555	1,627	1,700	1,774
Al Mughayyir	301530	1,683	1,758	1,838	1,923	2,020	2,129	2,239	2,352	2,468	2,585	2,704	2,825	2,948
'Abud	301535	1,716	1,793	1,874	1,961	2,061	2,171	2,284	2,399	2,517	2,636	2,758	2,881	3,007
An Nabi Salih	301540	366	382	400	418	440	463	487	512	537	562	588	615	641
Khirbet Abu Falah	301545	2,863	2,991	3,127	3,272	3,437	3,622	3,810	4,002	4,198	4,398	4,601	4,807	5,015
Umm Safa	301550	503	526	550	575	604	637	670	704	738	773	809	845	882
Al Mazra'a ash Sharqiya	301555	3,612	3,773	3,945	4,127	4,337	4,569	4,807	5,050	5,297	5,549	5,805	6,064	6,328
Deir Nidham	301560	635	663	693	725	762	803	844	887	931	975	1,020	1,065	1,112
'Atara	301565	1,640	1,713	1,791	1,874	1,969	2,075	2,183	2,293	2,405	2,520	2,636	2,754	2,873
Deir Abu Mash'al	301570	2,402	2,509	2,623	2,745	2,884	3,039	3,197	3,358	3,523	3,690	3,860	4,033	4,208
Jibiya	301575	112	116	122	127	134	141	148	156	164	171	179	187	195
'Ein Samiya	301580	122	128	134	140	147	155	163	171	179	188	197	205	214
Burham	301585	395	412	431	451	474	499	525	552	579	606	634	663	692
Kafr Malik	301590	2,098	2,192	2,291	2,398	2,519	2,654	2,792	2,933	3,077	3,223	3,372	3,522	3,676
Shuqba	301595	3,027	3,162	3,306	3,459	3,634	3,829	4,028	4,231	4,439	4,650	4,864	5,082	5,302

Locality Name	Locality Code	Population												
		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Kobar	301600	2,563	2,677	2,799	2,929	3,077	3,242	3,411	3,583	3,758	3,937	4,119	4,303	4,490
Qibya	301605	3,441	3,595	3,758	3,932	4,132	4,353	4,580	4,811	5,046	5,286	5,530	5,777	6,029
Silwad	301610	5,064	5,290	5,530	5,786	6,080	6,406	6,739	7,079	7,426	7,779	8,137	8,501	8,871
Yabrud	301615	481	502	525	549	577	608	640	672	705	738	772	807	842
Beitillu	301620	2,152	2,248	2,351	2,460	2,584	2,723	2,864	3,009	3,156	3,307	3,459	3,614	3,771
Shabtin	301625	610	637	666	697	732	772	812	853	894	937	980	1,024	1,068
Jammala	301630	1,015	1,060	1,108	1,159	1,218	1,283	1,350	1,418	1,488	1,558	1,630	1,703	1,777
Bir Zeit	301635	4,625	4,831	5,051	5,285	5,552	5,850	6,154	6,465	6,782	7,104	7,432	7,764	8,102
'Ein Siniya	301640	526	549	574	601	632	665	700	735	771	808	845	883	921
Silwad Camp	301645	296	309	323	338	355	375	394	414	434	455	476	497	519
Deir Jarir	301650	3,004	3,138	3,281	3,433	3,607	3,800	3,998	4,200	4,405	4,615	4,828	5,043	5,263
Deir 'Ammar	301655	1,686	1,761	1,841	1,926	2,024	2,132	2,243	2,356	2,472	2,589	2,709	2,830	2,953
Deir 'Ammar Camp	301660	1,556	1,626	1,700	1,778	1,869	1,969	2,071	2,176	2,282	2,391	2,501	2,613	2,726
Budrus	301665	1,056	1,103	1,153	1,207	1,268	1,336	1,405	1,476	1,549	1,622	1,697	1,773	1,850
Abu Shukheidim	301670	1,299	1,357	1,418	1,484	1,559	1,643	1,728	1,816	1,905	1,995	2,087	2,180	2,275
Jifna	301675	948	991	1,036	1,084	1,139	1,200	1,262	1,326	1,391	1,457	1,524	1,592	1,661
Dura al Qar'	301680	1,913	1,998	2,089	2,186	2,296	2,419	2,545	2,674	2,805	2,938	3,074	3,211	3,351
At Tayba	301685	1,484	1,551	1,621	1,696	1,782	1,878	1,975	2,075	2,177	2,280	2,385	2,492	2,600
Al Mazra'a al Qibliya	301695	2,964	3,096	3,237	3,387	3,558	3,749	3,944	4,143	4,346	4,553	4,763	4,976	5,192
Al Jalazun Camp	301700	6,064	6,334	6,622	6,929	7,280	7,670	8,069	8,477	8,892	9,315	9,744	10,180	10,622
Abu Qash	301705	1,092	1,140	1,192	1,247	1,310	1,381	1,453	1,526	1,601	1,677	1,754	1,832	1,912
Deir Qaddis	301710	1,374	1,435	1,500	1,570	1,649	1,738	1,828	1,920	2,015	2,110	2,208	2,306	2,407
Ni'lin	301715	3,317	3,465	3,623	3,790	3,982	4,196	4,414	4,637	4,864	5,095	5,330	5,569	5,811
'Ein Yabrud	301720	2,483	2,594	2,712	2,837	2,981	3,141	3,304	3,471	3,641	3,814	3,990	4,169	4,350
Kharbatha Bani Harith	301725	2,029	2,120	2,216	2,319	2,436	2,567	2,700	2,837	2,975	3,117	3,261	3,406	3,555
Ras Karkar	301730	1,325	1,385	1,448	1,515	1,591	1,677	1,764	1,853	1,944	2,036	2,130	2,225	2,322
Surda	301735	993	1,037	1,084	1,134	1,192	1,256	1,321	1,388	1,456	1,525	1,595	1,667	1,739
Al Janiya	301740	817	854	892	934	981	1,034	1,087	1,142	1,198	1,255	1,313	1,372	1,432

Locality Name	Locality Code	Population												
		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Al Midya	301745	911	952	995	1,041	1,094	1,152	1,212	1,273	1,336	1,399	1,464	1,529	1,596
Rammun	301750	2,241	2,341	2,448	2,561	2,691	2,835	2,983	3,133	3,287	3,443	3,602	3,763	3,926
Kafr Ni'ma	301755	2,704	2,825	2,953	3,090	3,247	3,421	3,599	3,780	3,965	4,154	4,345	4,540	4,737
Bil'in	301760	1,226	1,280	1,339	1,401	1,472	1,551	1,631	1,714	1,797	1,883	1,970	2,058	2,147
Beitin	301765	2,131	2,226	2,327	2,435	2,558	2,695	2,836	2,979	3,125	3,273	3,424	3,577	3,733
'Ein Qiniya	301770	564	589	615	644	677	713	750	788	826	866	906	946	987
Badiw al Mu'arrajat	301775	558	582	609	637	669	705	742	780	818	857	896	936	977
Deir Ibzi'	301780	1,452	1,516	1,585	1,659	1,743	1,836	1,932	2,029	2,129	2,230	2,333	2,437	2,543
Deir Dibwan	301785	4,837	5,053	5,282	5,527	5,807	6,118	6,437	6,762	7,093	7,430	7,773	8,120	8,473
Al Bireh	301790	27,606	28,837	30,149	31,545	33,144	34,920	36,737	38,592	40,482	42,407	44,362	46,345	48,360
'Ein 'Arik	301800	1,190	1,243	1,300	1,360	1,429	1,506	1,584	1,664	1,745	1,828	1,913	1,998	2,085
Saffa	301805	2,822	2,947	3,081	3,224	3,388	3,569	3,755	3,944	4,138	4,334	4,534	4,737	4,943
Ramallah	301810	17,781	18,574	19,419	20,318	21,348	22,493	23,663	24,857	26,075	27,315	28,574	29,852	31,149
Burqa	301815	1,618	1,690	1,767	1,848	1,942	2,046	2,153	2,261	2,372	2,485	2,599	2,716	2,834
Beit 'Ur at Tahta	301820	3,081	3,219	3,365	3,521	3,699	3,898	4,100	4,307	4,518	4,733	4,951	5,173	5,398
Beituniya	301825	9,268	9,681	10,122	10,591	11,127	11,724	12,334	12,956	13,591	14,237	14,894	15,560	16,236
Al Am'ari Camp	301830	3,993	4,171	4,361	4,563	4,794	5,051	5,314	5,582	5,855	6,134	6,417	6,704	6,995
Qaddura Camp	301835	1,088	1,136	1,188	1,243	1,306	1,376	1,447	1,520	1,595	1,671	1,748	1,826	1,905
Beit Sira	301850	1,984	2,072	2,166	2,267	2,382	2,509	2,640	2,773	2,909	3,047	3,188	3,330	3,475
Kharbatha al Misbah	301855	3,662	3,826	4,000	4,185	4,397	4,633	4,874	5,120	5,371	5,626	5,885	6,149	6,416
Beit 'Ur al Fauqa	301860	647	676	707	740	777	819	862	905	949	995	1,040	1,087	1,134
At Tira	301890	1,148	1,199	1,254	1,312	1,378	1,452	1,527	1,605	1,683	1,763	1,844	1,927	2,011
Beit Liqya	301895	5,634	5,886	6,153	6,438	6,765	7,127	7,498	7,876	8,262	8,655	9,054	9,459	9,870
Beit Nuba	301925	204	213	223	233	245	258	272	286	300	314	328	343	358
Other Localities		25	26	27	28	30	31	33	34	36	38	40	41	43
Ramallah & Al Bireh Governorate		202,759	211,800	221,436	231,690	243,432	256,483	269,827	283,446	297,330	311,469	325,827	340,397	355,195

Appendix A

General Features for Ramallah & Al-Bireh Districts

A.1 General features

In the hilly region of central West Bank, ten miles north of Jerusalem, lies the pleasant cities of Ramallah and Al-Bireh (Fig. A-1). Built on several hills at an altitude of 900 meters above sea level, Ramallah-Albireh district enjoys a moderate temperate climate. Ramallah-Albireh district is considered as the future economical capital of the state Palestine, where the urban population is connected to water and sanitation services.

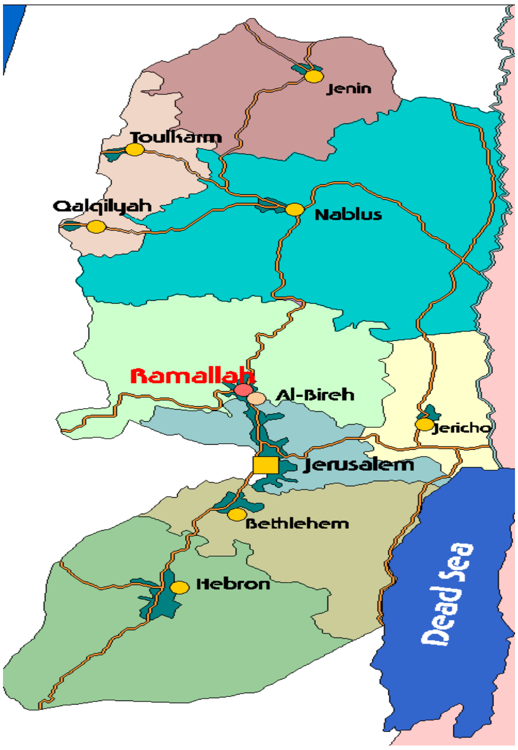


Fig A-1: Location of Ramallah / Al-Bireh district on the Map of Palestine

The main selection criteria for on-site or off-site sanitation are the population density (number of people per hectare) and produced wastewater volume (in cubic meters per hectare per day). The presence of shallow water wells susceptible to sewage pollution, soil permeability and unit cost of sewerage are also major factors. Social considerations also play an important role in the choice of the sanitation system, especially for on-site systems. Cultural and local differences (cultural conceptions about excreta) can result in a specific on-site system being effective in one place but not acceptable in another. Even if a certain technology appears acceptable, important bottlenecks frequently appear in the proper operation and maintenance of these systems.

Table A-1 illustrates the rural population numbers and households in all districts of the West Bank (PCBS, 1997). About 38.1 % (609203 capita) of the total population in the West Bank is concentrated in small rural communities, where the Ramallah / Albireh districts have the most rural areas among the West Bank districts. Ramallah/Al Bireh rural areas occupy about 21.8% (133084 capita) and around 8.3% of the total rural population and total population in the whole West Bank respectively.

