

**An-Najah National University**  
**Faculty of Graduate Studies**

**Appraisal of Socio-Economic and Cultural Factors  
Affecting Wastewater Reuse in the West Bank**

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بسم الله الرحمن الرحيم

"وقل اعملوا فسيرى الله عملكم ورسوله المؤمنون"

صدق الله العظيم

قرآن كريم

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**Dedicated to My Parents,**

**Wife, Daughters and Brothers**

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## **Abstract**

The reuse of treated wastewater offers opportunities of reducing demand on scarce potable water resources, especially within the semi-arid environment of the West Bank. The benefit of such additional supplies of water is further augmented by a reduction in the disposal of raw wastewater to the nearby wadis existing in the West Bank.

Importantly, social acceptance issues may pose a barrier to the effective use of this resource should the concept not be comprehensively presented. This research highlights the potential for reuse of wastewater, identifies the areas of concern, and examines the most important factors that affect the wastewater in the Palestinian Territories, particularly in the West Bank.

The research was conducted in the West Bank by applying questionnaires to different levels of the Palestinian community. The target groups were classified into four categories of different characteristics. The questionnaires included several questions which discuss several factors that may affect the concerns and hence the acceptance of the West Bank community. The most important factors that were taken into consideration are the social, religion, economic, health, political situation in the Palestinian Territories, scarce fresh water in the area in addition to the institutional situation related to water and wastewater sectors.

The questionnaires were collected and analyzed. Several factors were found to be interacted and affect the community opinion. Recommendations were given at the end of the study. It was generally

found that religion and traditions have negative effect of the acceptance to the wastewater reuse. In this context, the psychological factor has a negative effect on the opinion of the community. The public awareness is weak, the information provided to the community is not sufficient.

Most of the respondents accepted the reuse if this would provide them with additional water quantities. Acceptability of reusing treated effluent decrease by increasing the opportunity to be utilized in human contact purposes or in unrestricted agriculture.

People seem do not understand the religious opinion of the reuse. Most of the respondents of the four types considered the treated effluent unclean from a religious thinking.

# Chapter 1

## Introduction

### 1-1 General

With increasing global population, its living needs, and the qualitative and quantitative limitations in water resources availability, the gap between the water supply and demand is widening and is reaching such alarming levels. In some parts of the world these water gaps are posing a threat to human existence. This gap resulted in shortage of fresh water to be used in agricultural and other non-human purpose. As an example showing the severity of water scarcity in number, in China, a study conducted by the World Bank calculated an annual deficit of 37,000 MCM of water. Score of other countries are running up regional water deficits. A release of the United Nations predicted that a severe water shortage for about 2.7 billions people is expected to occur in the year 2025 (*Kertschmer, Ribbe and Gaese, 2003*). This includes nearly all of those in Central Asia, the Middle East, North Africa, India, and the United States (*Earth Policy Institute, 2002*). A rough estimate indicates that at least 20 million hectares in 50 countries are irrigated with raw or partially treated wastewater (*Hussain, I. Raschid, L. 2001*).

In Palestine, for example, the gap between demand and supply is expected to reach to 238 MCM in 2005, and to 341 MCM in 2010

*(PECDAR, 2001).*

Scientists around the world are working on new ways of conserving water and bridging the water gap. One of these ways is to recycle the wastewater and reuse the treated effluent. Several methods were tested in order to bring an effluent quality convenient for human use in different purposes such as in irrigation, industrial and other non-household

*purposes (Hussain, I. Raschid, L. 2002).*

In general, wastewater comprises liquid wastes generated by households, industry, commercial sources, as a result of daily usage, production and consumption activities.

Treated wastewater can be used for irrigation and other ecosystem services. Its reuse can deliver positive benefits to the farming community, society, and municipalities. Reuse of treated wastewater in agriculture or other purposes will replace a sizable volume of fresh water and save or divert them to other uses or sectors in need.

Wastewater reuse also causes negative effects on humans and ecological systems such as biological contamination, aesthetic problems, salt and solid build up in irrigated soils, which need to be identified and continuously assessed.

The disposal of wastewater is a major problem facing the municipalities, particularly in the case of metropolitan areas in undeveloped countries. The metropolitan areas are of limited spaces for land-based treatment and disposal. On the other hand, wastewater is also a supplementary water source that can be utilized in productive uses.

In both developed and developing countries, the most prevalent wastewater disposal practice is the land application of municipal wastewater (both treated and untreated) (*Hussain, I. Raschid, L. 2001*).

In developed countries where environmental standards are applied, much of the wastewater is treated prior to use for irrigation of fodder, fiber and seed crops and, to a limited extent, for the irrigation of orchards, vineyards, and other crops. Other important uses of wastewater include, recharge of groundwater, landscaping (golf courses, freeways, playgrounds, schoolyards and parks), industry, construction, dust control, wildlife habitat, improvement and aquaculture (*Hussain, I. Raschid, L. 2002*).

In developing countries, though standards are yet set, these are not always strictly adhered to. Wastewater, in its untreated form, is widely used for

agriculture and aquaculture and has been the practice for centuries in some countries (*Hussain, I. Raschid, L. 2002*).

Before one can endorse wastewater as a means of increasing water supply, thorough analysis must be taken from an economic perspective as well. Moreover, the social and ecological impacts of wastewater reuse need to be evaluated (*Hussain, I. Raschid, L. 2001*).

Many countries wish to increase fresh water supplies to domestic, and industrial usages, and at the same time, expand irrigated agriculture. In order to fulfill this demand, one specific component is to increasingly reuse domestic wastewater, for industry (*Kertschmer, Ribbe and Gaese, 2003*).

In Palestine, which is a semi arid country, has an average annual population growth at 3.2% (*PCPS, 1997*). It has one of the highest average population growth rates in the world. The increase in the water demand, the limited available water supply, possible contamination of ground water, uneven distribution of water resources between the Israelis and the Palestinians and the periodic droughts put the Palestinians on the track of searching for innovative sources of water supply. These resulted in very low per capita water availability. Palestinians in the West Bank and Gaza are currently using annually 246 MCM for their domestic, industrial and agricultural needs. Israel consumes 1959 MCM. The increase in demand due to population growth in Palestine is estimated at 300% (*Passia*). At present, the water consumption of the Palestinian population is approximately 55 l/c/d, 55% of the WHO minimum standards (*B.A.A.A. Zahra, 2000*).

Palestine should develop all of its conventional water resources in a carefully planned program. This program should be designed to achieve the maximum development of the country's agricultural potential. Accordingly, wastewater reuse as an additional source of water should be considered as an important component of the management of the Palestinian water resources. It can be considered as a reliable and sustainable water source, which will augment the natural resources.

### **1-2 Practices in the Middle East Region**

Countries in the Middle East region which practice wastewater treatment and reuse include Kuwait, Saudi Arabia, Oman, UAE and Egypt. However, only Israel and Tunisia, and to a certain extent, Jordan, already practice wastewater treatment and reuse as an integral component of their water management and environmental protection strategies. About eighty percent of Israel's wastewater is treated. In Tunisia, treated effluent with a total flow of 250 m<sup>3</sup> / d is used to irrigate about 4500 ha of orchards (citrus, grapes, olives, peaches, pears, apples, pomegranate), fodder, cotton, cereals, golf courses and lawns (*Farouki Naser, 1999*). In Jordan, all of the treated wastewater collected from the As-Samra treatment plant (serving greater Amman area) is blended with fresh water from the King Talal reservoir and used for unrestricted irrigation downstream in the Jordan Valley (*Farouki Naser, 1999*).

### **1-3 Problems**

The main problem with wastewater reuse is the threat to public health and soil and water if treated wastewater reuse is not done carefully. While the main impact on health in developing countries from wastewater reuse is from helminthic diseases, microbial pathogens are the second largest threat. The worst case situation is when untreated wastewater is used to

irrigate vegetables or salad crops eaten raw. This practice resulted in cholera outbreak in Amman in 1981 (*Farouki Naser, 1999*), and in Gaza in October and November 1994 (*PECDAR, 1994*).

In the West Bank, The Palestinian National Authority prohibits using raw wastewater in irrigation. However, there are many examples of this ongoing practice. For example, due to water scarcity, the irrigation of market vegetables such as eggplant and cucumber with raw wastewater flowing the Kedron Valley, West Bank (*Farouki Naser, 1999*). These raw wastewaters are generated and discharged from Bethlehem district the east side, which is a mix of industrial and domestic wastewater. This practice is also examined in Wadi Al Fara'a and part of the Jordan Valley. Components in wastewater highly impact crops include sodium, chloride, and boron (*Dayman, 2000*).

In addition, it has been reported by *PECDAR (1994)* that heavy metals including Chromium have been traced in the samples taken from Hebron and Bethlehem wastewater, but no values have been given. Both microbial pathogens and over the longer term, nitrates from wastewater can contaminate shallow aquifers such as the case of the GAZA Strip. In addition to the problems that are related to technical issues, there are other problems that are related to the social, religion, cultural, economic and public awareness. These problems are related with each other and affect on the public acceptance of the reuse of the treated wastewater. These issues are discussed thoroughly in the succeeding chapters, particularly in the methodology and hypothesis sections.

#### **1-4 Importance**

In the West Bank, wastewater generation and flow rates increased due to accelerating population growth and service area expansion. This increase

resulted in increasing the quantity of wastewater discharged outside urban areas with little or no treatment. This situation leads to environmental pollution and health hazards, particularly in the areas where raw wastewater is used for irrigation.

As a result of the second Intifada in Palestine which has started in September, 2000:

- Israeli brutal actions being practiced against the Palestinian people, demolishing human and physical infrastructure including water and wastewater works,
- Oslo Declaration is no more valid,
- Israeli colonies on Palestinian land are being rapidly spread using great amounts of the Palestinian water.

As a result, current access to freshwater only barely meets the domestic, industrial and agricultural demand in West Bank and water and wastewater services and infrastructure are in very bad shape.

The importance of this study lay in that (1) wastewater is an important supplementary water sources, and (2) the understanding, awareness, and attitude of the society in the West Bank about the various aspects of wastewater treatment and reuse in Palestine was not conducted, documented and/or disseminated before this study. This importance is specific due to the current political status and consequences on the subject matter.

The study will examine the most important factors that affect the acceptance of the reuse of treated wastewater by application of four types of questionnaires. It connects, for the main public groups, the different

factors of influence, such as social, religious and cultural, economic, political, institutional, health, technical and public awareness, and gives relations between these factors and the acceptance or non acceptance of the reuse.

This study can also be considered as an inception for further studies that examine one or more factors affecting the reuse. It will also provides detailed recommendations regarding the various elements and aspects of wastewater treatment and reuse in Palestine.

### **1-5 Objectives**

The purpose of this research is not to argue for or against the option of reusing treated wastewater—because the need to do so is already clearly apparent-, but rather to figure out and explore the opinions of the society in Palestine, especially in the West Bank through different levels and layers, regarding the wastewater treatment and reuse, in addition to examine the potential purposes for the reuse.

The main objective of the study is to explore the attitudes, preferences and perceptions upon which decision about acquiring and reusing the treated wastewater. It aims to determine the effects of social, economic, religious, political factors on this decision.

The followings are the other objectives of the study:

- 1) To determine whether the community in general is informed or not about the water reuse.
- 2) To determine whether the community believe that religion and social customs are against the reuse
- 3) To specify the most acceptable sector for reuse in the opinion of the community

- 4) To determine the most acceptable agency or authority for the community in order to be in charge of the management of the wastewater and treatment sector
- 5) To find out whether the community is willing to pay for the cost of reuse
- 6) To present several aspects of the influence of social, religious, political, economical and other related factors on public acceptance of water reuse.

### **1-6 Hypothesis**

The development of the wastewater and reuse schemes needs to include an understanding of social and cultural aspects of wastewater reuse. In order to do so, many factors proposed to affect the understanding of the community of the subject should be appraised and studied.

In this research, it is proposed that the community acceptance to the reuse issues will be affected by many factors. Some of these factors positively affect the opinion of the community and others are proposed to have negative effects. In addition to the acceptance, the attitude of the community toward the issue will also be affected.

The religion and the social aspects are very important to be addressed in any development in the wastewater reuse. There is a persistent notion within the West Bank that wastewater reuse is against the religion and social traditions and customs. It is proposed that people are prejudiced against the wastewater reuse from the religion and social point of view.

Taking into consideration the water scarcity in the West Bank, and the unrealized water rights by the Israelis, the economical and current

political situation in the Palestinian Territories has a crucial effect on the acceptance of the community to the reuse.

Health considerations should also be taken into consideration before implementing reuse. Many Amoebiasis and other symptoms related with raw wastewater reuse have been witnessed in the recorded in the West Bank; this will also affect acceptance to the reuse, especially amongst those who were infected.

Awareness about the wastewater treatment and reuse, will also affect the acceptance of the community. The age, level of education and the type of work may also affect the opinion regarding reuse.

The hypothesis and its findings are detailed in Table 5-1-3 and 5-2-2 in sections 5-1-9 and 5-2-9 respectively.

## **Chapter 2**

### **Methodology**

#### **2-1 Research Program**

To fulfill the objectives of the study, the following research activities were conducted:

- 1) Detailed field survey covering the main public groups of interest to wastewater management including treatment and reuse,
- 2) Four questionnaires were designed for the various target groups, the hypothesis was tested through two main groups of data: general and specific, and the sample size and distribution for the study area with its districts was estimated according to accredited methods,
- 3) The designed questionnaires were distributed, filled, collected, sorted, and documented. Descriptive statistics were performed on the data collected using SPSS.

#### **2-2 Field Survey**

The field survey has been conducted by applying questionnaires to different types and layers of people in the west Bank. The questionnaires mainly aim to assess the attitudes of the people toward water supply and wastewater treatment reuse.

### **2-2-1 Questionnaires Design**

The questionnaires have focused on some issues which are very common all over Palestine. The questions included took into consideration the characteristics of the inhabitants from different aspects, as well as the level of education and the position of the individual by whom the questionnaire was answered.

The questionnaires have focused on the following objectives:

- 1) Whether the community in general is informed or not about the wastewater reuse.
- 2) Do people seem to be prejudiced against the benefits of the wastewater reuse?
- 3) To determine the most important factors that make the Palestinians prejudiced against the wastewater treatment and reuse.
- 4) Do people favor water reuse to be applied in agriculture? And what kind of irrigation (direct or indirect contact) is acceptable to the Palestinians?
- 5) To determine the most acceptable institutions in order to be responsible for the management of water and wastewater sector.
- 6) To address the most important aspects of management in which the society prefer to participate.

- 7) To specify the most acceptable sectors for reuse of treated wastewater effluent.
- 8) To present the several aspects of influence of social factors on public acceptance of water reuse.
- 9) To find the relationship between the society characteristics and the acceptance or rejection to the reuse of the wastewater.
- 10) To discuss the effect of the political situation, particularly the unrealized Palestinian rights in using the natural resources, and the Israeli manipulation on the water resources and the effect of this on the acceptance of the reuse of the treated wastewater.

#### **2-2-1-1 Target Group**

To identify the target groups, the Palestinian society was explored. The characteristics of these groups were studied, they were aggregated in to four groups.

It was found that some individuals have a far greater level of interest in deciding up on the reuse of treated wastewater. These are persons who want to have an actual voice in the process. These individuals are often associated with “interest groups” such as a community or Ministry of Agriculture, Palestinian Agricultural Relief CommitteeG, Palestinian Water Authority (PWA), local government units, NGOs and in line ministries.

Others are associated with groups that have an even higher level of interest because they are more directly impacted by activities and policy

decisions. These “stakeholder” groups include the farmers, Agricultural committees, Agriculture industry. These would have direct impacts by the wastewater treatment and reuse

Some people have a less level of interest in wastewater reuse issues. This would include, but not be limited to the public people such as households. These individuals are not directly impacted by the wastewater treatment and reuse.

Others are considered as experts in the subject, they deal with the environment and several processes associated with the environment.

To identify the target groups, it is required to recognize and to proactively engage those types of people. It is also crucial that these groups are given the opportunity to engage in ways that take into consideration their interests and other ethnic and cultural differences (if any), and preferences.

To determine a specific target public, the following factors were taken into consideration:

- Self identification (those who have made their interest known)
- Proximity (those who live near or frequent a proposed feature, such as a proposed treatment plant or irrigation project)
- Mandate (agencies that have a similar authority or groups that have an interest in the reuse)

- Use (people who may use the treated effluent)
- Economics (those who might be affected by the reuse)

During the study, it was found that the interest groups and individuals can be classified into the following interest groups (layers)

- Farmers: those individual who work in agriculture, and there income depend on agriculture. These farmers have good experience in agriculture, and growing different types of crops.
- Public: the individuals who work in any career but not in agricultural sector and do not have technical experience in the wastewater and the reuse. This layer includes different ages, sex and level of education.
- The experts: Those (particularly engineers) who work in the water and wastewater sector. The experts were chosen among the engineers who have technical experience in the wastewater and treatment subject.
- The Institutions: This layer includes the individuals who are considered as key persons and decision makers amongst the Palestinians.

This layer includes the individual who work in some known related agencies such as the World Bank, Welfare Association (WAC), PECDAR, Palestinian Water Authority (PWA), UNDP, KARE, Save the Children, Palestinian Hydrology Group, the Universities, Municipality Mayors, and in line ministries like Ministry of Agriculture (MOA), Ministry of Local Government (MOLG), and Ministry of Planning (MOP).

### 2-2-1-2 Testing the Hypothesis

Before starting the analyses of the questionnaires, the proposed factors that affect the reuse of wastewater in Palestine were related to the questions in line with the subject. These factors are summarized as follow:

- **Social Factor:** The West Bank society is considered a highly adhered to the social traditions and customs. These traditions and customs control many aspects of life in the West Bank. In the questionnaires, some questions take into consideration some social aspects that are proposed to affect the acceptance or non acceptance of the reuse of treated wastewater. The proposed hypothesis is that the application of wastewater reuse has the potential to be confronted by the society of the West Bank from the social and moral point of view.

In this context, the social factor can be defined as the concerns or doubts expressed by the public about their perceptions on wastewater reuse.

- **Religious and cultural factor:** Given that Islam, like other religions, places on cleanliness. There is a persistent notion within the West Bank society that wastewater reuse is against Islam. However, the council of Leading Islamic Scholars of Saudi Arabia issued a special fatwa “to regulate the rules of treated effluents for different purposes. Wastewater reuse was made permissible for all purposes, including (wadu), provided that the wastewater was treated to the required level of purity for its intended use and did not result in any adverse public health effect (*Farouki Naser, 1999*).

The religion was taken into consideration as one of the important factors that is proposed to affect the acceptance of the wastewater reuse. The

society understanding of the religion judgment on the issue is the most important. Although the religion allows the reuse of the wastewater under conditions, the society might not be aware of this rule. Accordingly, people seem to be prejudiced against wastewater reuse.

- **Economic Factor:** The financial situation of the individual, and the economic situation of the society have an obvious effect on the acceptance of the reuse of treated wastewater. In the hypothesis, it is assumed that the lower the income of the individual, the higher the tendency for the acceptance of the reuse. This proposition is rationale, since most of the people believe that the process of the reuse will augment natural water resources, which will be preserved for the essential purposes, and hence the water prices will be decreased accordingly.

