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Importance of Developing Standards for Greywater Reuse in Palestine

Master's Thesis Submitted By
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أهمية تطوير معايير فلسطينية خاصة بإعادة استخدام المياه الرمادية المعالجة

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This thesis was submitted in partial fulfillment of the requirements for the Master's Degree in Water and Environmental Engineering from the Faculty of Graduate Studies, at Birzeit University, Palestine.

Dedicated to my wonderful family,

Dear Parents

My Fiance (Taj)

Sisters& Brother

Mom and Dad, I could never have done this without your faith, support, and constant encouragement. Thank you for teaching me to believe in God, in myself, and in my dreams.

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Abbreviations

Abbreviation	Name
ACH	Action Against Hunger
ARIJ	Applied Research Institute- Jerusalem
DFID	Department for International Development
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
GECF	Global Environment Centre Foundation
GW	Greywater
GWS	Greywater Systems
HWE	House of Water and Environment
IDRC	International Development Research Centre
MCM	Million Cubic Meters
MDG	Millenium Development Goals
NGO	Nongovernmental Organization
PARC	Palestinian Agricultural Relief Committee
PCBS	Palestinian Central Bureau of Statistics
PHG	Palestinian Hydrology Group
PWA	Palestinian Water Authority
PWEG	Palestinian Wastewater Engineers Group
SCF	Save the Children Foundation
UAWC	Union of Agricultural Work Committees
UNEP	United Nations Environment Programme
WEDO	Water and Environmental Development Organization

Abstract

Increasing pressure to conserve water resources has prompted the idea that the separation of greywater from sewerage through the use of two separate systems may enable greywater to be reused at the household level for such non-potable demands as toilet flushing or landscape irrigation. This research deals with the importance of developing onsite treated greywater reuse standards for Palestine from experts and beneficiaries' point of view. Knowing the importance of developing guidelines and standards will better represent the delicate balance between protection of public health and the levels of risk posed by greywater re-use within the context of everyday human activity, and make an effort to identify areas where there is either an expectation for responsibility or a personal acceptance of responsibility with regard to public or personal health. Two questionnaires have been designed for this purpose. The onsite greywater treatment plants (GWTPs) beneficiaries and experts opinions have been investigated through two detailed surveys. This research is of great importance for policy makers, researchers, people who develop and enforce standards and regulations, educators, environmental and public health scientists, engineers, and others. There is a common encouragement of treated greywater re-use among water and environmental experts as 91.1% of them supported that but provision of proper monitoring and technical solutions is very significant. In spite of that, up-to-date, there are no onsite treated greywater reuse standards and guidelines for Palestine and most of experts (95%) and beneficiaries (97.5%) confirm the importance of having Palestinian standards for treated greywater reuse. Financial issues are the main incentives for applying this system at the household level for agricultural purposes, which is socially accepted. External funds should be secured for implementing more greywater treatment units taking into consideration that long term monitoring, maintenance and sampling should be important components of such projects.

الخلاصة

تعاني فلسطين، شأنها شأن دول المنطقة، من أزمة مياه حادة مما عزز فكرة فصل المياه الرمادية عن المياه العادمة السوداء من خلال استخدام نظامين منفصلين و بالتالي إمكانية إعادة استخدام المياه الرمادية المعالجة في عدة استخدامات على مستوى المنزل والتي لا تتطلب جودة مياه عالية كما هو المطلوب لمياه الشرب مثل اعادة استخدامها لأغراض الزراعة. يتناول هذا البحث أهمية تطوير معايير فلسطينية خاصة بإعادة استخدام المياه الرمادية المعالجة من وجهة نظر الخبراء في قطاع المياه و البيئة والمستفيدين من وحدات المعالجة. معرفة أهمية تطوير هذه معايير يساعد على تحقيق التوازن بين الحفاظ على الصحة العامة والتعرف على مخاطر إعادة استخدام المياه الرمادية الغير معالجة ، وتحديد المسؤوليات التي تقع على عاتق مختلف الجهات الرسمية ذات العلاقة. منهجية البحث تتضمن إنشاء نوعين من الاستبيانات، الاستبيان الأول استهدف الخبراء في قطاع المياه والبيئة ، والثاني استهدف المستفيدين من وحدات المعالجة الرمادية وتم اجراء مسح ميداني لتوزيع هذه الاستبيانات وجمع المعلومات المطلوبة ومن ثم تحليلها. يعد هذا البحث ذا أهمية كبيرة للباحثين ومتخذي القرارات والسياسات والجهات المسؤولة عن وضع المعايير والمواصفات وعلماء البيئة والصحة العامة، والمهندسين، وغيرهم. هناك تشجيع مشترك لإعادة استخدام المياه الرمادية المعالجة من قبل خبراء المياه والبيئة ، حيث أن 91.1٪ منهم أيدوا ذلك مع التركيز على أهمية وجود متابعة مستمرة من قبل الجهات الرقابية. 95% من الخبراء و 97.5% من المستفيدين أكدوا على أهمية وجود معايير فلسطينية خاصة بإعادة استخدام المياه الرمادية المعالجة. يعد الدعم المادي من المحفزات الرئيسية لتطبيق هذا النظام للأغراض الزراعية على مستوى الأسرة ، مع الأخذ بعين الاعتبار الصيانة وأخذ العينات بصورة دورية والتي تعد عناصر هامة لاستدامة هذه المشاريع .

Chapter One
Introduction

1 Chapter One: Introduction

1.1 Background

Palestine is among the Middle Eastern countries that intensively experience water problems. The current water crisis in Palestine is mainly due to the Israeli occupation and their control over the Palestinian aquifers which prevent Palestinians from having sufficient access to clean water (Jayyousi and Srouji, 2009).

According to Palestinian Water Authority (2012), this lack of access to sufficient, safe, and adequate drinking water is a major problem for Palestinians whose standard of living has been decreased to the minimum, depriving them from the basic human rights to health, food security and water.

The daily water consumption of Palestinian households that are connected to a network is less than 50% of the recommended value by the World Health Organization's and about 1/6 of Israeli household consumption. In the West Bank, the average daily per capita domestic water consumption is only 72; while it is 90 l/c/d in Gaza Strip (PWA, 2013).

To address this enormous issue, water recycling should be taken into account. In Palestine, there are different sources of water for recycling such as rainwater, sewage and greywater (GW). GW is one of the most important water sources, its contribution to daily household total wastewater (Grey and Black) production is about 80%. This amount of wastewater when being properly treated can be reused for agriculture resulting in saving of fresh drinking water and reducing the desludging frequency of cesspits (Burnat and Mahmoud, 2003). But, it is important to control the quality of treated greywater in order to avoid many problems that may result from it, and this can be achieved by using guidelines and standards that control treated greywater parameters (USEPA, 2012).

1.2 Problem Statement

There are many Palestinians that irrigate their agricultural lands with untreated greywater or dispose it into valleys without treatment. This situation carries potential hazards to public health and cause groundwater pollution (Hansen, 2012). Therefore, the opinion of experts and GWTPs beneficiaries regarding the importance of having Palestinian standards for treated greywater reuseshould be taken into account to encourage the use of greywater in a manner that protects the environment and public health, as well as acknowledges the benefits of using this worthy resource. In addition, the greywater rules should harmonize the requirements of multiple agencies, provide clear guidelines to the public, and educate both the public and regulatory bodies on its potential hazards.

1.3 Research Question

Some of the questions which this research aims to answer are:

1. What is the extent of population's awareness about the seriousness of treated greywater reuse without guidelines and standards?
2. What is experts' point of view about the importance of having guidelines and standards for treated greywater reuse?

1.4 Aims and Objectives

The objectives of this research are to assess:-

1- The extent of population's awareness about the seriousness of treated greywater reuse without guidelines and standards.

2- Experts' point of view about the importance of having guidelines and standards for the reuse of treated greywater.

1.5 Thesis Outline

Chapter One is an introduction that provides an overview about water situation in Palestine. It also defines problem statement, research question, aims and objectives.

Chapter Two is a literature review that describes past and related studies about water and sanitation conditions in Palestine, wastewater reuse, greywater in terms of its definition and potential risks. It also presents greywater practices in Palestine. In addition to that, it shows regional and international greywater guidelines and standards.

Chapter Three describes research approach and methodology that includes questionnaire building, sample size calculation and its distribution, piloting survey, field survey, and data analysis.

Chapter Four discusses the research results.

Chapter Five presents research conclusions and gives recommendations that fit the Palestinian reality.

Chapter Two
Literature Review

2 Chapter Two: Literature Review

2.1 Water and Sanitation Conditions in Palestine

Palestine is suffering from water scarcity which is considered as major constraint for the sustainability of the agricultural sector, social and economic development. The estimated water deficit in Palestine in the year 2020 is about 271 Million Cubic Meters (MCM) (PWA, 2005; Abu-Madi et al., 2008). Therefore, wastewater in Palestine should be considered as an important renewable water resource (Abu-Madi and Al-Sa' ed, 2009).

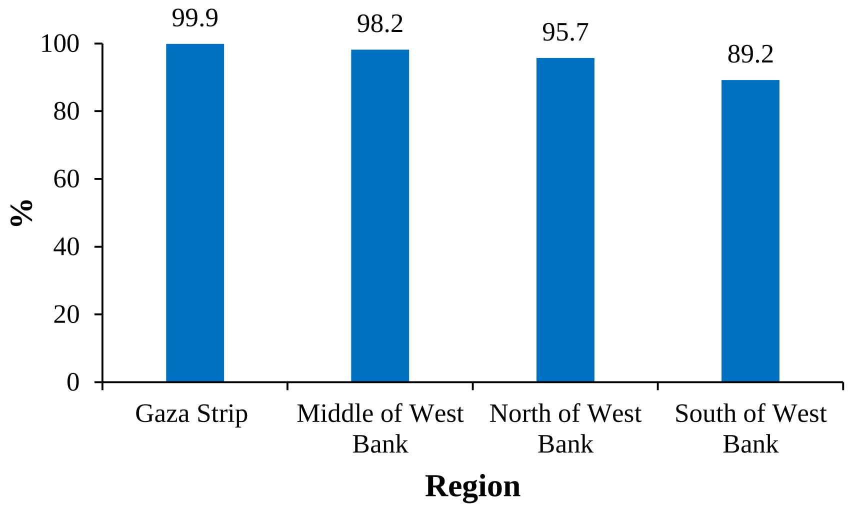

Figure 2-1: Percentage of Households in Palestine whom living in Housing Units Connected to Public Water Network, 2013.
Source: PCBS, 2013

According to the Palestinian Central Bureau of Statistics (PCBS, 2013), it was found that the household sector in Palestine consumed about 16 MCM/month. Monthly average household consumption of water in Palestine was 22.1 m^3. In addition, 96.4 % of households are connected to a water supply network. Figure 2-1 shows the percentage of households in Palestine whom living in housing units connected to public water network, 2013.

Disposal of wastewater using the wastewater network increased significantly in 2013 compared to previous years. In 2013, 55.3% of households in Palestine used a wastewater network to dispose of their wastewater compared to 55.0% in 2011 and 52.1% in 2009 (PCBS, 2013).

2.2 Wastewater Reuse

In countries suffering from water scarcity, non-conventional water resources such as wastewater are used for non-potable and potable purposes that both increase water supply. Wastewater contains impurities at levels higher than in freshwater, such as organic compounds, metals and salts. Public health and environmental risks are sometimes associated with using partially or fully treated wastewater (Özerol, 2013).

Standards for wastewater effluent quality for various uses have been established by the Palestinian Ministry of the Environment, but they are often not enforced (WHO, 2006a).

Proper treatment of wastewater is challenging due to limited funding, the depressed economy, and lack of infrastructure. Sewage infrastructure is poor in Palestine due to many reasons which are mainly: insufficient maintenance of sewage facilities, lack of technical and financial human resources, and poor environmental commitment and awareness (Al-Sa`ed, 2005). The situation is further complicated by the ongoing Israeli occupation. The Israeli occupation controls the planning and permitting process for new facilities, and restricts the movement of Palestinian people and supplies. The Israeli military incursions often damage water and wastewater infrastructure, and many Israeli settlements discharge their untreated wastewater onto Palestinian lands (McNeill et al, 2009).

2.3 Current Status of Greywater Treatment and Reuse in Palestine

2.3.1 Definition of Greywater

Greywater is any domestic wastewater produced, excluding sewage, which consists of wide-ranging quantities of components of wastewater that may come from different sources such as hand basin, shower, laundry, kitchen and sink bath (Boyjoo et al. 2013). This means that greywater does not come from a urinal or toilet. Greywater contains micro-organisms and impurities derived from personal cleaning activities and household (Friedler et al. 2005).

Greywater is different from blackwater (from the urinal or toilet), the main difference between them is the organic loading, blackwater has a much larger organic loading compared to greywater were fewer health and environmental risks related with its use (Mcllwaine and Redwood, 2010).