Table A-1: Distribution of rural communities in the West Bank districts

District	Population	Households (HH)	Capita per Household	Percentage (%)	
				Capita	Households
Bethlehem	53440	8440	6.3	8.8	8.6
Hebron	73131	10494	7.0	12.0	10.7
Jenin	89279	15017	5.9	14.7	15.4
Jericho	16757	2699	6.2	2.8	2.8
Jerusalem	45944	7306	6.3	7.5	7.5
Nablus	96996	15738	6.2	15.9	16.1
Qalqiliya	31625	4827	6.6	5.2	4.9
Ramallah/Al-Bireh	**133084**	**21621**	**6.2**	***21.8***	***22.1***
Salfit	33524	5504	6.1	5.5	5.6
Tulkarem	35423	6102	5.8	5.8	6.2
Rural areas (Total)	609203	97748	6.3		
West Bank (Total)	1600100	262736	6.1		
Rural areas (%)	38.1	37.2		100.0	100.0
Ramallah/Al-Bireh (%)	*8.3*	*8.2*			

Taking into account that urgent need for the provision of sustainable wastewater treatment facilities in Palestinian rural communities, Ramallah/Al-Bireh district should have the first priority to start. Major reasons behind are the followings:

- Population represent about 22% of the small communities among the districts, hence public health protection is of crucial role
- Groundwater is vulnerable to pollution from septic tanks leakage and septage disposal method; first signs of pollution are apparent in some springs
- Few rural communities have established small onsite sanitation systems and the urgent need for technical evaluation to minimize process familiar and optimize the treatment efficiency
- Need to develop technical guidelines for technology selection to minimize monopoly of certain technology type over another and to unify the technologies applied.

A.1.1 Palestinian built-up areas

There are 76 Palestinian areas in the district. Ramallah, Al-Bireh, Silwad, BaniZeid, Bir Zeit, Deir Dibwan and Bitunia are the only communities designated as municipalities. Other built-up areas are governed either by village councils or village mukhtars. In addition, there are four refugee camps, Al-Ama'ri, Qaddura, Al-Jalazone, and Deir A'mmar. Due to the restrictions imposed by Israelis on giving building permits for the Palestinians, the Palestinian built-up areas are very limited and comprise only 4.35% of the Ramallah District area. On average, the population density is reaching to more than 730 person/km^2. The built up areas are mainly located on more than one soil association such as brown rendzinas and pale rendzinas soils, and terra rossa, brown rendzinas and pale rendzinas soils. These soil types constitute the most suitable land for agricultural purposes in the district.

A.1.2 Topography

The topography of Ramallah District can be divided into three parts: the eastern slopes, mountain crests and western slopes. The eastern slopes are located between the Jordan Valley and the Mountains. They are characterized by steep slope, which contribute to forming young wadis such as wadi El-Maquk. Mountain crests form the watershed line and separate the eastern and western slopes. Elevation ranges on average between 750 and 800 meters above sea level. Western slopes, characterized by gentle slopes, and have elevation ranges between 250 and 500 meters above sea level. The highest point in Ramallah District is 1022 m above sea level at Tal A'sur, and the lowest elevation is 24 m below sea level at the southeast comer of the district.

Two main drainage systems are distinguished in the Ramallah District. The first system runs to the west towards the Mediterranean such as wadi Sarida, wadi El-Shamiyah, wadi El-Durib, wadi Salman and wadi El-Kabeir. The second system runs to the east towards the Jordan River, such as wadi El-Maquk and Wadi El-Ein.

A.1.3 Climate

The Ramallah District is influenced by the Mediterranean climate, a rainy winter and dry summer. Little climatic data are available for the Ramallah District. The climatic data from October 1994 up to September 1995 were taken from the recently installed weather station at Bir Zeit University, and the rainfall data for the past 20 years were obtained from the Ramallah Department of Agriculture.

A.1.4 Temperature

Ramallah District is part of the Hill Regions, which have lower temperatures than other places in the West Bank. Table 2.1 shows the variation in temperature for the year 1994/95. Like other districts in the West Bank, January is the coldest month and August is the hottest. During the 1994/95, the highest temperature was registered at 37.5 °C in May 1995 and the lowest at 1.2 °C in February 1995. The mean annual temperature ranges between 15-20 °C. The temperature of the coldest month (January) is 6-12 °C, while the hottest month (August) ranges between 22-27 °C.

A.1.5 Rainfall

Winds from the west and southwest, which are saturated with moisture from the Mediterranean Sea, precipitate a mean annual rainfall of 694 mm on the Ramallah District. This amount is distributed over an average of 59 days; and almost 85% of the total rainfall occurs between November and February. The steep slopes of Bir Zeit and Bitunia receive most of the precipitation ranging between 400-900 mm. The areas that are wide spread on or near mountain summits like Beit U'r Tihta have an annual precipitation ranges from 300-700 mm.

A.1.6 Humidity

The mean humidity level in 1994/95 was 70.2% in the Ramallah District. The minimum relative humidity was registered in May at 57.2% and the maximum in December with a value of 77.1%.

A.1.7 Evaporation

The high temperature in the summer time, the intensive insulation under a cloudiness sky, with 306.3 wattm^2 as maximum energy reached to the soil surface in June, and the low air humidity results in a high evaporation rate. The evaporation rate decreases in the winter due to high humidity, and low radiation of 98.3 wattm^2 reached to the soil surface in December. The monthly variation in radiation for the year 1994/95 is shown in Table A-2.

A.1.8 Wind

During the summer, the area is influenced by regional winds with an average daily wind speed of 216 km in August. During the winter season, the rain-bearing winds move in a general west-east direction with an average daily wind speed of 294 km in December, causing precipitation. Between April and June the area is influenced by *Khamseen* winds which blow frequently from the Arabian Desert, full of sand and dust. This wind brings high temperature and reduced humidity.

Table A-2: Climatic Parameters in the Ramallah/AlBireh districts

Month	Rainfall (mm)	Relative Humidity (%)	Min Temp (°C)	Max Temp (°C)	Avg. Temp (°C)	Radiation (watt/m²)	Wind Speed (m/sec)	Wind Direction (deg)
October	17.3	71.2	13.1	26.5	19.8	198.1	2.8	202.3
November	267.2	73.4	11.2	24.3	15.1	137.2	3	198.4
December	195.6	77.1	1.4	20.2	8.2	98.3	3.4	192.9
January	36.4	76.6	3.6	17.4	9.3	115.7	2.6	192.1
February	94.6	75.9	1.2	17.8	9.9	140.1	2.8	185.3
March	37.6	70.7	3.7	21.3	12.1	202.2	2.5	214.1
April	33	63.6	3.9	29.7	14.7	238.6	2.8	210.6
May	2.2	57.2	8.8	37.5	19.9	281.2	2.3	221.7
June	1.2	60.5	13.5	35.2	22.9	306.3	2.3	250.9
July	3.4	71.5	16.3	35.1	23.2	283.7	2.5	254.3
August	2.8	74.6	17.5	34.3	23.6	282.7	2.6	263.2
September	2.8	69.6	16.1	33.5	22.7	238	2.3	227.4
Total	694.1	70.2	9.2	27.7	16.8	210.2	2.66	217.8

A.1.9 Land use

The majority of the land use consists of residential areas, with high-rise building, single unit houses and other residential/commercial buildings. It should be noted that no enforcement has been applied according to the rules of the planning commission, during the Israeli occupation.

A.2 Development of the project area

The field survey indicates that there are no major industries or commercial sites present in rural areas. Small family owns light metal and glass processing industries.

The study area is about to be completely saturated with residential and commercial constructions; only few vacant plots are available for construction. The only possibility of expansion is vertically and no possibility of expanding the town boundaries is foreseen.

A.3 Geology and soils

Soil plays a very important role in determining the type of wastewater treatment system best suited for a site. The soil survey report is a valuable starting point for evaluating soil at a site. The survey report shows soil characteristics such as soil type, soil permeability, depth to bedrock or seasonal high groundwater table; slope; and limitation ratings for drain-fields.

The project area primarily comprises outcrops of upper Cretaceous formations (Cenomanian, Turonian, and Senonian age). However, these formations consist of dolomite, limestone, soft chalky limestone, and marl. Recent Wadi-Fill deposits are also present, but mainly in the beds of valleys. The detailed geology of Ramallah & Al-Bireh areas, as outlined in Table A-3 shows the following formations:

Table A-3: Geological column in the Ramallah District.

Geological Formation	Geological Time Scale	Lithology	Thickness (m)
Nari Formation	Recent	Limestone	10-15
Lisan Formation	Pleistocene	Marl, limestone	Unknown
Khan El Ahmar	Maestrichtian Danian	Marl, limestone	Variable
Abu Dis Formation	Senonian	Chalk, chalky limestone	60 - 220
Jerusalem Formation	Upper Cenomanian -Turonian	Limestone, cherts	75 - 130
Bethlehem Formation	Upper Cenomanian	Chalky limestone	90- 150
Hebron Formation	Upper part of middle	Dolomitic limestone, Dolomite	170
Yatta Formation	Lower part of middle	Marl, limestone, chalks	110
Upper Beit Kahil	Upper part of lower	Marly limestone, dolomitic limestone	180-205
Lower Beit Kahil	Lowest part of lower	Dolomitic limestone, massive	216
Kobar Formation	Aptian - Albian	Limestone, marl, sandstone	180

Wastewater from cesspits and unsanitary disposal of wastes contaminate even deep groundwater because of the karstic and fissured geological formations in the West Bank. Cesspits also cause contamination of fresh water collected in underground cisterns. Wastewater infiltrates through the ground to reach the cistern, which is supposed to be leak-free but may be vulnerable to pollution through fissures, and cracks in the rock wall.

A.4 Water resources

Until the 1950's, Ramallah District depended upon rainfall collection cisterns and small local springs for its water supply. However, the growth in population and the influx of thousands of refugees from the nearby cities and villages, have multiplied the demand on drinking water. The existing infrastructure could not provide the needed water, so the municipalities of Ramallah and Al-Bireh and the municipal council of the Arab sector of Jerusalem established the Ramallah and Al-Bireh Water Company. This company expanded the water supply by drawing water from the E'in Fara springs northeast of Jerusalem and from E'in Qinya springs. Even after these two projects, the water supply could not meet the domestic water needs.

In 1963, the Jordanian government concluded an agreement with the International Development Agency (IDA) to construct new drinking water projects in Jordan. One of these projects was the E'in Samia Water Project designed to supplement the Ramallah District with drinking water supply. Also, the IDA agreed with the Jordanian Government to establish the Jerusalem Water Undertaking in 1966 (JWU, 1991). Since that time, the Jerusalem Water Undertaking (JWU) is responsible for administrating water sources and providing domestic water for most of the population in the Ramallah District and some villages in Jerusalem District.

A.4.1 Hydro-geological status

I. Groundwater aquifer systems

The Ramallah / AlBireh District overlies two main aquifer systems:

- **Lower cenomanian aquifer system**

  The geologic formations representing this aquifer system are the Lower and Upper Beit Kahil. Lower Beit Kahil constitutes the lower part of the Lower Cenomanian that is composed of gray marly and dolomitic limestone with some joints forming an aquitard Upper Beit Kahil constitutes the upper part of the Lower Cenomanian and consists of dolomitic, chalky, and marly limestone with karstification and well-jointed features forming a good aquifer confined by the overlying Yatta aquitard (Rofe & Raffety,1965).

- **Upper cenomanian aquifer system**

  The geologic formation comprising this aquifer system is the Hebron formation, and is composed of limestone and dolomitic limestone with chalky bands and chert nodules. Karsts and joints give this formation excellent aquiferous characteristics (Rofe & Raffety. 1965).

II. Groundwater basins

Groundwater basins in the Ramallah District are divided as follows:

1. The western groundwater basin (Auja Tamaseeh sub-basin): This basin underlies approximately 65% of the Ramallah District and its water flows towards the west. Shebtin wells tap this basin.
2. The eastern groundwater basin: This basin underlies the eastern part of the Ramallah District (35%). Its water flows towards the east and southeast. The Jerusalem-Ramallah sub-basin underlies a large part of the eastern area of the Ramallah District.

About 80% of the population is served by central wastewater treatment facilities. The majority of small rural communities in Ramallah / Al-Bireh districts are still lacking adequate sanitation facilities. About 93% of the population in rural areas is served by septic tanks, while more than 50% of the septage is discharged into receiving water bodies as dry wadi beds (PCBS, 1998). According to the hydrological maps published by MOPIC (2000), the groundwater in the area catchments is vulnerable to pollution has been classified as sensitive to highly sensitive water resources.