- **Political Factor:** Despite that the overall recharge area of the mountainous aquifers lie to 78% in the West Bank (*Christine S. et al. 1996*), the Israelis exploit some 80% of the aquifers and some 75% of the Jordan River. Israel controls the water natural resources by occupation and military forces. During the current situation, the water and wastewater sectors were imposed to enormous damages occurred during the incursions of the West Bank. In addition to that, Israel hindered and stopped most of the development schemes related to these sectors, such as digging of new or even rehabilitation of existing old wells and installation of water and irrigation networks. Enormous damages occurred to the irrigation systems particularly in Qalqilia, Tulkarem and Jenin districts due to the construction of the Apartheid Separation Wall on the most fertile lands of these districts.

These have affected the way of thinking of farmers and other individuals.

The proposition is that although some of the individuals may refuse the principle of wastewater treatment and reuse of the effluent, in order to augment the shortage of water. But, at the same time the principle may be accepted by others, since they know that this future resource of water is essential to supplement other natural resources, particularly to augment non-human water purposes.

The political situation and the behavior of Israel toward the Palestinian water rights, might make the priority of the Palestinians to practice their rights in utilizing and developing natural water resources, not to thing about reusing their wastewater.

- Health Factor: The main problem with the reuse of wastewater is the threat to public health, the soil and water if reuse is not done carefully. In developing countries, the main impact on health from reuse is from diseases caused by helminth, such as roundworm, hookworm and guinea worm microbial pathogens pose the second largest threat (*Farouki Naser, 1999*). The worst case situation occurs when untreated wastewater is used to irrigate eaten raw vegetables or salad crops. Unfortunately, although Ministry of Health prohibited the irrigation with raw wastewater, there are many on going instances of raw wastewater reuse which result in occasional gastrointestinal illness, and have the potential for causing widespread illness. These practices have been examined in many areas of the West Bank like Wadi Kedron, near Bethlehem. In addition to helminth and pathogens, the wastewater dischargers to Wadi Kedron contain other components that are most toxic such as chloride and boron (*Farouki Naser, 1999*).

Given the high costs of the wastewater treatment to zero risk level, prior to reuse for crop irrigation, treatment to this level may not be justified on economic, social or political grounds. Nevertheless, valuation of public health risk should be an important decision variable in wastewater irrigation policy analyses.

Many cases of Amoebiasis and Ascariasis were witnessed within some districts in the West Bank. The proposition is to connect the areas which witnessed these cases with irrigation practices of raw wastewater in those districts. On the other hand, it is proposed that the family health may affect the decision on the reuse, those who suffered from Amoebiasis and Ascariasis may not accept the reuse practices even for highly level of treatment.

- **Technical and water supply Factors:** The technical and water supply factors consist of the situation of natural water supplies, the capability to treat wastewater and the potential to reuse the effluent for irrigation. These factors take into consideration the groundwater, type of irrigation, and the most acceptable sector the treated wastewater should be applied to. The groundwater is taken into account since the reuse of treated wastewater will benefit the ground water either by augmenting the natural resources, or by decreasing the contamination levels.

The situation of the water and wastewater networks and other facilities is considered another technical factor, in addition to the quantities of potable waters.

- **Public Awareness factor:** The public awareness has a major effect on the acceptance and rejection of the reuse of the treated wastewater. Given

that the traditions and customs are prejudiced against the reuse, then if the public are not informed properly about treatment and reuse, they may reject the process. This factor is highly related to the social and religious factors. The public should be informed about wastewater treatment and reuse by the available mass media and newspapers. The public should be informed about the advantages, disadvantages and potential risks of the reuse. The mass media must make discussions and seminars with religious references, illustrating the religious outlook about the reuse. In addition, decisions issued by other Islamic countries must be published and discussed with interest group.

On the other hand, the academic institutes and schools must include courses about the environment, this helps enhance awareness among young people.

- **Institutional Factor:** Since water is an essential good for the society, the central functions of water resources management and planning are in the hands of public institutions. Recently, the Palestinian Water Authority (PWA) has developed according to the requirements of the by-law No. 2. The PNA has entered into agreement with Norwegian government regarding the development of the water sector, which was signed in February, 1996. This agreement provides extensive financial and professional assistance to the PWA until 1999. Although the mandate of the PWA is to have full supervision over all Palestinian water institutions, some municipalities have their own separate system.

In discussing the Institutional topic, the opinion of the public is taken into consideration about the best institution (authority) that must take the

responsibility of the management and administration of the water and wastewater sector.

Tables 2.1, 2.2, 2.3 and 2.4 summarize the above factors with related questions for each type of questionnaire.

Table 2.1: Factors taken into consideration by (Type I) Public questionnaire

<b>Factor</b>	<b>Related questions</b>	<b>Parameter</b>
Social	1,2,5,6,7,14,15,16,18,28,30,31,33,34,46,64,	S
Religious and cultural	3,35,36,37	C
Economic	4,8,10,13,41A,42,61	E
Political	49,60	P
Health	17,21,22,23,32	H
Technical and water supply	9,11,12,26,27,50,51,52,53,54,55,59,62,63	T
Public Awareness and participation	43,44,45,67,68,46,47	A
Institutional	56,58,69,70,71	G
Socio-economic	19,20,24,25,28,39A,39B,41B,41C,47	SE

Table 2.2: Factors taken into consideration by (Type II) Farmer questionnaire

<b>Factor</b>	<b>Related questions</b>	<b>Parameter</b>
Social	1,2,5,6,7,14,15,16,18,28,30,31,33,34,46,64,	S
Religious and cultural	3,35,36,37	C
Economic	4,8,10,13,41A,42,61	E
Political	49,60	P
Health	17,21,22,23,32	H
Technical and water supply and agriculture	9,11,12,26,27,50,51,52,53,54,55,59,62,63,72,73,74,75,76,77,78,79	T
Public Awareness and participation	43,44,45,67,68,46,47	A
Institutional	56,58,69,70,71	G
Socio-economic	19,20,24,25,28,39A,39B,41B,41C,47	SE

Table 2.3: Factors taken into consideration by (Type III) Institutions questionnaire

<b>Factor</b>	<b>Related questions</b>	<b>Parameter</b>
Social	1,2,5,6,7,14,15,16,18,28,35 ,40B,40C	S
Religious and cultural	3,33,34,36,37	C
Economic	4,8,10,13,38,39A,39B,40A,51	E
Political	44,45,46,71,72	P
Health	17,21,22,23,29,30,31,32,73	H
Technical and water supply	9,11,12,26,27,47,48,,49,50,51,52,53,54, 59,60,61,62,63,64,66,68,70	T
Public Awareness and participation	55,56,57,58,75,76	A
Institutional	65,67,69,74,77,78,79	G
Socio-economic	19,20,24,25,28,39A,39B,40B,40C	SE

Table 2.4: Factors taken into consideration by (Type IV) Experts questionnaire

<b>Factor</b>	<b>Related questions</b>	<b>Parameter</b>
Social	1,2,5,6,7,14,15,16,18,28,35 ,40B,40C	S
Religious and cultural	3,33,34,36,37	C
Economic	4,8,10,13,38,39A,39B,40A,51	E
Political	44,45,46,71,72	P
Health	17,21,22,23,29,30,31,32,73	H
Technical and water supply	9,11,12,26,27,47,48,,49,50,51,52,53,54, 59,60,61,62,63,64,66,68,70	T
Public Awareness and participation	55,56,57,58,75,76	A
Institutional	65,67,69,74,77,78,79	G
Socio-economic	19,20,24,25,28,39A,39B,40B,40C	SE

### 2-2-1-3 Sample Size and Distribution

The questionnaires based survey was applied to 554 individuals in seven districts of the West Bank. The following are the districts ordered according to its geographical location from the south to the north of the West Bank (See map on the following page)

- Hebron & Bethlehem (Hebron city, Dura, Halhoul, Bet Ummer, Bet Ta'amer, Al Fawwar Camp)
- Jerusalem (Al Ram, Jerusalem, Anata, Qlandia)
- Ramallah (Ramallah, Singel, Turmos Aya, Ain Sinya, Bet Rima, Der Aghassaneh, Der Qiddees)

- Salfeet (Salfeet, Hares, Kuful Hares)
- Nablus (Nablus, Hiwwara, Awarta, Bureen, Madama, Rujeeb, Rujeeb Employees Housing, Blata Camp)
- Jenin & Tubas (Jenin, Jenin Camp, Tubas, Tammoun, Anza, Al Seelet Al Harithiyyeh, Al Yamoun)
- Qalqilia & Tulkarem ( Qalqilia, Tulkarem, Asleh, Der El Ghsoun, Azzoun, Bala'a, Anabta, Bet Leed)

The sampling procedure, or experimental design, affects the quantity of information per measurement. This procedure and the sample size  $n$  control the total amount of relevant information in a sample.

In our research, we were concerned with the simplest sampling situation, random sampling from a relatively large population, and focused our attention on the selection of the sample size  $n$  (Walpole, R. Mayers, R, 1985).

The Central Limit theorem states that "If random sample of  $n$  observations are drawn from a population with finite mean  $\mu$  and standard deviation  $\sigma/\sqrt{n}$ . The approximation will become more and more accurate as  $n$  becomes larger and larger".

The Central Limit Theorem can be restated to apply the sum of the sample measurements  $\sum y_i$ , which also tends to have a normal sampling distribution with mean equal to  $n\mu$  and standard deviation  $\sigma/\sqrt{n}$ , as  $n$  becomes larger.

If the population distribution is non normal, the sampling distribution of  $Y$  will be for larger samples, approximately normally distributed (by the central Limit Theorem). This means that the sampling distributions of  $Y$

will be approximately normal for sample sizes as small as  $n = 25$  for most populations of measurements. However, our samples number is greater than 25, so the Central Limit Theorem is valid, the distribution of these samples is assumed to be normal (*Walpole, R. Mayers, R, 1985*).

In order to make our sampling procedure representative, the following statistical procedure was followed:

- 1) The bound on the error of estimation ( $\beta$ ) was chosen, its value was assumed  $\pm.06$
- 2) The confidence coefficient ( $1-\alpha$ ) was chosen, the value of  $\alpha$  was assumed .05
- 3) The confidence level ( $1-\alpha$ ) was calculated to be .95
- 4) From the normal distribution tables,  $z\alpha/2 = 1.964$
- 5) Define  $\sigma p = \sqrt{(P*q/n)}$ , (4-1)
- 6) The formulae will be  $\beta = 1.964*\sqrt{(P*q/n)}$  (4-2)

Where,  $q$  is the probability to choose one answer of the multiple choice questions. Since we have five choices, then  $q$  will be equal 0.2.

$P = 1 - q$ , and is equal 0.8 in our case.

$\sqrt{\quad}$  is the square root

Solving for n, the required number of samples is 170.

However, since four types of questionnaires are used in the research, about 554 questionnaires of different types have been collected and analyzed.

The following calculations are presented here to give the bound error for each type of questionnaire at a confidence error of 95%:

- 1) For the public type questionnaires, 187 samples were collected and analyzed:

From formula (4-2),  $\beta = 1.964 \cdot \sqrt{(P \cdot q/n)}$

$\beta = 1.964 \cdot \sqrt{(0.2 \cdot 0.8/187)} = 0.057$ . This means that an error of  $\pm 0.057$  may occur at a confidence level of 95% in the answers of the multiple choice questions of the public questionnaires.

The same procedure was used for the other types of questionnaires and the following results were found

- 2) Farmers type questionnaires, 168 samples were collected and analyzed:

From formula (4-2),  $\beta = 1.964 \cdot \sqrt{(0.2 \cdot 0.8/168)} = 0.061$ . This means that an error of  $\pm 0.061$  may occur at a confidence level of 95% in the answers of the multiple choice questions of the farmers questionnaires.

- 3) Institutes type questionnaires, 127 samples were collected and analyzed:

From formula (4-2),  $\beta = 1.964 * \sqrt{(0.2 * 0.8 / 127)} = 0.07$ . This means that an error of  $\pm 0.07$  may occur at a confidence level of 95% in the answers of the multiple choice questions of the institutes questionnaires.

4) Experts type questionnaires, 72 samples were collected and analyzed: From formula (4-2),  $\beta = 1.964 * \sqrt{(0.2 * 0.8 / 72)} = 0.092$ . This means that an error of  $\pm 0.092$  may occur at a confidence level of 95% in the answers of the multiple choice questions of the experts questionnaires.

The sampling method used, allows the data to be considered representative of the different targeted groups in the West Bank. Confidence level assumed is 95% to within  $\pm 0.057$ ,  $\pm 0.061$ ,  $\pm 0.07$ ,  $\pm 0.092$  percentage points of error for the public, farmers, experts and institutes questionnaires respectively.

#### **2-2-1-4 Questionnaire Procedure**

To meet the above objectives, questionnaires were applied to the West Bank society. In order to cover the four types of target groups effectively, the questionnaire were divided into four types. Each type of the questionnaires has targeted one of the four interest groups as follow

- Type I; Public questionnaire (layer 1): It was applied to the public people and households. This includes those who live inside cities, villages, refugee camps and other locations.
- Type II; Farmers questionnaire (layer 2): It was applied to the agriculture related individuals and communities, such as farmers, agriculture relief and other communities related to agriculture.

- Type III; Experts questionnaire (layer 3): It was applied to the expert persons who are specialized in water, water resources, water management, wastewater treatment and reuse, and other environmental related subjects.
- Type IV; institutions questionnaire (layer 4): was applied to the officials, including elected and designated individuals, interested NGOs and other entities concerned in the subject.

The four type questionnaires discuss different topics in a simple procedure. These topics contain simple related questions concerning subjects in line with wastewater treatment and reuse. The questionnaires were divided into different topics of interest. Each topic consists of a group of simple related questions.

The following are the most common subjects that have been handled by the four types of questionnaires

- Section A, General Information: This section contains information about the district, type of location (city, village, camp or housing complex), gender, age, marital state, religion, information about the work, education level, residency and accommodation, information about water consumption, method of water supply, method of wastewater collection (if any), methods of solid waste collection, income, information about the family and family size.
- Section B&D, luxury aspects: it contains questions about the car and home gardens. Whether the individual use hose to wash his car. Whether water available is sufficient for home yards irrigation and car washing.

- Section C, family health status: this section contains questions about the Diarrhoea cases within the family, Amoebiasis and Ascariasis cases. These symptoms are related to environmental health aspects.
- Section E, public health aspects: it contains questions about water quality, water shortage and its effect on health, and the effect of water and wastewater services on the migration to better serviced places.
- Section F, religion and social aspects: the section contains questions related to Islam as a main religion in the West Bank. It contains questions which are used as a means to measure the adherence of the individual to the religion and social customs and traditions. From this section, it can be determined if the society is prejudiced against the wastewater treatment and reuse from the religious point of view. Also it can be determined whether people believe that the reuse of treated wastewater is acceptable by the religion and social traditions or not.
- Section G, Economic and financial Aspects: The section contains questions used as a means to determine whether the water price is considered a burden. The section also helps find out whether the society is willing to participate financially in the development of water and wastewater sectors. The effects of the economic and financial situation of the individual toward the willingness to pay the cost of treated water.
- Section H (Public &Farmers), Section K (Experts &Institutions), Public awareness: discuss the growing awareness of water resource scarcity in Palestine, the competition of water resources and the

negative impact of contaminated water on human health and the environment demand and the development of adequate strategies in water management. The sections also discuss the awareness of the society of wastewater treatment and reuse, and whether the information provided by the mass media is sufficient.

- Section I (Public &Farmers), section L (Experts &Institutions), Public and social participation: the willingness activation of the individuals and local communities to participate in the development of a new resource management system. The willingness to privatize the water and wastewater sector.
- Section J (Public &Farmers), section M (Public &Farmers), water and wastewater technical aspects: the section talks about the types of reuse, particularly in agricultural sector. What type of irrigation is preferred. Whether the experts in the West Bank have any criticism against some of the international standards.
- Section K (Public &Farmers), section N (Expert &Institutions), water situation: the section discusses the situation of water resource, the future of water in Palestine, the effect of the reuse on ground water situation, and whether the natural water resources are available for different purposes.
- Section T (Experts &Institutions), political Aspects: This section discuss the political situation in the West Bank and its effect on the acceptance of people, particularly the experts and institutional levels. These aspects are discussed explicitly in the experts and institutional questionnaires level, and implicitly in the farmers and public questionnaires level.

- Section L (Public & Farmers), section M (Expert & Institutions), Wrong practices: This section debates the use of raw wastewater in the irrigation in some area of the West Bank.
- Section M (Public & Farmers), section N (Experts & Institutes): The opinion of the society must be explored before the implementation of any wastewater treatment and reuse scheme. The section discusses the aspects that should be taken into consideration when the society is explored about this issue.
- Section N (Public & Farmers), section Q (Experts & Institutes):
- Section O (Farmers), Agriculture: This section discusses types of crops and irrigation resources, and what are the main factors that adversely affect the agricultural sector.

### **2-2-2 Data and Data Analysis**

Questionnaires have been applied to about 554 persons; 168 were applied to the farmers, 187 applied to the public (households and citizens), and 72 to experts in the subject. 127 questionnaires were applied to the different institutions, NGOs, donors, related entities and in line ministries. The questionnaires were collected and analyzed using SPSS 11.5 software.

Descriptive analysis have been conducted to the questions. The answers of the question were divided into three categories; first category is those who agree upon the question, they are the individuals who answer with either Strongly Agree or Agree (merely) or Fairly agree (Fair); second

category is those who answer with Reject; the third is for those who have No Opinion.

Frequency tables have been produced for each question showing the frequency and percentages of each answer for each question. These tables are included in the Annexes for each type of questionnaires. For the conclusions of hypothesis in section 5-1-9 and 5-2-9, the necessary tables and figures are included in Chapter 5.

Histograms and bar charts have been constructed for some of the important results. These graphs are included in the Annexes for each type of questionnaires. The histograms and bar charts for hypothesis conclusions are included in Chapter5.

Cross tables were constructed in order to relate two or more factors. To determine the decision of a specific group toward a specific aspect, cross tables (crosstab) were constructed, and cluster histograms and bar charts were also constructed. These (crosstabs) are included in the Appendixes. For the hypothesis testing, they are included in Chapter5.

### **2-2-3 Difficulties Faced During Field Survey Implementation**

The field survey was conducted in September beginning of October, 2003.

During this survey, the researcher conducted many interviews with different types of people. Those interviews enabled the researcher to explore some opinions directly. At the same time, many difficulties and obstacles were faced. These difficulties and obstacles hindered and even some times stopped the survey. The most tough difficulties are summarized as follow

- 1) The Israeli closures and sanctions strictly imposed on different areas of the West Bank. These measures stopped the survey in many occasions, this delayed the distribution of questionnaire in different districts like Hebron, Qalqilia, Jenin and Salfet areas. Some times the researcher could not reach the destination. Due to these measures, transportation from an area to another was very difficult and sometimes it was dangerous.
- 2) Some of the individuals were not interested in filling the questionnaire. The researcher had to skip those persons and to find others. This was faced particularly with the Public Type Questionnaires.
- 3) Some of the individuals did not find half an hour to fill the Questionnaire. This problem was encountered with the Institutes Type Questionnaires.
- 4) About 731 questionnaires were distributed, the researcher collected only 589 questionnaires, and skipped 35 questionnaires because it were not filled properly. The final number of representative questionnaires was as mentioned 554 questionnaires.
- 5) The researcher was many times forced to explain the meaning of treatment and reuse. A significant number of the public and farmers do not know the process.
- 6) The most tedious job was to collect the questionnaires, then to empty the answers in excel files. This job took a long time, more than a month.