Greywater volumes produced may be as low as 20-30 liters/person/day in poor areas where water often is hand-carried from taps (Ridderstolpe, 2004; Winblad and Simpsoa-Hebert, 2004; WHO, 2006e). When availability increases, the production of greywater increases, but it seldom exceeds 100 liters per person per day in developing countries. In industrialized countries, greywater production is normally in the range of 100-200 liters/person/day (the highest figures are reported from the USA and Canada) and sometimes exceeds 200 liters/person/day (Crites and Tchobanoglous, 1998; Bertaglial et al., 2005; WHO, 2006e).

Greywater represents 50–80% of the total wastewater generated in households (Li et al. 2009a), with the value changing for commercial establishments. The quality of GW will change depending on the source as well as cultural habits, living standard, type of household chemicals used, household demography, and numerous site-specific (Pidou et al. 2008; Baawain et al. 2014).

The principal forces driving GW reuse are increasing water stress and scarcity; growing populations, with increasing environmental contamination from inappropriate wastewater disposal (WHO, 2006b and 2006e).

Thus, greywater is used as an important component of sustainable urban water management (United Nations Environment Programme (UNEP) and Global Environment Centre Foundation (GECF), 2005). “If used appropriately and wisely, greywater can be a simple home-based water-demand management strategy that has benefits at the household level as it can be considered as an alternative water resource to optimize productivity” (Mcllwaine and Redwood, 2010). The reuse of treated greywater has become in the center of activity and policy discussions in the arid countries (Bazza 2006; Al Salem and Abouzaid 2003).

The issue of GW management is increasingly gaining significance, especially in countries where ineffective wastewater management has a detrimental impact on the environment and public health. Suitable reuse of GW has many benefits such as reducing agricultural use of drinking water and water costs, improving public health and increasing food security (Morel et al., 2006).

If treated appropriately, GW from a single household can be considered a resource and can be used on-site for toilet flushing, washing machines, lawn irrigation and garden, and other outdoor uses (Al-Hamaiedeh and Bino, 2010). Garden watering and toilet flushing, for example, do not require water with drinking quality (Bino et al. 2010).

The reuse of treated GW for irrigation can cut down up to 40% of domestic water consumption, and decrease pressure on central wastewater treatment plants (Arava Institute, 2015).There are other benefits of GW reuse in agriculture as crops benefit from the nutrients they contain which help people to grow more food without the costs of using more fertilizers. Thus, GW can reduce environmental impacts on soil and water resources, help to meet water demand, as well as reducing potential health impacts on communities and allow the preservation of high-quality water resources for drinking water supplies (WHO, 2006b).

Different types of GW treatment systems have been developed and installed, such as aerobic and anaerobic biofilters, sand filtration, activated sludge systems, bio-rotors, submerged aerated filters, and bio-rolls (Friedler et al., 2005; Allen et al., 2010).

However, implementation of GW systems with simple cost, operation, installation, maintenance, and energy requirements will help in rural community acceptance of these systems for reuse of a percentage of their effluents for irrigation (Al-Mashaqbeh et al. 2012).

2.3.2 Potential Risks of Untreated Greywater Reuse

There are different applications for GW in the outdoor uses, mainly crop irrigation and landscape. However, the sanitary implications of reusing greywater on edible crops and the impact of greywater on soils remain of anxiety (Allen et al., 2010; Ghneim, 2010).It was noticed that untreated greywater clog the soil void space preventing the ventilation which has high negative affect on the plants. In addition to offensive smells and bad odors around the houses affect the neighborhoods (Burnat and Eshtayah, 2010).

In low and middle income countries, GW is normally discharged untreated into sewers or storm water drains, and then it mainly flows into aquatic systems. This leads to increased turbidity, eutrophication, oxygen depletion, as well as chemical and contamination microbial of the aquatic systems. Untreated GW is mainly used untreated in rural and peri-urban areas for agricultural purposes, thereby exposing the population to health risks and leading to environmental degradation. Untreated GW may contain high levels of suspended solids and substances such as detergents, soaps, other household chemicals and pathogenic microorganisms (Morel et al., 2006).

Both treated and raw GW contain salts, especially sodium from powdered detergents. These substances may potentially have a harmful effect on groundwater quality, soil structure, and human health. Raw GW from kitchen contains fats, oils and grease (FOG) that should not be disposed in gardens as the FOG can decrease the presence of air to plants and harm micro-organisms (Victoria, 2013).

The incidence of disease due to the presence organisms in GW is dependent on their concentration. Other factors include the degree of contact, age, and health of affected persons (Dixon et al., 1999).

Raw GW contains relatively high concentration of different pathogens that originate from excreta of infected persons. Examples of these pathogens are intestinal parasites, protozoa, viruses, and bacteria. They can end up in GW through diaper washing or diaper changes, washing of children and babies after defecation, and hand washing after toilet use (Ledin et al., 2001).

There are different routes of the environmental transmission of pathogens such as directly through contaminated drinking-water; directly contact with greywater; indirectly through food products or other shellfish exposed to soil or contaminated water; washing of raw meat and vegetables, by inhalation of dust or aerosols due to irrigation with GW; by ingestion of contaminated water during recreational activities; vector-borne transmission where the intermediate host or the vector breeds in water (WHO, 2006f).

2.3.3 Greywater Practices in Palestine

Currently, water conservation and the use of reclaimed greywater are being considered as strategic solutions in many arid and semi-arid countries such as Palestine to cope with increasing water shortage (Al-Sa'ed and Mubarak, 2006; Mahmoud and Mimi, 2008). Fresh-water problem in Palestine dates back to the early 1900's due to various geographical settings and political turbulences. The problem is exacerbated by the ever-increasing demand on water by population growth and development. As high demand on freshwater resources increases in Palestine and as new sources of supply become expensive, politically controversial, increasingly scarce, utilizing alternative options has become a must, to meet water needs. GW could be one option to reduce water demand through enhancing the efficiency of GW reuse (Houshia et al., 2012).

There are numerous benefits for the GW reuse in Palestine at the household-level such as economic incentives that include: reducing pollution, decreasing the frequency of cesspits evacuation, decreasing the demand for chemical fertilizers, reducing the amount of monthly income allocated to purchasing water for irrigation, increasing the overall quantity of water possible for irrigation, and increasing the potential for higher biomass yields in crops (Gross et al., 2007; Abu-Madi et al., 2010; Alfiya et al., 2013).In addition, most (80%) of the household wastewater is GW, and about 60% of this can be recovered for reuse (Tamimi et al., 2010).

Most of the executed greywater systems (GWS) in the West Bank have been technically supported by Nongovernmental Organization (NGOs) such as (e.g. Applied Research Institute- Jerusalem(ARIJ), Palestinian Hydrology Group (PHG), Water and Environmental Development Organization (WEDO), Palestinian Agricultural Relief Committee (PARC), Union of Agricultural Work Committees (UAWC), and Palestinian Wastewater Engineers Group (PWEG), and financially supported by international governmental and nongovernmental organizations such as Action Against Hunger (ACH), Food and Agriculture Organization (FAO), Save the Children Foundation (SCF) and aid agencies (e.g. Department for International Development (DFID) and International Development Research Centre (IDRC)). Many GW treatment-and-use projects were unsuccessful, where planning, design, and implementation were based mainly on technical aspects, without adequate evaluation of the socio-cultural or economic issues. Therefore, a cost–benefit, ecological and socio-cultural analysis should be taken into consideration to make sure that on-site GW treatment-and-use schemes are planned, designed and implemented to be sustainable, irrespective of the project size (Abu-Madi et al., 2010).

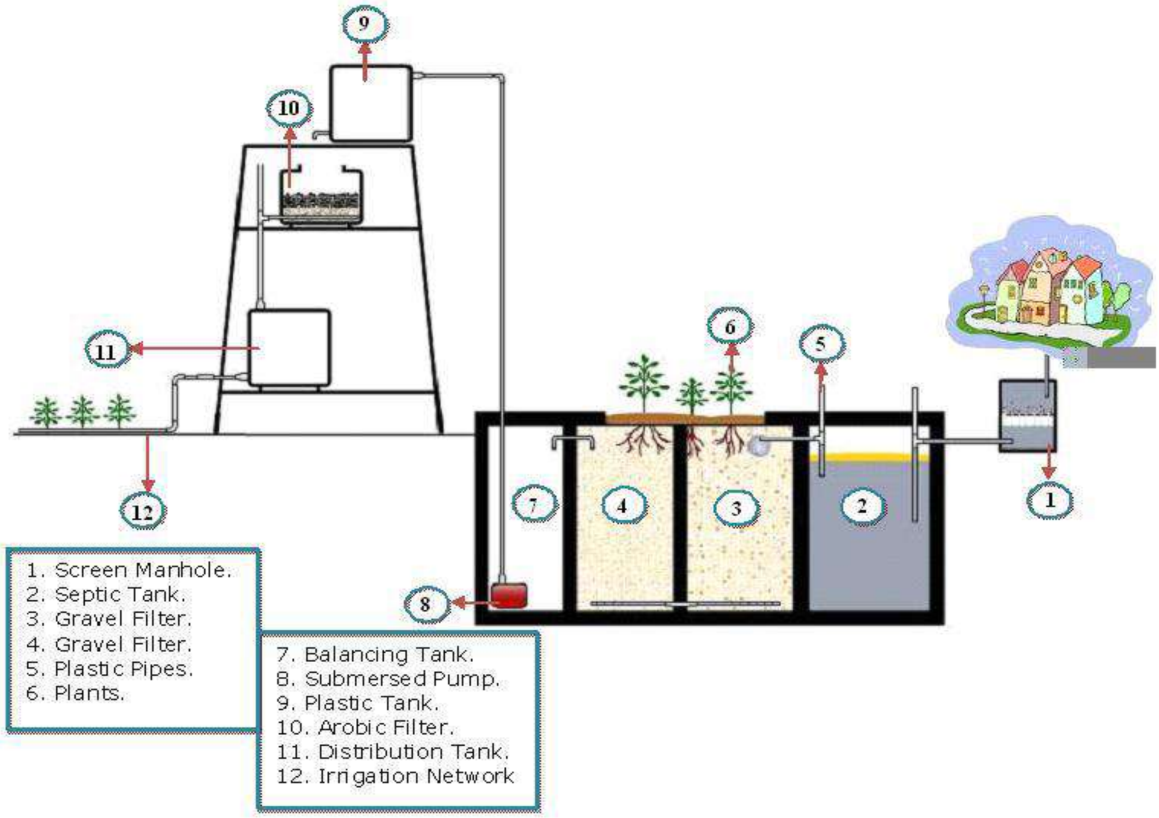

Figure 2-2 : Up-Flow gravel filter Grey water treatment technology Developed by PHG
Source: PHG, 2011.

Figure 2-3: Up-Flow gravel filter Grey water treatment technology after construction
Source: PHG, 2011

Due to the high potential for GW reuse in Palestine, different NGO's have installed many GW treatment and reuse systems in Gaza Strip the and West Bank. Figure 2-2 shows an example of the implemented projects in the northern West Bank that reuses the treated greywater for agricultural irrigation. Figure 2-3, shows Up-Flow gravel filter Greywater treatment technology developed by PHG after construction (PHG, 2011).

Since on-site GW recycling is recently practiced in Palestine, only few systems can be constructed in this area due to its geographical location. The treatment stations build are based on physical process that diverts water after treatment and allows immediate use of water for landscape and garden irrigation or storing it temporarily in a tank. Overall, the greywater stations worked well, and surveys with Palestinian households indicated high interest in GW stations (Houshia et al., 2012).

Table 2-1 shows an example about water quality for fresh water, treated and untreated grey wastewater from Beit Doko GW treatment plant which consists of anaerobic pond, gravel filter, sand filter and a polishing pond. It started operation under anaerobic conditions in September 2000. It is connected to around 21 houses with about 180 inhabitants (Othman, 2004).

Table 2-1: Water quality for fresh water, treated and untreated grey wastewater from Beit Doko greywater treatment plant

Parameter	Unit	Drinking water	Untreated Greywater	Treated Greywater
Temperature	ºC	**	**	**
Dissolved Oxygen	mg/l as O_2	**	**	**
PH	**	7.37	6.6	7.61
Conductivity (EC)	Ms/cm	1118	1585	1190
TDS	mg/l	543.3	935	620
COD	mg/l	**	1270	97
BOD_5	mg/l	**	590	32
Settable Solids	mg/l	**	11.4	**
TS	mg/l	**	1780	866.4
TSS	mg/l	**	1396	**
Chloride (cl^-)	mg/l as Cl^-	173	255	152
Bicarbonate	mg/l as $CaCO_3$	230	230	297
Nitrate (NO_3^-)	mg/l as NO_3	1.7	38	10.76
Sulphate (SO_4^{-2})	mg/l as SO_4	11	74	21
Phosphate (PO_4^{-3})	mg/l as PO_4	0.2	4.4	4.4
Calcium (Ca^{+2})	mg/l as Ca^{+2}	69	75	42.5
Magnesium (Mg^{+2})	mg/l as Mg^{+2}	32	35	8
Sodium (Na^+)	mg/l as Na^+	90	126	153.3
Potassium (K^+)	mg/l as K^+	3.6	16	25.31
Total Coliforms	CFU/100 ml	**	3100	2500
Fecal Coliforms	CFU/100 ml	**	60	**

Source: Othman, 2004.