A.4.2 Sources of water

The water quality of groundwater wells and some freshwater springs are experiencing gradual nitrate pollution signs (Mukhallalati and Safi, 1995; Alawneh and Al-Sa`ed, 1997). Among the nitrogen pollution sources is untreated municipal sewage from urban areas, domestic discharges and septic tanks from Palestinian rural communities and Israeli colonies, excessive fertilizers usage, leachate from solid waste dumpsites. The newly issued Palestinian Environmental Law aiming at the improvement of aquatic environment imposes stringent penalties for polluters. However, regulations for effluent quality standards for sewage works, industrial discharges, and wastewater and biosolids reuses are still missing (PNA, 1999).

Figure A-2 shows the location map of the water sources in the Ramallah /AlBireh District These water sources could be divided as follows:

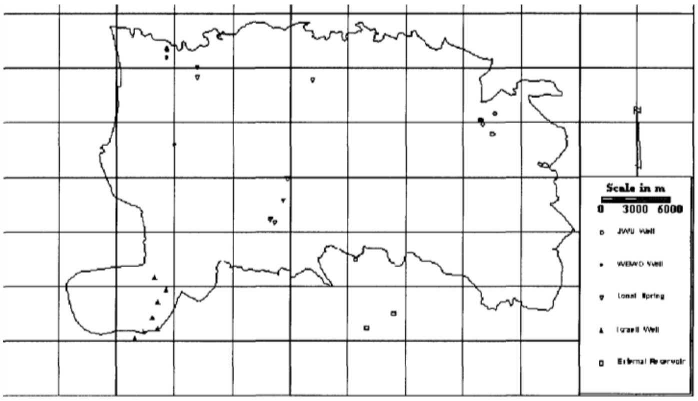


Fig A-2: Locations of wells in the Ramallah/AlBireh District

A.4.3 Groundwater wells

The groundwater wells which supplying domestic water to the people in the Ramallah District are controlled by the Jerusalem Water undertaking (JWU), Mekorot and Jerusalem Municipality. Israeli companies are also controlling other groundwater wells in the Ramallah District directed to provide the Israeli settlers living in the West Bank with domestic water.

A.4.4 Springs

Springs are a major source of domestic water for many villages in the West Bank. Villages not connected to municipal water are depending on spring water for their living. In the Ramallah District, there are 122 minor springs with an average discharge little exceeding 0.01 liters/sec. Some of these springs are used for domestic and low scale irrigation purposes and many of them are not utilized. The water of these springs flows in open channels causing water losses by evaporation and percolation through the ground to be very high. However, the total average annual discharge (1970-1994) of the seven major springs in the district is estimated to be 3.83 MCM, about 90% of the total discharge of all springs in the Ramallah District (Nuseibeh & Nasser Eddin. 1995).

Percolation of wastewater from cesspits in the villages is the major cause of the contamination of the spring water. Pollution has been discovered in the springs of the villages of Beittin, Al-Janiya, Silwad, Yabroud, Deir Jarir and Abu Shkheidem in the Ramallah District. It is believed that there are many undiscovered polluted springs, which may be causing serious health problems in the people. Regular quality measurements, especially the E-coli test, are needed to ensure the safety of the springs. The cesspits are forming danger to the rest of the springs. Sewage from the villages must be properly managed so as to protect the limited drinking water resources of the area.

A.5 Agriculture

In terms of agriculture, Ramallah District is impressively diverse in the types of crops produced. This is due to the diversity in the climate and growing conditions within the district.

The district's total agricultural area is estimated at (2,3831.1 hectares) during the 1993/94 growing season. This area encompasses three distinctive agro-ecological zones within the regions of the Eastern Slopes and the Central High Lands (Ramallah Agricultural Department. 1994). The altitude of the eastern region ranges from 0 to 200 m above sea level, and rainfall is minimal, only 200 to 400 mm, therefore, agricultural production is limited. The topography of the central region raises westerly from 200 m to more than 1000 m above sea level. Average rainfall in this area ranges between 400 and 700 mm per year, making it quite suitable for rained agricultural production. The western area descends gradually to almost 500 m above sea level at the western border of the district and receives 500 and 600 mm of rainfall annually, making it also suitable for rained agriculture.

Palestinian agriculture is constrained by available land and water, as well as access to markets. These constraints have been the object of political conflict, as Israeli authorities have limited available land, water and markets. It is widely recognized that resolution of these conflicts is essential to the establishment of peace in the region (Dinar and Wolf, 1994a; Dinar and Wolf ,1994b).

Irrigation with treated wastewater as an additional source of water should be encouraged among farmers. Large urban projects of reuse of treated effluent are still lacking; however, small pilot scale projects have failed. Among the reasons behind are of legal, technical and socio-cultural nature. Nevertheless, it seems clear that hygienic concern related to sanitation and reuses schemes and the need to demonstrate safety of these schemes should be investigated. Small rural onsite projects are successfully implemented where wide public awareness campaigns and environmental education programs were made. Environmental awareness is a key task of most NGOs, like PHG, where lectures, workshops, environmental educational materials and environmental week were organized and conducted.

A.6 Socio-economic characteristics

A.6.1 Demography and population

Demographic trends in the Ramallah District, as is the case of other districts in the West Bank, have been closely related to the political situation. In 1922, the total population of Ramallah District was approximately 3,000 inhabitants. By the end of the 1945 and 1966, the estimated population of Ramallah District reached approximately 47,280 and 134,288 inhabitants respectively (Encyclopedia Palaestina, 1984).

According to the population statistics estimated by the Palestinian Central Bureau of Statistics (PCBS) for the Palestinian cities, towns and villages in 1994, and the UNRWA estimation for the refugee camps, the total population in the Ramallah District was estimated at 176,154 people, close to 12 % of the total population in the West Bank. This number includes the four refugee camps, Al-Ama'ri, Al-Jalazone, Qaddura and Deir A'mmar (PCBS, 1997; UNRWA, 1994).

It is difficult to draw a clear distinction between urban and rural communities in the Ramallah District. Urban areas will be defined as the communities administrated by municipalities and with population of more than 10,000 inhabitants, semi-urban communities for those with population between 5,000 and 10,000, while rural areas are those with population less than 5,000 people. Ramallah, Al-Bireh, Silwad, Qarawat Bani Zeid, Bitunia, Bir Zeit and Deir Dibwan are the only Palestinian built up areas administrated by municipalities in the Ramallah District. Ramallah and Al-Bireh are the only Palestinian communities in the district, which have a population of more than 10,000 people. The population of Ramallah and Al-Bireh comprises approximately 26% of the total population of the district, while those living in rural areas represent 65% of the total population. Approximately, 9% of the people (16,500) live in the four refugee camps (PCBS, 1997; UNRWA, 1994).

A.6.2 Infrastructure - utilities

Management of most of the infrastructure services in the West Bank has been handed over to the new Palestinian National Authority (PNA). With very limited resources, the authority is working to increase the quality of these services.

A.6.3 Piped water supply

According to the survey conducted by ARIJ in 1995, approximately 90% of the population in the Ramallah District has access to the piped water supply through either the Jerusalem Water Undertaking, which covers 72% of the population, or the West Bank Water Department, which covers approximately 18% of the population. People in the district who do not have access to piped water depend upon cisterns or local springs for water supply. The Palestinian Economic Council for Development and Research (PECDAR) is working to construct new water networks for some of the villages that currently lack a piped water supply such as Beit *U'r* Tihta, Beit Leqia, Saffa and Kharbatha Al-Misbah.

Not all areas depend on a continuous supply of water; some villages suffer from water shortages, especially in the summer.

A.6.4 Sewage disposal facilities

According to the survey conducted by ARIJ in July 1995, approximately 21% of the houses in the Ramallah District are connected to the sewage network. This sewerage collects wastewater from approximately 70% of the population of Ramallah and Al-Bireh cities and the entire population of Al-Ama'ri Refugee Camps. All the villages in the Ramallah District, as well as other districts, lack sewage collection networks and is therefore dependent on cesspits and open channels as a way for sewage disposal.

A.6.5 Wastewater characteristics and flows in study area

In general wastewater is characterized in terms of its physical, chemical, and biological composition. The domestic sewage is composed of toilet wastewater (black water) and household wastewater (gray water) from the kitchen and bathroom (Haandel, *et, al.,* 1994). The quantity and strength of domestic wastewater depends on the size and the behavior of the population constituting the community. These factors socio-economic influence the design of the treatment plant, particularly the size of the plant. In rural villages the average water consumption in the year 2000 was estimated at about 60l/c.d (PCBS, 2000).

Few cases were found to vise untreated gray wastewater irrigating trees in backyards in order to minimize the regular pumping out of their cesspits, which, costs allot. The general shortage of water in Palestine and the problems experienced with existing on-site systems require a careful consideration of alternative solutions that can be locally applied. Studies on septic tank- gravel filter in the West Bank are very limited. Septic tanks were reported to provide for partial treatment of wastewater and the effluents might not satisfactorily meet the standards and environmental pollution control requirements. Since the reduction of BOD_5 concentration in the septic tank is of the order 25 — 50 percent depending on the retention time. One study on gray and black wastewater for household wastewater characteristics, made by Mustafa (1997), who evaluated an onsite septic-tank trickling filter, these characteristics are shown in Table A-4.

Table A-4: Characteristics of domestic wastewater at Beilien village (one house, 13 persons).

Parameters	Gray Wastewater*		Black Wastewater***	
	Range	Median	Range	Median
BOD (mg/1)	222 - 375	286	255 - 322	282
COD** (mg/1)	600-850	630	566 - 643	560
BOD:COD	1.6-2.58	2.25	2.1 -2.7	2.26
Dissolved Oxygen (DO in mg/1)	5.24-6.5	5.9	5.5-7.0	6.25
Temperature C°	18.5-25.4	22	15- 16	15.7
NH3-N (mg/1)	7 - 12	10	371	N/A
Kj-N (mg/1)	16-17	16.7	292-381	358
Phosphate total (mgP/1)	15-17	16	34	34
P04- (mg P04-/1)	45-52	49	N/A	N/A
Sulfate S04- (mg/1)	52-54	53	46	N/A
N03- (mg/1)	0-1.3	1	N/A	N/A
Total Suspended Solids(TSS) (mg/1)	94-181	125	N/A	N/A
Settling Solids (ml/1)	0.3 -4.5	1.7	N/A	N/A
Total Dissolved Solids (TDS) (mg/1)	628-1212	N/A	2540	N/A
Chloride (mg/1)	180-220	200	773	N/A
PH	6.6-7.4	7	8-8.5	8.2

Cations+	K mg/1	Mn mg/1	Na mg/1	Mg mg/1	Ca mg/1	Cu mg/1	Fe mg/1	Pb mg/1	Zn mg/1
Gray wastewater	18.37	0.06	87.58	27.15	64.1	0.014	0.777	0.133	0.00

** The samples were collected from the first compartment of the septic tank. where the retention time of the wastewater is one to one and half day, hence some treatment might take place there.*

*** The COD values are for fresh gray wastewater samples are collected before the first compartment of the septic tank, the dissolved Oxygen measured for a sample is 5.24 ppm at temperature 18.5 C° while the fresh water DO was 5.44 ppm at 16 C^0.*

**** The samples were taken from the top part of the cesspit from a place next to the outlet of the toilet pipe to the cesspit. The dissolved oxygen in the samples was 0.0 ppm.*

+ Cations were checked once in triplicate, all tests showed the same result.