7) How to represent the output results? This was the dilemma. A very large output was produced; too many tables and graphs. Too many relations can be thought of. How to relate the variables and factors? ...etc.

Finally those obstacles were confronted, and the research is completed.

## Chapter 3

### Background

#### 3-1 General Background

Wastewater reuse is not a recent invention. There are indicators that wastewater was used back for irrigation in ancient Greece and to the Minan civilization (ca. 3000 – 1000 BC) (*Angelakis et al., 1999; Asano and Levin, 1996*).

Seventy percent of world water use, including all the water diverted from rivers and pumped from underground, is used for irrigation, 20 percent is used by industry, and 10 percent goes to residences (*Kertschmer, Ribbe, Gaeste, 1996*).

During 1950-60, interest in applying wastewater on land in the western hemisphere as wastewater treatment technology advanced and quality of treated effluents steadfastly improved. Land application became a cost-effective alternative of discharging effluent into surface water bodies (*Asano, T. 1998*).

Recently, the use of wastewater in what was called “sewage farming” was started in Australia, France, Germany, India, the United Kingdom and the USA in the later 19<sup>th</sup> century (*WHO, 1989*). More recently wastewater reclamation and reuse projects and schemes have been considered and implemented not only by countries with chronic water shortage, but also urban areas in temperate climates as a matter of necessity to meet growing water needs (*Metcalf & Eddy, 1991*)

In Palestine, it has been concluded by several studies that handle the wastewater disposal and treatment strategies and the water supply management that it is an important element to establish and construct wastewater treatment plants and to reuse its treated wastewater for irrigation. This will result in shifting fresh water resources to domestic use and in helping solve the problems of waste contamination and disposal (*Haddad, M. 1993*).

### **3-2 Possibilities of reuse**

(Kretshmer, Ribbe and Gaese, 1996) concluded that are two major types of reuse have been developed and practiced throughout the world. The first use is the potable use, which include the direct use of reclaimed water to augment drinking water supply following high levels of treatment, and the indirect use after passing the natural environment. The second type of reuses is the non-potable uses. This includes agriculture, irrigation of parks and forestry, aquaculture, aquifer recharge and industry.

Concerning the reuse in the agriculture, (*Shelef, 1991*) classified the irrigation of agricultural crops by the treated wastewater into four categories according to the requirement of purity. Each category was given an alphabet such that the first ordered alphabet denotes to least treatment requirements, and the second higher requirements, and so forth. For each type of agriculture, (*Shelef, 1991*) specified criteria to be used as characteristics of the treated effluent intended to be used in the irrigation of the crop which is included in the classification

Table 3.1 illustrates Shelef criteria for the treated effluent depending on type of irrigation

Table 3.1: Quality Criteria of Treated Wastewater Effluent to be reused for Agricultural Irrigation

Group of crops	A	B	C	D
Principal Crops	Cotton, sugar, beet, cereals, dry fodder seeds, forest irrigation	Green fodder, olives, peanuts, citrus, bananas, almonds, nuts	Deciduous fruits, conserved vegetables, cooked and peeled vegetables, green belts, football fields and golf courses	Unrestricted crops, including vegetables eaten uncooked (raw), parks and lawns

Quoted from (*Shelef, 1991*)

(*Idelovitch, RingskogK, 1997 and Shelef, 1996*) explained the distinction between restricted and unrestricted irrigation depending on the kind of crop 1) Restricted irrigation which uses the low quality effluents in limited areas and specific crops. This type of irrigation is simple and low cost, and applied to small amounts of wastewater to crops that are well defined and unlikely to change. The farmers must be trained to handle the low-quality effluent (Non-contact uses).

2) Unrestricted irrigation which requires the use of high quality effluents, instead of freshwater. It is used to irrigate any crop on any type of soil, without limitations. Contact uses or even accidental drinking do not pose health risks. It can be applied to vegetables eaten raw without any restriction.

Regarding industrial reuse, treated wastewater can be used in different industries in the West Bank. Some of these industries are quarrying, stone cutting, ready mix concrete, leather tanning, soap factories and others.

### 3-3 Public Acceptance

The psychological factor is essential for initiating, and implementing of wastewater treatment and reuse scheme. Therefore the development of wastewater and reuse schemes needs to include an understanding of the social and cultural aspects of wastewater reuse. In absence of social support, a reuse project may fail. Even for non-potable reuse purposes, the public attitude plays an important role, including the perception of water quality, willingness to pay or to accept any wastewater reuse project (*Lazarova, V. 2000*).

By working on the public as well as on the institutional acceptance, one has also to keep in mind that wastewater reuse is a supplemental water supply in water scarce regions such as West Bank, and can be alternative to the disposal of treated effluents in the nearby wadis.

Related to public acceptance and health issues a risk assessment should be part of the planning process. For example a careful assessment of the extent of potential health risks involved in wastewater reuse for irrigation is necessary. The extent of risks then might be weighted against urgency and derived benefits of the water reuse in order to make a sound decision on the project (*Shahalam, et al., 1989*).

As an example of widespread public relation work associated with water reuse or recycling is shown. The “Queensland water recycling strategy” serves as an example (*Queensland Government, 2001*). This strategy was initiated from the department of Natural Resources (DNR) in Australia and is managed from the EPA to increase the beneficial use of a largely untapped resource. The reports, which range from educational needs, agricultural water recycling, urban water recycling, health effects and legislative considerations were all published (the last in 2001) with the goal to reach all people involved in water management issues, to promote the possibilities of water recycling in all sectors and give governmental support by planning and implementation.

#### **3-4 Socio-Economic Considerations in the study area**

During the current crisis, and due to the Israeli measures of closing the territories, incursions and dividing the West Bank into cantons, the unemployment rate has reached a tremendous level. The unemployment percentage in the west Bank was recorded to be 66% in the year 2000 (*World Bank Report*). This issue wrecked the Palestinian economy with the result of a lower income and a lower ability of the Palestinian people to pay their water bills. This started in the first Intifada and continued at a larger scale during the current crisis.

During the incursions to the West Bank cities and villages which started in April 2002, and in addition to the high unemployment rates due to the sanctions imposed on the territories, and to the high mortality due to Israeli abnormal violence against the Palestinians, very large damages to the infrastructure resulted from these incursions, these damages were assessed and estimated about \$526,000,000. Of which about \$62,345,000

is the estimated damage in the water sector, and about \$76,464,000 in the sewage and sanitation sector (*PECDAR & IMG, 2003*).

The other major issue which will affect the socio-economic aspects of the Palestinians is the building of the Apartheid Separation Wall by the Israeli government. (*PECDAR, 2003*) reported that in addition to the confiscation of thousands of hectares of the most fertile lands in the west Bank and expropriation of water wells, about 12,000 Palestinians living in 15 different villages will be jailed behind the wall and will lose their livelihoods. Almost 200,000 Palestinians will be adversely affected by this wall, which will increase the unemployment to even higher rates than those recorded in the year 2002. About 30,000 Palestinians have already lost their livelihood because their lands and farms are behind the Wall. The agricultural sector will be the most adversely affected sector by this wall, according to PECDAR report about 40% of the agricultural fertile lands are either destroyed or expropriated or kept behind the wall.

The value of damages caused by the construction of the first stage of the Separation Wall is estimated at about \$37,000,000 (*PECDAR, 2003*). This figure does not include the value of confiscated lands, wells and does not include the damages in the villages behind the wall.

These Issues force the Palestinians to confront the resulting water shortage and to think about other water resources to be used as supplements to the conventional resources, although it is the legal Palestinian rights to obtain their demands from their natural water resources.

### **3-5 Political Considerations**

Palestinian Territories had been ruled under several political administrations in the past 500 years starting from Turkish and ending with the Israeli occupation. The water regulations in Palestine were always interpreted for the benefit of the occupiers.

During the Turkish State, the Turkish laws prevailed which was relayed on the Islamic Water law, which states that water must be available to all members of the Islamic community and is prohibited to be sold.

In the 1930's, the British mandate was introduced which was changed several times. Between 1952 and 1967, the Jordanian laws were reflected in the West Bank, although the British prevailed in Gaza.

The changing laws can be summarized as follow:

- The ownership of the resources was related to the ownership of land
- the setting of regulations for distribution were delegated to regional and local authorities
- Standards regarding quantity and quality were not specified
- there were no legal guidelines or court responsible for water conflicts and problems disputes
- sewage disposal and pollution management were delegated to local authorities, but no references about the reuse of water. (*Issa, Bruijne, 1995*)

After the Israeli occupation of the West Bank in 1967, The water resource were ruled by military authority. All surface water and ground water resources became property of the state of Israel. The 1959 Israeli water law has realized several military orders in the West Bank and Gaza, this controlled and restricted Palestinian use of water resources.

In the West Bank the following three orders mainly defined water affairs

- Military order No. 92 of August 1967, Israel transferred the full control over water resources and their management to an appointed Israeli Water Officer, who became the only responsible for the granting of permits and operating licenses, the setting of fees, taxes and quotas, the monitoring of water use, the decision the decision on appeals and the controlling of all water entities and committees. The drilling of new wells was impossible without a permission of the water officer, who did not give a single permission for the drilling of wells for industrial or agricultural purposes. The order also fixed the water contingent for Palestinian use and expropriated all wells of absent owners and of expropriated Arabic land (*Baskin, 1993*)

- Military Order No. 158 of November 1967 adjusted the Jordanian Water Monitoring Law, which originally concerned only irrigation water rights, and prohibited the construction of any new water installation without a license from the Water Officer. But he could refrain from approving a permit without giving reasons and he could cancel or change the permit or impose conditions on it, without possibility to appeal against his decision. Thus this order forbade the unlicensed construction of new water infrastructures.

- Military Order No. 291 of December 1968, declared all prior settlements of disputes regarding water invalid. It was based on Jordanian law No. 40 of 1952 and transferred all responsibilities of the former Jordanian Water Department to the Water Officer. Hereby it increased the jurisdiction of the Water Officer once again (*Issa, Buijne, 1995*).

In 1982, the Israeli water authority Mekorot took control. As a result of this situation, the Palestinian wells were destroyed and supplies were dried up by widespread digging and pumping from deeper wells for the Israeli use (*Sturn, Ribbe and Schwabe, Water Resource Management in the West Bank, 1996*). Israel also delays approval of Palestinian water projects; as of July 2001, 17 requests submitted since the year 1997 by the Palestinian Water Authority, but still considered pending (*Passia, 2003*).

In 1986, Israel reduced the quotas for the amount of water to be pumped from wells in the West Bank by 10%, which resulted not only not only in a widespread scarcity, but also in a drop in the water table and increased salinity. Additional loss of available water due to leaky pipes is estimated at 30% (*Passia, 2003*).

In 1999, experts estimated the compensation for damages to Palestinian water resources caused by Israeli measures, and for Palestinian water used by Israel over the years at a minimum of 45\$ billions (*Jad Isaac, 1999*).

In September 1991, the Middle East Peace Process began, in Article 40 of Oslo II, Israel for the first recognized the Palestinian rights concerning the water, which is summarized by supplying the Palestinians additional

28,600,000 m<sup>3</sup>/annum as immediate needs, and 70 to 80 millions m<sup>3</sup> per annum as future needs (*OSLO II Declaration*). But it did not explain from where these amounts should come, and taking into consideration that the Jordan River is excluded at that stage, and taking into consideration that the aquifer system is being completely utilized (*Sturn, C. Ribbe, L. Schwabe, C. 1996*).

As of 1990, until now, Israel is using for agriculture sector ten times as much as the total water use in the West Bank (*Sturn, C. Ribbe, L. Schwabe, C. 1996*).

These several rules under several administrations put the Palestinian water resources under stringent circumstances to be used in the development of agricultural and other ecosystems, and even made the available of the underground water resources limited, while on the other side, no limitations for the water used in the development of the Israeli agriculture, industrial and other ecosystems.

In the second Intifada, starting September 2000, Israel expanded there settlements over the West Bank making use of every single aquifer in order to meet the increasing demand of the expanded settlements, also making use of the military force to prevent the Palestinians from using there own and limited resources.

In the current situation, all the permits for opening new wells were completely stopped, the rehabilitation of the existing wells was also hindered by the closers, curfews, strict sanctions imposed on the territories,

especially the northern part of the West Bank; Jenin, Nablus, Tulkarem, Qalqilia and Salfet Districts. These measures, in addition to the incursions of the Israeli Forces to the West Bank in April, 2002, made it very difficult to plan, or to make studies for any future comprehensive water master plan.

Another major issue concerning the current crises is building of the Apartheid Separation Wall by the Israelis, which will surround the West Bank in a circle, this wall will swallow about quarter of the most fertile agricultural lands in the west Bank, about 28 water wells will be sieged inside the west side of the Apartheid wall area and will be out of the jurisdiction of the Palestinians, which accounts to about 18% of the Palestinian quota from this aquifer (*PECDAR, 2003*). This will affect the agricultural sector in both ways; it will lower the amount of available water for agriculture, and will decrease the area of the agricultural lands. The Wall will keep all of the Jordan Valley and the Judean Desert under Israel's manipulation; a 20-30 km wide strip will be also sieged inside the Wall.

### **3-6 Health Considerations**

Wastewater contains pathogenic microorganism such as bacteria, viruses and parasites. These microorganisms have the potential to cause diseases in the user communities. The use of untreated or insufficiently treated wastewater in agriculture will lead to potential risks to human health. Due to unrestricted use of wastewater in west Bank and Gaza, possible parasitic infestation rates were high than some of the surrounding countries (*PECDAR, 1994*).

Untreated wastewater irrigation leads to relatively higher prevalence of hookworm (*Feenstra et al, 2000*). It also causes Ascariasis infections among children (*Cifuentes et al, 2000*).

(*PECDAR*) reported in 1994 that in the West Bank, 12% positive Ascariasis results were indicated in the study of stool samples in problem areas and 8.5% positive *Giardia Lamblia*. Therefore the public health will affect the public opinion towards the reuse of treated wastewater.

Due to the scarcity of water in the West Bank, many cases were recorded of using raw wastewater to irrigate market vegetables, and eaten raw vegetables.

In Jordan, which is one of the region countries, and due to using raw wastewater to irrigate different type of vegetables, Cholera outbreaks have been recorded in 1981 (*Farouki Naser, 1999*).

### **3-7 Institutional and Legal Considerations**

Successful application of a good management in water and wastewater sector need the coordination between human, agencies and interest groups in order to resolve any conflict.

The influence of the regulations and political boundaries, agency missions, funding issues, social traditions and customs, religion and cultural heritage in the society, have all interacted to create conflicts in deciding up on the decisions regarding the wastewater and reuse. Institutions in this subject must have a clear mandate and objectives.

They must be built on legal foundation in order to be able to take the right decision about any conflict that might arise.

In the West Bank, opportunities for the development of new sources have not been exhausted yet, but due to political reasons, these opportunities are hindered. It is becoming increasingly necessary for the West Bank to put laws that define wastewater issues and regulate the rule and laws regarding the use of raw wastewater and treatment and reuse. In addition, it is necessary to nominate an authorized institute whose mandate is to supervise, audit and to put code of practice to regulate this practice.

## Chapter 4

### Assessment of Wastewater and Water Situation

#### 4-1 Wastewater Collection Systems

In the West Bank, Wastewater treatment has been neglected to a certain extent, with most attention focused on measures to solve water quantity and supply problems.

Approximately 62% of all Palestinian localities in the Inland Region (non Coastal), representing 86% of the population, including Jerusalem, are served with water supply networks (*PECDAR, 2001*). This service is generally deficient with an average per capita consumption of about 70 l/c/d in the West Bank and substantial unmet demand. As a result and because the water supply is limited, the search for new sources of water is of great importance in the last few years.

Few municipalities have installed wastewater collection systems, with only about 70% coverage within these municipalities (*Farouki Naser, 1999*).

Actually there is no accurate record concerning the percentage of sewerage population in the West Bank. The (*Farouki Naser, 1999*) states that only 20% of the West Bank is part of a sewer system; all rural and suburban areas rely on onsite cesspits. (*PASSIA, 2002*), reported that 37.5% of the West Bank inhabitants are connected with sewage system. In some other studies, only 30%-35% of the population of the West Bank as a whole is connected to sewage networks.

Table 4.1 shows the percentage of served inhabitants in the major cities of the West Bank:

Table 4.1: Existing Wastewater collection systems in the Main Cities of the West Bank, 2003

City	Inhabitants served	% Wastewater Collected	Total sewage network Length (Km)
Jenin city & camp	45,000	40	40
Nablus		85	80
Tulkarem	40,000	70	45
Qalqilia	37,500	90	85
Bethlehem (district)	N/A	75	83
Hebron	120,000	80	124
Ramallah	12,000	65	35
Al Bireh	35,000	95	60
Salfeet	7,000	70	30

Source: Water and wastewater departments in the municipalities.

In the rural and suburban areas, cesspits themselves constitute a threat to freshwater, if they overflow, as frequently happens. They contaminate the soil and groundwater with raw sewage. If the cesspits are pumped out, the sewage is usually dumped into the nearest wadis. So not only freshwater is declining due to population growth, it is also under the threat from pollution (*Farouki Naser, 1999*).

The following gives a brief description of the status of the wastewater collection systems in the major cities of the West Bank:

• **Jenin Wastewater Collection system**

The raw wastewater in Jenin can be classified as strong wastewater especially in BOD and suspended solids loading. The BOD and TSS in

## Figure 4.1

Jenin were estimated to be 1100 mg/l and 1088 ppm, respectively (*PECDAR, 1994*).

The total wastewater quantities generated in Jenin are about 2400 m<sup>3</sup>/d. Approximately, 40% of Jenin's population is connected to the sewage collection system (*Jenin municipality, 2003*). The other 60% of the population use septic tanks or cesspits that are emptied by vacuumed tanks to the nearby wadis. This untreated effluent is being discharged into the nearby wadis causing potential serious environmental and health hazards.

Before the current Intifada, only 13% of the wastewater was inadequately treated by the old and insufficient treatment plant. Recently, a bypass was constructed to take the discharged wastewater into the nearest wadis, without passing into the treatment plant.

The total length of the sewage network in Jenin is about 40 km. The majority length of the network is 80 years old and undersized. A very large portion of this network has been destroyed by the Israeli tanks.

The future plans require the construction of 130 km of sewage pipe. This is still under study and design and will be connected to a proposed new treatment plant.

#### • **Nablus Wastewater Collection System**

Nablus is one of the largest cities in the West Bank, about 85% of the households in Nablus city is connected with sewer systems (*Nablus municipality, 2003*). Due to the topography of Nablus city, the sewage collection system consists of two parts, the western part and the eastern part. In the old city of Nablus, the sewage system is a combined system,

sewage and storm water. The combined system has two effects on the wastewater generated in winter season. One is negative which is increasing the volume of the wastewater quantities, and the other is a positive effect which is diluting concentrations of the resulting domestic and industrial wastewater, which means decreasing the BOD and COD. Despite this fact, the BOD of the discharged raw wastewater and the TSS are considered to be relatively high. BOD was estimated to be 600 mg/l and 560 mg/l in the west side and east side of Nablus respectively. The TSS was estimated to be about 488 ppm and 840 ppm in the west side and east side respectively (*PECDAR, 1994*).