From Table 2-1 it is clear that BOD and COD after treatment are lower than BOD and COD before treatment. The value of COD after treatment indicates that this kind of wastewater is suitable for unrestricted irrigation. Concerning salinity, the EC of the water was 1.19 dS/m. According to FAO guidelines (Table 2-2) this water could be used for crops moderately tolerant to salinity similar to olives. Since sodium concentration was 153 mg/l and the chloride concentration was 152 mg/l, this water can be used to irrigate olive trees without any complication of sodium and chloride toxicity (Othman, 2004).

Table 2-2: Guidelines for reuse in agriculture

Crop	BOD_5 (mg/l)	Fecal Coliforms (CFU/100 ml)	Suspended solid (mg/l)
Food Crops	30	75	35
Forages	40	100	45
Gardening	40	800	45

Source: FAO, 2001

According to the Pacific Institute`s study on GW reuse notes, appropriate technology means choosing a grey-water treatment system that follows local grey-water codes and matches the quantity and quality of water to its intended use (Allen et al., 2010).

Up to date, there are no specific GW local guidelines or codes for reuse. The GW system should be able to supply safe water for small scale crop irrigation. Any technology used for GW treatment should produce GW that is in compliance with the WHO`s guidelines for GW ruse in crop irrigation (Hansen, 2012).

2.4 Greywater Treatment and Reuse Guidelines and Standards

The development of GW reuse guidelines and standards will help in the protection of public health, poverty reduction, integrated water resources management, protection of the environment, consumer protection, food security, and energy reliance. So, it is important to control the quality of treated greywater by using guidelines and standards that control treated greywater parameters (USEPA, 2012).

Reclaimed greywater should realize four criteria (economical feasibility, hygienic safety, aesthetics, and environmental tolerance) for reuse (Nolde, 2005; Li et al., 2009b). The absence of suitable water quality guidelines and standards has held back suitable greywater reuse (Lazarova et al., 2003). It is worth mentioning that various reuse purposes need various water quality requirements and thus demand different treatments that varying from advanced ones to simple processes (Nolde, 2005; Lazarova et al., 2003).

2.4.1 International Greywater Guidelines and Standards

- **WHO Guidelines**

To ease the rational use of wastewater and protect public health, the first WHO Guidelines was issued in 1973 (Havelaar et al., 2001; WHO, 2005). A comprehensive review of epidemiological studies and other new information led to the publication of a second edition of WHO Guidelines in 1989 (WHO, 2006c).

The present third edition of '*Guidelines for the safe use of wastewater, excreta and greywater*' has been updated in 2006 and presented in four separate volumes. Volume 4 is about e*xcreta and greywater use in agriculture* based on the new health evidence concerning pathogens, chemicals and other factors, including changes in sanitation practices, changes in population characteristics, better methods for evaluating social/equity, risk issues and sociocultural practices. (WHO, 2005; WHO, 2006d).

These guidelines describe the recommended reasonable minimum safe practice requirements and system performance to protect the health of farmers, local communities in close proximity to activities, and people who otherwise may have contact with fields, greywater or products contaminated by them and product consumers (WHO, 2006d).

According to the WHO (2006e), it is suggested that E. coli guideline values, which are applicable for wastewater use, be applied cautiously for GW. If applied they will give a level of additional safety in this application, since the faecal load is usually 10-1000 times less than in wastewater. For helminth infections, the treatment verification monitoring level in terms of number of helminth eggs is presented in Table 2-3.The health-based protection to achieve the required pathogen reduction may consist of treatment alone or may be a combination of several measures. A guideline value of $<10^3$ E. coli per 100 ml and $<10^5$ E. coli per100 ml is suggested for unrestricted and restricted irrigation with GW respectively.

Table 2-3: Guideline values for verification monitoring in large-scale treatment systems of GW for use in agriculture

GW for use in	Helminth eggs (number per gram total solids or per liter)	E.coli (number per100 ml)
Restricted irrigation	<liter	$<10^{5a}$ Relaxed to $<10^6$ when exposure is limited or regrowth is likely
Unrestricted irrigation of crops eaten raw	<liter	$<l0^{3a}$ Relaxed to $<10^4$ for high-growing leaf crops or drip Irrigation
[a] These values are acceptable due to the high regrowth potential of E. coli and other faecal Coliforms in greywater		

Source: WHO, 2006e

- **EPA Guidelines**

The U.S. Environmental Protection Agency (EPA) has developed comprehensive, up-to-date water reuse guidelines in support of regulations and guidelines developed by states, tribes, and other authorities (USEPA, 2012).

In 2011, NSF/ANSI Standard 350 Onsite Residential and Commercial Water Reuse Treatment Systems and NSF/ANSI Standard 350-1 Onsite Residential and Commercial Greywater Treatment Systems for Subsurface Discharge were adopted. These standards provide detailed methods of product specifications; evaluation; and criteria related to materials, product literature, design and construction, effluent quality and wastewater treatment performance for on-site treatment systems (NSF, 2011a and 2011b; USEPA, 2012).

The NSF/ANSI Standard 350 (Table2-4) is for GW treatment systems with flows up to 5.7 m^3/d or larger. End uses appropriate for reclaimed water from these systems include indoor restricted urban water use, such as toilet flushing, and outdoor unrestricted urban use, such as surface irrigation (USEPA, 2012).

Table 2-4: Summary of NSF Standard 350 Effluent Criteria for individual classifications

Parameter	**Class R**		**Class C**	
	Test Average	**Single Sample Maximum**	**Test Average**	**Single Sample Maximum**
$CBOD_5$ (mg/l)	10	25	10	25
TSS (mg/L)	10	30	10	30
Turbidity (NTU)	5	10	2	5
E. coli [2] (MPN/100 mL)	14	240	2.2	200
pH (SU)	6-9	NA[1]	6-9	NA
Storage vessel disinfection (mg/L)[3]	≥ 0.5 - ≤ 2.5	NA	≥ 0.5 - ≤ 2.5	NA
Color	MR[4]	NA	MR	NA
Odor	No offensive	NA	Non offensive	NA
Oily film and foam	Non-detectable	Non-detectable	Non-detectable	Non-detectable
Energy consumption	MR	NA	MR	NA

[1] NA: not applicable
[2] Calculated as geometric mean
[3] As total chlorine; other disinfectants can be used
[4] MR: Measured reported only

Source: USEPA, 2012

The Standard 350 effluent criteria (Table 2-4) are applied to all treatment systems regardless of influent quality application, or size. Effluent criteria in Table 2-4 must be met for a system to be classified as either a residential treatment system for unrestricted outdoor and restricted indoor use (Class R) or a multi-family and commercial facility water treatment system for unrestricted outdoor and restricted indoor use (Class C) (USEPA,2012).

The NSF/ANSI Standard 350-1 is for GW treatment systems with flows up to 5.7 m^3/d. The effluent requirements of GW systems seeking certification through the ANSI/NSF Standard 350-1 for subsurface discharge are provided in Table 2-5 (USEPA, 2012).

Table 2-5: Summary of ANSI/NSF Standard 350-1 for subsurface discharges

Parameter	**Test Average**
$CBOD_5$ (mg/l)	25 mg/l
TSS (mg/L)	30 mg/l
pH (SU)	6-9
Color	MR[1]
Odor	Non-offensive
Oily film and foam	Non-detectable
Energy consumption	MR
[1] MR: Measured reported only.	

Source: USEPA, 2012

- **United States of America Standards**

Greywater treatment standards have been established by the states of Wisconsin, Alabama, and California (Table 2-6). California needs that GW reused for non-potable indoor and aboveground applications must be treated to achieve the minimum water quality equivalent to that of disinfected tertiary wastewater effluent. Alabama only reports GW treatment for drip irrigation to secondary wastewater effluent standard with post-filtration prior to use in drip irrigation. It is noted that Wisconsin approved separate water quality standard for toilet flushing, subsurface irrigation, and other aboveground non-potable reuse applications (Zita et al., 2013).

Table 2-6: Water quality criteria for onsite greywater reuse

Standards	Type of reuse	Treatment level equivalent	Water quality criteria
California	Aboveground non-potable reuse	Disinfected tertiary	Turbidity: 2 NTU (avg); 5 NTU (max) Total Coliforms: 2.2 MPN/100 mL (avg), 23/100 mL (max in 30 days)
	Subsurface irrigation	Primary	Not specified
Wisconsin	Toilet and urinal flushing	Disinfected primary with filtration	pH 6–9; 200 mg/L BOD_5; ≤ 5 mg/L TSS; Free chlorine residual 0.1–4.0 mg/L
	Surface irrigation except food crops, vehicle washing, clothes washing, air conditioning, soil compaction, dust control, washing aggregate, and making concrete	Disinfected tertiary	pH 6–9; 10 mg/L BOD_5; 5 mg/L TSS Free chlorine residual 1.0–10 mg/L
	Subsurface irrigation	Secondary	≤ 15 mg/L oil and grease; ≤ 30 mg/L BOD_5≤ 35 mg/L TSS; , 200 fecal Coliforms cfu/100 mL
Alabama	Drip irrigation	Secondary	Secondary with filtration

Source: Zita et al., 2013

2.4.2 Regional Greywater Guidelines and Standards

The practice of greywater reuse has been increased in many countries. The following are some examples on the countries where greywater reuse is currently being practiced.

- **Jordanian Standards**

Guidelines for various reuse options were issued in 1995 (JS 893/1995). Revised more stringent standards were enacted in 2002 (JS 893/2002), prohibiting the irrigation of vegetables eaten raw or recharging aquifers for potable use. The use of sprinklers and irrigation two weeks before harvest are also forbidden, E. coli should not exceed 100 count/100 ml for cooked vegetables and helminth egg criterion has been maintained for all uses. Further revisions (JISM, 2006; Table 2-7) specify conditions for reclaimed domestic wastewater quality standards when discharged to wadis/streams or used for irrigation and they are less strict for BOD, COD and E.coli than previous guidelines, but include advice on irrigation practices and human exposure control (Jimenez and Asano, 2008 ; CDR and BRG, 2011).

The standards were set for the protection of the health of both consumers and agricultural workers, and also for the protection of the environment, in particular pollution of the groundwater and surface water resources, due to the extensive use of treated wastewater (CSBE, 2003).

The latest version of the standards (JS 893, 2006) require that the black water should be entirely separated from the GW with the possibility to divert GW to the normal wastewater drain system if the GW system is closed down. In addition, GW pipes should be color coded to prevent mixing with drinking water system. Moreover, control party monitoring GW systems should consider the standards for the purpose of assessing the quality of treated GW (INWRDAM, 2007).

Table 2-7: Current Jordanian standards for wastewater reuse in irrigation and discharge to Wadis/streams JS 893/2006

Standards	Class 1	Class 2	Class 3	Discharge to wadis or streams
	Cooked vegetables	Fruit trees	Field crops, industrial crops and trees	
PH	6-9	6-9	6-9	6-9
TSS (mg/L)	50	200	300	60 (120 WSP)
BOD5 (mg/L)	30	200	300	60
COD (mg/L)	100	500	500	150 (300 WSP)
Tot-N (mg/L)	45	70	100	70 (100 WSP)
Helminth eggs/L	≤1	≤1	≤1	≤1
E.coli (MPN100mL-1)	<100	<1000	unlimited	1000*
FOG (mg/L)	8	8	8	8
FOG: fat, oil and grease; *In WWTP applying WSP (wastewater stabilization ponds) E.Coli levels (1000 CFU) can be exceeded if the wadi or stream water will be stored in a reservoir used for Irrigation.				

Source: JISM, 2006

- **Egyptian Standards**

Egyptian Code (501/2005) for the reuse of treated wastewater in agriculture was developed by the ministry of Housing, Utilities and New communities. Irrespective of the treatment level the Egyptian Code prohibits the use of treated wastewater for the export-oriented crops (i.e. potatoes, rice, cotton, onions, aromatic and medicinal plants),production of vegetables eaten raw or cooked, as well as irrigating school gardens and citrus fruit trees, respectively. It is noticed that there is no difference between blackwater and GW (EEAA, 2000; MHPUNC, 2005; Abdel-Shafy and Mansour, 2013).

Crops and plants irrigated with treated wastewater are classified into three agricultural groups that correspond to three different levels of wastewater treatment. The Code further specifies restrictions and conditions for irrigation methods, type of crops, and health protection measures for consumers, those living on neighboring farms and farm workers, (MHPUNC,2005; Abdel-Shafy and Mansour, 2013).

The Code classifies wastewater into three grades (A, B, and C), depending on the level of treatment it has obtained (Table 2-8) and specifies the maximum allowable concentrations of the contaminants consistent with each grade, and the crops that can, and importantly cannot, be irrigated with each grade of treated wastewater as shown in Table 2-9 (MHPUNC, 2005; Abdel-Shafy and Mansour, 2013).