Appendix B

On-site household gray wastewater treatment and community treatment plants installed by PARC in Ramallah rural areas

TABLE B-1: ON-SITE TREATMENT: ON-SITE HOUSEHOLD GRAY WASTEWATER TREATMENT

PROJECT	DISTRICT	LOCATION	NAME OF BENEFICIARY	BENEFICIARIES NO:	OUT PUT	DATE OF START	DATE OF FINISH
OTO12202	Ramallah	Hai-Alakbat	Abed Al-Nasser Al-Najar	6	0.5 m3/day	01/10/1999	01/02/2000
OTO12202	Ramallah	Bido	Wajeha Mansour	9	1 m3/day	01/06/2000	01/08/2000
OTO12202	Ramallah	Bido	Yousra Saleem	9	1 m3/day	01/06/2000	01/08/2000
OTO12202	Ramallah	Bido	Yousra Lekhdour	12	1 m3/day	01/06/2000	01/08/2000
OTO12202	Ramallah	Bilien	Mohammed Abu Arba'a	15	2 m3/day	01/06/2000	01/08/2000
OTO12202	Ramallah	Bilien	Khadeja Abu-Rahma	11	1 m3/day	15/8/2000	15/9/2000
OTO12202	Ramallah	Bilien	Shahran Yasin	7	1 m3/day	01/07/2000	01/08/2000
OTO12202	Ramallah	Bilien	Mustafa Mustafa	12	2 m3/day	01/06/2000	01/06/2000
OTO12202	Ramallah	Bitunya	Nael Tahseen	7	1 m3/day	01/07/2000	01/08/2000
OTO12202	Ramallah	Silwad	Samer Abu Arkoob	20	2 m3/day	01/07/2000	01/09/2000
OTO12202	Jenin	Anza	Yusra Alkasem (Um Al-ezz)	15	2 m3/day	01/01/2000	01/06/2000
OTO12202	Jenin	Anza	Sumaya Obied	8		01/07/2000	07/10/2000
OTO12202	Jenin	Anza	Najiya Abdefatah	6		01/07/2000	07/10/2000
OTO12202	Nablus	Kabalan	Yousef Nijim	25	4 m3/day	06/07/2000	N/A
GVC	Nablus	Kabalan	Mustafa Nashta	10	1 m3/day	25/7/2000	N/A
GVC	Nablus	Kabalan	Abbas Abed-elfatah	18	3 m3/day	26/7/2000	N/A
OTO12202	Tul-Karem	Saida	Ata Al-Ashqar	11	1 m3/day	20/7/2000	N/A
OTO12202	Tul-Karem	Saida	Azmi - Al-Ashqar	10	1 m3/day	20/7/2000	N/A
OTO12202	Tul-Karem	Al-nazla Al-wasta	Khayri Kitana	9	1 m3/day	20/7/2000	N/A
OTO12202	Tul-Karem	Al-nazla Al-wasta	Saleem Kitana	7	1 m3/day	20/7/2000	N/A
OTO12202	Jericho	Kitf - alwad	Training Center	30	1.5 m3/day	15/9/1999	15/1/2000
OTO12202	Bethlehem	Biet-Fajar	Musa Takatka	21	3 m3/day	29/8/2000	27/9/2000
OTO12202	Bethlehem	Biet-Fajar	Nuha Takatka	11	1.5 m3/day	15/7/2000	28/8/2000
OTO12202	Bethlehem	Biet-Fajar	Aziza Ihmadat	18	1.5 m3/day	10/08/2000	10/09/2000
OTO12202	Bethlehem	Husan	Khadra Abed-rabo	16	1.8 m3/day	15/6/2000	27/9/2000
OTO12202	Bethlehem	Husan	FahimaKhalil	13	1.5 m3/day	11/09/2000	11/10/2000
OTO12202	Bethlehem	Husan	Muna Al-shosha	11	1.5 m3/day	20/7/2000	20/9/2000
OTO12202	Hebron						N/A
OTO12202	Gaza	khan younes bani Suhayla	Ahmad salim alfara	9	1m3/day	21/6/2000	N/A
OTO12202	Gaza	khan younes ras al-khraba	yousef Isleh	20	2m3/day	08/04/2000	N/A
OTO12202	Gaza	Dier Albalah Alqrara	naieem Alabadla	17	2m3/day	27/6/2000	N/A
OTO12202	Gaza	Dier Albalah Alqrara	sameer khashan	18	2m3/day	25/6/2000	N/A
OTO12202	Gaza	Biet-hanon	saed abd-aldayem	12	1.5m3/day	28/10/2000	N/A
OTO12202	Gaza	Biet-hanon	tahseen sadat	14	1.5m3/day	03/11/2000	N/A
	Total	Total		400	50.8		N/A

Table B-2: COMMUNITY Treatment Plants

Description	PROJECT	DISTRICT	LOCATION	Beneficiaries No:	Date of Start	Date of Finish
Gray wastewater treatment plant for 15 houses	IDRC	Ramallah	Biet-Diko	150	01/06/2000	15/8/2000
On-site gray wastewater treatment plant for 12 houses, 1 mosque and 1 swimming pool	OTO12202	Bethlehem	Al-Ebidiya	200	N/A	N/A
Wastewater treatment plant for Star Mountain Campus for the Handicap people in the region of Ramallah	JAPAN	Ramallah	Star Mountain	150	N/A	N/A
Total				**500**		

Appendix C

C1: Brief description of WAWTTAR software package

WAWTTAR

A Decision Support Model for Prefeasibility Analysis of

WATER AND WASTEWATER TREATMENT

TECHNOLOGIES APPROPRIATE FOR REUSE

Developed and Programmed by

Brad A. Finney and Robert A. Gearheart, Professors of Engineering

Assisted by

James Howell,

Sophie Lagacé,

Mercy Lawson-Doe,

Tapley Jordan,

Gregory Cross

Environmental Resources Engineering,

Humboldt State University

Arcata, CA 95521

For the

Environmental Health Project

Which is operated by

Camp Dresser & McKee International Inc. and Associates

And sponsored by

The U.S. Agency for International Development

July 1998

I. Description of procedure and capability

The WAWTTAR program was designed to assist financiers, engineers, planners and decision-makers in improving their strategies toward sustainable water and sanitation coverage while minimizing impacts on water resources. It was developed specifically for application at the pre-feasibility stage of project development to assist planners select suitable water and wastewater treatment processes which are appropriate to the material and manpower resources available in their particular location at particular times. The program is designed to assist decision-makers dealing with the following types of issues:

1. Identification of the least-cost treatment scheme for a community with site-specific socio-economic and geographical conditions;
2. Presentation of risks to long-term sustainability of selection of identified treatment schemes;
3. Collection of viable combinations of technologies available to a specific community to meet water reuse standards or guidelines;
4. Identification of least-cost wastewater collection and treatment options for high-density, peri-urban communities;
5. Balancing of coverage and risk for selection of treatment schemes within financial constraints;
6. Selection of technologies to meet particular water quality and/or reclamation standards; and
7. Sensitization of decision-makers to the issues of sustainability related to water, sanitation, wastewater and/or water reuse.

II. Technology Selection

The main use of WAWTTAR is as a tool for individuals with a technical background to screen and investigate possible water and wastewater treatment options. It enables the user to accomplish this by examining the public health status, water resource requirements, material availability, cost structures and ecological conditions, which exist in a particular community. The program assesses these combined factors to generate a set of comparable and refinable feasible technical solutions.

WAWTTAR incorporates innovative and alternative technologies and emphasizes water reuse as an integral component of treatment schemes. WAWTTAR does not, however, exclude conventional options and is of equal usefulness in the screening and examination of such options as well. The main application of WAWTTAR is in technology assessment and evaluation for urban population centers with significant human, material and financial resources available for infrastructure improvement. In most of these urban centers, access to adequate sanitation is typically available for most residents through sewers or individual septic tanks.

For many others, especially those living in peri-urban zones, residents are typically without acceptable wastewater collection and treatment systems. What systems do exist in these communities generally follow conventional designs although alternative systems may be applicable? WAWTTAR has also been designed to account for the particular, non-conventional wastewater collection and treatment systems, which are applicable to these types of settings.

III. Data Collection

WAWTTAR presents numerous tables in which the user is required to supply information. These tables serve not only as inputs to the software, but also as guides for planners and decision-makers regarding the range and quality of information which should be considered in the development of infrastructure initiatives.

IV. Community Data

The principal set of data, which the user must individually input are those, which are site-specific to the location being considered for infrastructure improvement. These community data are divided into several categories as displayed below:

1. **General**
   Community identification / Community location / Stakeholders.
2. **Demographic**
   Population, density and growth rate / Household size / Spatial growth / Current and projected water use / Current and projected wastewater production.
3. **Resources**
   Availability of construction, operation and maintenance equipment and materials / Energy and labor resources / Availability of chemicals, media and laboratory services.

4. **Hydro-meteorological**

   Precipitation and evaporations rates / Surface temperatures and frost lines / Raw water and wastewater quality / Point source inputs / Collection system description.

5. **Financial**

   Planning horizons / Exchange rates / Interest, discount and inflation rates / Construction and O&M cost indices / Land values.

6. **On-site**

   Soil and ground types / Depth to water table / Isolation distances from relevant features / Dwelling types / Defecation practices / Gender issues / Accessibility and waste hauling practices.

V. Treatment Process Data

The second type of data utilized by WAWTTAR is Treatment Process Data. Such information for nearly 200 water and wastewater treatment processes is provided in the WAWTTAR database. For each process, a set of tables contains information that defines the characteristics of the process. The tables and their content are shown below:

1. **General**

   Type of process / Identification of descriptive files for process.

2. **Construction**

   Equipment, energy, labor and material requirements / Construction costs relative to hydraulic, solids and organic loadings / Economic life span of process.

3. **Operation and Maintenance**

   Land requirements relative to hydraulic, solids and organic loadings / Equipment, chemical, media, laboratory and material requirements / Process control and energy needs / Operation and Maintenance costs relative to hydraulic, solids and organic loadings / Solids production rate and moisture content / Allowable influent quality values / Removal efficiency for influent constituents / Adaptability of process to upgrading, flow variations and influent quality.

4. **Sitting**

   Allowable precipitation and surface temperatures / Required surface soil types and percolation rates / Necessary horizontal and vertical isolation distances.

5. **Impacts**

   Nutrient management / Pathogenic organism production / Pest breeding / Odor generation / Requirements for education

6. **On-site Miscellaneous**

   Institutional requirements / Allowable population density and dwelling requirements / Adaptability to social practices and living conditions / Waste handling requirements

Each process is defined by up to three generic constructions cost, O&M cost and land requirement curves based on hydraulic loading, organic loading and solids loading.

VI. Results

After WAWTTAR has completed the calculations resulting from the combination of site-specific community information and the selected treatment trains, the program output is written into two output files. These files are the Feasible Solution File and the Infeasible Solution File. A display menu is used to view these files along with other output files.

C2: Preliminary Cost Estimates for 46 Different

On-Site Systems in Rmallah / Al-Bireh rural areas

Run out by WAWTTAR software

Table C-2. Overview of systems evaluated by WAWTTAR

A1	Septic tank & gravity distribution
A2	Septic tank & gravity distribution with chambers
A3	Septic tank & gravity distribution with styrene foam
A4	Septic tank & gravity distribution with large diameter pipes
A5	Septic tank & gravity distribution with panel blocks
A6	Septic tank & gravity distribution with biofabric treatment
B	Septic tank & gravity distribution w/ tile drainage
C	Septic tank & gravity distribution w/ pump tile drainage
D	Septic tank & gravity distribution w/sand lined trenches
E	Septic tank & gravity distribution w/sand lined trenches & tile drainage
F	Septic tank & gravity distribution w/sand lined trenches & pump drainage
G1	Septic tank & gravity distribution w/ pressure manifold
G2	Septic tank & gravity distribution w/ pressure manifold and chambers
G3	Septic tank & gravity distribution w/ pressure manifold and styrene foam
G4	Septic tank & gravity distribution w/ pressure manifold and large diameter pipes
G5	Septic tank & gravity distribution w/ pressure manifold and panel blocks
G6	Septic tank & gravity distribution w/ pressure manifold and biofabric treatment
H1	Septic tank & gravity distribution w/ sand filter pretreatment
H2	Septic tank & gravity distribution w/ peat filter pretreatment
I	Septic tank & gravity distribution w/ recirculating sand filter pretreatment
J	Septic tank & LPP distribution
K	Septic tank & LPP distribution w/sand filter pretreatment
L	Septic tank & LPP distribution w/recirculating sand filter pretreatment
M	Septic tank & drip distribution
N	Septic tank & drip distribution w/sand filter pre-treatment
O	Septic tank & drip distribution w/recirculating sand filter pre-treatment
P	Septic tank & drip distribution w/sand filter pre-treatment & chlorine disinfection
Q	Septic tank & drip distrib w/ recirc. sand filter pre-treatment & chlorine disinfection
R	Septic tank & drip distribution w/sand filter pre-treatment & UV disinfection
S	Septic tank & drip distribution w/recirc. sand filter pre-treatment & UV disinfection
T	Septic tank & spray irrigation w/ sand filter pre-treatment and chlorine disinfection
U	Septic tank & spray irrigation w/ recirc. sand filter pre-treatment and chlorination
V	Septic tank & spray irrigation w/ sand filter pre-treatment and UV
W	Septic tank & spray irrigation w/ recirculating sand filter pre-treatment and UV
X	Septic tank and gravity distribution with wetland cell
Y	Aerobic treatment unit and gravity distribution
Z1	Denitrification system w/ blackwater & graywater separation and gravity distribution
Z2	Denitrification system w/ blackwater & graywater separation and LPP distribution
ZA1	Septic tank & gravity distribution w/ 18" fill mound
ZA2	Septic tank & gravity distribution w/ 18" fill mound and chambers
ZA3	Septic tank & gravity distribution w/ 18" fill mound and styrene foam
ZA4	Septic tank & gravity distribution w/ 18" fill mound and large diameter pipes
ZA5	Septic tank & gravity distribution w/ 18" fill mound and panel blocks
ZA6	Septic tank & gravity distribution w/ 18" fill mound and biofabric treatment
ZB	Septic tank & LPP distribution in at-grade system
ZC	Septic tank & pressure-dosed sand mound system

C3: Feasible and Infeasible Files

(WAWTTAR Questions)

Community Data Questions

I. Community General Tab Questions (1-7)

1. What is the name you wish to use to identify this community or problem?
2. What is the name of the neighborhood?
3. In what state or province is the community located?
4. In what country is the community located?
5. What is the planning group or department?
6. What is the name of the responsible Agency, Ministry, or institutional stakeholders?
7. Specify the base year for the demographic data, land value, and water use data?