The western part of the sewer in system Nablus city discharges into Wadi Zeimar towards Tulkarem. Along this wadi other villages and stone cutting factories close to the city also discharge into this wadi. A design plan for a future treatment plant for this part of the system is ready for construction, but due to land acquisition issues, the construction did not start.

The eastern side discharge into Wadi Al Sajoor, from where sewage flows through Wadi El Badan down into the Jordan Valley.

The resulting wastewater either pollutes the aquifer through percolation or is used by the farmers for irrigation, causing serious hazardous effects for both the Groundwater and health. The untreated wastewater is used for irrigating vegetables, fodder crops and fruit trees with no consideration of water quality.

In Nablus district, as well as other districts of the West Bank, cesspits are the common form of sewage collection in the villages. This accounts for more than 60% of the district's overall population (*UNEP*). This is

leading to environmental and health risks, with leakages polluting wells and springs.

#### • **Tulkarem Wastewater Collection System**

Tulkarem district has the same situation as other parts of the West Bank. Wastewater is either discharged into the nearby wadis, or temporarily stored in cesspits prior to dumping (*ARIJ, 2002a*).

About 70% of the population of Tulkarem is connected to the Wastewater collection system. The rest depend on cesspits for Wastewater disposal. The sewage network in Tulkarem extends to about 45 km. Only 50% of the Wastewater flows into the stabilization ponds operated by the municipality. The other half flows into Wadi Zeimar. An emergency treatment facility has been constructed to prevent the pollution of Alexander stream.

The leakage from the sewage network of Tulkarem reaches 50%. Most of the cesspits in Tulkarem district are built without cement lining in order to encourage sewage infiltration to the ground and thereby minimize emptying costs (*ARIJ, 1996e*). This causes further groundwater pollution effects.

#### • **Qalqilia Wastewater Collection System**

The situation of the wastewater collection in Qalqilia city is better than Tulkarem in terms of percentage of population connected to the collection system, which is about 90%, but the system suffers from the same technical problems.

The sewage collecting system in Qalqilia extends to a length of about 85km covering about 90% of the population, of which only 40% of the wastewater flows into the stabilization ponds. The rest also flows into Wadi Zeimar and is being treated by a treating facility and discharges into Alexander stream. The main sewer of Qalqilia and an Israeli settlement close to the city discharge their sewage into an open channel which is connected to the Yarakon river and heading for Tel Aviv. Some of the generated sewage is being collected in an oxidation pool by a nearby settlement and the effluent is used irrigation. Wastewater generated from another nearby settlement directly flows into Wadi Qana nearby Qalqilia and causes problems for the Palestinian people living there. Until now the Health Department of the municipality did not find out if their groundwater wells are contaminated.

(*ARIJ, 2002a*) survey mentioned that the leakage of the Qalqilia wastewater collection system reaches 50%, in addition to the cesspits which are built without cement lining causing further groundwater contamination.

#### • **Ramallah Wastewater Collection System**

The metropolitan area of Ramallah (and Al Bireh) is growing fast. Many ministries and governmental institutions are located in the district.

The area of Ramallah City is 19,000 dunums, of which 5000 is built up. The existing municipal wastewater collection system covers about 65% of the built-up area of Ramallah. The average present dry weather flow into the existing treatment plant is estimated to be 1457 m<sup>3</sup>/day (*Arabtech-Jardaneh, May, 2003*).

The existing treatment plant, located in Ramallah industrial zone, discharges the sewage freely in a very bad condition to a nearby Wadi of Beitunia through a discharge pipe. The pipe is located about 1.5 km downstream the existing Wastewater treatment plant, which is overloaded.

#### • **Al Bireh Wastewater Collection System**

The situation of the Wastewater Collection System of Al Bireh City is the best among all the cities of the West Bank, if not in all over Palestine. About 95% (35,000 inhabitants) of Al Bireh population has been connected to the collection system. This wastewater is being treated by a recently operated new treatment plant, which also treats the discharges that come from some of the surrounding settlements. The total length of the sewage network is about 60 km.

#### • **Jericho Wastewater Collection System**

There is no collection network in the whole district. All the residents of Jericho district are depending entirely on cesspits for wastewater disposal. Trucks abstract the sewage and dispose it into Wadi Al Kilt.

The wastewater in the Jericho city is composed of only domestic wastewater, with minimal industrial proportion. The farmers in the district use the discharged raw wastewater in growing their crops.

#### • **Salfeet Wastewater Collection System**

The wastewater collection system of Salfeet city is being recently under construction. The collection sewer system is considered the first phase of an integrated collection system for Salfeet city. The system is proposed to consist of sewage network as a first stage, followed by a treatment plant

as the second stage of the system. About 30 km of the network is constructed which serves about 7,000 inhabitants, or 70% of the population.

#### • **Hebron Wastewater Collection System**

About 80% of the population of Hebron is connected to the wastewater collection system. Sewage Pipe lines and households connections are currently being installed in Hebron city. The wastewater in Hebron is characterized by high COD, Chlorine and TSS contents. These parameters were estimated to be 2736 mg/l, 1794 ppm and 3540 mg/l as CL The present wastewater network is very old and has many problems, such as accumulation of solid wastes, that causes clogging and flooding of the system. In addition to the absence of a storm water drainage system causes overloading in the winter season. The existing network has a total length of about 124 km. The generated domestic and industrial wastewater should be discharged by pumping it about 11km to a storage reservoir on top of a hill and then to a sedimentation pond east of the city. Because the pumping station is recently out of order, the raw sewage is collected and then discharged to the nearest wadis such as Wadi Al Samen and Wadi Al Hariyyah in the southern part of Hebron. The raw wastewater is being used by farmers.

The sewage network of Hebron serves about 80% (120,000 inhabitants) of the population of the city. Designs are ready to extend the network in order to serve 95% of the population.

#### • **Bethlehem District Wastewater Treatment Collection System**

The total population of the district is about 125,000 inhabitants producing about 12,000 m<sup>3</sup>/d of wastewater. By the year 2000, about 75% of the

population of Bethlehem city is connected with a collection system, which was extended by the project Bethlehem 2000. The generated wastewater from the district is discharged by gravity either to the western side or to the eastern side of the city of Bethlehem. The western side discharge through 400mm diameter pipe to the Jerusalem main trunk which is discharged to a treatment plant nearby Jerusalem.

The eastern part of Bethlehem district drains to the north and south which is pumped to flow in an open ditch in Wadi Kidron (Wadi Al Nar), then combining the sewage discharged from the eastern Jerusalem.

The eastern side of the discharge produces about 2400m<sup>3</sup> / d. There are two existing pumping stations, one in the northern side and the other in the southern side of Bet Sahour city. Those pumps divert the collected wastewater to the Wadi Kidron. This quantity is proposed to be collected and treated by the future proposed treatment plant. Until recently, no treating process takes place and the plant does not exist yet.

The generated wastewater in Bethlehem district include a great proportions of industrial wastewater, several types of industries are existing in Bethlehem and are located in the residential areas. These industries include stone cutting facilities, textiles, chemical detergents, paint, tobacco, food and beverage factories. Most of these factories discharge their wastewater into wadis, without any treatment, and flows towards the Dead Sea. Where as a major part of the sewage is treated at the Soreq wastewater treatment Plant.

The major problem related to the Bethlehem wastewater is the stone cutting facilities that use large quantities of water for cooling of the

cutting blades. This causes high quantities of total suspended solids, in addition to metals generated from the cutting blades, greases, as well as the large quantities of used water in the cooling.

• **Status of the Wastewater Collection Systems in the Refugee Camps**

In most of the refugee camps of the West Bank, wastewater flows through open channels which were originally constructed by the U.N. in order to collect the storm water in these camps. These channels are liable to overflow during heavy rains. In summer seasons, an unpleasant smell is annoying the people living in and around these camps.

During the Israeli military incursions of April 2002, great damage to the system in Jenin Camp occurred, which caused wastewater seepage through the destroyed houses.

**4-2 Wastewater Current Reuse in the West Bank**

In all localities in the West Bank, partially treated or raw wastewater is discharged to wadis and valleys where discharges are used for irrigating vegetables without any consideration to the effluent quality. In different localities in the West Bank (Jenin, Nablus, Bethlehem and Jerusalem), raw sewage is used to irrigate hundred of dunoms with different kinds of crops including vegetables eaten raw (eggplants, squash, parsley, radish, pepper, onion, mint).

### **4-3 Status of Wastewater Treatment in the West Bank**

Few treatment plants exist in the West Bank, recent investigations has shown that wastewater treatment plants in the West Bank do not produce safe effluent. Such plants are producing a partially treated effluent and their performance is inadequate (*PECDAR, 1994*), except Al Bireh treatment plant.

Most of these treatment plants were constructed in the seventies, although the resulted effluents are not considered of better quality from the influent.

Due to the unsafe effluent and because there has been no maintenance and repairs as well as there is no institutional agency responsible for the proper updating of the operation. These facilities are considered as poor examples of wastewater treatment. In addition, small scale reuse schemes are used in the West Bank (Jenin and Sawahreh in Jerusalem Governate). Most of these schemes are utilizing the untreated wastewater for irrigation of unrestricted farming (vegetables, fruits, and salad crops).

During the current crisis (the second Intifada started September, 2000), the access of municipal maintenance staff to wastewater treatment plants has, at various times, been difficult or impossible as a result of curfews, partial or full closures, and overall worker safety and security considerations.

Israel measures have also raised difficulties in obtaining spare parts and disinfectants such as chlorine. The Palestinian Environmental Quality

Authority stated that more than two thirds of the West Bank is categorized as being vulnerable in terms of pollution.

Due to the low water consumption of water per capita in the West Bank, the wastewater influent is characterized of high concentrations and high BOD. The existing treatment plants are of low efficiency and do not produce safe effluents as mentioned earlier. The current status of the existing treatment in the West Bank is as follows

- **Jenin Treatment Plant**

The wastewater treatment plant of Jenin is an old, small, and not an efficient facility which was constructed in 1972 and rehabilitated in the year 1993.

The system consists of three aerated lagoons with a surface area of 10,500m<sup>2</sup> with a depth of 3m in addition to one polishing pond with a design flow of 760 m<sup>3</sup>/d. Influent concentrations of COD and BOD were detected at higher than the design level of 1440 and 800 mg/l respectively (*Nashashibi, and Van Duijl, 1995*). Although the plant is newly rehabilitated, recently the plant is out of order.

During the current crisis, the aerators of the lagoons are broken, no maintenance can be performed, and no spare parts can be imported to the plant due to the strict closures imposed on the territories. The influent is being bypassed by a sewer pipe without any treatment. This untreated effluent is being discharged into wadis, resulting in potentially serious environmental and health risks, in addition to potential groundwater contamination.

- **Tulkarem Treatment Ponds**

The treatment ponds in Tulkarem consist of three 0.5 hectare anaerobic lagoons constructed in 1975 for a design flow of approximately 200m<sup>3</sup>/d. The plant is hydraulically and organically overloaded with hydrogen sulfide odors being emitted (*Gearheart, Bahri and Al Hamdi, 1994*). The final effluent is discharged through a nearby wadi which crosses the green line where pumped to a large pond in Yad Hana Kibbutz. The effluent is used for irrigation.

#### • **Ramallah Treatment Plant**

The plant consists of a bar screen, Parshall flume, two parallel aeration ponds and two stabilization ponds in series. Aeration ponds have a volume of 3,800m<sup>3</sup> each. The total volume of stabilization ponds is 10,000 m<sup>3</sup> (with an average surface area of 1,000 m<sup>2</sup>). The wastewater flow to the treatment plant far exceeds the design capacity of the plant and the treatment efficiency does not exceed 20%. The existing effluent is discharged through 2km long 300 mm diameter pipe into a nearby wadi.

The treatment plant is recently being extended. The extension process has completed the concrete works.

#### • **Hebron Treatment Plant**

The plant was constructed by the Israeli Civil Administration in 1988 on a hilltop, and raw wastewater must be pumped about 11 km. The plant consists of two small lagoons followed by a larger one. The final effluent was originally planned to be discharged to nearby wadis. The plant has no capacity for handling solids or sludge. The plant has not been used since the pumping station was clogged by sediments and debris carried by stormwater. The overall system is extremely undersized capacity and has a high operational cost for pumping. The observed high COD and

Chlorine levels can be attributed to the fact that the industrial wastewater originates from the main industries in Hebron city, which are leather tanning, shoe making, quarrying and stone cutting facilities. Especially the tanning industry produces hazardous wastewater which contains chromium ions and hardly removable complex organic compounds. Therefore wastewater collection and treatment is urgently needed.

With the assumption that 80% of the water provisional supply in the year 2020, base on 120 l/c/d, a design for a proposed treatment plant is completed to treat 95% of the discharged wastewater with the following characteristics

Influent flow 15000 m<sup>3</sup>/d, with BOD load 930 mg/l, and COD 2061 mg/l and Nitrogen 148 TKN. The effluent BOD is expected to be 20mg/l, COD 25 mg/l and Nitrogen 45 TKN. The resulting effluent should be reused in restricted agricultural purposes in the nearby wadis.

#### • **Al-Bireh Treatment Plant**

Al Bireh treatment plant is recently constructed and operated. The treatment plant consists of an extended aeration tanks followed by sedimentation tanks. The following parts are the main components of the plant

-Two aeration tanks rectangular shape of a volume of 6924 m<sup>3</sup> each. The retention time of the wastewater is >25 days.

-Two sedimentation tanks (circular) with a volume of 1800 m<sup>3</sup> each. The retention time is about 2 days.

-A screening unit

- Balancing tank used for emergency cases and over flow cases.
- Grit removal tank for removing the smaller size particles
- Flow measurement Flume to measure the inflow of the wastewater
- A primary sedimentation tank and a sludge pumping station
- Ultra violet disinfection unit
- Effluent regulation tank
- Sludge thickening tank
- Sludge dewatering building

The plant is designed for sewage flow of 5750m<sup>3</sup>/d in dry weather, and 11500m<sup>3</sup>/d in wet weather. The Plant is designed to take BOD of the influent of about 522mg/l and COD of about 1044mg/l. The effluent BOD and COD is about 20mg/l and 100 mg/l respectively.

The treatment plant is fed by two main pipe lines; the first one is 700mm diameter collects wastewater from the northern, western and middle parts of the city, the other pipe is 500mm collect wastewater from the south and east of the city.

The daily total influent volume which flows into the treatment plant is between 3000 to 3500 m<sup>3</sup>/d.

The effluent resulting from the plant is being discharged into the near by wadi of Der Dibwan, where some of the farmers are using the effluent in there agriculture.

A successful experimental agriculture is being processed in the area surrounding the treatment plant. The land around the treatment plant has been divided into several parcels. Each parcel is being planted by different types of crops, and irrigated with the resulting effluent.

The most important planted crops are Almonds, apricots, orange, Lemon, Grapefruits, Pistacio, sweet corn, ornamental trees and shrubs, flowers, rose bushes, Bougainvillae, and Olives trees.

In the area of the treatment plant, an experiment of eaten cooked vegetables is also under process. A green house was constructed and zuchinni and eggplants were successfully planted. It can be said that the resulting effluent is being used for restricted type of agriculture. But this is done under the supervision of Al Bireh municipality and Ministry of Agriculture.

#### • **Salfeet Proposed Treatment Plant**

The design phase of the treatment plant is completed, the proposed treatment system is an extended aerated lagoons. The treated effluent will be discharged to a nearby are and ultimately utilized for restricted irrigation.

The design of the wastewater treatment shall be based on a long term concept relying on two implementation stages. These stages will satisfy the medium and long term demand. The first stage will serve 12,000

inhabitants up to the year 2010. The second stage will serve up to 24,000 inhabitants.

The design loads and effluent characteristics of the proposed treatment plant are as follow

Influent characteristics	Effluent characteristics
BOD 720 kg/d	< 20 mg/l
TSS 840 kg/d	< 20 mg/l
TN 130 kg/d	< 30mg NO3/l

The design sewage average flow is 65m<sup>3</sup>/h in the dry weather. The peak dry weather flow is 140m<sup>3</sup>/h, and the peak wet weather flow is designed at 230m<sup>3</sup>/h.

Table 4.2 summarizes the status of the current treatment plants in the major cities of the West Bank in terms of the estimated efficiencies and the proposed future treatment processes

#### **4-4 Wastewater Composition in the West Bank**

Total annual wastewater for the Occupied Palestinian Territories is estimated at 72 MCM (*PCBS, 2002*). The West Bank low per-capita water consumption within Palestinian households affects the sewage composition by increasing the organic constituents and influent salinity. The biochemical oxygen demand (BOD) level in the West Bank average 600 mg/l and may reach 1100 mg/l in some places. This is higher than the common BOD levels of 200-300 mg/l in many developed countries (*PECDAR, 1994*).

Table 4.2: Existing and proposed Wastewater Treatment Systems and there efficiencies in the Main Cities of the West Bank

<b>City</b>	<b>Existing Treatment System</b>	<b>Status</b>	<b>Proposed</b>	<b>% working efficiency</b>
Jenin	Anaerobic Ponds	Old, idle with broken aerator	Design is ready for a new plant	0
Nablus	None	No wastewater treatment	Activated Sludge, design is ready	N/A
Tulkarem	Ponds	Very low efficiency	Activated Sludge	N/A
Bethlehem	None	No wastewater treatment	Design is ready	N/A
Hebron	Ponds	No wastewater treatment	Design is ready	0
Salfeet	Sewer system is under construction	No wastewater treatment	Design is ready	N/A
Ramallah	Aerated Lagoons	Under construction, concrete phase is completed	Extension of the existing	<50
Al Bireh	Extended aerated tanks and sedimentation tanks	Wastewater is efficiently being treated, effluent is used in restricted irrigation	None	95%

As in other Muslim and Arab Countries, Palestine is very strictly related to its culture, and the Palestinians are adhered to the social traditions and customs like hospitality. In many occasions such as feasts and Ramadan, great amounts of food are consumed. The food contents and cuisine habits in the West Bank in addition to the low per capita consumption of water lead to a clear influence at the BOD.

Industrial wastewater, although representing small proportion of the overall effluent is largely discharged untreated into municipal sewage networks causing pollution to the soil, groundwater and surface water.

Table 4.3 below shows characteristics of wastewater in the major cities of the West Bank. These values are partially quoted from *PECDAR (1994)*.

The table shows that BOD are high compared with the developed countries, this is attributed to the fact that the per capita water consumption is much lower than that in the developed countries. In addition and partially, social and cultural habits and cuisine attitude in Arab Muslim countries like Palestine may increase the wastewater concentration, and hence raise the BOD. The existence of slaughter houses in most of the cities, with no treatment to the discharged effluent from these houses, will result in high BOD in the main collection system.