Table 2-8: Egyptian requirements for treated wastewater reused in agriculture (in mg/l)

Treatment Grade requirements		**A**	**B**	**C**
Effluent limit values for BOD and Suspended Solids (SS)	BOD_5	<20	<60	<400
	SS	<20	<50	<250
Effluent limit values for faecal Coliforms and nematode cells of eggs (per liter)	Faecal Coliforms count (2) in $100cm^3$	<1000	<5000	Unspecified

Source: MHPUNC, 2005.

- Grade A represents advanced or tertiary treatment that can be attained through upgrading the secondary treatment plants to include sand filtration, disinfection and other processes.
- Grade B represents secondary treatment performed at most facilities serving Egyptian cities, townships and villages. It is undertaken by any of the following techniques: activated sludge, oxidation ditches, trickling filters, and stabilization ponds.
- Grade C is primary treatment that is limited to sand and oil removal basins and use of sedimentation basins.

Table 2-9: Classification of Plants and Crops Irrigable with Treated Wastewater

Grade	Agricultural Group	
A	G1-1: Plants an trees grown for greenery at touristic villages and hotels	Palm, Saint Augustin grass, cactaceous plants, ornamental palm trees, climbing plants, fencing bushes and trees, wood trees and shade trees.
	G1-2: Plants and trees grown for greenery inside residential areas at the new cities.	Palm, Saint Augustin grass, cactaceous plants, ornamental palm trees, climbing plants, fencing bushes and trees, wood trees and shade trees.
B	G2-1: Fodder/ Feed Crops	Sorghum sp
	G2-2: Trees producing fruits with epicarp.	On condition that they are produced for processing purpose such as lemon, mango, date palm and almonds.
	G2-3: Trees used for green belts around cities and afforestation of high ways or roads.	Casuarina, camphor, athel tamarix (salt tree), oleander, fruit producing trees, date palm and olive trees.
	G2-4: Nursery Plants	Nuresry plants of wood trees, ornamental plants and fruit trees
	G2-5: Roses & Cut Flowers	Local rose, eagle rose, onions (e.g. gladiolus)
	G2-6: Fiber Crops	Flax, jute, hibiscus, sisal
	G2-7: Mullberry for the production of silk	Japanese mulberry
C	G3-1: Industrial Oil Crops	Jojoba and Jatropha
	G3-2: Wood Trees	Caya, camphor and other wood trees.

Source: MHPUNC, 2005.

- **Omani Standards**

Omani wastewater reuse standards (Table 2-10) were developed in 1993 in order to provide the maximum amount of potential health and social well-being for citizens and the protection of water resources and land. It is noticed that there is no distinguish between greywater and blackwater (Ministry of Environment and Climate Affairs, 2013).

Table 2-10: Omani wastewater reuse standards

Parameter	Units	Standard A[1]	Standard B[2]
PH		6-9	6-9
Electrical Conductivity (EC)	$\mu S\ cm^{-1}$	2000	2700
BOD_5	$mg\ l^{-1}$	15	20
COD	$mg\ l^{-1}$	150	200
Fecal Coliforms Bacteria	N/100 ml	200	1000
TSS	$mg\ l^{-1}$	15	30
TDS	$mg\ l^{-1}$	1500	2000

[1]A: Fruits & Vegetables likely to be eaten raw. Areas with public access.
[2]B: Fruits and Vegetables likely to be cooked and eaten. Areas with no public access.

Source: Ministry of Environment and Climate Affairs, 2013.

- **Lebanese Standards**

In Lebanon, currently there are no national standards for water re-use and the effluent has to meet the WHO guidelines for reuse in agriculture. A draft wastewater reuse guidelines have already been prepared in 2010 by FAO as shown in Table 2-11. However, Lebanese regulations prohibit the reuse of treated effluents for irrigation of fruits and vegetables. National environmental standards for discharge of treated effluents into surface water and sea have been established (Karaa, 2005; Jimenez and Asano, 2008; CDR and BRG, 2011).

Table 2-11: Draft Lebanese guideline for wastewater reuse

Class	I	II	III
Restrictions	produce eaten cooked; irrigation of greens with public access	fruit trees, irrigation of greens and with limited public access; impoundments with no public water contact	cereals, oil plants, fiber and seed crops, canned crops, industrial crops, fruit trees (no sprinkler irrigation); nurseries, greens and wooden areas without public access
Proposed Treatment	secondary + filtration + disinfection	secondary + storage or maturation ponds or infiltration percolation	secondary + storage /oxidation ponds
BOD_5 (mg/L)	25	100	100
COD (mg/L)	125	250	250
TSS (mg/L)	60 (200 WSP)	200	200
PH	6-9	6-9	6-9
FC (/100ml)	<200	<1000	none required
Helminth eggs (/1 L)	<1	<1	<1
Note: Irrigation of vegetables eaten raw is not allowed			

Source: CDR and BRG, 2011.

Chapter Three
Approach and Methodology

3 Chapter Three: Approach and Methodology

3.1 Study Area

The study area includes Palestinian rural communities in the West Bank in five governorates (Nablus, Jenin, Ramallah, Tubas and Hebron) as shown in Table 3-1. The targeted households in each village were selected randomly according to availability of onsite greywater treatment plants. Care was taken during the selection process to ensure coverage of a wide range of geographical locations covering the whole West Bank.

Table 3-1: Palestinian rural communities population in the study area

Region	Governorate	Community	No. of population
North Region	**Jenin**	Misliya	2,896
		Raba	3,814
		Sanur	4,933
		Az Zababida	4,445
	Nablus	Tell	5,158
	Tubas	Ras al Faria'	909
Middle Region	**Ramallah**	Rantis	3,153
		Qibya	6,099
		Dura al Qar'	3,605
		Kafr Ni'ma	4,667
		Bil'in	2,117
		Beit Sira	3,421
		Kharbatha al Misbah	6,485
		Deir 'Ammar	2,282
		Jamala	-
		Beitillu	-
South Region	**Hebron**	Yatta	62,277

Source: PCBS, 2015.

3.2 Questionnaire

3.2.1 Target Group

Target groups were classified into two categories:

1) The first one is the Palestinian experts in the field of water and wastewater;

2) and the second one is the owners “beneficiaries” of onsite GWTP.

3.2.2 Questionnaire Building

Two types of questionnaire were developed to fulfill the purpose of this study. The two questionnaires forms are provided in Appendix (I).

- **Experts’ Questionnaire**

Experts’ questionnaire is divided into the following main headings:

- **Questionnaire information:** this section includes questionnaire number, date of questionnaire filling and the researcher name.
- **General information about the interviewee:** this section includes information about experts like age, gender, scientific degree, job description, and experts’ institution name.
- **Standard importance:** this section includes information about treated greywater re-use; healthy, social, environmental, economic, and religious importance of having Palestinian Standards for treated greywater re-use.
- **The role of the institutions where experts work:** this section includes information about institutions role in monitoring treated greywater quality, monitoring treated greywater reuse, and the development of treated greywater re-use standards.

- **GWTPs Beneficiaries' Questionnaire**

The beneficiary questionnaire is divided into the following main headings:

- **Questionnaire information:** this section includes questionnaire number, date of questionnaire filling and the researcher name.
- **General information about the interviewee:** this section includes information about the owners "beneficiaries" of onsite GWTP such as age, gender, scientific degree, village name, number of families served by the greywater treatment unit, number of family members served by the greywater treatment unit, interviewee profession, and average household income.
- **General information regarding the treatment unit:** this section includes information about GWTP like sources of greywater, age of treatment unit, construction cost, and the implemented agency.
- **System monitoring:** this section examine the role of implementing agencies including inspection of their implemented projects and taking samples to monitor treated greywater quality.
- **Standard importance:** this section includes GWTPs beneficiaries' opinion regarding the importance of having Palestinian Standards for treated greywater re-use.
- **Miscellaneous:** this section includes information about users' satisfaction level, reasons for GWTP acceptance, greywater uses, and types of irrigated plants.
- **The impacts of the treatment unit on the health aspects:** this section includes information about the negative impacts of GWTP such as foul odors, spread of insects and the spread of epidemic diseases.

3.3 Sample Description

3.3.1 Sample Size Calculation

According to Yates et al., (1999), the calculation for the sample size is considered based on the following equations:

$$n = \left(\frac{z}{m}\right)^2 p(1-p) \quad (1)$$

Where,

n: The sample size.

z: The value (1.96 for 95% confidence level)

m: The margin of error (± 5%) and

p: The estimated value for the proportion of a sample that will respond a given way to a survey question (85%).

The sample size equation solving for n' (new sample size) when taking the Finite Population Correction (FPC) Factor into account is:

$$n' = \frac{n}{1+\frac{n}{N}} \quad (2)$$

Where,

n`: The new sample size.

n: The population size.

N: The sample size based on the calculations above, and

Sample size calculations of onsite GWTPs according to Yates equations:

$$n = \left(\frac{1.96}{0.05}\right)^2 * 0.85 * (1 - 0.85) = 196$$

$$n` = \frac{800}{1+\frac{800}{196}} = 158$$

Based on the equations and the data for total number of greywater treatment units in the West Bank (800 units) according to PWA (2013) the sample size of units needed for the survey is found to be 158.

3.3.2 Sample Size Distribution

- **Experts' Questionnaire**

103 questionnaire were distributed to the Palestinian experts in the field of water and wastewater from various institutions in the West Bank including: Palestinian Water Authority, Environmental Quality Authority, Ministry of Health, Ministry of Agriculture, Ministry of Local Government, Jerusalem Water Undertaking, Palestinian Standards Institution, Water regulatory council, West Bank Water Department, Universities (An-Najah National University, Hebron University, Palestinian Technical University-Kadoorie, Birzeit University), Municipalities, Non-governmental Organizations (House of Water and Environment (HWE), PHG, ARIJ, Palestinian Agricultural Relief Committee (PARC), and SIF), Private sector (Consulting Engineering Center (CEC) and Universal Group for Engineering and Consulting (Maalem). Recovery is 87% where (90 questionnaire) were filled.

- **GWTPs Beneficiaries' Questionnaire**

165 questionnaire were distributed to GWTPs beneficiaries' at household level in 17 rural communities in the West Bank. Recovery is 97 % where (160 questionnaire) were filled.

3.4 Piloting Survey

It is one of the key elements in conducting surveys and other data gathering methods. It is important to utilize money, time and effort in the most efficient way possible to achieve success in performing surveys, especially those that require a large number of participants. To promote efficiency in conducting surveys, researchers usually perform a pilot survey.

A piloting survey was conducted and it targeted 18 GWTPs beneficiaries in six villages. These villages are Raba, Az Zababida and Sanor in Jenin; Qebia, Dura Al-Qarea and Kharbatha Al-Musbah in Ramallah; three beneficiaries were targeted in each village.

3.5 Field Survey

Field survey took two months (November and December) 2015. The used method for data collection and gathering at the local level is Face-to-Face Method (Personal interview). In this method, an interviewer is physically present to ask the survey questions and to assist the respondent in answering them.

3.6 Data Analysis

Data from various sources is gathered, reviewed, and then analyzed to form some sort of finding or conclusion. The Statistical Package for Social Science (SPSS) was used for data analysis to examine each component of the data provided.

Chapter Four
Results and Discussion

4 Chapter Four: Results and Discussion

4.1 Experts' Questionnaire

4.1.1 General information about experts

During this study, questionnaires were collected from 90 experts from various institutions and ministries in the West Bank. From the analyzed questionnaires, the surveyed sample distribution for experts based on education, age, and gender are presented in Table 4-1. 50% of respondents in terms of the level of education were for those who have a master degree, whereas the two highest percentages (26% each) of respondents regarding age were the same for the age groups between (31-40) and (41-50) years old and the lowest percentage was for those who were > 50 years old. In terms of gender, the highest percentage (64.4%) was for males, and the lowest percentage (35.6 %) was for females.

Table 4-1: Surveyed sample distribution (numbers and percentages) based on education, age, and gender

Independent Group	Number of respondents (percentage in parentheses)				Total
Level of Education	**Diploma**	**Bachelor**	**Master**	**PhD**	
	4 (4.4 %)	31(34.4%)	45 (50 %)	10 (11.1 %)	90 (100%)
Age	**20-30 years**	**31-40 years**	**41-50 years**	**>50 years**	
	15 (18.5%)	26 (32.1%)	26 (32.1%)	14 (17.3%)	81 (100%)
Gender	**Male**		**Female**		
	58 (64.4%)		32 (35.6 %)		90 (100%)

4.1.2 Treated greywater reuse and standards importance

- **Treated greywater reuse**

GW reuse is a hopeful strategy in terms of the important local water, energy, and cost savings that it can yield. Due to the increased water scarcity and demand, traditional water resources are no longer sufficient to meet the growing demand. As a result, other nontraditional water resources such as GW are used (Allen et al., 2010; Özerol, 2013).