II. Community Demographic Tab Questions (8-16)

8. What is the population of the community (in 1,000s of people) in the base year?
9. What is the annual population growth rate (in percent) for the community?
10. What is the base year gross population density of the community (in persons /km^2) ?
11. What is the average number of persons living in a single dwelling in the community?
12. What is the estimated annual growth rate (in percent) in community land area?
13. What is the base year per capita water use rate per day (liter/day/person)?
14. What is the estimated expected annual rate of change per capita water use (% per year)?
15. What is the base year per capita wastewater production (liters/day/person)?
16. What is the estimated expected annual rate of change in per capita wastewater production (percent/year)?

III. Community Resource Tab Questions (17-26)

17. Please check construction equipment types that are available in the community.
18. Please check O&M equipment types that are available in the community.
19. Please check construction and O&M materials that are available in the community.
20. Please check energy resources that are available in the community.
21. Please check types of labor that are available in the community.
22. Please check types of chemicals that are available in the community.
23. Please check types of media supplies that are available in the community.
24. Please check types of laboratory equipment that are available in the community.
25. Please check types of process control equipment that are available in the community.
26. Is there a state/central government agency or institution that would provide institutional supervision for operation and maintenance of distribution/collection and treatment facilities?

IV. Community Hydro/Met Tab Questions (27-33)

27. Please provide the average monthly precipitation and evaporation rates (in mm/month) in the community.

28. What is the average annual minimum ground surface temperature (in degrees C)?

29. What is the average depth to the frost line (in meters)?

30. Provide information on results of tests on the quality of raw water intended for use as a potable water supply for the community:

31. Provide information on the quality of wastewater that is produced by the community:

The principle constituent normally considered in domestic wastewater include:

1. CBOD
2. settleable solid
3. suspended solids
4. pH
5. oil and grease
6. fecal/total coliform

The other constituents are critical for advance secondary, tertiary, reuse and industrial treatment systems. Second tier constituents could be:

1) nitrogen forms
2) phosphorus forms
3) metals
4) oocysts
5) COD

32. If the wastewater treatment system receives a point source input other than the collection system, please provide the name of the point-source loading file:

33. Is a central wastewater collection system in existence for the community? (Yes/No)

V.Community Financial Tab Questions (34-42)

34. What year is the project scheduled to begin (first year in the planning horizon)?

35. How many years are to be included in the planning horizon (length of the proposed project)?

36. What is the name (or abbreviation) for the local currency? (10 char., max.)

37. What is the US dollar exchange rate for the local currency (i.e., U.S.$1.00 = how many units of local currency)?

38. What is the annual interest rate or public works discount rate (percent per year) that should be used in evaluating costs of water and wastewater treatment facilities?

39. What is the anticipated annual rate of inflation (percent per year)?

40. Construction cost indices: Please give an estimate for the ratio of the following construction cost categories in the community to the cost in the U.S:.

41. O&M cost indices: Please give an estimate for the ratio in the community of the following O&M cost categories to the cost in the U.S.

42. What is the base year value of land (in 1000 U.S. dollars per hectare) where treatment facilities would be built?

VI. Community On-Site Tab Questions (43-53)

43. Which of the following is the predominant surface soil/ground type to a depth of 2 meters?

44. What is the characteristic percolation rate for the area? (seconds /cm)

45. What is the minimum wet weather depth to the water table (meters)?

46. What is the minimum horizontal distance (in meters) between the boundaries of the proposed treatment and disposal sites and a potable water well)?

47. What is the minimum horizontal distance (in meters) between the boundaries of the proposed treatment and disposal sites and a natural watercourse (e.g., stream, lake, estuary, etc.)?

48. Do the majority of community members live in multistory buildings?

49. In the community, is squatting the most predominant position for defecating?

50. In this community, are there cultural/religious factors that require males and females to use different structures for defecating?

51. Please check types of anal cleansing materials used in the community.

52. Please check types of waste handling categories for which cultural/religious barriers exist in the community

53. Which of the following street widths best describes the accessibility to 90% of the dwellings of the community?

Appendix D

Questionnaire analysis and results

I. Village and questionnaire analysis

The questionnaire form was divided into three sections; the first section was concerned with providing a general description of the situation in hand; i.e. absence of sewerage network in the area and its adverse impacts. The second involved questions on the socioeconomic characteristics of the respondents. The third section, was concerned with willingness to pay for the provision of the service.

Concerning the presence of the problem of absence of sewerage, it was found that all the respondents were well aware of the problem and its impacts. Furthermore, all respondents suggested that they, and their families, suffered from the absence of sewerage services in the area.

Fig (D-1): House area and family size relationship

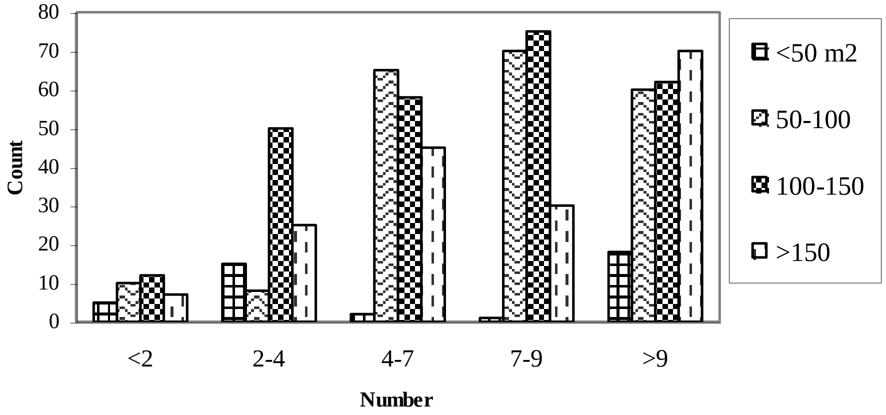


Fig (D-2): Monthly consumption and family size relationship

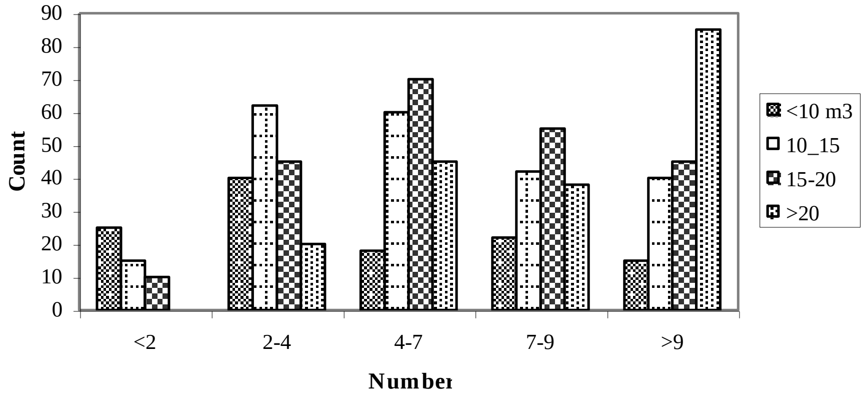


Fig (D-3): Relation between amount of water used for agriculture and Water source

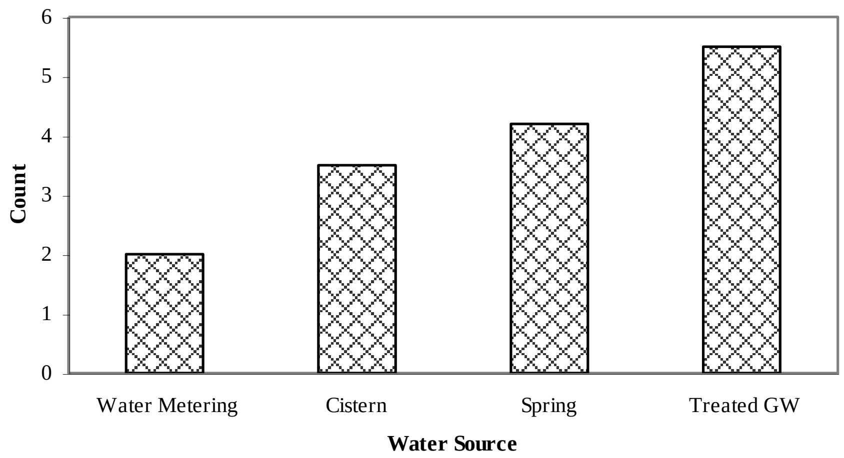


Fig (D-4): Relation of monthly consumption and kind of washing machine

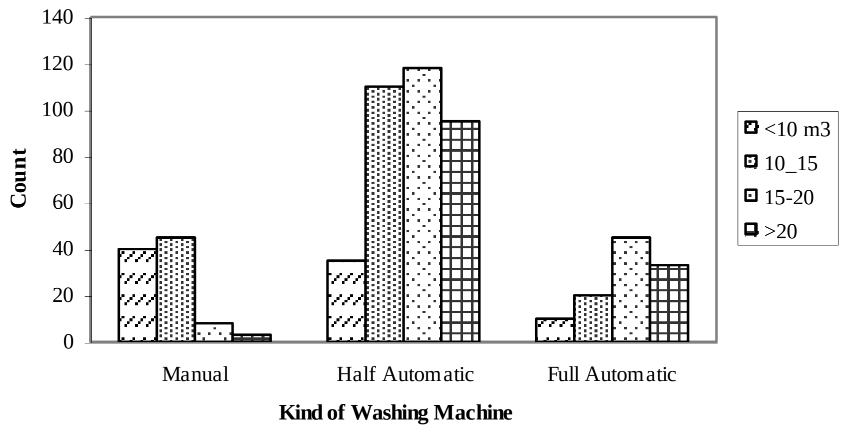


Fig (D-5): Location of toilet

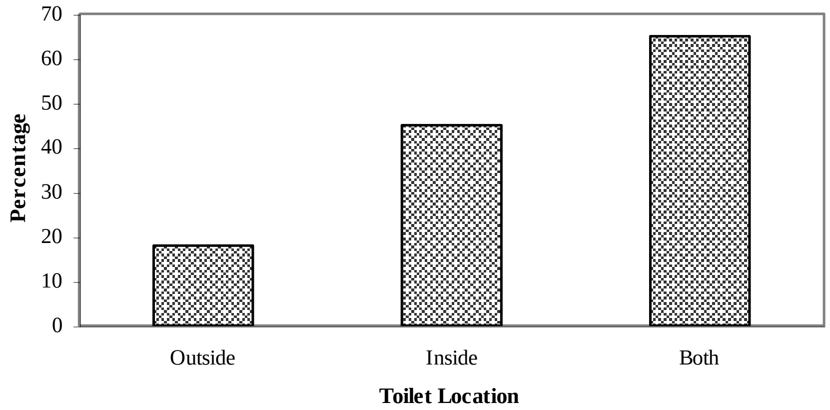


Fig (D-6): Gray water from (washing, bathing, kitchen) drainage

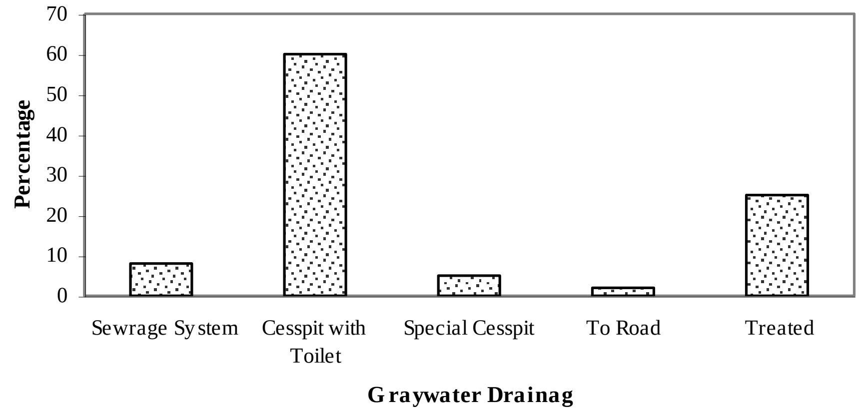


Fig (D-7): Dispose off wastewater (Excreta / Urine)