The high COD contents in Jenin, Nablus, Bethlehem and Hebron indicate that there are industrial facilities discharging their raw wastewater into the sewage collection systems. This fact is empowered by the total dissolved solids which results mainly from industrial facilities. These facilities are concentrated heavily in Hebron, Bethlehem, Nablus and Jenin.

In Bethlehem, Textile industries, paint, tobacco, stone cutting facilities and chemical detergents industries are located in the city. The wastewater of these facilities is being discharged into the wastewater collection system. This results in a very high BOD, COD and TSS concentrations.

Table 4.3: Characteristic of raw wastewater in the West Bank major cities

City Parameter	Jenin	Tulkarm	Nablus (West side)	Nablus (East side)	Bethlehem	Hebron
PH	7.5	6.5	6.0	6.5	6.5	6.0
COD	1440	540	954	1338	2724	2736
BOD	1100	250	600	560	660	520
Chlorine	1400	801	1180	9300	1080	3540
TSS	1088	398	488	840	688	1794
Nitrates	182.1	122.7	128.7	201.9	249.9	33.4
Nitrates N	41.4	27.9	29.3	45.9	56.8	7.6

Quoted from *PECDAR, 1994*

In Hebron, leather tanning which is the most hazardous industry that discharges high chromium contents, shoes, food, diary and stone quarrying and cutting facilities are located in the city and increase the BOD, COD and TSS contents.

In Nablus, and due to the topographic characteristics of the city, the wastewater collection system is naturally divided into two parts, the western side and the eastern side. Both sides are being polluted by industrial wastewater that result from stone cutting facilities, tiles industries, soap factories and food industries like (White Tahina). The eastern side contains higher COD, TSS as well as Chlorine content. This is due to the fact that more industrial activities are discharging into this collection system. The type of industries include cosmetics industry, metal furniture including assembly workshop, diary factory, plastic factory, chemical detergents factories in addition to stone cutting facilities, a ready mix concrete factory and steel factory

In Tulkarem, the low BOD, COD, TSS and chlorine content indicate that there are no major industries in the city. Although some industries has started in the eastern side of the city, but these industries are not considered to have a major effect on the wastewater quality.

#### **4-5 Water Resources in the West Bank**

##### **4-5-1 Surface water**

The main surface water resource in the region is the Jordan River drainage basin. The basin is located from the Israeli occupied Golan Heights in the southern of Lebanon, It feeds the Lake of Tebarias. The southern part of the Jordan river is fed from the springs and runoff from the West Bank catchments, Syria and Jordan mostly from the Yarmouk Branch.

75% of the Jordan River's water is being used by Israel before even it reaches the West Bank (*PASSIA, 2002*). Although it is full riparian, and the Jordan River is considered as the Jordan International drainage Basin, Palestinians has been denied any of the Jordan River's water.

##### **4-5-2 Groundwater**

This is the main water resources for the West Bank, it consists of the aquifer system that feed this resource.

The aquifer system is being recharged by the rainfall, return flow from irrigation, sewage effluent, and by a minor proportion from the water pipe leakage which is estimated about 30% of the water running inside the networks, some 80% of the West Bank and Gaza ground water is exploited by Israel, which accounts for 25% of the Israeli's water

consumption (*Passia, 2002*). In figures, the Palestinian currently exploit between 115-123 MCM (*Zahra, B.A.A.A. 2001*). The Israelis exploit between 480-530 MCM of the total production of the aquifer system, which total amount is estimated between 600-660 MCM. Overall recharge area of the mountainous aquifers lie to 78% in the West Bank (*Sturn, C. Ribbe, L. Schwabe, C. 1996*).

The ground water table varies between less than 10m under ground near Jenin and 200-300m near Hebron. The Bet Kahel formation is sometimes even deeper. In the Jerusalem – Bethlehem area, groundwater occurs 130-160m under ground (*MOPIC, 1996*).

The aquifer system in the West Bank consists of three aquifers:

- The Western Basin, which is supplied from the West Bank Mountains, the recharge area is 1800 km<sup>2</sup> of which 1400 km<sup>2</sup> lie in the West Bank. The storage area of 2500 km<sup>2</sup>, lie almost completely in Israel. The major natural outlets are Rosh Haa'yin and Tanninim springs. Total annual water supplied by this aquifer is 360 MCM.
- The Northeastern Basin located inside the West Bank near Nablus and Jenin. The feeding area of this basin is about 700 km<sup>2</sup>, the storage area 650 km<sup>2</sup> in the West Bank. It drains into the Eocene and Cenomanian-Turonian aquifer under the north of the West Bank. The total annual water supply is 140 MCM.
- Eastern Basin is located in the West Bank at about 2200 km<sup>2</sup> storage area. A small part of this basin is located within the green line, and about 90% of the springs are discharged from this aquifer. Total annual yield of this aquifer is 100 MCM (*Gvirtzman, 1994*).

Table 4.4 summarizes the Basin basic information within the West Bank:

Table 4.4: Basic information about basins in the West Bank

Aquifer	Recharge area km <sup>2</sup>	Storage area km <sup>2</sup>	Total yield MCM/ annum	Notes
Western	1800	2500	360	1400km <sup>2</sup> of the recharge area lie in the West Bank
North-eastern	700	700	140	650 km <sup>2</sup> of the recharge and storage area lie in the West Bank
Eastern	2200	2200	100	Only a small part of the area lie in the green line
Total	4700	5400	600	

Source (*Sturn, Ribbe, Schwabe, ASA, 1996*)

#### 4-6 Water Supply-Demand Gap

Palestinians are currently living under conditions of suppressed demand. Water development has been curtailed and not allowed to meet the aspiration of water uses in domestic, industrial, nor agricultural sectors.

The over riding need is to raise water consumption to levels that ensure good health and promote economic development. Extensive development is needed to rehabilitate existing systems and to build new infrastructure in order to supply these demands.

There is a significant gap between existing resources and demand. The gap is narrowed using additional fresh water resources and water quality water for agriculture. By the year 2020, under the most optimistic scenario, the annual gap grows to 144MCM in the West Bank and Gaza (*PECDAR, 2001*).

Table 4.5 shows the forecast deficit between demand and available water resources in the Palestinian territories:

Table 4.5: Gap between Water Demand and Available Water Resources in the Palestinian Territories

Year	Supply/Demand MCM/year	Gap with Oslo II MCM/year	Gap using developed water resources MCM/year	Gap utilizing low quality sources MCM/year
1997	280	-44	-44	-1
2000	354	-75	-112	-60
2005	518	-238	-202	-142
2010	620	341	-233	-147
2020	846	-566	-286	-144

Source (*PECDAR, 2001*)

Figure 4.2 shows the expected gap for the years 1997, 2000, 2005, 2010, 2020 in the Palestinian territories. It predicts the gap between the demand and supply in the case of application of Oslo II resolution, the gap when a full development of all available fresh water resources and the gap when the Palestinians utilize low quality sources. The figure shows that the gap between supply and demand will decrease when the Palestinian utilize low quality sources.

#### **4-7 Water Distribution Networks in the West Bank Major Cities**

As mentioned in the introduction, 62% of all Palestinian localities in the Inland Region which represents 86% of the population, including Jerusalem, are served with supply networks. However much of this supply is providing inadequate quantity and quality water at insufficient pressure for less than 24 hours per day.

## Figure 4.2

The following is an assessment of the water distribution networks in the main cities of the West Bank

- **Jenin Water Network**

The main source of Jenin municipal water supply is a well located in the center of the city, yielding an average of 1000 m<sup>3</sup>/d. The municipality buys additional water from Mekorot.

According to Jenin municipality, the total length of the water network is about 122 km. The served population with potable pipe service is about 39,000 inhabitants, which account to 89% of the city inhabitants. Average consumption rates is about 68 l/c/d. The average network losses is ranging between 30% to 48% during the Israeli incursions.

- **Nablus Water Network**

In Nablus city, about 160,000 inhabitants are supplied with tapped water. The total length of the network is about 150 km (Nablus municipality). The main sources of water supply are three production wells with 200, 190 and 170 m<sup>3</sup>/h capacity. In addition to that, five springs supply a total of 5.7 MCM/a supplement the wells.

According to the municipality, about 95% of the water is used for domestic purposes, 5% is for industries. Farmers use private springs outside the city limits.

- **Tulkarem Water Network**

Tulkarem municipality utilizes three well to serve about 60,000 inhabitants, with average consumption rate of 75 l/c/d. As mentioned by the municipality engineers, the water supply is insufficient in summer, the municipality has to purchase additional water supplies from private wells.

The network which is about 170 km length serves 100% of the city inhabitants and some of the surrounding villages. The water losses due to leakage are estimated to 35%.

- **Qalqilia Water Network**

Qalqilia municipality is serving about 42,000 inhabitants with fresh water, or 100% of the people living in the city. The total length of the network is about 110 km, the average total consumption of the population is about 6000 m<sup>3</sup>/d.

According to the city engineer, 60% of the network needs to be rehabilitated, and the losses are accounted to 28%.

The city uses two artesian wells with a discharge of about 300 m<sup>3</sup>/h, these wells belong the municipality.

- **Jericho Water Network**

The first phase of the network of Jericho city was operated in 1997. Recently, the total length of the network is about 40 km serves 97% of the city population, about 15,000 inhabitants. The network is in a good condition with no leakage recorded.

The municipality engineer stated that the total average consumption is about 650m<sup>3</sup>/h. Two thirds of this consumption goes to the local agriculture, and the rest for domestic uses.

The main source of the water is the spring of Ain Al Sultan with an average discharge of 700m<sup>3</sup>/h.

- **Salfet Water Network**

The total length of Salfect network is about 65 km. The network serves about 10,000 inhabitants, 100% of the city population.

According to the city engineer, the network needs rehabilitation since the total leakage is about 38%.

- **Jerusalem and Ramallah & Al Bireh Districts Water Networks**

The responsible entity which manages the water supply and distributions in the districts of Jerusalem and Ramallah & Al Bireh is the Jerusalem Water Undertaking (JWU) which was established in 1966.

Currently the JWU distributes water to more than 200,000 people including Ramallah, AlBireh, four other municipalities, 40 villages in Ramallah and Jerusalem districts and five refugee camps (ASA, 1996).

The JWU utilizes five well at Ain Samia in the area east of Ramallah city and tap the eastern basin aquifer.

The total length of the distribution network including all the different types of pipes is about 750 km. The water losses were approximated at 22% (ASA, 1996).

- **Hebron Water Network**

The total water network of Hebron city is about 240 km. It supplies fresh water to about 152,000 people, about 85% of Hebron inhabitants. The average daily consumption is about 5500 m<sup>3</sup>/d. According to municipality engineer, the average water losses are estimated at about 32%.

#### 4-8 Water and Wastewater Damages

Due to Israeli measure against the Palestinians which started in September, 2000 like strict closers, curfews, and incursions, the water and wastewater sectors suffered from great damages. In West Bank and Gaza, these damages were estimated at a value of \$62,345,944 and \$76,464,860 in the water and wastewater respectively. The following table shows the values of damages in the water and wastewater sector inside the governorates in the West Bank.

Table 4.6 shows the direct damages that resulted from Israeli incursions to the West Bank

Table 4.6: Direct damages in the water and wastewater sectors resulting from Israeli incursions up to March, 2003

<b>Governorate</b>	<b>Water (\$)</b>	<b>Wastewater (\$)</b>	<b>Total Damages (\$)</b>
Bethlehem	6,389,800	2,843,000	9,232,800
Hebron	13,969,332	9,444,500	23,413,832
Jenin	3,603,883	6,327,925	9,931,808
Jericho	1,172,500	7,906,170	9,078,670
Jerusalem	0	0	0
Nablus	9,244,150	25,661,750	34,905,900
Qalqilia	1,194,579	50,940	1,245,519
Ramallah & Al Bireh	6,455,604	3,647,750	10,103,354
Salfeet	4,520,051	295,000	4,815,051
Tubas	2,729,800	5,000,000	7,729,800
Tulkarem	5,879,300	1,745,785	7,625,085
Total	55,158,999	62,922,820	118,081,819

Source (*PECDAR & IMG, 2003*)

Figure 4-3 shows the damages that occurred in the Water and Wastewater sectors as a result of Israeli military incursions which started in April, 2002.

## Figure 4-3

## **Chapter 5**

### **Data Analyses and Hypothesis Testing**

#### **5-1 Public and Farmers**

##### **5-1-1 Social Aspects**

From the analyzed questionnaires, general Information about the age frequencies of respondents, gender percentages, education level, distribution within districts and localities are presented in Table 5.1-1 and Table 5.1-2 for the Public and Farmers Respondents respectively. The detailed analyses of the all the factors which resulted from the questionnaires are presented in tables in the attached Appendix-1 and Appendix-2 for the Public and Farmers respectively.

It was found that there is a relationship between the social traditions and customs, and the acceptance or non-acceptance of the reuse of the treated wastewater in the West Bank. Applying the t-test the critical region is between 2.41 and 2.81. The t statistics is computed to be 25.647, degrees of freedom (df) = 182, Significance (Sig.) = 0 which is less than the assumed  $\alpha/2 = 0.025$ .

In general, most of the people agree that the social traditions and customs practiced in the West Bank do not accept the reuse of the treated wastewater in any sector. Despite that, raw wastewater has been used by farmers without control in some areas of the West Bank, 69.6% of the farmers and 66.7% of the public, considered that reuse of treated wastewater is not acceptable by social traditions and customs in the West

Bank. However, 70.5% and 78.5% of the farmers and the public respectively, said that if the area suffered from a draught season, they are willing to utilize the treated wastewater in any purpose, except for drinking.

Cross tabs were constructed between some social indicators (respondents living locations, respondents ages, income, level of education and gender) and the non acceptance of reuse (Q33). Q33 states that reuse is rejected by social traditions and customs. The results from cross tabs are as follow:

- Location\*Q33: 81.4% of respondents who live in cities consider that reuse is rejected by traditions and customs. This percentage was 59.8% in villages, 75% in camps and 44.4% amongst housing complexes respondents. A T-test was conducted, it was found that the correlation is not significant ( $r=.214$ ), and  $t=-7.578$ . One way ANOVA test was conducted;  $F=5.345$  and  $Sig.=.002$
- Age\*Q33: 67.7% of respondents who are between 20-30 years old consider that reuse is rejected by traditions and customs. This percentage was 60.4% for those between 30-40 years old, 65.6% amongst 40-50 years old and 73.9% amongst older than 50 years old. A T-test was conducted, it was found that the correlation is not significant ( $r=-.035$ ), and  $t=-3.647$ . One way ANOVA test was conducted;  $F=.179$  and  $Sig=.911$
- Gender\*Q33: 66.9% of the male respondents consider that reuse is rejected by traditions and customs. This percentage was 60.4% amongst respondents females. A T-test was conducted, it was found that the correlation is not significant ( $r=-.066$ ), and  $t=-12.753$ . One way ANOVA was conducted;  $F=.968$  and  $Sig=.382$
- Education\*Q33: 63.15% of the graduated respondents consider that reuse is rejected by traditions and customs. This percentage was 69.6%

amongst under graduated and 80.95% amongst respondents who did not complete the school level. A T-test was conducted, it was found that the correlation is not significant ( $r=-.215$ ), and  $t=-9.004$ . One way ANOVA test was conducted;  $F=4.316$  and  $Sig=.015$

On the other hand, 64.7% of the farmers and 68.1% of the public considered that one of the main reasons for the reverse migration in the West Bank is the bad services provided in the rural areas in terms of the health, water and wastewater. They might migrate to other areas looking for better health, water and wastewater services. However, about 87% of the farmers and 93.5% of the public stated that they contact the responsible authorities in order to fix any seepage in the sewage system, or the septic tanks in there areas, and any other fault in these services. Putting efforts to participate in improving the water, wastewater networks and other related facilities, 89.1% of the farmers and 91.2% of the public expressed there potential willingness to provide voluntary participation in social services and to attend periodic meetings in order to improve the situation in their areas.

Concerning the public awareness, and public exploration, 84% of the farmers and 81.9% of the public said that public opinion must be taken into consideration regarding any scheme related with the wastewater reuse and other environmental issues. The public must participate in any decision concerning the wastewater management. The following wastewater management responsibilities are the most important concerns, in which the public must participate, ranked in descending order in terms of its importance according to farmers and public opinions:

- Legal Aspects & Financial Aspects
- Technical Aspects
- Management and administrative Aspects

- Reuse considerations
- Environmental Impacts
- Health Impacts

**Table 5.1-1 General Information about Public Respondents  
Distribution of Public Respondents within District**

	Frequency	Percent	Valid Percent	Cumulative Percent
Ramallah	33	17.6	17.6	17.6
Jerusalem	1	0.5	0.5	18.2
Salfeet	10	5.3	5.3	23.5
Nablus	55	29.4	29.4	52.9
Tulkarem&Qalqilia	29	15.5	15.5	68.4
Jenin&Tubas	30	16.0	16.0	84.5
Hebron	27	14.4	14.4	98.9
Jericho	1	0.5	0.5	99.5
Bethlehem	1	0.5	0.5	100.0
Total	187	100.0	100.0	

**Distribution of Public Respondents within Location**

	Frequency	Percent	Valid Percent	Cumulative Percent
city	60	32.1	32.1	32.1
village	109	58.3	58.3	90.4
camp	9	4.8	4.8	95.2
Housing	9	4.8	4.8	100.0
Total	187	100.0	100.0	

**Distribution of Public Respondents according to the Gender**

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	162	86.6	90.0	90.0
Female	17	9.1	9.4	99.4
missing	1	0.5	0.6	100.0
Total	180	96.3	100.0	
Total	187	100.0		

<b>Education Level of Public Respondents</b>				
	Frequency	Percent	Valid Percent	Cumulative Percent
Graduate	116	62.0	62.7	62.7
Under graduate	46	24.6	24.9	87.6
School	23	12.3	12.4	100.0
Total	185	98.9	100.0	
Total	187	100.0		

**Table 5.1-2 General Information about Farmers Respondents  
Distribution of Farmers Respondents within District**

	Frequency	Percent	Valid Percent	Cumulative Percent
Ramallah	25	14.9	14.9	14.9
Salfeet	5	3.0	3.0	17.9
Nablus	39	23.2	23.2	41.1
Tulkarem&Qalqilia	37	22.0	22.0	63.1
Jenin&Tubas	32	19.0	19.0	82.1
Hebron	30	17.9	17.9	100.0
Total	168	100.0	100.0	

**Distribution of Farmers Respondents within Location**

	Frequency	Percent	Valid Percent	Cumulative Percent
city	23	13.7	13.7	13.7
village	140	83.3	83.3	97.0
camp	5	3.0	3.0	100.0
Total	168	100.0	100.0	

**Distribution of Farmers Respondents according to the Gender**

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	159	94.6	94.6	94.6
Female	9	5.4	5.4	100.0
Total	168	100.0	100.0	

**Education Level of Farmers Respondents**

	Frequency	Percent	Valid Percent	Cumulative Percent
Grduate	75	44.6	44.9	44.9
Under graduate	56	33.3	33.5	78.4
School	36	21.4	21.6	100.0
Total	167	99.4	100.0	
System	1	0.6		
Total	168	100.0		

### **5-1-2 Economic Aspects**

In order to address the economic aspects as a factor that affects the farmer acceptance of the wastewater and reuse, the economic and financial situation of the farmers has been taken into consideration. The economic situation of the farmers has an obvious effect on the decision of the farmer regarding the reuse of the treated wastewater. If the reuse of the treated wastewater will lower the price of the cubic meter of irrigation water, this might be the driving force for the farmer to accept the principle of the reuse of the treated wastewater.