When asked "Do you encourage treated greywater re-use?" about 91.1% of experts reported yes, while only 8.9 % of them said no. These results are emphasized by local and international literature as the use of treated effluents is an efficient way to recycle nutrients (N & P),preserve water resources, and help to prevent some of the environmental and health impacts (WHO, 2005; Al-Sa`ed, 2007).

- **Standards importance**

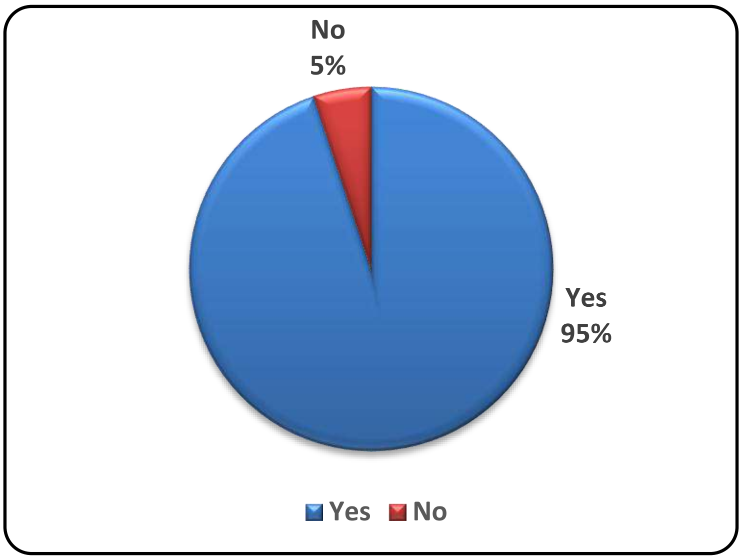

Figure 4-1: Experts opinion regarding the importance of having Palestinian Standards for treated greywater re-use.

As can be seen from Fig.4-1, most of experts (95%) emphasized the importance of having Palestinian Standards for treated greywater re-use. Our results totally agree with the literature reported by different authors who mentioned that there are several key reasons to develop treated greywater guidelines and standards such as the protection of public health, integrated water resources management, poverty reduction, food security, consumer protection, and energy reliance (WHO, 2006a; USEPA, 2012).

Table 4-2: Overall experts' response to the survey question "Why it is important to have Palestinian Standards for treated greywater re-use?"

Answer No.	Experts Answers	(%)
1	Provide clear reference and regulatory instructions for beneficiaries and responsible agency about the design, control, quality of treated greywater and areas of treated greywater reuse	34.7
2	Because it has environmental, social, economic and healthy dimensions	26.4
3	Help to reuse the treated greywater as an alternative source for clean water which reduces the pressure on water resources.	30.6
4	Due to the absence of greywater specifications and the use of treated wastewater specification as a reference for greywater	1.4
5	Because the re-use of treated greywater reduces the wastewater, which reduces the pressure on wastewater treatment plants	1.4
6	Contribute to community awareness about the importance of treated greywater reuse	1.4
7	To ensure compliance with the required degree of treatment	1.4
8	Encourage the consumption of agricultural products produced using this treated water safely and without obstacles	1.4
9	Because greywater is widely used and there should be an oversight on it	1.4

Table 4-2 shows the overall experts' responses to survey question "Why it is important to have Palestinian Standards for treated greywater re-use?". As can be seen, the highest percentage (34.7%) of answers was "To provide clear reference and regulatory instructions for beneficiaries and responsible agencies about the design, control, quality of treated greywater and areas of treated greywater reuse", while the second highest percentage (30.6%) was "Standards help to reuse the treated greywater as an alternative source for clean water which reduces the pressure on water resources", and the third highest percentage (26.4%) was "Because it has environmental, social, economic and healthy dimensions". There are many other answers with low percentages of 1.4%.

On the other hand, only 5% of experts said that the standards are not important and they justified their refusal due to the following reasons: Because greywater reuse is limited only to homes and it is difficult to establish a network for it, while others believe that greywater is an unclean water and it should not be reused.

- **Healthy importance**

Greywater can be polluted with human excretions from laundry and bathing. Chemical and microbial contamination of GW pretense a potential danger to human health. It is important to recognize that GW does have the capability to transmit disease (WHO, 2006f).

It was found that 94.9% of expert's answers agreed that there is a healthy importance for having a Palestinian Standards for treated greywater re-use due to many reasons including first, "To reduce illness, maintain the health of farmers and community and to ensure the safety of food products" with a percentage of 50%, Second; "Educate the users about how to reuse the treated greywater in the best way and to identify crops type that can be irrigated with this water" with a percentage of 21.2%, third; "To clarify the quality of treated greywater which allowed to be reused" with a percentage of 12.1%. Other experts mentioned that having standards are important “To clarify the negative impacts of untreated greywater reuse to avoid them”, “To ensure health control” and “Due to the presence of some parties that reuse untreated greywater, and this poses a hazard on their health” as shown in Table 4-3, while only 5.1% of experts said that there is no healthy importance.

Table 4-3: Reasons for standards’ healthy importance

Answer No.	Experts Answers	(%)
1	To reduce illness, maintain the health of farmers and community and to ensure the safety of food products	50
2	Educate users about how to reuse the treated greywater in the best way and to identify crops type that can be irrigated with this water	21.2
3	To clarify the negative impacts of untreated greywater reuse to avoid them	9.1
4	To clarify the quality of treated greywater which allowed to be reused	12.1
5	To ensure health control	6.1
6	Due to the presence of some parties that reuse untreated greywater, and this poses a hazard on their health	1.5

- **Social importance**

The data revealed that 76.6 % of expert’s answers emphasize that having a Palestinian Standards for treated greywater re-use has an impact on the social aspects of the society. From Table 4-4, the highest percentage of answers regarding the social importance was “Standards help in the provision of national awareness programs and convince the society to accept the reuse of this type of water” with a percentage of 66%”, while the second highest percentage (12.8%) was “Standards help the society members to contribute in reducing water shortage problem through clarifying the mechanism and areas of greywater reuse ”, and the third highest percentage (8.5%)

was "To maintain civil and social peace and prevent the problems resulting from bad smells and insects caused by using untreated greywater", while only 23.4% of them said that there is no social importance.

Table 4-4: Reasons for standards' social importance

Answer No.	Experts Answers	(%)
1	Help in the provision of national awareness programs and convince the society to accept the reuse of this type of water	66
2	Because the improperly treated greywater causes odors and spread of insects which result in problems with neighbors	2.1
3	Because the community is the first beneficiary of this technique and should be responsible in the first place	6.4
4	To maintain civil and social peace	8.5
5	Help society members to contribute in reducing water shortage problem through clarifying the mechanism and areas of greywater reuse	12.8
6	To facilitate the implementation of relevant projects and ensure the prevention of its random use	4.3

- **Environmental importance**

From experts' perspective regarding the environmental importance (Table 4-5), about 96.1 % of them seeing that treated greywater standards are very important for many reasons. Firstly, to maintain the environmental elements, including living organisms, trees, soil and air with a percentage of 63.5%. Secondly, to reduce the risk of the surrounding water sources contamination and to identify the required quantity and quality of treated greywater reuse. Moreover, standards are important to preserve scarce water resources and provide an alternative source for fresh water, results in planting additional plants and increasing green area which improves the environmental landscape. In addition to that, the implementation of standards prevent the spread of odors, insects and pests in places where this water is reused.

Table 4-5: Reasons for standards' environmental importance

Answer No.	Experts Answers	(%)
1	To reduce the risk of contamination of the surrounding water sources	7.9
2	To preserve the scarce water sources and provide an alternative source	4.8
3	Planting additional plants and increasing green area which improves the environmental landscape	3.2
4	To maintain the environmental elements, including living organisms, trees, soil and air	63.5
5	To prevent the spread of odors and insects and pests in places that use this water	3.2
6	To identify the required quantity and quality of treated greywater reuse	7.9
7	To reduce the amount of generated wastewater in general and thus reduce the resulting pollution, especially ground water pollution	3.2
8	To ensure the public health	4.8
9	To learn how to get rid of the treated wastewater in a manner that is not harmful to the environment and do not cause pollution	1.6

- **Economic importance**

In order to address the economic aspects as a factor that affects the society acceptance regarding greywater reuse, experts' opinion from the economic aspects have been taken into consideration. Findings showed that 86.7% of experts' responses confirm that having a Palestinian Standards for treated greywater re-use contribute in the improvement of the national economy, 50.7% of the respondent experts stated that the standards economic importance is represented by providing an additional source of water for irrigation at low prices which reduces water consumption and prevent wasting of water sources. On the other hand, 35.2% of the respondent experts considered the importance in taking the advantage of treated greywater to increase green area and planting crops which serve the household economy.

Others experts' point of view regarding the economic importance (Table 4-6), that it contributes in increasing the agricultural production, reducing the amount of wastewater generated which reduces the pressure on sewage systems and reduce cesspit evacuation and thus influence the construction cost for treatment plants establishment, ensuring the ease of marketing and maintain the product's reputation and persuade beneficiaries, institutions, and companies which have interest in this field to implement relevant projects.

Table 4-6: Reasons for standards' economic importance

Answer No.	Experts Answers	(%)
1	To take advantage of treated water to increase green area and planting crops that serve the household economy	35.2
2	To provide an additional source of water for irrigation at low prices which reduces water consumption and prevent wasting water sources	50.7
3	To make a profit for farmers as a result of increasing the agricultural production	1.4
4	To reduce the amount of wastewater generated, which reduces the pressure on sewage systems and reduce cesspit evacuation and thus influence the construction costs of treatment plants	2.8
5	To encourage greywater reuse for different purposes such as industry	2.8
6	Encourage wastewater treatment and identify the type of crops that can be irrigated with this water	2.8
7	To persuade beneficiaries, institutions, and companies which have interest in this field to implement relevant projects	1.4
8	Ease of marketing and maintain the product's reputation	2.8

The results of this study totally agree with the study of Abu Madi et al., (2010), in which they found that the direct benefits of using grey wastewater system were high even before considering the indirect benefits associated with reducing groundwater contamination, the nutrient-rich irrigation water, and protecting public health.

- **Religious importance**

In the West Bank, Islam is considered as the religion of the majority. 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" (Al- Kharouf, 2003).

Table 4-7: Reasons for standards' religious importance

Answer No.	Experts Answers	(%)
1	To prevent contamination and the application of religious rule "do no harm"	2.2
2	To raise any embarrassment by providing scientific evidence, and to emphasize the absence of water from najas.	56.5
3	To ensure water conservation, the prevention of excessive consumption and its re-use in various fields, thus preserving the resources to serve future generations	13
4	Change the reality of the lack of psychological acceptance of treated greywater re-use for religious reasons thus increasing their confidence for using it	26.1
5	To adjust the social relations and prevent problems	2.2

Religion has an obvious effect on the opinion of 61.8% of experts towards the religious importance of having standards. As shown in Table 4-7, most of the respondents (56.5%) said that "Standards are important to raise any embarrassment and to correct the understanding of the religion concerning this subject by providing scientific evidence to emphasize the absence of water from najas". Others (26.1%) point of view "Standards are essential to change the reality of the lack of psychological acceptance of treated greywater re-use thus increasing their confidence for using it.

In addition to that, other experts stated that standards are important "To ensure water conservation, prevention of excessive consumption and its re-use in various fields, thus preserving resources to serve future generations", "To prevent contamination and the application of religious rule "do no harm", and "To adjust the social relations and prevent problems caused by bad odors and smells resulting from untreated greywater". On the other hand, 38.2% of the experts believe in the opposite, they consider this issue as a pure scientific issue, and the religion does not contradict with science.

There is a statistically significant relationship between the scientific degree of experts and their opinion of the religious importance for the existence of a Palestinian Standards for treated greywater re-use results (Table 4-8). It was found that experts with the PhD scientific degree were the highest (80.0%) among respondents who see that there is a religious importance for the existence of a Palestinian Standards for treated greywater re-use.

Table 4-8:Cross-tabulation between the scientific degree and religious importance for having a Palestinian Standards for treated greywater re-use

Scientific degree	Do you see a religious importance for having a Palestinian Standards for treated greywater re-use?	
	Yes	No
Diploma	2 50.0%	2 50.0%
Bachelor	13 43.3%	17 56.7%
Master	32 71.1%	13 28.9%
PhD	8 80.0%	2 20.0%
Total	55 61.8%	34 38.2%

(P-value = 0.049, Chi-Square = 7.625, df = 3)

4.1.3 The role of institutions where experts work

- **Monitoring treated greywater quality**

Post 2015 Millenium Development Goals (MDG) include water quality for the first time because it is quite possible to improve sources that deliver unsafe water. It is often said "water is life" but it must also be said that Water Quality is Health. Water quality are interlinked with global bio-health, servicing a sustainable plant, animal and human network. The understanding of water quality at larger scales is essential to future investments for protection and restoration (Young et al. 2015).