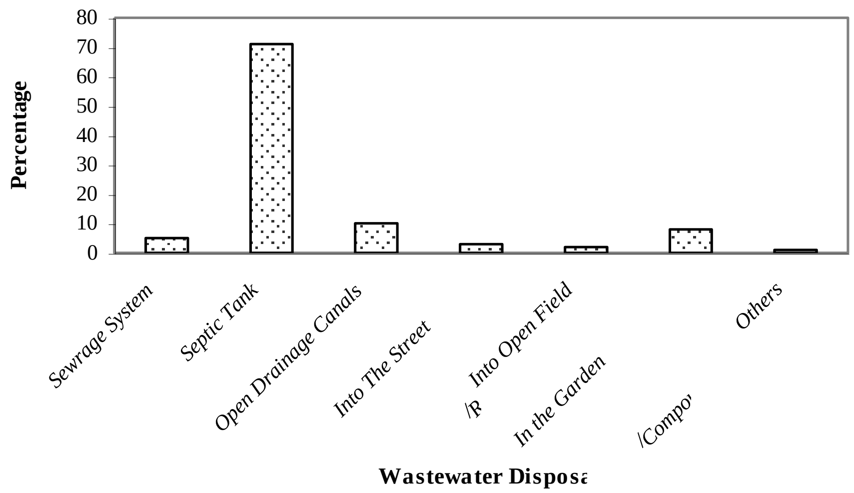


Fig (D-8): Percentage of families that used land around house in Agriculture

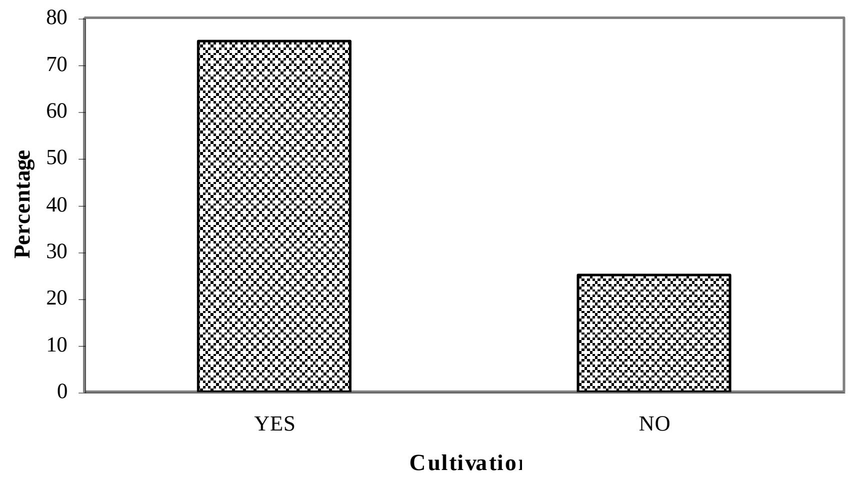


Fig (D-9): The land area used for agriculture

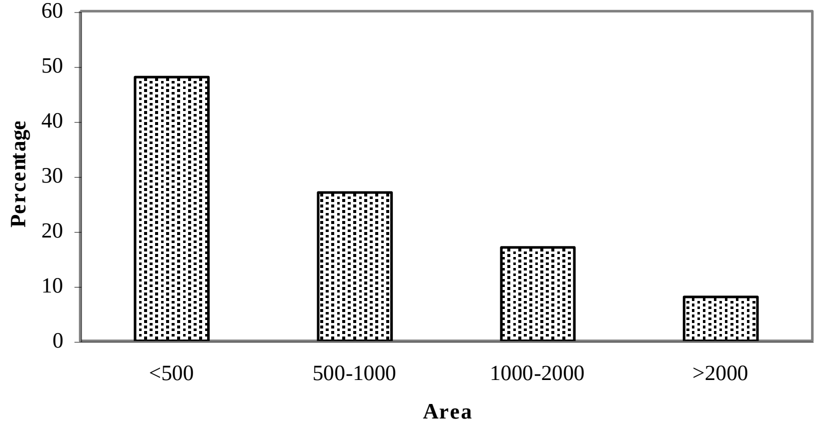


Fig (D-10): Number of roof tanks used

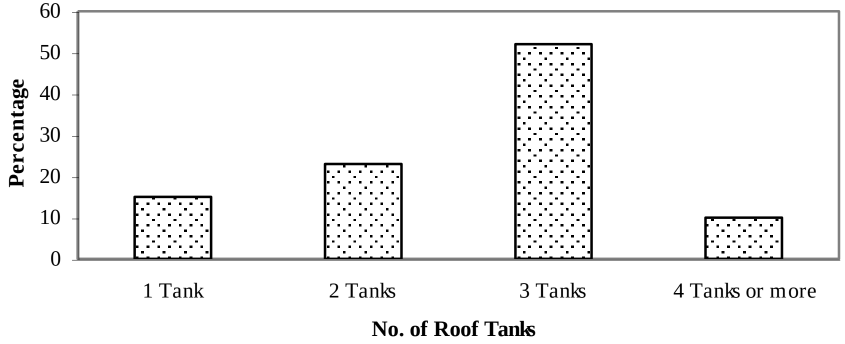


Fig (D-11): Percent of households that use water network for irrigation

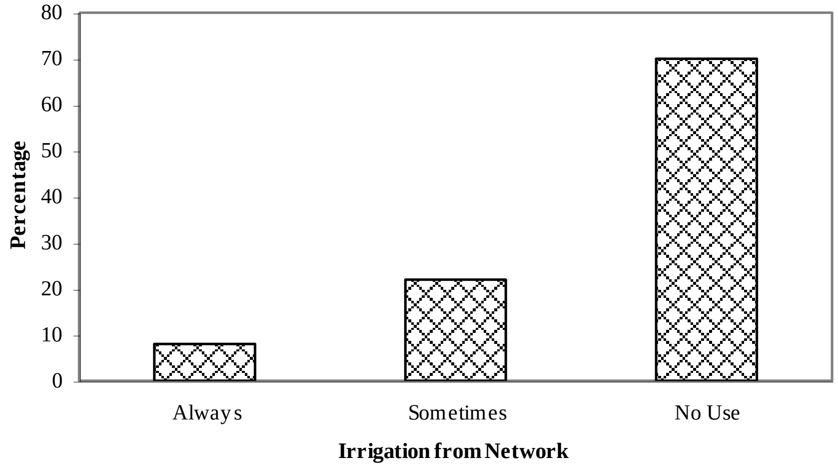


Fig (D-12): Relation between number of roof tanks and network connection

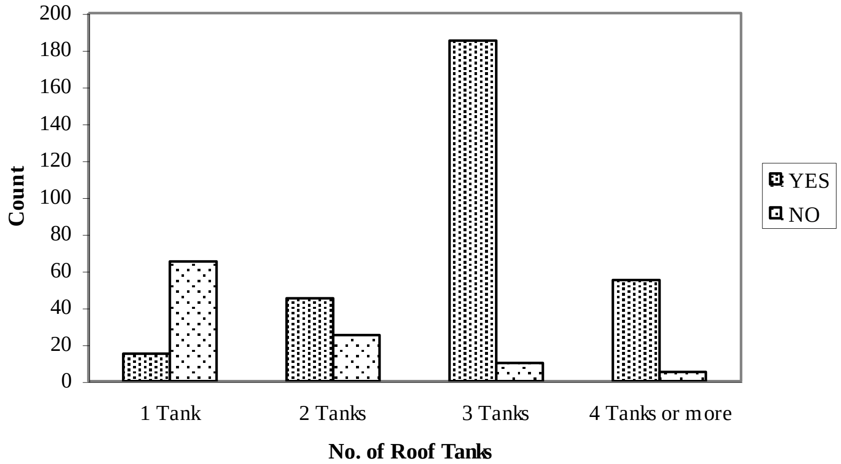


Fig (D-13): Drinking and cooking water source

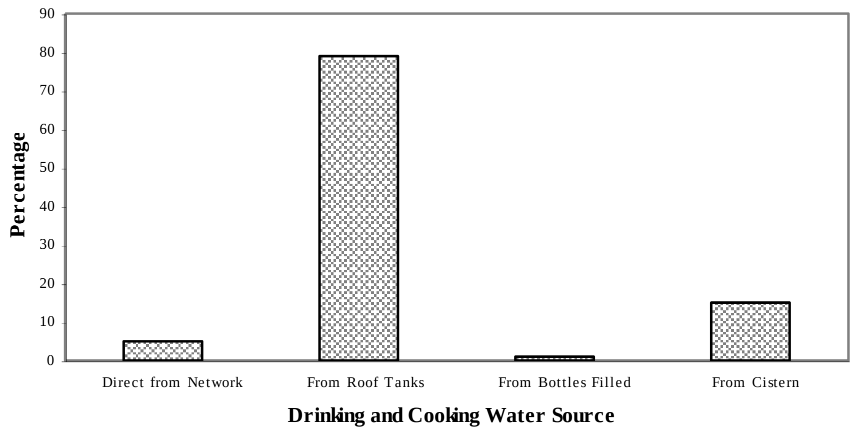


Fig (D-14): Water born disease of any member in the family

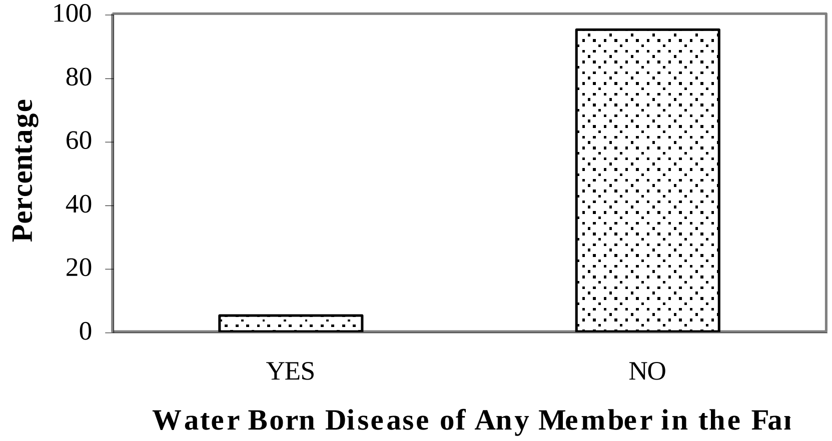


Fig (D-15): Network supply cutting times in the month

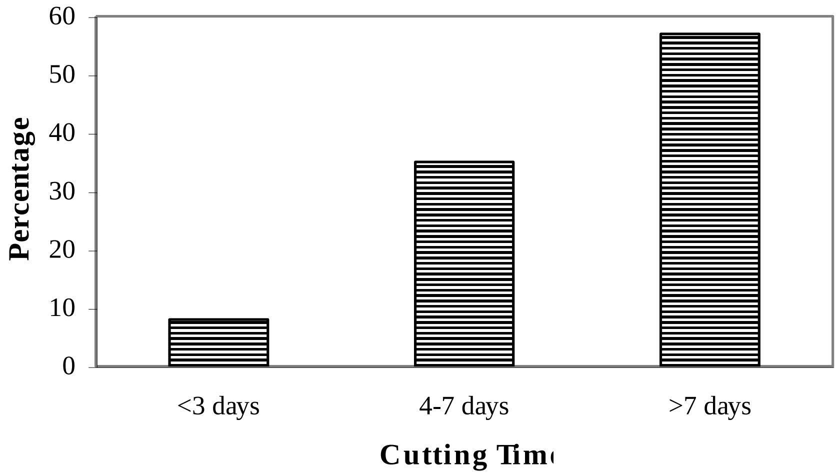


Fig (D-16): Cesspit evacuation times during the year

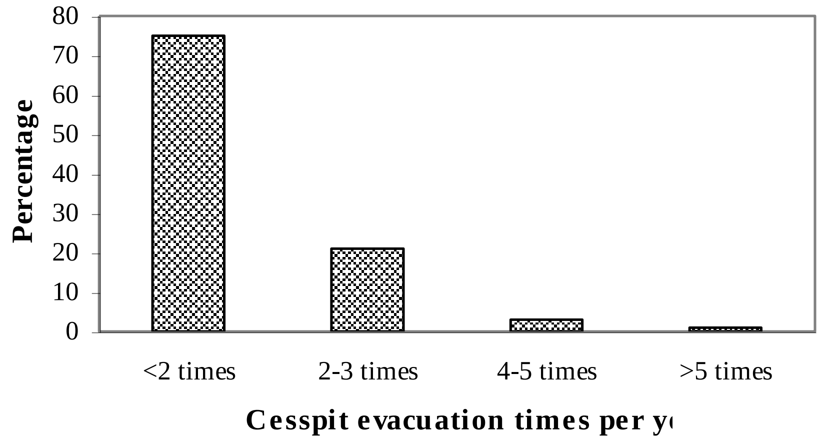


Fig (D-17): Water source alternatives at shortage time

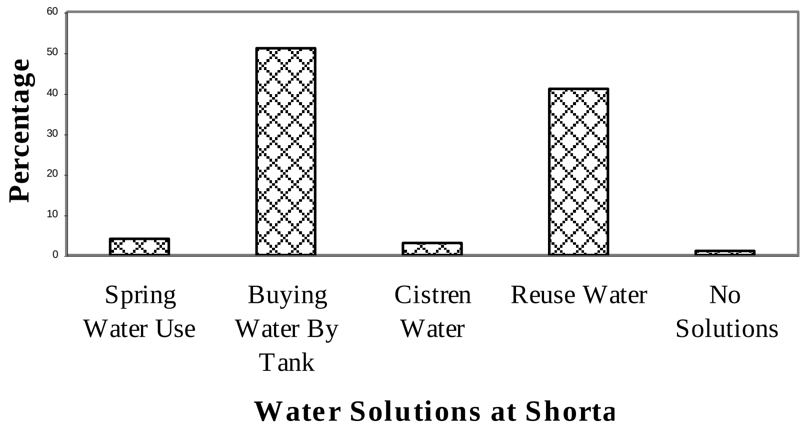


Fig (D-18): Gray water reuse opinion

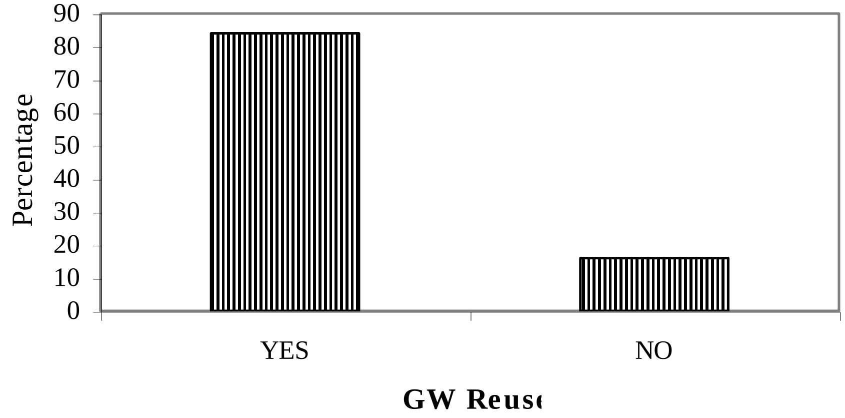


Fig (D-19): Opinion about separate installation for gray water and black wastewater

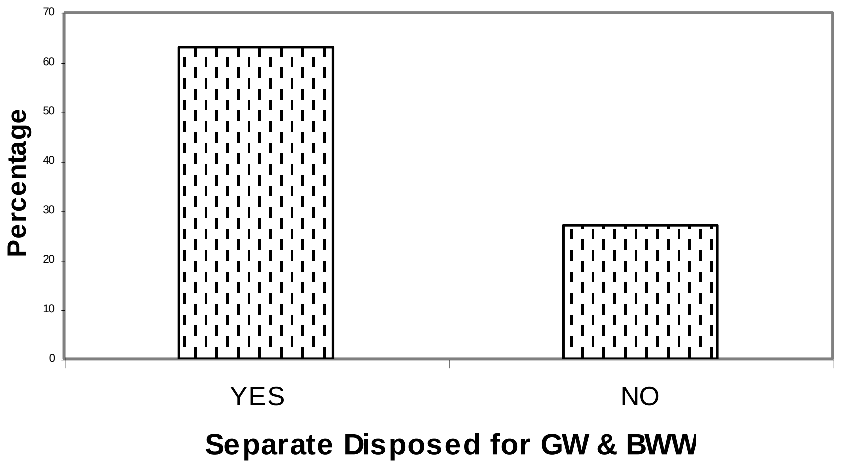


Fig (D-20): Have understanding about OWTS

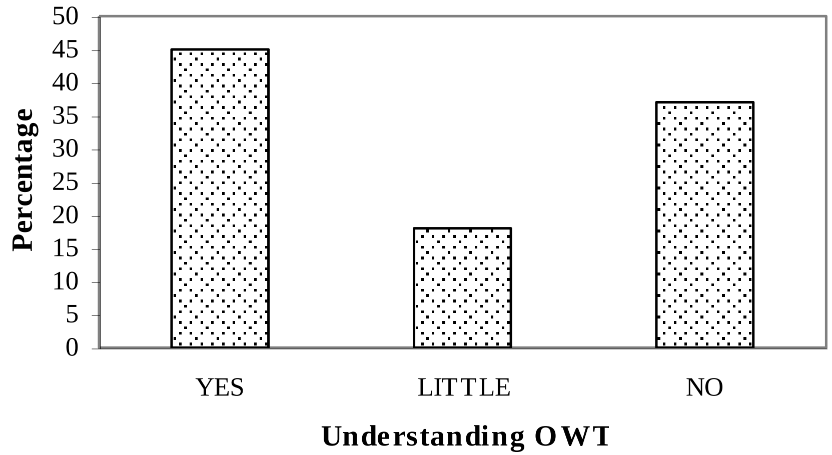


Fig (D-21): Reuse treated water for agriculture purposes