It was found that 67.5% of the farmers get an income less than 2000 NIS/Month. 38.3% of them get an income less than 1000 NIS/Month. This means that a large percentage of the farmers get less than the average income in the West Bank. About 66% of the Palestinians are considered unemployed in the year 2000 due to the current crises. 10.2% of the farmers consider themselves unemployed persons due to their low income.

72.5% of the farmers and 74.2% of the public considered the water bill a heavy burden on their budget, 44% of the farmers and 50% of the public considered the water prices in their areas as reasonable prices, while about 44% considered it not reasonable. However, between 76% and 81.2% of the farmers and the public agreed to pay additional fees in order to improve the water and wastewater networks and facilities, despite the relatively low income of the farmers.

On the other hand, 62% of the farmers will accept the reuse of the treated wastewater if this will lower the price of water, the percentage for the public was about 64.6%. The rest said that the municipality and the water authority must support and lower the water prices. 64.1% of the farmers

and 65.9% of the public agreed upon the reuse of the treated wastewater if this will provide them with additional water quantities. The farmers expressed less interest in the recreational purposes; only 54.5% of the farmers will accept the reuse of the treated wastewater if it will provide more recreational areas. They said that the wastewater treatment and reuse should be utilized to supplement the water shortage in the essential purposes, such as agriculture, washing and other ecosystems. But the public people need these places where 65.4% voted in favor of the recreational area.

### **5-1-3 Religious and Cultural Aspects**

Islam is the religion of the majority in the West Bank. Given the emphasis that Islam, like other religions, places on cleanliness, there is also a persistent notion within the West Bank that wastewater is against Islam. In 1978, the Council of Leading Islamic Scholars of Saudi Arabia issued a special fatwa "to regulate the rules of treated effluents for different purposes". Wastewater reuse was made permissible for all purposes, including (wudu), provided that wastewater was treated to the required level of purity for its intended use and did not result in any adverse public health effect. Despite this rule, in the West Bank, 64.7% of the farmers and 60% of the public think that from the Islam point of view that the treated wastewater will be still considered unclean (najas). On the other hand, only 16.2% of the farmers and 11.7% of the public believe that the treated wastewater is considered clean from the Islam point of view, provided that it was treated to the required level of purity for its intended use. While, 18.6% of the farmers said that they do not know what the opinion of Islam in the subject, the percentage between the public went up to 28.3%.

71.1% of the farmers and 74.2% of the public said that there reference in the wastewater treatment and reuse will be abided to any decision issued by the official religious authorities. This indicates that the (fatwa) that was issued in 1978 regarding the subject is not realized either by the farmers or by the public. Even between those who declared that Islam considers the treated wastewater unclean, they do not know the actual Islam judgment on the subject. 17.5% of the farmers and 12.1% of the public refused to interfere the religion in this subject for their private reasons.

The religion has an obvious effect on the opinion of the farmers and public toward the reuse of treated wastewater. Most of the respondents said that in order to find acceptable solutions particularly from the religious point of view, the technical experts must work closely and cooperate with the religious references.

From the above, and from the religion point of view, it is obvious that the respondents seem to be prejudiced against the reuse of the treated wastewater. The public should be aware and informed about the religion judgment toward this issue.

#### **5-1-4 Health Aspects**

Only 37.5% of Palestinian household are connected to the sewage system in unconnected areas (villages and most refugee camps), the wastewater is discharged into percolating pits or septic tanks. These tanks are either emptied by vacuum trucks, or disposed into the wadis. This practice will cause environmental hazards to the underground aquifers (*PASSIA, 2003*).

In the rural and suburban areas, cesspits themselves constitute a threat to freshwater, if they overflow, as frequently happens, they contaminate the soil and groundwater with raw sewage. If these cesspits are pumped out, the sewage is usually dumped into the nearest wadis (*Sturn, C. Ribbe, L. Schwabe, C. 1996*).

In addition to that, the sewage seepage from the cesspits and the leakage from the sewer systems, this will adversely affect the health within these communities in the West Bank. However, 67.7% of the respondent farmers and 73.0% of the public would rather prefer to boil the water before drinking, indicating that they think that the water quality is not good enough for human use without boiling or further treatment.

The use of raw wastewater in the irrigation in the West Bank, also affected the health in the areas in which this practice has been used. 12.5% of the respondent farmers and 27% of the public said that one or more of his family suffer from consecutive Diarrhoea symptoms. While, 23.2% of the farmers declared that one or more in his family suffered from Amoebiasis and Ascariasis symptoms, 27.0% of the respondent people said so. The main reason for those symptoms is the unclean water used in irrigation. If we compare these percentages with the fact that 22.3% of the respondent farmers and 24.0% of the public stated that in there area the farmers utilize the raw wastewater in irrigation, in addition to that, 25.5% of the farmers and 33.7% of the public declared that sometimes they eat vegetables irrigated with raw wastewater, we find that the percentages are very close. This indicates that most of the Amoebiasis and Ascariasis cases come from the practices of raw wastewater irrigation in some areas.

For a deeper study of the Amoebiasis and Ascariasis symptoms, 30.8% of the respondent farmers and 40.7% of the public in Nablus district declared that the farmers in Nablus district utilize the raw wastewater in the irrigation. 33.3% of the farmers and 45.5% of the public in Nablus district suffer from Amoebiasis and Ascariasis. In Tulkarem & Qalqilia Districts, 30.6% of the farmers declared that the farmers in their area use the raw wastewater to irrigate their crops. 32.4% of the farmers in Qalqilia & Tulkarem districts suffer from Amoebiasis and Ascariasis, these percentages are negligible between the public within these districts. Other districts have much less percentages.

The above percentages indicate that the main reason for Amoebiasis and Ascariasis is the irrigation with raw wastewater. These practices are common practices in Nablus, Tulkarem & Qalqilia districts more than other areas.

#### **5-1-5 Political Aspects**

During the past 500 years, the Palestinian Territories and the West Bank had been ruled by several administrations. This put the Palestinian water resources under severe circumstances to be used in the development of agricultural and other ecosystems.

This also even made the available of the underground water resources limited. While, on the other side, there is no limitations for the water used in the development of the Israeli agriculture, industrial and other ecosystems.

In the second Intifada, starting September 2000, the Israeli settlements were expanded over the West Bank, making use of every single aquifer in order to meet the increasing demand of this expansion. Israel also used

the military force to prevent the Palestinians from using their own limited resources.

In the current situation, all the permits for opening new wells were completely stopped, the rehabilitation of the existing wells was also hindered by the closers, curfews, strict sanctions imposed on the territories, especially the northern part of the West Bank; Jenin, Tulkarem, Qalqilia and Salfet Districts. These measures, in addition to the incursions of the Israeli Forces to the West Bank in April, 2002, made it very difficult to plan, or to conduct studies for any future comprehensive water master plan.

The construction of the first phase of the Apartheid Separation Wall particularly in Jenin, Tulkarem and Qalqilia districts, detained about 28 of the high yield water wells behind the wall. In addition to the confiscation of large areas of the most fertile lands in the West Bank. This kept these lands without enough water for irrigation.

Most of the respondent farmers and public in the West Bank were pessimistic about the water future in the West Bank. Only 36.1% of the respondent farmers and 38.5% of the public were either optimistic or fairly optimistic, the rest were so pessimistic. Many of the respondents argued that "as far as the land is under occupation, the water will never be ours". Accordingly, it is found that the respondents are thinking of new water resources to compensate for the natural resources. 83.1% of the respondent farmers and 77.3% of the public considered the wastewater an important future water resource that should be considered in the Palestinian comprehensive water management studies. Amongst the respondent farmers, 11.4% and 13.8% of the public said that we first

must think of our water rights, obtain the ultimate quantities of natural water resources, which is according to their opinion, sufficient for agriculture and other ecosystems, subsequently, think about wastewater reuse.

As a result, the political factor can be considered to have two opposite effects. One effect is to reject the wastewater reuse as future water resource. Those who rejected considered that this idea is introduced by Israel, in order to divert our thinking from our rights in the natural water resources. The other effect is to accept the wastewater reuse, because this water source can be used as a supplement to the natural resources.

However, Israel is also practicing the reuse of treated wastewater in agriculture and other ecosystems.

#### **5-1-6 Technical Aspects**

These aspects include the water status as a natural resource, and the wastewater considerations in the West Bank, in addition to the purposes in which the treated wastewater is intended to be reused.

#### **• Water and water facilities in the West Bank**

The questionnaires contain inquiries about the water, water quality and quantity, water abundances in the different areas of the West Bank, as well as the water facilities, water services and water networks. These factors have crucial effects on the attitude of the farmers and other citizens toward the acceptance or non-acceptance of the wastewater treatment and reuse considerations.

66.4% of the respondent farmers and 68.4% of the public said that the water quantities are not sufficient even for their home gardens. 53.7% of the farmers said that water shortage is the main reason for not utilizing 100% of their lands to, and stated that they have to buy additional quantities of water in order to irrigate their home gardens. 55.7% of the public said that they have to buy additional quantities of water to irrigate their home gardens. Accordingly, 70.4% of the farmers and 73.6% of the public who own home gardens do not have any objection to irrigate their private gardens with treated wastewater.

Concerning water facilities, 78.9% of the farmers and 84.1% of the public believe that the water networks and other water facilities are in bad conditions. It needs rehabilitation and improvement.

• **Wastewater treatment and reuse considerations**

Despite that the major of the respondents considered the reuse of treated wastewater not acceptable from the social, cultural and religious point of view. It was found out that 83.1% of the farmers and 82.4% of the public believe that if the wastewater was treated to specific standards, it can be used for agricultural purposes. However, almost the same percentages encourage the process of the reuse for agricultural and industrial purposes. 80.1% of the farmers and 85.7% of the public believe that this process will improve the ground waters quality, eliminate the pollution and improve the agricultural sector.

Concerning what type of agriculture the treated wastewater should be utilized in, about 60% of the respondent farmers and the public said that the treated wastewater should only be used for restricted irrigation, such as fruit trees and vegetables eaten cooked, and other crops eaten cooked, but they would rather that treated wastewater not be reused for any type

of agriculture. Only 42.2% of the farmers accept to buy vegetables eaten raw irrigated with treated wastewater, this percentage goes up to 46.2% amongst the public. 37.3% and 36.3% amongst farmers and public respectively, do not think that wastewater can be reused in any type of agriculture after treatment.

#### **5-1-7 Institutional Aspects**

The institutions of the West Bank should reflect the tasks that have to be fulfilled in that society. Regarding water, the institutions have to be able to fulfill different fields of water management. The objectives of these institutions should include data acquisition; storage and distribution, water resources planning, construction of water works, operation and maintenance, water charges application and monitoring and evaluation. Since water is essential for the society, the central functions of water resources management and planning are in the hand of public institutions. In the West Bank these institutions are very mature or they even do not exist yet.

In the West Bank, the water distribution networks in the major cities are the responsibility of the municipalities, except for Bethlehem. However, the Palestinian Water Authority (PWA) was established in 1995 with the main objective of the development and management of all the water resources in Palestine in terms of quality and quantity. This is a very vital objective to achieve a balance between availability and demand for water in the present and the future.

In order to evaluate the status of the water institutions in the West Bank, from the farmers and other citizens opinion, some inquiries were included in the questionnaires. Despite that 78.9% of the farmers and 84.1% of the public claimed that the water facilities need rehabilitation and

improvement, 57.2% of the farmers and 55.5% of the public said that there is continuous improvement of the water resources (water wells and water networks) by the authorities in the West Bank. The responsibility of the wastewater management in the major cities should be within the hands of PWA; this was the opinion of 41.1% of the farmers and 42.5% of the public. 34.5% of the farmers and 32.0% of the public said that the municipality with partial public participation should be the responsible entity for the wastewater management. 14.9% of the farmers and 12.2% of the public voted to an NGO, 9.5% of the farmers and 16.5% of the public voted to an international foreign private company, 8.3% of the farmers and 11.0% of the public wanted a local private company, they said that they will not decide even to buy shares in such a company, because this entity will make no profit since investing in this sector is not feasible.

On the other hand, 51.5% of the farmers and 48.4% of the public seem have no confidence with the local experts and responsible authorized key persons within the local authorities. However, Private sector participation is an important new tool to assist local governments in their tasks of financing and operating the infrastructure for wastewater treatment.

The mixing of regulatory and operational responsibilities of the PWA gave rise to criticism. This criticism is because an institutional separation of regulatory and service activities is considered to be the key for an effective and decentralized water resources management (*Sturn, C. Ribbe, L. Schwabe, C. 1996*).

Therefore, although the PWA and municipalities got the highest percentages, these percentages are not high enough. The rest of the farmers said that the PWA as regulatory body should not touch the tasks of other management units. At the same level, only 53.6% of the farmers think that the PWA and other related units provide equal services to all the citizens, while the rest do not think so.

Finally, although the majority of the farmers and the public wanted the responsibility of the wastewater management to be within the jurisdiction of the PWA and the municipalities, they encouraged that the Ministry of Health (MOH) and Environment Quality Authority (EQA) should have the authority to audit these entities, and to penalize those who breach the rules.

#### **5-1-8 Public Awareness and Mass Media**

Before conducting any scheme related to the wastewater treatment and reuse, the opinion of the public of different levels should be taken into consideration. In the beginning of this section, the most important aspects of the public opinions which should be taken into consideration in the wastewater and treatment were mentioned and ordered according to its importance.

The public should be informed about the wastewater treatment and reuse in different purposes. This can be achieved by utilizing the mass media, conducting seminars and workshops and by applying publications which explain the process, the risks, advantages and potential disadvantages.

In order to measure the public awareness among the people in the West Bank and the awareness toward the process, some questions were raised about the effect of the mass media on the water conservation, and about water and wastewater treatment. It was found that 89.2% of the farmers

and 87.9% of the public are positively affected by the mass media regarding the water conservation and water preservation. But only 42.2% of the farmers and the public declared that they get sufficient information about the wastewater and treatment, while about 50% said that the mass media do not provide any information about the subject. Therefore, 96.4% of the farmers and 98.4% of the public stated that the academic institutions and schools should include subjects about water and environment in academic courses.

#### **5-1-9 Hypothesis Findings of the Farmers and Public**

The conclusions of the farmers and public levels are tabulated in table 5.1-3. The table shows the proposed hypothesis and the findings concluded from the above analysis.

The detailed analysis of the hypotheses is represented in tables and figures in the pages 97 to 110.

Table 5.1-3: Hypothesis Findings of the Farmers and Public Perception questionnaires

No.	Table	Hypothesis	Finding
1	5.1-2	From religion point of view, people seem to be prejudiced against wastewater reuse	This proposition is supported by the data, most of the respondent people think that Islam will still consider the treated wastewater as unclean, despite treated according to standards
2	5.1-3	People believe that the wastewater reuse is not acceptable by the social traditions and customs	This proposition is supported by the data. Respondent people think that our traditions urge us to avoid using treated wastewater
3	5.1-4	Acceptability of using treated wastewater will decrease with increased potential for unrestricted agriculture or human contact or ingestion	The proposition is supported by the data. The percentage of those who accept the fruit to be irrigated with treated wastewater is more than those who accept it for vegetables eaten cooked. The least acceptance percentage was for the irrigation of vegetables eaten raw
4	5.1-8	People do not accept reusing treated wastewater in agriculture	The proposition is not supported by the data, only 36.5% of respondents accept the proposition
5	5.1-9	People do not trust experts in the wastewater and treatment	The proposition is not supported by the data, although about 50% accept it
6	5.1-10	Wastewater treatment and reuse will attract more support amongst respondents connected with Sewage and Water networks rather than those not connected	This proposition is consistently upheld by the data, although the degree of acceptance between those who are not connected varies according to the type of water supply
7	5.1-11	Wastewater treatment and reuse will attract more support amongst respondents who take action to save water than amongst those who do not	The proposition is not supported by the data. There is no relation between those who make action to save water and the degree of acceptance of the process
8	5.1-12	Wastewater treatment and reuse will attract more support amongst respondents who own home gardens rather than those who do not	The proposition is not supported by the data. There is no relation between those who own gardens and acceptance or non-acceptance of the process

No.	Table	Hypothesis	Finding
9	5.1-13	Respondents who know more about treatment and reuse will be more likely to accept the process	The proposition is not supported by the data. On the contrary, it was found that 92.7% of the farmers who claim that the information provided to them is insufficient while only 87.1% of those who get sufficient information support the process.
10	5.1-14	Wastewater and treatment will attract more support amongst respondents who do not suffer from Amoebiasis and Ascariasis than those who suffer	The proposition is not supported by the data. There is no relation between the family health history and the acceptance or non-acceptance of the process.
11	5.1-15	Acceptability of treatment and reuse will be less amongst those who are adhered to the religion than those who are not	The proposition is supported by the data. There is a relation between the religion and the acceptance or non-acceptance of the process
12	5.1-16	Treatment and reuse will attract less amongst those who believe that the traditions and customs reject the reuse of the treated wastewater	The proposition is supported by the data. There is a relation between the social traditions and the acceptance or non-acceptance of the reuse.
13	5.1-17	Treatment and reuse will attract more amongst those who do not obtain sufficient water quantities for their livelihood than those who do not	The proposition is not supported by the data
14	5.1-18	Treatment and reuse will attract more amongst respondents who say that water price is a heavy burden than those who do not	The hypothesis is supported by the data. Although the degree of acceptance is not related directly with the degree of acceptance that water price is a burden
15	5.1-19	Wastewater treatment and reuse will attract more amongst respondents who are university graduated than those who are under graduated or school level	The hypothesis is supported by the data. Although the degree of acceptance is not related to the level of education



## **Hypothesis table 5.1-3**





























## **5-2 Experts and Institutes**

### **5-2-1 Social and psychological Aspects**

From the analyzed questionnaires, general Information about age frequencies of the respondents, gender percentages, distribution within districts and localities are presented in Table 5.2.1a, for Experts. The detailed analyses of the all the factors which resulted from the questionnaires are presented in tables and figure in Appendix-3 and Appendix-4 for Experts and Institutes respectively. It should be notified that the expression (Institutes) is used to represent the respondent individuals, decision makers, and politicians who work in governmental or non governmental organizations.

It was found that the opinion of the experts and those who work with the institutions that the main reason for not accepting the reuse is psychological.

In this context, the experts and institutions proposed that there is a relationship between the social traditions and customs from one side, and the psychological aspects from the other side. These two factors interact in a way such that there is no distinct boarder between the two sides.

In the public and farmers levels, it was found that most of the people agree that the social traditions and customs practiced in the West Bank do not accept the reuse of the treated wastewater in any sector. 88.9% of the respondent experts in the West Bank said that the main reasons for rejecting the reuse of the treated wastewater are psychological reasons.

Although the wastewater is treated, but it is very difficult to forget the original nature of this water was before treatment.