Table 4-9: Institutions' role in monitoring treated greywater quality

Answer No.	Experts Answers	(%)
1	Help in the implementation of treatment units taking into account the technical, operational and maintenance matters to ensure the quality of treated water	30.3
2	Doing control visits and inspection	27.3
3	Conduct periodic laboratory tests and compare the results with the approved specifications	33.3
4	Conduct research	3
5	Educate and guide	6.1

In Palestine, there are many institutions working on monitoring the quality of treated greywater where many experts work there. According to experts' answers, only 42.2% of these institutions has a role in monitoring treated greywater quality. The roles of these institutions are varied as shown in Table 4-9, 33.3% of experts think that the institution in which they work has a role in conducting periodic laboratory tests and comparing the results with the approved specifications, 30.3% in the implementation of treatment units taking into consideration technical, operational and maintenance matters to ensure the quality of treated greywater, 27.3% in doing control visits and inspections, 6.1% in education and guidance, and 3.0% in conducting research's. It is clear that the higher percent of these institutions (33.3%) give more attention for conducting periodic laboratory tests, where the least attention is for conducting researches (3.0%).

- **Monitoring treated greywater re-use**

Treated greywater re-use monitoring is the role of different institutions where experts' work according to 29.5% of experts' answers. The following responsibilities (Table 4-10) are the most important concerns, in which experts' think that their institutions participate in such as: Controlling treatment units and the areas of treated greywater reuse with a percent of 59.1%. In addition to that, providing training courses, awareness and guidance for the beneficiaries, conducting scientific research on this subject and clarify its impact on local agriculture, conducting laboratory tests for samples taken during the project life, comparing treated greywater quality with the approved Palestinian standards, controlling water users on the commercial level and monitoring their performance, and supporting the implementation of relevant projects.

Table 4-10: Institutions' role in monitoring treated greywater reuse

Answer No.	Experts Answers	(%)
1	Conduct laboratory tests for samples taken during the project life	9.1
2	Provide training courses, awareness and guidance for the beneficiaries	9.1
3	Control the treatment units and the areas of the treated greywater reuse	59.1
4	Comparing treated greywater quality with the approved Palestinian standards	4.5
5	Implementation of relevant projects	4.5
6	Control water users on a commercial level and monitor their performance and determine selling prices	4.5
7	Conduct scientific research on this subject and its impact on local agriculture	9.1

- **Development of treated greywater re-use standards**

In case a Palestinian technical team was formed for the development of treated greywater re-use standards, there is a need for the participation of different institutions.92.2% of experts' see that the participation of their institutions is important.

Moreover, 60% of experts' have a knowledge about the standards used regionally and internationally for treated greywater reuse. But, 41.1% of experts' think that regional and international standards for treated greywater reuse are appropriate to the Palestinian reality and the experience of other developed countries in the region must be adopted, developed in order to suit the situation in Palestine. While only 12.2% of experts said "no", and 46.7% of them said "I do not know". On the other hand, 80% of experts emphasizes the importance of local community participation in standards preparation to ensure their acceptance for the adopted standards.

Table 4-11: Cross-tabulation between the scientific degree and the experts' knowledge about the standards used regionally and internationally for treated greywater reuse

Scientific degree	**Do you have a knowledge about the standards used regionally and internationally for treated greywater reuse?**	
	Yes	**No**
Community College-Diploma	0 0.0%	4 100.0%
Bachelor	16 51.6%	15 48.4%
Master	32 71.1%	13 28.9%
PhD	6 60.0%	4 40.0%
Total	54 60.0%	36 40.0%

(P-value = 0.022, Chi-Square = 9.223, df = 3)

From Table 4-11, there was an effect of the level of education on experts' knowledge about the standards used regionally and internationally for treated greywater reuse (P-value = 0.022), as the level of education increases, experts' knowledge increases, this result agrees with the nature of experts' specialization where they are all specialists in the field of water and environment. It was found that experts with master degree were the highest category (71.1%) among other experts who were aware with the standards. Experts with Community College Diploma were the least (0.0%).

Table 4-12: Cross-tabulation between the experts' institution and their knowledge about the standards used regionally and internationally for treated greywater reuse

Institution	Do you have knowledge about the standards used regionally and internationally for treated greywater reuse?	
	Yes	No
Water Authority	4 100.0%	0 0.0%
Environment Quality Authority	3 33.3%	6 66.7%
Ministry of Health	2 33.3%	4 66.7%
Ministry of Agriculture	5 35.7%	9 64.3%
Ministry of Local Government	4 100.0%	0 0.0%
Jerusalem Water Undertaking	2 50.0%	2 50.0%
Palestinian Standards Institution	0 0.0%	1 100.0%
University	10 55.6%	8 44.4%
Water regulatory council	1 100.0%	0 0.0%
Non-governmental Organization	14 93.7%	1 6.7%
Municipality	4 80.0%	1 20.0%
West Bank Water Department	1 20.0%	4 80.0%
Private Sector	4 100.0%	0 0.0%
Total	54 60.0%	36 40.0%

(P-value = 0.001, Chi-Square = 29.478, df = 12)

Table 4-12 shows that there is a statistically significant relationship between the experts' institution and their knowledge about the standards used regionally and internationally for treated greywater reuse. The highest six percentages of institutions whose experts were aware of the standards were the Palestinian Water Authority, Ministry of Local Government, Water regulatory council, Non-governmental Organizations, Private sectors and Municipalities with percentages ranging from 80%-100%.

4.2 Onsite GWTP Questionnaire

4.2.1 General information about onsite GWTPs beneficiaries

Table 4-13: Surveyed sample distribution (numbers and percentages) based on age, gender and education

<table>
<tr><th>Independent Group</th><th colspan="5">Number of respondents (percentage in parentheses)</th><th>Total</th></tr>
<tr><td rowspan="2">Age</td><td>20-30 years</td><td>31-40 years</td><td>41-50 years</td><td colspan="2">>50 years</td><td rowspan="2">155 (100%)</td></tr>
<tr><td>6 (3.9 %)</td><td>23 (14.8%)</td><td>56 (36.1%)</td><td colspan="2">70 (45.2%)</td></tr>
<tr><td rowspan="2">Gender</td><td colspan="2">Male</td><td colspan="3">Female</td><td rowspan="2">160 (100%)</td></tr>
<tr><td colspan="2">148 (92.5%)</td><td colspan="3">12 (7.5%)</td></tr>
<tr><td rowspan="2">Level of Education</td><td>Elementary</td><td>Preparatory</td><td>Secondary</td><td>Diploma</td><td>Bachelor or more</td><td rowspan="2">159 (100%)</td></tr>
<tr><td>17 (10.7%)</td><td>56 (35.2%)</td><td>43 (27.0%)</td><td>16 (10.1%)</td><td>27 (17.0%)</td></tr>
</table>

Questionnaires were distributed to 160 GWTPs beneficiaries from various rural communities in the West Bank. From the analyzed questionnaires, the surveyed sample distribution based on age, gender and education are presented in Table 4-13. About 92.5% of respondents were males and 7.5% were females. In terms of age, the highest percentage of respondents (45.2%) was higher than 50 years old, while the lowest percentage (3.9 %) was in the age group between 20 and 30 years old. Moreover, the highest percentage of respondents (35.2 %) in terms of the level of education were for those who have a preparatory degree.

Number of families served by greywater treatment units in rural communities varied. Survey results revealed that most of GWTPs (48.7%) serve one family, 22.8% serve two families, 17.7% serve three families, 8.9% serve four families, and only 1.9% serve more than four families.

In terms of the number of family members served by greywater treatment units, the highest percentage of respondents (50.3%) were in the range of 4 to 6 family members, while the lowest percentage (7.5%) were greater than 10 family members. Regarding the level of income for onsite GWTPs beneficiaries, the highest percentage (36.3%) consisted of those whose family that has a monthly income of 2000 to 3000 New Israeli Shekels (NIS), and the lowest percentage (2.5%) was of those whose monthly family income less than 1000 NIS.

4.2.2 General information about greywater treatment units

Treated greywater resulting from the surveyed households has various sources such as hand basin, shower, laundry, and kitchen as shown in Figure 4-2. Findings showed that 48.0% of greywater treatment plants were constructed over the past 7 to 9 years, 36.8% were constructed over the past 1 to 3 years, 11.2% were constructed over the past 4 to 6 years, and 4% were constructed over the past 10 years or more.

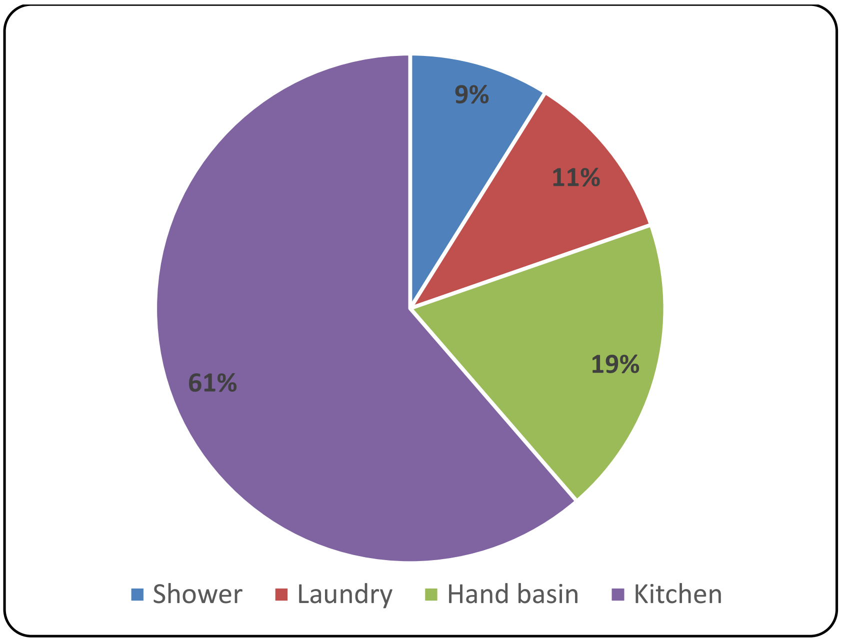

Figure 4-2: Sources of greywater resulting from the surveyed households

Greywater treatment plants construction cost varies from 1500 NIS to 15000 NIS, 56.8% of units constructed with a cost ranging from 5000-10000 NIS, 21.6% of units constructed with a cost ranging from12000-15000 NIS, 15.1% of units constructed with a cost ranging from 1500-5000 NIS, and 6.5% of units constructed with a cost ranging from10000-12000 NIS.

Data revealed that 53.5% of GWTPs costs were paid part on the expense of donors and the other part on the expense of GWTPs beneficiaries, 45.3% of GWTPs costs were paid at the expense of donors only such as GIZ, ACAD, PHG, SIF, European Commission, World Vision, Youth Development Association, and Care Institution; and only 1.3% of units costs were paid at the expense of GWTPs beneficiaries.

4.2.3 Reasons for GWTPs acceptance

GWTPs beneficiaries' gave several reasons for their acceptance to replace cesspits into GWTPs. As shown in Fig. 4-3, 30.2% of respondents accept to have GWTPs due to water shortage, 28.3% approved because it is financed by donors, 25.8% are in favor to reuse treated greywater in agriculture. Saving the cost of cesspit evacuation is another reason. The least percent 3.8% goes for saving in water bill.