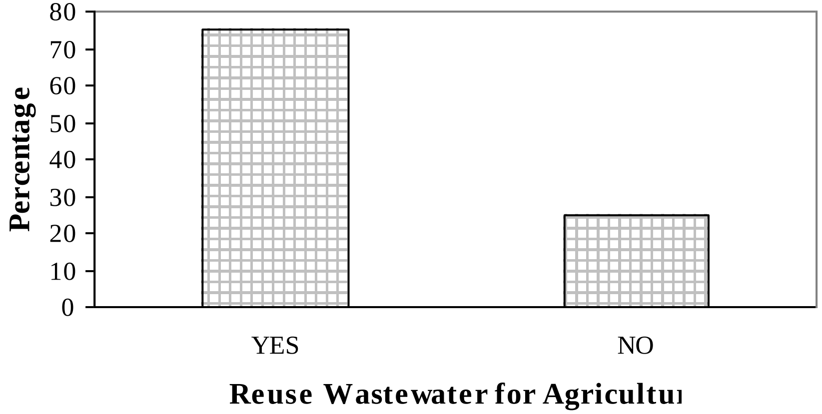


Fig (D-22): Ability to pay for installation of TP

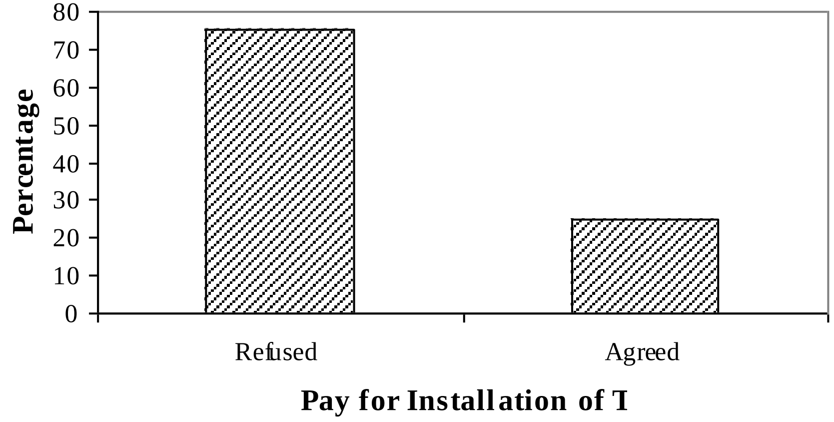


Fig (D-23): Reuse treated gray water option

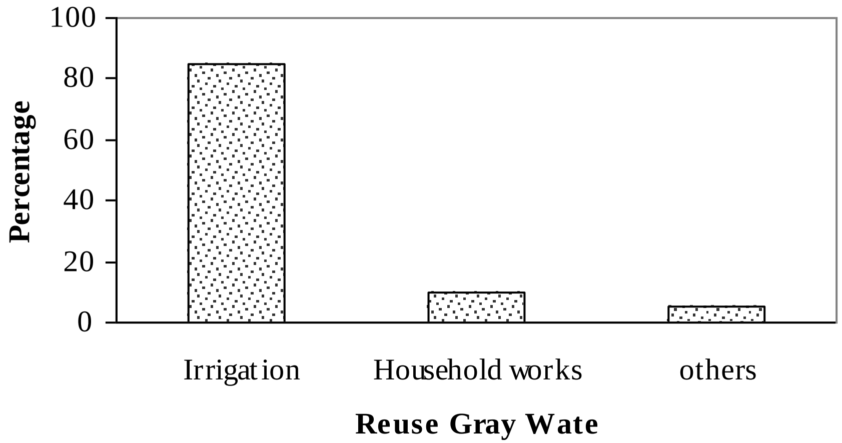
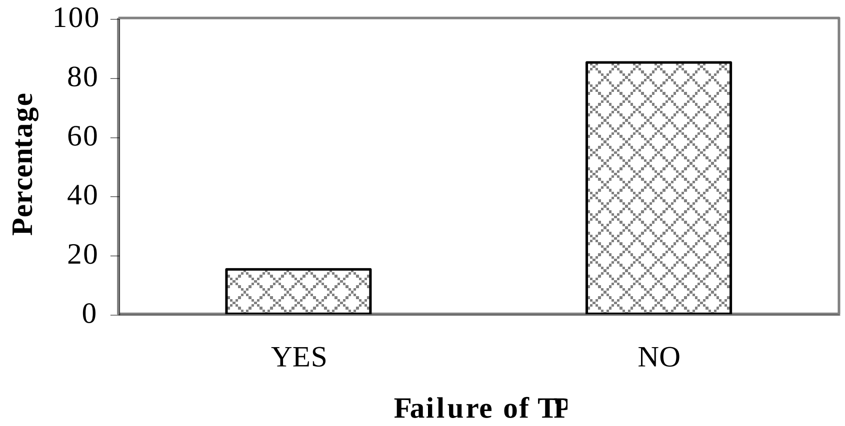


Fig (D-24): Failure of TP



الاســتمارة الخاصـــة بمشـــروع رســــالة الماجستيـــر

لدراسـة استدامة محطة التنقيـة المنزليـة للميـاه العـادمة وتقييـم الجوانب الفنيـة والاجتماعيـة والبيئيـة والماليـة لها في المنــاطق الريـفية الفلسطينية التـابعة لمدينـتي رام اللـــه والبيــرة

الجزء الأول: معلومات عامة

البلدة: ______________________

اسم صاحب البيت: ___________________________

تاريخ استيفاء الاستمارة:_______________

1. **معلومات حول أفراد الأسرة:**

1 .1 عدد أفراد الأسرة : _____________

عدد الإناث في العائلة: _____________

لمعلومات خاصة بأفراد الأسرة الأكثر من 18 سنة الرجاء تعبئة الجدول التالي:

البيانات الشخصية	(1)	(2)	(3)	(4)	(5)
العمر					
الجنس : ذكر / أنثى					
أعلى تحصيل علمي					
التخصص					
المهنة الرئيسية					

عدد أفراد الأسرة المدخنين: _____________________

1.5 معدل المصروف اليومي على الدخان: _____________ (شيكل جديد)

1.6 متوسط الدخل الشهري للأسرة: _________________ (شيكل جديد)

2. **معلومات حول المنزل:**

2.1 هل البيت

◇ *ملك* ◇ *مستأجر* ◇ *أخرى/حدد -------*

2.2 نوع السكن (شقة، بيت مستقل): _____________

2.3 عدد طوابق البيت:______________

2.4 عدد غرف البيت:________________

2.5 مساحة البيت: _____________ (م^2)