**Table 5.2-1a General Information about Respondents Experts  
Distribution of Experts Respondents within District**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Ramallah	17	13.4	13.5	13.5
	Jerusalem	14	11.0	11.1	24.6
	Salfeet	1	0.8	0.8	25.4
	Nablus	32	25.2	25.4	50.8
	Tulkarem&Qalqilia	5	3.9	4.0	54.8
	Jenin&Tubas	16	12.6	12.7	67.5
	Hebron	40	31.5	31.7	99.2
	Jericho	1	0.8	0.8	100.0
	Total	126	99.2	100.0	
Missing	System	1	0.8		
Total		127	100.0		

**Distribution of Experts Respondents within Location**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	city	94	74.0	74.0	74.0
	village	28	22.0	22.0	96.1
	camp	4	3.1	3.1	99.2
	Housing	1	0.8	0.8	100.0
	Total	127	100.0	100.0	

**Distribution of Respondents Experts according to the Gender**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	106	83.5	84.1	84.1
	Female	20	15.7	15.9	100.0
	Total	126	99.2	100.0	
Missing	System	1	0.8		
Total		127	100.0		

The opinions of the experts and the institutions were different from the public and farmers, the following wastewater management responsibilities are the most important concerns, in which the experts and the institutions think that public must participate in the following aspects ranked in descending order in terms of its importance according to experts and institutions opinions:

- Reuse considerations & Environmental Impacts
- Health Impacts
- Management and administrative Aspects
- Financial Aspects
- Technical Aspects
- Legal Aspects

#### **5-2-2 Economic Aspects**

84.3% of the respondent experts considered the water bill a heavy burden on the budget of the society. However, between 89.7% and 86.6% of the experts said that our water and wastewater institutions need financial support and public participation. In order to maintain continuous and sustainable rehabilitation and improvement of the water networks and wastewater facilities, the local society must be willing to financially participate in the system improvement.

On the other hand, 78.0% of the respondent experts stated that they agree on the wastewater treatment and reuse if it ends up of lowering the water prices. 80.3% said that it should provide additional quantities of water, and 74.8% said that it must provide recreational areas.

### **5-2-3 Religious and Cultural Aspects**

Despite most of the experts (89%) and (91.3%) of the institutions believe that the psychology is the main reason for non accepting the reuse, 59.8% of the experts and 54.3% of the institutions stated that the society incorrect understanding of the religion concerning this subject, make the society prejudiced against the reuse of the treated wastewater. They believe that the conservative societies do not accept the reuse. On the other hand, 30.7% of the experts and 34.6% of the institutions believe in the opposite.

However, 71.4% and 74.6% of the respondent experts and institutions respectively, think that the reuse of the treated wastewater is accepted by the religion if the resulting effluent was not harmful to the human health. This result coincides with the (fatwa) that was issued in 1978 about the subject. However, only 16.7% of the experts said that they do not know what the opinion of Islam in the subject.

Only 54.3% of the experts and 56.7% of the institutions said that there reference in the wastewater treatment and reuse will be abided to any decision issued by the official religious authorities. About 40% of the experts refuse to let the religion interfere in this subject. They consider this issue as a pure scientific issue, and the religion does not contradict with science.

### **5-2-4 Health Aspects**

83.5% of the respondent experts and 80.3% of the institutes stated that water shortage leads to epidemic diseases. However, about 90% of the experts and the institutes said that if the septic tanks and pits continue seeping, this will be a main reason for the diseases. Almost all the respondent experts and institutions stated that if the wastewater is treated,

the public health will be improved. About 87% of the respondent experts and institutions said that the farmers grow different crops using raw wastewater.

The results emphasize the experts and the related institutes are very worried about the wastewater situation in the West Bank. They raised an alarm about the issue. They understand the economic situation, but they said that this issue can be solved on individual level. Percolating pits should be frequently emptied; any potential over flow should be prevented. This will improve the public health situation, particularly Amoebiasis and Ascariasis will be eliminated in the society.

Concerning the health issues related to the irrigation with raw wastewater, 46.4% of the experts declared that there is a serious public health problem. Thorough analyses of this issue using crosstabs show the following

- 60% of the respondent experts from Hebron district agreed with that
- 75% of the experts who live in Tulkarem & Qalqilia agreed
- 50% of the experts who live in Nablus agreed
- 44% in Jenin & Tubas agreed
- 40% in Jerusalem district agreed
- and only 25% agreed in Ramallah district

### **5-2-5 Political Aspects**

96% of the experts and 98.4% of the institutions agreed that the Israeli manipulation on the natural water resources is one of the important reasons for unstable political situation in the Palestinian territories. Although they understand that the reuse of the treated wastewater is to augment the fresh water resources, 71.6% of the experts and 73.2% of the institutions stated that Palestinians must not think of an alternative of the natural resources. The Palestinians initially must achieve their confiscated natural water rights; then they start innovation supplementary resources. Using alternative supplementary resources will encourage Israel to manipulate the Palestinian water rights.

However, 93.7% of the experts and institutes believe that wastewater will be one the important future supplementary water resources that should be taken into consideration.

### **5-2-6 Technical Aspects**

As mentioned in section 5-1-6, the technical aspects include the water status as a natural resource, and the wastewater considerations in the West Bank, in addition to the purposes in which the treated wastewater is intended to be reused.

#### **• Water and Water Facilities in the West Bank**

60.6% of the respondent experts and 65.4% of the institutes believe that the water quantities provided to the citizens are not sufficient even for home gardens. Only 33.7% of the experts and 34% of the institutes have to buy additional quantities of water in order to irrigate there home gardens. Accordingly, 74.1% of the experts and 75.9% of the institutes who own home gardens do not have any objection to irrigate there private gardens with treated wastewater.

Concerning water facilities, 80.3% of the experts and 80.3% of the institutes believe that the water networks and other water facilities are in bad conditions. It needs rehabilitation and improvement. However, 61.1% of the experts and 60.6% of the institutes believe that the water quality in the West Bank territories is below international standards.

#### • **Wastewater Treatment and Reuse Considerations**

Despite that most of the experts stated that the Palestinian society is psychologically not ready for the reuse idea, 93.7% of the experts and 93.7% of the institutes agreed that treated wastewater should be reused in agriculture, industry and other ecosystems. They also agreed that this process will improve the public health, ground water and agriculture in the West Bank. 37.8% of the experts said that due to the high BOD and TSS concentrations, the treatment of wastewater for reuse purposes is not feasible. The rest of the experts refused that and, it is feasible even for high BOD concentrations to be treated and utilized in several purposes. 78% of the experts and 74.8% of the institutes believe that the cost of cubic meter of the treated wastewater will become lower than the cost of fresh water. 96% of the experts and 92.1% of the institutes said that the treated wastewater should be used for irrigation of crops as the highest priority. The industry and washing purposes are a second priority.

Concerning types of irrigation, the answers are as follow:

- 87.3% of the experts and 80.2% of the institutes are with restricted irrigation, and to use effluent to irrigate only trees, like Olives, Almonds, Grapefruit, Orange...etc, (restricted irrigation type B according to Shelef).

- Only 54.0% of the experts and 42.1% of the institutes accept to utilize the treated wastewater in irrigating the eaten cooked vegetables, (restricted type C according to Shelef).
- The acceptance percentages of the experts and institutes dropped down to 39.7% and 42.1% respectively for the eaten row vegetables, (unrestricted irrigation).

The surprise was when 53.2% of the experts and 49.2% of the institutes (relatively high percentages), agreed that they do not trust those who are responsible for water and wastewater sectors. Almost equal results were found among farmers and public.

On the other hand, 46.4% of the experts and only 37.6% of institutes believe that there are some defaults within the WHO (1989) proposed guidelines.

Almost all respondent Palestinian experts and institutes recommended that the Palestinian strategy in utilizing the treated wastewater should be gradual. This means a stage-based strategy should be adopted. First stage is to utilize the treated effluent in street washing, car washing and industry. Second stage is to utilize the treated effluent in a very restricted irrigation; to irrigate non-fruit able trees, bushes, ...etc. Third stage is to utilize the effluent in the restricted irrigation; to irrigate fruit trees and eaten cooked vegetables. The fourth stage is to use the treated wastewater for unrestricted crops irrigation. These strategic stages should be under a strict control of authorized highly experienced institutes. Codes of practice should be established for each stage. The standards and codes should be suitable to the wastewater characteristics in the West Bank. Chapter 6 details a proposed integrated strategy for the wastewater sector

in the West Bank relying on the Public perception results of the questionnaires.

Palestinian Water strategic Planning Study of PECNDAR, 2001 adopted the treatment standards of the WHO guidelines ( $\leq 200$  fecal coliforms per 100ml, and  $\leq 1$  intestinal nematodes arithmetic mean no. of eggs/liter) to be adopted where direct contact with the public is possible, or for spraying of crops which will be consumed uncooked. For general irrigation (indirect contact with public), WHO guidelines A ( $\leq 1000$  fecal coliforms per 100 ml, and  $\leq 1$  intestinal nematodes arithmetic mean no. of eggs/liter) should be adopted (*PECNDAR, 2001*).

However, many countries particularly European and North American countries do not adopt the proposal "Health Guidelines for the use of wastewater in Agriculture and Aquaculture" (*Shelef, 1991*).

Since it is safe to assume that most modern and developed countries will not adopt the proposed WHO Guidelines, there is a subtle implication that Guidelines are actually aimed only for developing and less than developed countries. This approach does not only border with paternalism, but also contradicts the WHO long-cherished policy of opposing the validity of "Plebeian Law" versus "Patrician Law" in matters of health protection. (*Shelef, 1991*).

The Palestinians must utilize and gain from the experience of other countries in the region. The code of practice in Palestine should be established to enforce, by legislation for both existing and new development areas, increased control and reuse of treated wastewater. The experience of other developed countries in the region must be adopted, developed in order to suit the situation in Palestine.

The characteristics of the effluent discharged from Al Bireh treatment plant should be compared with other effluents from other plants in the region.

#### **5-2-7 Institutional Aspects**

Legislations should be established to authorize specific institutes to be responsible for supervising and monitoring the application of wastewater treatment and reuse.

About 60% of experts and 52.0% of institutes stated that the performance of existing Palestinian Water Institutes is not sufficiently efficient. Although many studies were issued in this domain, only 56.8% of experts and 45.6% of the institutes believe that the Palestinian Authority put enough efforts in order to improve and develop the Palestinian water resource in a comprehensive manner. The rest said that the efforts are not sufficient. The Palestinian Authority must put the wastewater treatment and reuse on the top priority. Both experts and institutes said that the Palestinians need experts in the wastewater and treatment subject.

Concerning the responsible institutions and agencies, the results for experts and institutes were analogous. The opinions of 41.6% of experts and 39.7% of institutes were given to the Palestinian Water Authority (PWA), 29.8% of experts and 35.2% of institutes were given to the municipalities with public partial participation, 16.8% of experts and 15.1% of institutes were given to NGO, only 12.0% of experts and 12.7% of institutes voted to local private company, and only 8.7% of experts and same percentage of institutes have given their votes to an international foreign private company.

The experts and institutes highly agreed that the Authority must establish legislations to supervise and monitor the wastewater treatment and reuse process. These legislations mandate the entities who are authorized to monitor the process to castigate and penalize those who breach the standards and codes, especially in the reuse process. The experts and institutes highly recommended the Ministry of Health and the Environment Quality Authority to be the authorized agencies for this mandate.

#### **5-2-8 Public Awareness and Mass Media**

Although experts and institutes said that the public must be explored concerning wastewater treatment and reuse projects, 53.2% of both experts and institutes stated that the public and farmers are not given information about wastewater treatment and reuse. 75.4% of experts and 78.6% of institutes criticized the mass media regarding this issue. In this context, the mass media be should given more a better role in this subject. This will help improve public awareness and increase the acceptance toward the reuse.

#### **5-2-9 Hypothesis Findings of the Experts and Institutes**

The conclusions of the Experts and Institutes levels are tabulated in table 5.2-2. This table shows the proposed hypothesis and the findings concluded from the above analysis.

The detailed analysis of the hypotheses is represented in tables and figures in the pages 142 to 152.

Table 5.2-2: Hypothesis Findings of the Experts and Institutes Perception questionnaires

<b>No.</b>	<b>Table</b>	<b>Hypothesis</b>	<b>Finding</b>
1	5.2-3	From religion point of view, Experts believe that reuse of the treated wastewater is accepted	This proposition is sustained by the data, 71.4% of the respondent experts think that Islam accepts the reuse of treated wastewater under the condition that it is treated to the level accepted for the desired purpose
2	5.2-4	The reason for not accepting the reuse of the wastewater is mainly psychological	This proposition is supported by respondent Experts; about 89% of respondent Expert propose that the public are psychologically prejudiced against the reuse
3	5.2-5	Experts believe that one of the important reasons behind some diseases like Amoebiasis, Ascariasis and Diarrhoea symptoms is the use of raw wastewater in irrigation.	This proposition is supported by the data; 87% of respondent experts agree using raw wastewater in irrigating crops in some area is one of the main reasons for Amoebiasis, Ascariasis and Diarrhoea symptoms.
4	5.2-4a 5.2-4b	The Experts priority for reuse is to provide further water quantities, and to lower the water prices	The proposition is sustained by the data. The respondent Experts and Institutes expressed more interest in the recreational areas than the farmers and public.
5	5.2-5a 5.2-5b 5.2-5c 5.2-5d	Experts prefer that treated wastewater to be utilized avoiding contact with human and/or for restricted agriculture. They are prejudiced against reuse for unrestricted irrigation.	The proposition is highly supported by the data. The percentage of Experts who prefer to utilize treated wastewater in industry, washing services and restricted irrigation of trees is much higher than those who accept reuse for growing vegetables, especially, vegetables eaten raw

No.	Table	Hypothesis	Finding
6	5.2-6a 5.2-6b	The Palestinian experts in the subject of wastewater treatment are highly adhered to the religion references and religion judgment about the subject	The proposition is not supported by the data. Only 54.3% of the respondent experts would prefer to refer to religion, the rest rejected. Although, 87% of experts prefer that a close cooperation between the technical experts and religious references to find acceptable resolutions
7	5.2-7	Due to the political situation in Palestine, and the manipulated Palestinian water rights by Israel, Experts and Institutes prefer to retrieve those rights before development of artificial supplementary resources	The proposition is upheld by the data; 71.7% of respondent experts and 73.2% of Institutes agree with the proposition. Only 24.4% experts and 22.8% institutes rejected the proposition
8	5.2-8	Because of the high BOD and TSS concentrations in the raw wastewater in West Bank, treatment to an acceptable reuse standards will be expensive and not feasible	The hypothesis is not sustained; 38.8 % of experts and 40.2% of Institutes accept the hypothesis, the rest reject it. The experts believe that Al Bireh treatment plant is an example of a feasible treatment plant for high BOD and relatively small quantities of wastewater



## **Chapter 6**

### **Guidelines for a Strategic Plan for Wastewater Reuse**

#### **6-1 General**

Most crops in arid countries will have to be grown increasingly, and eventually solely, with treated wastewater. The economic, social and environmental benefits of such an approach are clear. To help the gradual and coherent introduction of such a policy, which protects the environment and public health, the Palestinian Notional Authority shall have to adapt an Integrated Water Management approach, facilitate public participation, disseminate existing knowledge, and generate new knowledge, and monitor and enforce standards.

The Palestinian Water Authority (PWA) proposed a Management Plan for the Wastewater Sector in June, 2003. In this chapter, guidelines for the application of a Strategic Plan for Wastewater Reuse are proposed.

#### **6-2 Creation of an Enabling Environment**

In order to do that, an enabling environment should be created by doing at least the following four things to safely reuse the treated effluent as one tool to combat food and water insecurity. These steps are also summarized schematically in figure 6.1:

- 1) Wastewater treatment and reuse must form part of an integrated water management strategy, at the basin level, with multi-disciplinary linkages between different sectors such as environment, health, industry, agriculture, and municipal affairs. For instance, the main producer of wastewater, municipalities, must interact with the main user, agriculture.

Urban and rural planning must be integrated so that industries are not sited in locations where their effluent, which might be dangerous

constituents such as heavy metals, will not contaminate water intended to be used for agriculture. From the farmers and public questionnaires perception, it is found that 82.5% and 78% of the farmers and public respectively prefer to utilize the treated wastewater for agricultural purposes.

In this context, and in order to make the reuse feasible from both sides, economic and quantity, clusters of locations, such as nearby villages, cities and camps can share one treatment plant which treats the discharged raw wastewater resulting from the cluster.

- 2) It is the duty of the Palestinian National Authority to facilitate the participation of stakeholders in wastewater treatment and reuse projects. This should include supporting non governmental organizations which help build institutions at the local level. Safe and sustainable decentralized wastewater treatment and reuse projects will never be established without the willing participation of the beneficiaries. From the questionnaires analyses, it was concluded that about 80% of the community are willing to participate by paying additional fees in order to improve water facilities and wastewater treatment plants. About 90% of the community expressed their willingness to provide voluntary participation in social services concerning water and wastewater. The Palestinian community expressed their willingness to participate in the legal and financial aspect, technical aspects, in addition to management and administration.
- 3) There is a need to disseminate existing knowledge about the danger of raw wastewater reuse, safe reuse guidelines, and to disseminate the position of Islam on wastewater reuses. Knowledge of cost effective treatment technologies, crop and soil protection must also be disseminated. Specific site research should be carried out to fill missing gaps. In this context, the quality of the treated wastewater needs to be

monitored and evaluated in order to decide on the types of crops to be irrigated.

- 4) To ensure the protection of public health and environment, the Palestinian National Authority, presented by Ministry of Health (MOH) and Environmental Quality Authority (EQA), must evaluate, regulate and monitor quality of effluent, reuse practices, public health, crop water quality, and soil and groundwater quality.
- 5) The Palestinian National Authority has proposed criteria which is similar to the Israeli criteria for unrestricted irrigation (type D group). But before introducing these advanced criteria, a step-by-step application of the reuse should be adapted. A continuous monitoring and evaluation should be carried out. Four steps of introducing the reuse are suggested here:

**First step:** Application of treated effluent in some non-food industries such as quarrying, stone cutting, ready mix concrete, leather tanning and other industries. In this step, irrigation of non-fruit able trees, forest irrigation and other human non-contact irrigation can be introduced (Type A Crops).

**Second step:** After a close monitoring of the resulting effluents, irrigation of some restricted crops such as olive trees, grapes, almonds and other fruit trees (Type B Crops)

**Third step:** Application of treated effluent to vegetable intended to be eaten cooked such as eggplants, squashes, beans and peeled vegetables (Type C Crops)

**Fourth step:** Application of treated effluent to unrestricted crops, including vegetables eaten raw, parks and lawns (Type D Crops). This step should come only after proving that quality has reached the high quality criteria for the unrestricted irrigation.

### **6-3 Proposed Institutions to Manage the Wastewater Treatment and Reuse Sector**

An independent specialized entity should take the responsibility of the wastewater sector and its activities. This entity should have the experience and sufficient specialized persons. This entity should be responsible for reviewing, evaluation and development of any strategic plan for treatment and reuse at different levels. It is proposed that this entity should be under the management of the Palestinian Water Authority for a better and easier coordination with water sector administrations and other in line ministries.

From the results of perception of the four types of questionnaires, most of the respondents stated that the Palestinian Water Authority (PWA) is the most capable entity to take the responsibility of the management and administration of the wastewater sector.