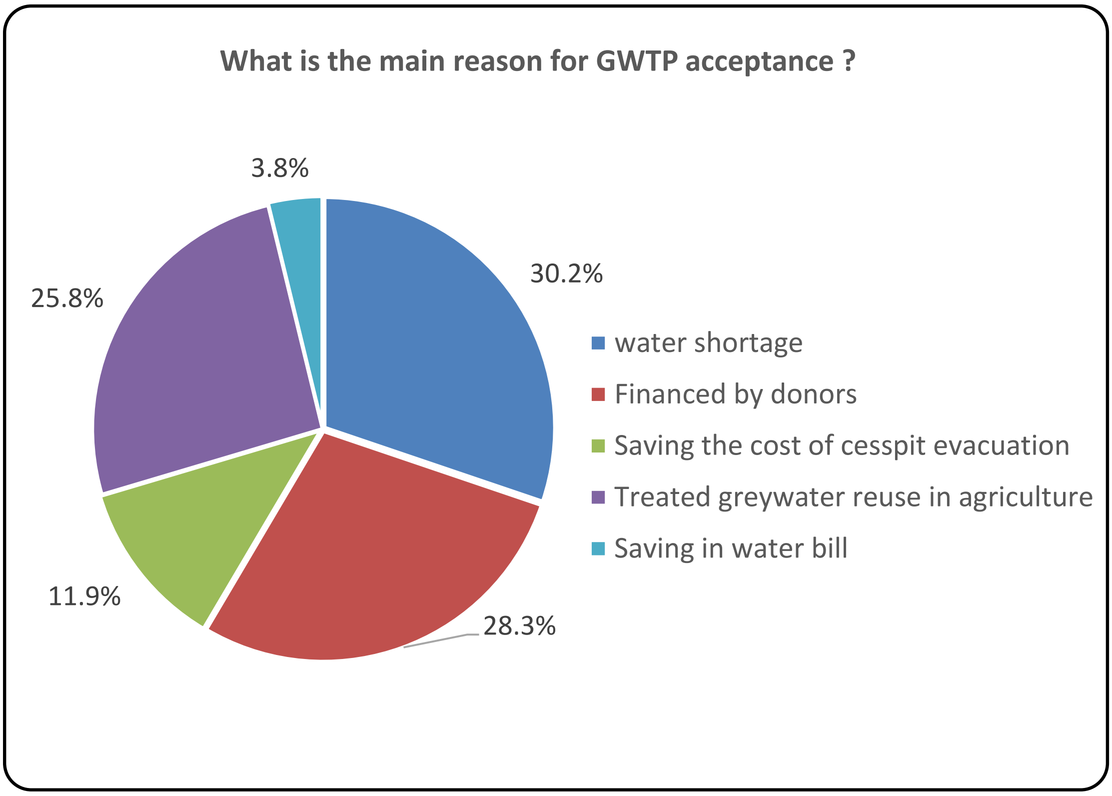

Figure 4-3: Reasons for GWTPs acceptance

- **Water shortage**

Water shortage remains one of the most contentious issues that needed to be resolved in Palestine. Treated greywater reuse is one of the solutions to this crisis. Findings showed that 76.3% of GWTPs beneficiaries' suffered from water shortage before the establishment of the treatment unit, where 63.6% of GWTPs beneficiaries' said that the treatment unit partially contribute in solving water shortage problem, 23.1% stated that GWTP contribute in solving water shortage, and only 13.2% said that GWTP does not contribute in solving water shortage.

- **Treated greywater reuse in agriculture**

Greywater reuse is a way to increase the productivity of backyard that produce vegetables, fruit trees, and ornamental plants as shown in Figure 4-4, and Figure 4-5.

Figure 4-4: Plants irrigated by treated greywater in Deir'Ammar village, Ramallah

According to the field survey, all the targeted households have a garden and 94.3% of them reuse the treated greywater. Different types of agriculture are used, 54.0% of respondents said that treated greywater is reused for fruitful trees, 28.7% reuse treated greywater in open cultivation, and 17.3% of them reuse treated greywater in greenhouses.

Figure 4-5: Vegetables and fruit trees irrigated by treated greywater in Deir'Ammar
village, Ramallah

Figure 4-5: Vegetables and fruit trees irrigated by treated greywater in Deir'Ammar village, Ramallah

Families that have greywater treatment plants irrigate different types of crops with the treated effluent. 58.4% of GWTPs' beneficiaries irrigate fruit trees by the treated greywater, 35.6% irrigate vegetables, and only 6.0% irrigate ornamental plants.

4.2.4 GWTPs monitoring

Proper monitoring is essential to ensure that the treatment program applied is satisfactorily controlled so that the desired results are achieved such as reducing risks associated with it and improving the quality of plant operation. Thus, inappropriate operation, management and monitoring results in the failure of many onsite systems.

Onsite greywater treatment plants follow-up is limited in Palestine. Findings showed that 56.0% of the implementing agencies follow their projects just during the first period of the project implementation, 31.4% never monitor their projects, and only 12.6% continuously follow-up their projects.

Moreover, testing the quality of treated greywater is important to ensure the effectiveness of the treatment unit. As shown in Fig. 4-6, 68.8% of implementing agencies only take samples during the first period of the unit implementation, 17.4% take samples continuously, and 13.8% never take samples.

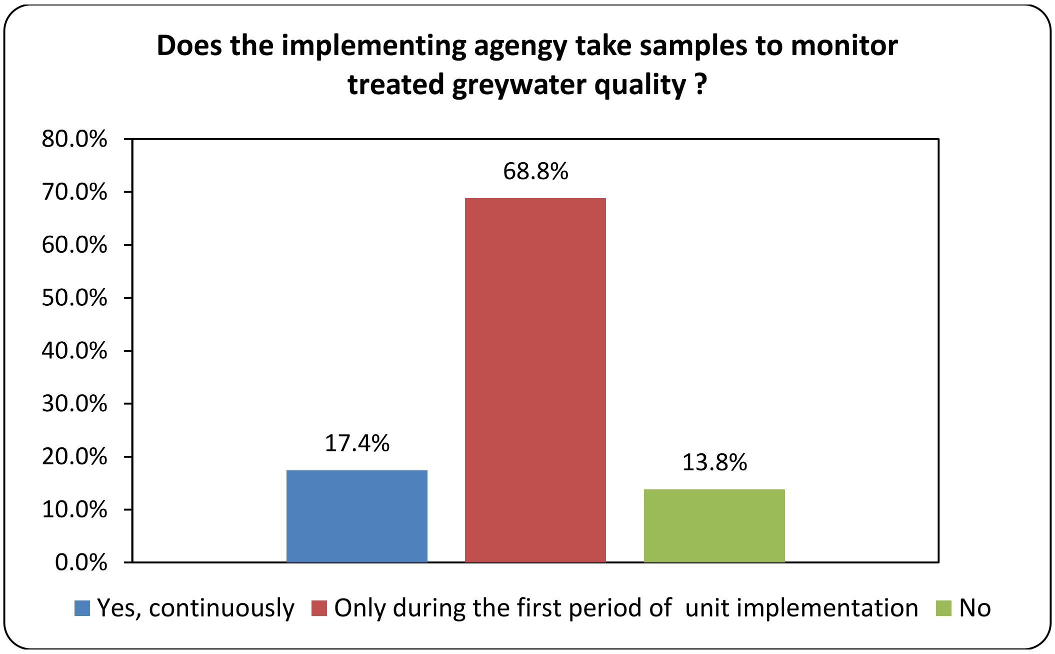

Figure 4-6: Monitoring treated greywater quality by the implementing agency

4.2.5 Standards importance

GWTPs beneficiaries showed their confidence regarding the Palestinian standards and the authorities that oversee them. Data revealed that 72.8% of GWTPs beneficiaries are confident regarding the Palestinian standards, 15.2% do not trust them, 7.0% do not know, and 5.1% are very confident.

Moreover, 97.5% of GWTPs beneficiaries confirm that it is important to have a Palestinian standards for treated greywater reuse (Fig. 4-7) for many reasons such as controlling the quality of treated greywater through conducting periodic lab tests, controlling health aspects and reducing the epidemic diseases, contribute in GWTPs success, provision of water at the lowest price, preserving the environment from pollution, help to increase the trust in the validity of agricultural products and treated greywater reuse, improve the economic situation, reduce the problems resulting from the treatment unit by providing appropriate solutions, and stimulate GWTPs beneficiaries for the cooperation with the institutions responsible for project success.

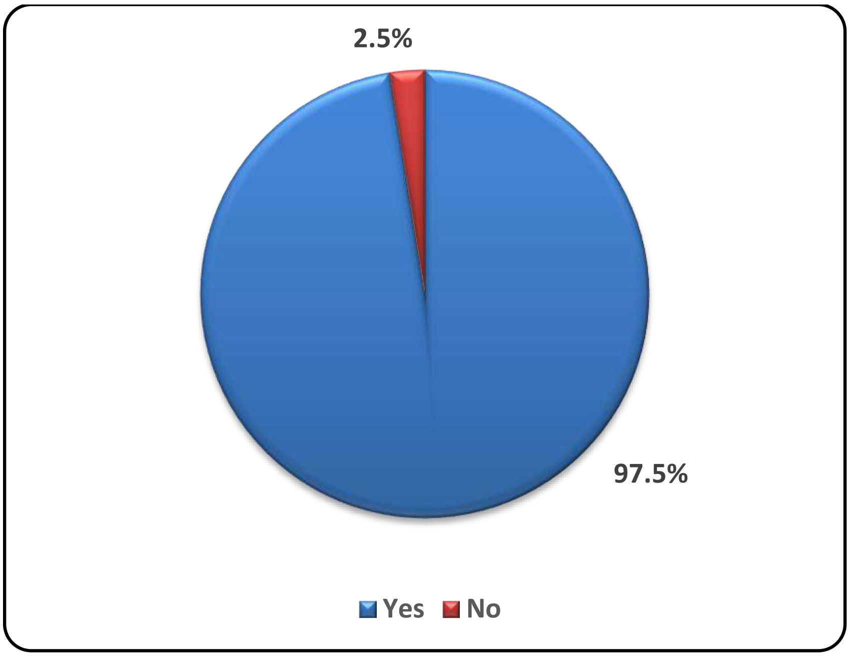

Figure 4-7: GWTPs beneficiaries' opinion regarding the importance of having Palestinian Standards for treated greywater re-use

On the other hand, only 2.5 % of GWTPs beneficiaries said that the standards are not important because greywater treatment units are easy to be used with no need for the existence of specifications and due to the absence of a continuous follow-up by the competent authorities.

4.2.6 Users satisfaction and confidence level

Greywater treatment plants received high satisfaction by beneficiaries, where 64.8% are satisfied, 11.9% are very satisfied, and only 23.3% are not satisfied due to various reasons including the negative impacts of the treatment unit like bad odors, spread of insects, and the need for constant cleaning because of the frequent closure. Moreover, dissatisfaction of some beneficiaries results from the absence of a continuous follow-up by the competent authorities, high construction cost, and environmental pollution as a result of seepage and execution mistakes.

In respect to beneficiaries' confidence regarding product validity and treated greywater quality, data revealed that high percent (63.3%) of beneficiaries' are confident, 30.4% are skeptical, and only 6.3% are not confident.

Regarding beneficiaries' religious acceptance for treated greywater reuse, 95% of users accept greywater reuse from their religious point of view. In terms of social aspects, 93.7% of GWTPs' beneficiaries are not shame of treated greywater reuse in their households.

4.2.7 Greywater treatment unit impacts

- **Aesthetic impacts**

Regarding foul odor emissions from the treatment unit, 38.4% of users said that sometimes there is a foul odor, 20.8 % of users stated that greywater units rarely produce foul odor, 20.8 % of users stated that there is often foul odor, and 20.1% stated that there is no existence for foul odor. Among those who mentioned that there is a foul odor, 42.5%, 35.4%, 22.0% of them stated that odors' severity is medium, light, and strong respectively.

With respect to insects' spread resulting from the treatment unit, 45.9% of users stated that the treatment unit cause low and acceptable spread, 28.3% of them stated that there is no effect on insects' spread, while 25.8% of users mentioned that there is large and significant spread of insects.

On the other hand, the existence of greywater treatment units did not adversely affect the relationship between the beneficiaries with their neighbors as mentioned by 81.8% of users.

- **Public health impacts**

Regarding family members exposure to direct contact with the treated greywater, 41.5% of users were not exposed at all, 28.3% sometimes exposed, 28.3% rarely exposed, and only 1.9% often exposed to direct contact with the treated greywater. Moreover, data revealed that there is no epidemic diseases caused during the previous 12 months as a result of having greywater treatment unit in beneficiaries' households.

4.3 Crosstabs results

- **Effect of gender**

Date revealed that gender had significant relationship (i.e., $P < 0.05$) with beneficiaries' opinion regarding treatment unit contribution in solving water shortage problem, as shown in Table 4-14. The highest percentage of responses by males was 'Partially contribute', whereas for females, the highest percentage answer was 'Yes'.

There was also an effect of gender on GWTP beneficiaries' confidence regarding product validity and treated greywater quality. It was found that 'confident 'was the highest category among males' responses with a percentage of 60.3%, while all females were confident regarding product validity and treated greywater quality.

Table 4-14: Percentage variation in respondents' answers based on gender (%)

Question	Answer	Gender		Statistical parameters
		Male	Female	
Has the treatment unit contributed in solving water shortage problem?	Yes	19.1	63.6	Chi-Square = 11.589, p-value = 0.005, df = 2
	Partially	66.4	36.4	
	No	14.5	0.0	
How much confidence do you have about the product and treated greywater quality?	Confident	60.3	100	Chi-Square = 7.532, p-value = 0.023, df = 2
	Skeptical	32.9	0.0	
	Not confident	6.8	0.0	

- **Effect of number of families served by GWTP**

Number of families had a significant relationship (i.e., $P < 0.05$) with the project funder as shown in Table 4-15. The highest percentage of responses when the number of families that served by GWTP are one or two family was ‘Donor’, whereas when the number of families is three or more the highest percentage of responses was ‘Part on my own expense and the other part on the donor’.

There was also an effect of the number of families on the main reason for treatment unit establishment. As the number of families increases, water shortage problems increase and their need for other sources of water such as greywater increases. Data revealed that the highest percentage of responses regarding treatment unit contribution in solving water shortage problem when the number of families that served by GWTP are one to four families is ‘Partially’, while when the number of families are more the four the highest percentage of responses is ‘Yes’.