2.6 مساحة الارض حول المنزل: __________(م^2)

2.7 مساحة الارض المستغلة للزراعة: ____________(م^2)

2.8 عدد مرات ري الحديقة في الأسبوع: ____________

2.9 ما هو مصدر مياه ري الحديقة

- شبكة المياه (حنفية ، بربيج)
- بئر
- نبع
- المياه العادمة (مياه الجلي أو الغسيل)

2.10 معدل كمية المياه التي تستهلك لري الحديقة في الأسبوع الواحد: _______________ (متر مكعب)

2.11 يرجى ترتيب نوع النباتات التي تزرع في الحديقة حسب النموذج التالي:

نوع المحصول	الوحدة 1.عدد/ م^2	الكمية	الإنتاج	تصريف الإنتاج يباع منه / يستهلك بالكامل / يهدى منه	يستخدم أسمدة	يستخدم مبيدات

2.12 عدد السيارات: _____________

2.13 عدد مرات غسل السيارة في الأسبوع: _____________

2.14 أسلوب غسل السيارة (بالخرطوم، الدلو): _____________

2.15 كمية المياه المستهلكة في غسيل السيارة في الأسبوع:

2.16 يتم تصريف المياه المستخدمة في غسيل السيارة في:

- ☐ الحفرة الامتصاصية
- ☐ ساحة المنزل (الى الحديقة)
- ☐ الشارع العام
- ☐ غيره (حدد) ________

2.17 هل توجد بركة سباحة: _____________

2.18 أذا كانت الاجابة نعم فما هو حجمها: ___________ (متر مكعب)

2.19 ما هوعدد الحمامات في البيت:_____________

2.20 هل الحمام الموجود في المنزل (ضع اشارة (✓) أمام الاجابة الصحيحة):

☐ عربي ☐ إفرنجي ☐ عربي وإفرنجي

2.21 سعة النيجرة: ______________

2.22 هل النيجرة دعسة واحدة أو دعستين: ______________

2.23 هل يتم استعمال الابريق للحمام العربي: ______________

2.24 عدد المغاسل في البيت: ______________

2.25 أي من التالي متوفر في البيت: (ضع إشارة ✓)

- ▤ تلفزيون ملون ▤ ثلاجة
- ▤ تلفزيون غير ملون ▤ سخان شمسي
- ▤ فيديو ▤ صحن(ستلايت)
- ▤ غسالة ▤ كمبيوتر

2.26 نوع سخان الماء:(اتمور,بويلر): ___________________

2.27 نوع الغسالة(اوتوماتيك,نصف اوتوماتيك) : ___________________

2.28 معدل صرف الغسالة اليومي للماء: ____________ (متر مكعب)

3. **معلومات حول استهلاك المياه وتصريف المياه العادمة:**

3.1 هل البيت متصل بشبكة مياه الشرب:

△ نعم △ لا

3.2 ما هي الوسائل البديلة لشبكة المياه:

- ◈ بئر جمع (حدد حجمه: ______________(متر مكعب))
- ◈ نبع (حدد اسم النبع : ___________________ ، حدد كمية المياه المستهلكه منه : ______________(م^3))
- ◈ تنكات مياه(صهاريج):حدد حجمها:___________(م^3) ، العدد المستهلك منها في الأسبوع:________
- ◈ أخرى/حدد: ____________________
- ◈ لا يوجد وسائل بديلة

3.3 ماهي التكلفة الشهرية للمياه المستهلكة من المصادر المختلفة:

	المصدر	الكمية ($م^3$)	التكلفة الشهرية (ش.ج.)
.1			
.2			
.3			
.4			

3.4 مجموع كمية المياه المستهلكة في الشهر هي: ________________ (م3)

3.5 ما هو معدل تكلفة استهلاك المنزل للكهرباء في الشهر: ______________________(ش.ج.)

3.6 هل تعاني من مشكلة شح المياه في البلدة:

△ نعم △ لا

3.7 يتم التخلص من المياه العادمة عن طريق:

- شبكة مجاري
- حفرة امتصاصية (انتقل الى (3.9))
- أخرى/حدد________________

3.8 في حالة وجود شبكة مجاري عامة الرجاء الاجابة عن التالي (خاص بالمجلس المحلي أو البلدية):

3.8.1 ما هو تاريخ انشاء الشبكة:____________

3.8.2 ماهي تكلفة إنشاء الشبكة:_____________ (ش.ج.)

3.8.3 ما هو اجمالي طول الشبكة:_____________ (م)

3.8.4 تتراوح أقطار الانابيب في الشبكة ما بين: _________________(ملم)

3.8.5 نوع أقطار الأنابيب المستخدمة: _____________________

3.8.6 عدد (الاشخاص/البيوت) المستفيدين من الشبكة: ______________

3.9 ما هو حجم الحفرة المتصاصية: _____________ ($م^3$)

3.10 كم مرة في السنة يتم نضح الحفرة: _____________

3.11 ما هي تكلفة النضح للمرة الواحدة: ___________ (شيكل جديد)

3.12 في حالة وجود بئر جمع وحفرة امتصاصية فان المسافة بينهما:

- اقل من 50 متر
- 50 متر
- اكثر من 50 متر

3.13 ما هو موقع البئر بالنسبة الى الحفرة

- اخفض من الحفرة
- على نفس المستوى
- اعلى من الحفرة

3.14 أي من المشاكل التالية تعاني منها بسبب المياه العادمة(المجاري)

- روائح كريهة
- حشرات ضارة
- فئران وجرذان
- لا يوجد مشاكل

3.15 هل لديك استعداد لاستعمال المياه المعالجة لري المزروعات :(نعم ، لا)

3.16 ما اقتراحاتك حول تصريف المياه العادمة:

____

____

_

3.17 هل تفضل مجلس محلي / قروي / بلدي لادارة معالجة المياه العادمة المنزلية: ____________________

3.18 هل لديك الاستعداد للمساهمة في تكلفة الانشاء:

△ نعم △ لا

3.19 اذا كانت الاجابة نعم ماهي النسبة التي تستطيع المساهمة بها:

- أقل من 20 %
- (20 – 50)%
- (50 – 80)%
- 100%

3.20 إذا كانت إجابتك لا أرجو شرح الأسباب: _______________________________________

____

___

____

___

3.21 هل لديك الاستعداد للمساهة في دفع كلفة الصيانة والتشغيل السنوية للمحطة::

△ نعم △ لا

3.19 اذا كانت الاجابة نعم ماهي النسبة التي تستطيع المساهمة بها:

- أقل من 20 %
- (20 – 50)%
- (50 – 80)%
- 100%

3.20 إذا كانت إجابتك لا أرجو شرح الأسباب: ____

الجزء الثاني: الاستمارة الخاصة بمحطة المعالجة المستخدمة

1. نوع المحطة: ________________________________
2. تاريخ إنشاء المحطة: ______________________________
3. اسم المسؤول عن المحطة: ___________________________
4. عدد البيوت المشتركة في المحطة: ________________________
5. عدد الاشخاص المنتفعين من المحطة:___________________
6. هل هناك عزل ما بين المياه الرمادية والسوداء: ___________
7. تكلفة انشاء المحطة كاملاً:____________________ (ش.ج.)
8. صيانة الاجهزة:

الجزء					
تكرار العطل لكل جزء					
تكاليف الصيانة (ش ج)					
تكاليف إصلاح (ش ج)					

9. مقدار الطاقة المستهلكة هو

◇ ___________كيلو واط/أسبوع ◇ _____________لتر/أسبوع

10. المصروفات الشهرية على الطاقة المستخدمة في المحطة هي (شيكل جديد): __________________
11. ما هي تكلفة المعالجة الشهرية (للشخص/للمنزل): ___________________(ش.ج.)
12. كمية المياه العادمة الداخلة للمحطة (م3/ أسبوع): ________________________
13. كمية المياه المعالجة الخارجة من المحطة (م3/أسبوع): ____________________

14. سعة المحطة (م3/ أسبوع) : ______________________________

15. هل هناك حمأة تخرج من المحطة:

△ نعم △ لا

16. (إذا أجبت بنعم في السؤال السابق) فما هي كمية الحمأة الخارجة من المحطة(م3/ أسبوع):

____

17. طريقة التخلص من الحمأة:

◈ كسماد ◈ دفن ◈ حرق ◈ أخرى/حدد-------

18. يتم استعمال المياه المعالجة في (يمكن اختيار اكثر من إجابة)

◈ ري الحديقة ◈ أعمال التنظيف المنزلية ◈ أخرى/حدد-------

19. ما هي النسبة المستخدمة لأهم خيار (في حالة اختيار اكثر من إجابة في السؤال السابق)

- ⊙ ري الحديقة
- ⊙ أعمال التنظيف
- ⊙ أخرى

20. كمية المياه المستهلكة الشهرية (بعد تركيب المحطة) حسب آخر فاتورة (م3) : __________________

21. مساحة الارض المستغلة للزراعة (بعد تركيب المحطة): _______________ (م2)

22. الوضع الصحي:

- ⊙ افضل بعد المحطة
- ⊙ لا تغيير
- ⊙ كان افضل قبل المحطة

23. انتشار الحشرات والقوارض:

- ⊙ انخفضت بشكل واضح
- ⊙ انخفضت
- ⊙ لا تغيير
- ⊙ زادت

24. الرائحة

- ⊙ انخفضت بشكل واضح
- ⊙ انخفضت
- ⊙ لا تغيير
- ⊙ زادت

الخلاصة

تكنولوجيا تنقية المياه العادمة المنزلية وتطهيرها من الشوائب والملوثات حاز على اهتمام معظم دول ا لعالم والمؤسسات التي تعمل في مجال البيئة والمياه وذلك بسبب تنامي الطلب على مصادر المياه المحدودة . تم في هذا البحث دراسة مشكلة السكان في المناطق الريفية لمدينتي رام الله والبيرة غير الموصولين بشبكات صرف صحي، حيث يتخلص هؤلاء من المياه العادمة عن طريق الحفر الامتصاصية. إن هذه الحفر الامتصاصية تتسبب في تلويث المياه الجوفية والسطحية كما تسبب في كثير من الأحيان في تلويث مياه آبار جمع مياه الأمطار الموجودة في المنازل نتيجة تسرب المياه العادمة من الحفر الامتصاصية إلى هذه المياه. بعد فترة تطول أو تقصر تصبح هذه الحفر غير قادرة على تصريف كل المياه العادمة من خلال التربة أو الصخور المحيطة بالحفرة الامتصاصية وينتج عن ذلك مشكلة لا تقل صعوبة عن مشكلة التلوث، وهذه عائدة للتكاليف الباهظة لعملية النضح، وتشكل مشكلة صحية كبيرة حيث يتم في الغالب طرح هذه المياه المنضوحة في الوديان والأراضي الزراعية قرب القرية.

تعتبر النظرة الغير مركزية وسيلة جديدة لعنونة حاجات إدارة المياه العادمة في المناطق المتصلة والغير متصلة بنظام صرف صحي. إنّ الفكرة الأساسية من هذه النظرة هي أن تعالج المياه العادمة في الموقع بواسطة أنظمة المعالجة البسيطة، وبلتالي إعادة استخدامها . هذا البديل عن أنظمة شبكات الصرف الصحي أفضل ما يكون في المناطق الريفية حيث قضايا تصريف المجاري والمياه يصبحان أكثر فأكثر قضية مهمة لتنمية البناء التحتي . وإن معالجة المياه العادمة الرمادية في الموقع، خاصة القريبة من أماكن السكن، تتيح الاستفادة من هذه المياه في الزراعة المحدودة.

فهذا البحث يقدّم أدبيات التنمية المستديمة لتعريف القيمة ودور المعالجة في الموقع حيث إستمرارية أنظمة المعالجة وتقييمها يندرج تحت تشكيلة واسعة من المعايير التي ترتبط بالخصائص السكانية المتغيرة من قيم وعادات ومصادر بيئية. إن إطار الاستمرارية يقدذم لتمييز مجموعة معقولة من المعايير البيئية والسياسية والإقتصادية والإجتماعية لمعالجة المياه العادمة.

وقد تم تقييم إنظمة المعالجة التي من الممكن أن يتم تطبيقها في المناطق الريفية وذلك لإختيار النظام الأكثر ملاءمة، مع الأخذ بالحسبان الظروف البيئية والإقتصادية والإجتماعية للسكان في القرى المحيطة بمدينتي رام الله والبيرة . وسيتم استخدام برنامج (WAWTTAR) للمساعدة في إختيار التقنية مستنداً على المظاهر الإجتماعية والإقتصادية.