The perception also concluded that the municipalities with partial public participation shall directly implement the treatment and reuse projects which are under their jurisdiction.

Figure 6.2 is a schematic diagram shows the administrative relations between the different ministries and other institutions.

The PWA shall supervise the implementation and evaluate the projects through these governmental bodies and municipalities. The PWA shall revise and improve the integrated water strategy in cooperation with in line ministries such as Ministry of Planning (MOPIC), Ministry of National Economy (MONE), Ministry of Agriculture (MOA) and Ministry of Local Government (MOLG) at the basin level. This operation shall be interacted with different sectors such as environment, economy, health, industry, and agriculture. All these authorities must be identified in parallel with the (PWA). A steering committee should be formed in order to coordinate the different activities for each of those

bodies. Authorities shall be identified for each of those ministries and implementation shall be coordinated by this steering committee.

The fund raising should be the role of Palestinian Water Authority (PWA) and Ministry of Local Government (MOLG) which coordinates all the projects of the local governments and municipalities. The PWA shall present the policy and other relevant regulations regarding the Strategic Plan and the Water Integrated Strategic Plan to the donors.

Ministry of Health shall develop, supervise and monitor the health impacts of the operations related to treatment and reuse. Ministry of Health shall report to the PWA, and find solutions for any urgent case related to health aspects that might take place during the implementation of any reuse project.

Environmental Quality Authority (EQA) shall be the responsible institution for evaluating the environmental impacts of the treatment and reuse schemes at the environment and other ecological systems. This should be in cooperation with relevant municipalities and any other local governmental bodies such as local governmental units in the villages. Impact assessment studies should be conducted prior and post the implementation of any reuse scheme. Decisions should be taken to mitigate any negative impact at the ecological level.

Legislations shall be established and developed in order to give each institution its role and to identify the authorities for each entity.

#### **6-4 Public Awareness and Acceptance**

As mentioned before, the psychological factor is essential for initiating, implementing and sustaining wastewater reuse program. In the absence of social support a reuse project may fail.

It is the duty of the Palestinian National Authority to disseminate the idea of reuse, the advantages and the potential risks if it is utilized incorrectly.

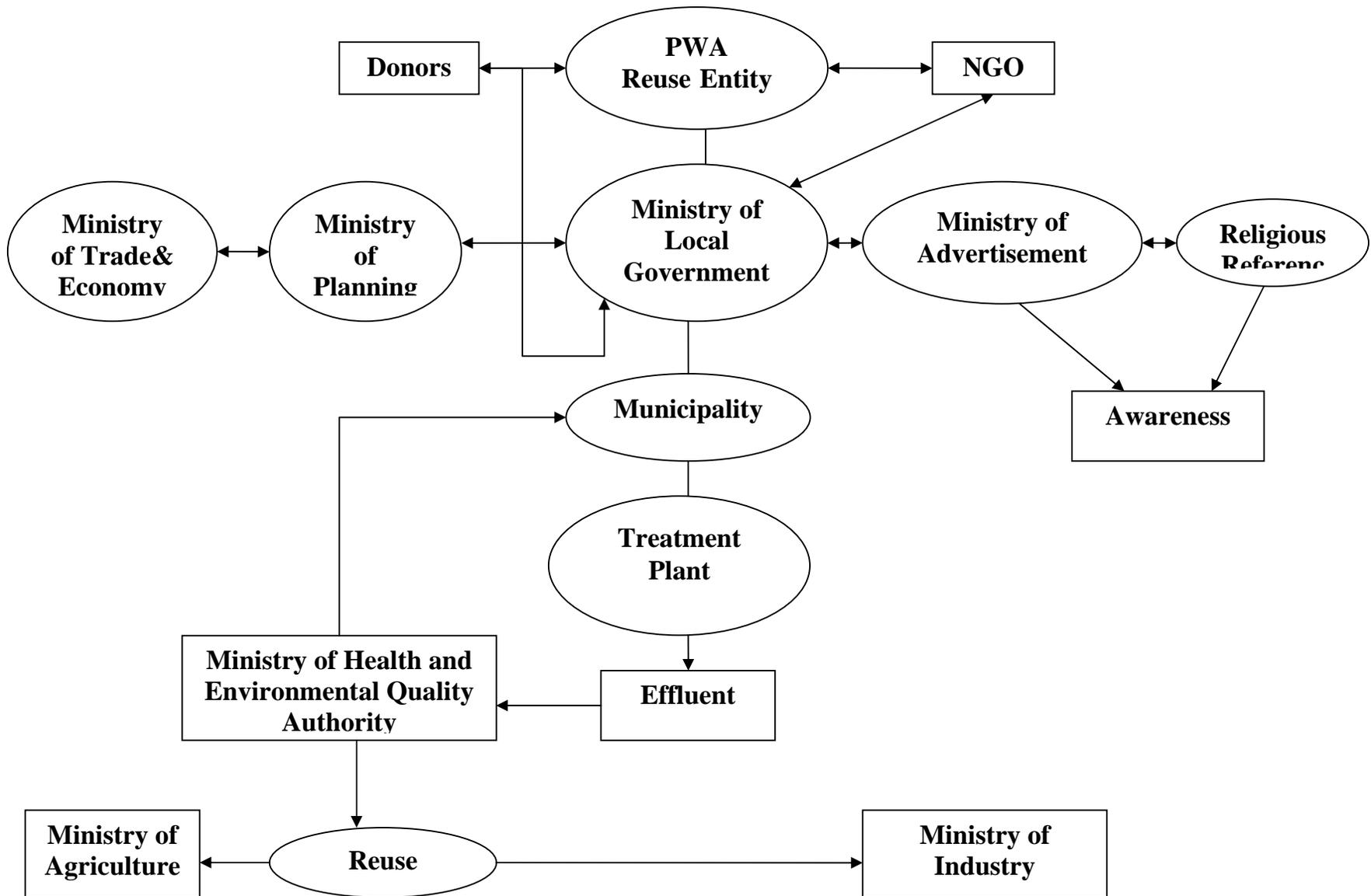
A cooperation and coordination plan must be done between Ministry of Advertisement and other religious references (such as Dar Al Fatwa) in order to disseminate Islam point of view regarding reuse. They should make contacts with other Islamic countries in the Middle East Region in order to develop a religious vision regarding the reuse. Figure 6.2 illustrates the relation between the Awareness and Ministry of Advertisement and the religious references.

The safe guidelines regarding reuse should be disseminated at local government level. Ministry of Advertisement shall cooperate with local mass media for this purpose. Awareness plan should be developed in cooperation with the religious references to introduce the position of Islam regarding reuse.

Public perception regarding treatment and reuse should be carried out continuously in order to examine the changes in the public opinion regarding reuse.

Stakeholders must be identified and approached according to international standard procedures. Responsible staff members in the PWA must be given the task as soon as the potential development is identified (*PWA, 2003*).

The contact with NGOs should be assessed for each development. NGOs could be important in order to mobilize stakeholders and to discuss elements of the development. For smaller investments, they will also be important for all the phases of the reuse project (*PWA, 2003*).



## **Chapter 7**

### **Conclusions and Recommendations**

#### **7-1 Conclusions**

Assessment and study of the factors that affect the attitude of the Palestinian communities at different levels is crucial before implementing any scheme related to wastewater sector. The link between the factors affecting the acceptance of the wastewater treatment and reuse is an unavoidable recurrent theme in the West Bank.

The questionnaires which were applied to the four groups have shown differences between the results. At the same time some results were analogous. The results of the different issues have shown similarities between the Farmers and Public as a group, and the Experts and Institutes as another group.

From the results it can be concluded that the social traditions and customs affect the opinion of the respondents toward the reuse issue. Most of the respondents think that the society does not accept the reuse.

The psychological factor is the most important factor that affects the acceptance. This factor negatively affects the opinion of the society regarding reuse. The original nature of the reused effluent will be always reflected in the trend of judgment of any person in the Palestinian society on the reuse issue.

In this context, the religion must be considered in the assessment of the factors affecting the reuse. From the results it was concluded that most of the respondents do not know the actual opinion of religion. They always remember that wastewater, although treated, will stay unclean from the religion point of view.

The public awareness about reuse is very weak. Most of the Public respondents do not understand the physical meaning of reuse. They think that religion and social traditions are prejudiced against the wastewater treatment and reuse.

In this context, it is concluded that the governmental and non-governmental organizations do not play sufficient roll in informing the community about reuse. Official and private mass media must be supported and given enough opportunities in this subject.

The timing of the study is critical as Palestinian Territories are suffering from the current crises which have started September, 2000. Stringent sanctions, incursions, curfews and closers are imposed on people affect the opinion of the respondents. The link between the political conflict and the opinion of the public can not be avoided. Regardless of whether the focus is wastewater treatment or water management, the current situation, and above all, the occupation will always impact the opinions of the people. It was concluded that the community would prefer to retrieve the Palestinians rights in natural water resources before the development of artificial supplementary resources.

Concerning the purposes of reuse, results of all the types have shown that acceptance of reuse decrease with increased potential for unrestricted agriculture or human contact and ingestion.

## **7-2 Recommendations**

As a result of the study, the following recommendations are considered important regarding the wastewater treatment and reuse in the Palestinian Territories:

- 1) Appropriate wastewater treatment technologies shall be adopted with due considerations to economy and quality assurance of effluent for the proposed type of reuse.
- 2) The priority criterion for the wastewater treatment and reuse shall be based on religious, social, economic and political considerations.
- 3) A comprehensive management plan of wastewater treatment and reuse shall take into consideration the political implications. This plan must consider the treated wastewater as a supplement to the groundwater and other natural water resources.
- 4) Public acceptance must be taken into consideration before conducting any wastewater treatment and reuse. Considerable attention must be directed to social, economic, and other factors.
- 5) Human resources development shall occupy an advanced rank in the priority scale. Continuous education, on-the-job training and overseas training programs shall be organized and implemented.
- 6) Management of wastewater shall receive attention with due regard to public health standards.
- 7) Periodically review institutional arrangements and legislations in effect to appraise adequacy of the status through the changing conditions and time. Institutional restructuring shall be made to match the changing needs.

- 8) Adopt code of practice for the reuse in different purposes and utilize from the experience of other countries in the region.
- 9) The public shall be educated through various means about the value of the wastewater as a supplementary future source. In this context, the mass media must proactively have an obvious role.
- 10) The roll of water conservation to be played by the different sectors of society shall be defined.
- 11) Enhancement of the communication between the water and wastewater departments and the community in order to increase the acceptance of utilizing low quality water sources, such as treated effluents.
- 12) Informing the community about using treated effluents depending on the level of treatment and related purposes.
- 13) For further analyses in regard with social aspects, it is recommended that a social specialist should conduct these analyses in cooperation with an environmental expert.
- 14) For further analyses in regard with religious aspects, it is recommended that a perception to be conducted amongst the religious references and scientists of different religions.

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## **Appendix-1**

This Appendix includes the Questionnaire that was applied to the Public Level. It also includes tables resulted from the detailed analyses of each question. It also includes cross tables which have been constructed to test different interacted relations between the proposed factors.







































































## **Appendix-2**

This Appendix includes the Questionnaire that was applied to the Farmers Level. It also includes tables resulted from the detailed analyses of each question. It also includes cross tables which have been constructed to test different interacted relations between the proposed factors.





































































### **Appendix-3**

This Appendix includes the Questionnaire that was applied to the Institutes Level. It also includes tables resulted from the detailed analyses of each question. It also includes cross tables which have been constructed to test different interacted relations between the proposed factors.











































































## **Appendix-4**

This Appendix includes the Questionnaire that was applied to the Experts Level. It also includes tables resulted from the detailed analyses of each question. It also includes cross tables which have been constructed to test different interacted relations between the proposed factors.







































## **Chapter 7**

### **Conclusions and Recommendations**

#### **7-1 Conclusions**

Assessment and study of the factors that affect the attitude of the Palestinian communities at different levels is crucial before implementing any scheme related to wastewater sector. The link between the factors affecting the acceptance of the wastewater treatment and reuse is an unavoidable recurrent theme in the West Bank.

The questionnaires which were applied to the four groups have shown differences between the results. At the same time some results were analogous. The results of the different issues have shown similarities between the Farmers and Public as a group, and the Experts and Institutes as another group.

From the results it can be concluded that the social traditions and customs affect the opinion of the respondents toward the reuse issue. Most of the respondents think that the society does not accept the reuse.

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The public awareness about reuse is very weak. Most of the Public respondents do not understand the physical meaning of reuse. They think that religion and social traditions are prejudiced against the wastewater treatment and reuse.

In this context, it is concluded that the governmental and non-governmental organizations do not play sufficient roll in informing the community about reuse. Official and private mass media must be supported and given enough opportunities in this subject.

The timing of the study is critical as Palestinian Territories are suffering from the current crises which have started September, 2000. Stringent sanctions, incursions, curfews and closers are imposed on people affect the opinion of the respondents. The link between the political conflict and the opinion of the public can not be avoided. Regardless of whether the focus is wastewater treatment or water management, the current situation, and above all, the occupation will always impact the opinions of the people. It was concluded that the community would prefer to retrieve the Palestinians rights in natural water resources before the development of artificial supplementary resources.

Concerning the purposes of reuse, results of all the types have shown that acceptance of reuse decrease with increased potential for unrestricted agriculture or human contact and ingestion.

## **7-2 Recommendations**

As a result of the study, the following recommendations are considered important regarding the wastewater treatment and reuse in the Palestinian Territories:

15) Appropriate wastewater treatment technologies shall be adopted with due considerations to economy and quality assurance of effluent for the proposed type of reuse.

16) The priority criterion for the wastewater treatment and reuse shall be based on religious, social, economic and political considerations.

17) A comprehensive management plan of wastewater treatment and reuse shall take into consideration the political implications. This plan must consider the treated wastewater as a supplement to the groundwater and other natural water resources.

18) Public acceptance must be taken into consideration before conducting any wastewater treatment and reuse. Considerable attention must be directed to social, economic, and other factors.

19) Human resources development shall occupy an advanced rank in the priority scale. Continuous education, on-the-job training and overseas training programs shall be organized and implemented.

20) Management of wastewater shall receive attention with due regard to public health standards.

21) Periodically review institutional arrangements and legislations in effect to appraise adequacy of the status through the changing conditions and time. Institutional restructuring shall be made to match the changing needs.

- 22) Adopt code of practice for the reuse in different purposes and utilize from the experience of other countries in the region.
- 23) The public shall be educated through various means about the value of the wastewater as a supplementary future source. In this context, the mass media must proactively have an obvious role.
- 24) The roll of water conservation to be played by the different sectors of society shall be defined.
- 25) Enhancement of the communication between the water and wastewater departments and the community in order to increase the acceptance of utilizing low quality water sources, such as treated effluents.
- 26) Informing the community about using treated effluents depending on the level of treatment and related purposes.
- 27) For further analyses in regard with social aspects, it is recommended that a social specialist should conduct these analyses in cooperation with an environmental expert.
- 28) For further analyses in regard with religious aspects, it is recommended that a perception to be conducted amongst the religious references and scientists of different religions.



## الملخص

إن موضوع معالجة المياه العادمة واعادة استخدامها في المناطق الفلسطينية هو من اهم المواضيع التي يجب ان توليها السلطة الوطنية الفلسطينية اولوية وذلك بسبب قلة الموارد المائية الطبيعية وبسبب الوضع السياسي الحساس في هذه المنطقه وقبل المباشرة باي مشروع يتعلق باعادة استعمال المياه العادمة يجب ان يتم دراسة تقبل الجمهور ومعرفة العوامل التي تؤثر على رأي الجمهور بمختلف قطاعاته بالنسبة لعملية اعادة الاستعمال في مختلف الاغراض .

لدراسة ذلك في الضفه الغربيه تم تقسيم الجمهور الى اربعة اقسام وهي العامه (public) ، المزارعين (Farmers) ، المتخصصين (Experts) في مجال معالجة المياه العادمة واعادة استخدامها والقسم الرابع هم من صناع القرار الفلسطيني والذين يعملون في المؤسسات الحكوميه وغير الحكوميه والبلديات سواء المنتخبين او المعيّنين حيث تم الاشارة اليهم بكلمة (مؤسسات - Institutes) في الاستبانة الخاصة بهم، و قد تم تصنيف هذه الاستبيانات الى اربعة انواع كل نوع يحتوي على اسئلة تتناسب مع القسم الذي ستوجه اليه هذه الإستبانة.

بعد ذلك تم توزيع هذه الإستبانات والتي احتوت على اسئلة تتعلق بالعوامل التي قام الباحث بدراستها مثل العوامل الاجتماعية، الدينيه، الثقافيه، الصحيه، الاقتصاديه، السياسيه، شح المياه بالاضافة الى النواحي المؤسساتيه

تم تحليل 554 استبانة من مختلف الأنواع بواسطة برنامج التحليل الاحصائي SPSS حيث تم عمل (تحليلات وصفيه Descriptive analyses) من حيث نسب القبول والرفض وتم ربط هذه النسب بالعوامل المتعلقة بها والحصول على النتائج كما تم ربط بعض العوامل المؤثره في القبول والرفض مع بعضها البعض في محاولة لمعرفة اسباب الرفض والقبول والفئات التي تميل الى القبول او الرفض اكثر من غيرها وجد ان الجمهور العام والمزارعين نتائجهم متشابهه كما ان المتخصصين والذين يعملون في المؤسسات الحكوميه وغير الحكوميه (صناع القرار) كانت نتائجهم متساويه تقريبا .

من النتائج ان غالبية الجمهور يقبل استعمال المياه العادمة بعد معالجتها وفقا للمعايير التي تناسب الاستعمال المنشود ، الا ان هذه الغالبية ومن مختلف الفئات لا تعرف عن رأي الدين في الموضوع، كما ان معظم المجاوبين للاستبانات اجمعوا ان العادات الاجتماعيه والتعاليم الدينيه لا تتقبل فكرة اعادة الاستعمال .

كما اظهرت النتائج ان الجمهور يحبذ انتشار محطات معالجة المياه العادمة لاعادة استعمالها خاصة في قطاعات الصناعة والزراعه، الا انه ابدى تحفظه من استعمال المياه العادمة المعالجه في زراعة الخضروات التي تؤكل نيئه (دون طبخ) وتحفظا اقل لري الخضروات التي تؤكل مطبوخه وتحفظا اقل في ري المزروعات الشجرية .

اما بالنسبة للمؤسسات المسؤوله عن ادارة المياه العادمة فقد اجمع المجيبون على الاستبانات ان الجهه المسؤوله هي سلطة المياه الفلسطينية (PWA) بالاضافة الى البلديات المعنية بمشاركه جزئيه من الجمهور .

كما اجمع المجيبون انهم مستعدون لقبول اعادة الاستعمال للمياه العادمة في حالة زودهم ذلك بكميات اضافيه من المياه .

هذا وقد اوصت الرسالة ان يكون هنالك اهتمام كبير في موضوع معالجة المياه العادمة لاعادة استعمالها وان يتم قبل ذلك توعية الجمهور بكافة فئاته عن هذا الموضوع عن طريق وسائل الاعلام والنشرات وحلقات البحث واية وسيلة متاحة اخرى .