There is a direct correlation between the number of families and the extent of their satisfaction with the treatment plant; the more the number of families, the more satisfaction is achieved. Moreover, GWTP beneficiaries’ confidence regarding the product validity and treated greywater quality increase as number of families increase.

Table 4-15: Percentage variation in respondents' answers based on number of families served by GWTP (%)

Question	Answer	Number of families served by GWTP					Statistical parameters
		1	2	3	4	> 4	
Who has funded the establishment of greywater treatment plant?	At my own expense	2.6	0.0	0.0	0.0	0.0	Chi-Square =24.497, p-value = 0.002, df = 8
	Donor	57.9	55.6	21.4	7.1	33.3	
	Part on my own expense and the other part on the donor	39.5	44.4	78.6	92.9	66.7	

What is the main reason for the establishment of the treatment unit?	Lack of water	19.5	20.0	46.4	85.7	0.0	Chi-Square =51.565, p-value = 0.00, df = 16
	Funded by donors	26.0	48.6	21.4	7.1	33.3	
	The cost of cesspit wastewater evacuation	10.4	5.7	25.0	7.1	33.3	
	Reuse of treated water in agriculture	37.7	22.9	7.1	0.0	33.3	
	Savings in the drinking water bill	6.5	2.9	0.0	0.0	0.0	
How much are you satisfied with the treatment unit?	Very satisfied	9.1	11.4	7.1	14.3	66.7	Chi-Square =24.536, p-value = 0.002, df = 8
	Satisfied	54.5	74.3	85.7	71.4	33.3	
	Not satisfied	36.4	14.3	7.1	14.3	0.0	
Have you been suffering from water shortage before the establishment of the treatment unit?	Yes	74.0	61.1	89.3	92.9	100.0	Chi-Square =10.363, p-value = 0.035, df =4
	No	26.0	38.9	10.7	7.1	0.0	
Has the treatment unit contributed in solving the water shortage problem?	Yes	12.3	40.9	29.2	7.7	66.7	Chi-Square =19.675, p-value = 0.012, df =8
	Partially	66.7	45.5	70.8	84.6	33.3	
	No	21.1	13.6	0.0	7.7	0.0	
How much confidence do you have about the product and treated greywater quality?	Confident	45.5	77.1	88.9	78.6	66.7	Chi-Square =24.330, p-value = 0.002, df =8
	Skeptical	44.2	22.9	7.4	14.3	33.3	
	Not confident	10.4	0.0	3.7	7.1	0.0	

- **Effect of number of family members served by GWTP**

Table 4-16 shows a summary of the significant test results correlating number of family members served by GWTP to various aspects. In the families that ranging from (1-3), (4-6), and (7-9) persons, the most common response to the question 'How much confidence do you have about the product and treated greywater quality?' was 'Confident', whereas in the group (10 ≤) the most common answer to the same question was 'Skeptical'.

Number of family members also seemed to have an impact on member's direct contact with the treated greywater. It was found that the highest percentage of direct contact in the families ranging from (1-3) was 'rarely', while the highest percentage in the families ranging from (4-6), (7-9) and (10 ≤) person was 'Not exposed at all'.

Table 4-16: Percentage variation in respondents' answers based on number of family members served by GWTP (%)

Question	Answer	Number of family members				Statistical parameters
		1-3	4-6	7-9	10 ≤	
How much confidence do you have about the product and treated greywater quality?	Confident	80.0	72.2	55.4	25.0	Chi-Square = 13.802, p-value = 0.032, df = 6
	Skeptical	20.0	22.8	35.7	66.7	
	Not confident	0.0	5.0	8.9	8.3	
Is the family exposed to direct contact with treated greywater?	Lot	10.0	1.3	0.0	8.3	Chi-Square = 19.741, p-value = 0.02, df = 9
	Sometimes	20.0	22.5	39.3	25.0	
	Rarely	50.0	35.0	17.9	8.3	
	Not exposed at all	20.0	41.3	42.9	58.3	

- **Effect of the level of education**

Data revealed that level of education had a significant relationship (i.e., P <0.05) with beneficiaries' opinion regarding treatment unit contribution in solving water shortage problem. The highest percentage of responses by interviewees was 'Partially contribute' as shown in Table 4-17.

There was also an effect of the level of education on the GWTP beneficiaries' confidence regarding product validity and treated greywater quality, as level of education increases their confidence decreases. In addition to that, beneficiaries' exposure to direct contact with the treated greywater decreases as level of education increases.

Table 4-17: Percentage variation in respondents' answers based on the scientific degree (%)

Question	Answer	Scientific degree of respondents					Statistical parameters
		Elementary	Preparatory	Secondary	Diploma	Bachelor or more	
Has the treatment unit contributed in solving the water shortage problem?	Yes	35.7	30.2	18.4	11.1	11.8	Chi-Square = 22.703, p-value = 0.004, df = 8
	Partially	64.3	69.8	52.6	55.6	76.5	
	No	0.0	0.0	28.9	33.3	11.8	

How much confidence do you have about the product and treated greywater quality?	Confident	94.1	80.4	48.8	53.3	34.6	Chi-Square = 29.089, p-value = 0.000, df = 8
	Skeptical	5.9	16.1	41.9	33.3	57.7	
	Not confident	0.0	3.6	9.3	13.3	7.7	
Is the family exposed to direct contact with treated greywater?	Lot	0.0	0.0	2.3	12.5	0.0	Chi-Square = 44.866, p-value = 0.000, df = 12
	Sometimes	11.8	14.3	51.2	31.3	30.8	
	Rarely	58.8	50.0	9.3	18.8	15.4	
	Not exposed at all	29.4	35.7	37.2	37.5	53.8	

- **Effect of household income**

Findings showed that five dependent groups have a statistically significant relationship (p-value < 0.05) with households' income, as shown in Table 4-18.The most common response to the question 'Does the responsible party visit you to make sure that there are no problems at the treatment unit?' was 'Only during the first period of treatment unit installation'. As a general trend; when household income increases, follow-up by the responsible party decreases.

It was found that households' income also had a significant relationship with taking samples by the responsible party. Moreover, GWTP beneficiaries' satisfaction with the treatment unit increases as income increases.

In addition to that, there was also an effect of households' income on beneficiaries' opinion regarding treatment unit contribution in solving water shortage problem. The highest percentage of responses by interviewees was 'Partially contribute', and this percentage increases as income increases. On the other hand, GWTP beneficiaries' confidence regarding product validity and treated greywater quality increases as income increases.

Table 4-18: Percentage variation in respondents' answers based on average household income (NIS / month) (%)

Question	Answer	Household income (NIS / month)					Statistical parameters
		> 1000	1000-2000	2000-3000	3000-4000	> 4000	
Does the responsible party visit you to make sure that there are no problems at the treatment unit?	Yes continuously	0.0	7.0	8.8	10.8	37.5	Chi-Square = 18.591, p-value = 0.017, df = 8
	Only during the first period of treatment unit installation	25.0	67.4	59.6	59.8	25.0	
	No	75.0	25.6	31.6	32.4	37.5	
Does the responsible party take samples to ensure the effectiveness of the treatment unit?	Yes continuously	0.0	6.5	12.8	16.0	60.0	Chi-Square = 19.022, p-value = 0.015, df = 8
	Only during the first period of treatment unit installation	100.0	80.6	74.4	72.0	20.0	
	No	0.0	12.9	12.8	12.0	20.0	
How much are you satisfied with the treatment unit?	Very satisfied	0.0	2.3	15.8	16.7	6.3	Chi-Square = 17.608, p-value = 0.024, df = 8
	Satisfied	25.0	62.8	66.7	72.2	68.8	
	Not satisfied	75.0	34.9	17.5	11.1	25.0	
Has the treatment unit contributed in solving the water shortage problem?	Yes	0.0	28.9	18.6	20.0	20.0	Chi-Square = 18.292, p-value = 0.019, df = 8
	Partially	66.7	42.1	74.4	76.0	80.0	
	No	33.3	28.9	7.0	4.0	0.0	
How much confidence do you have about the product and treated greywater quality?	Confident	25.0	55.8	67.9	77.8	43.8	Chi-Square = 15.704, p-value = 0.047, df = 8
	Skeptical	75.0	32.6	25.0	19.4	56.3	
	Not confident	0.0	11.6	7.1	2.8	0.0	

- **Effect of GWTP age**

Table 4-19 shows a summary of the significant test results correlating the age of GWTP to various aspects. In the age group over than 12 years, the most common response to the question 'Does the responsible party visit you to make sure that there are no problems at the treatment unit?' was 'Yes continuously', whereas in the age groups 1-3, 4-6, 7-9, and 10-12 years the most common answer to the same question was ‘Only during the first period of treatment unit installation’.

It was interesting to see that GWTP age had another impact on taking samples by the responsible party. For GWTP with age greater than 12 years, samples were taken continuously, whereas in the age groups 1-3, 4-6, 7-9, and 10-12 years the most common answer was ‘Only during the first period of treatment unit installation’.

Regarding treatment unit contribution in solving water shortage problem, the most common response by beneficiaries’ was ‘Partially’. It was found that as treatment unit age increase, its contribution increase.

GWTP age also seemed to have an impact on beneficiaries’ confidence regarding product validity and treated greywater quality. As age increases, their confidence increases and thus the reuse of treated greywater in the irrigation of agricultural land increases.

According to interviewees’ responses, the highest percentage of answers regarding the emission of foul odors from the treatment plant was ‘Sometimes’ in the age groups 4-6, 7-9, 10-12 and more than 12 years, whereas in the age group 1-3 the highest percentage of responses was ‘No odors’. On the other hand, greywater treatment plant contribution in the spread of insects was ‘Low and acceptable’ in the age groups 7-9, 10-12 and more than 12 years, whereas in the age group 4-6 was ‘Large and significant spread’ and ‘Has no effect’ in the age group 1-3 years.

Table 4-19: Percentage variation in respondents' answers based on GWTP age (%)

Question	Answer	GWTP age					Statistical parameters
		1-3	4-6	7-9	10-12	12 <	
Does the responsible party visit you to make sure that there are no problems at the treatment unit?	Yes continuously	39.1	0.0	0.0	0.0	50.0	Chi-Square = 43.141, p-value = 0.000, df = 8
	Only during the first period of treatment unit installation	50.0	57.1	60.0	100.0	0.0	
	No	10.9	42.9	40.0	0.0	50.0	
Does the responsible party take samples to ensure the effectiveness of the treatment unit?	Yes continuously	41.5	0.0	0.0	0.0	100.0	Chi-Square = 33.813, p-value = 0.000, df = 8
	Only during the first period of treatment unit installation	48.8	62.5	91.7	100.0	0.0	
	No	9.8	37.5	8.3	0.0	0.0	
Has the treatment unit contributed in solving water shortage problem?	Yes	54.3	20.0	15.8	0.0	0.0	Chi-Square = 16.735, p-value = 0.033, df = 8
	Partially	42.9	80.0	81.0	100.0	100.0	
	No	2.9	0.0	2.6	0.0	0.0	
Do you use the treated greywater in the irrigation of the agricultural land?	Yes	80.0	100.0	100.0	100.0	100.0	Chi-Square = 17.037, p-value = 0.002, df = 4
	No	20.0	0.0	0.0	0.0	0.0	
What type of agriculture that is being used after the establishment of the treatment unit and is being irrigated by treated greywater?	Greenhouses	41.7	14.3	11.7	33.3	0.0	Chi-Square = 23.717, p-value = 0.003, df = 8
	Open cultivation	44.4	35.7	30.0	0.0	50.0	
	Fruitful trees	13.9	50.0	58.3	66.7	50.0	
How much confidence do you have about the product and treated greywater quality?	Confident	84.1	28.6	86.7	100.0	100.0	Chi-Square = 33.848, p-value = 0.000, df = 8
	Skeptical	11.4	71.4	10.0	0.0	0.0	
	Not confident	4.5	0.0	3.3	0.0	0.0	
Are there foul odors from the greywater treatment plant?	Often	2.2	28.6	15.0	33.3	0.0	Chi-Square = 45.114, p-value = 0.000, df = 12
	Sometimes	22.2	35.7	46.7	66.7	50.0	
	Rarely	20.0	21.4	33.3	0.0	0.0	
	No odors	55.6	14.3	5.0	0.0	50.0	
How does greywater treatment plant contribute in the spread of insects around the house?	Large and significant spread	6.7	42.9	23.3	0.0	0.0	Chi-Square = 23.985, p-value = 0.002, df = 8
	Low and acceptable spread	35.6	28.6	56.7	66.7	50.0	
	Has no effect	57.8	28.6	20.0	33.3	50.0	

Do you have problems with the neighbors due to the treatment unit?	Yes	2.2	30.8	14.3	0.0	50.0	Chi-Square = 12.030, p-value = 0.017, df = 4
	No	97.8	69.2	85.7	100.0	50.0	

- **Effect of GWTP construction cost**

A summary of the significant test results (p-value < 0.05) correlating GWTP construction cost to different aspects is shown in Table 4-20. Most GWTPs with construction cost less than 5000 NIS and in the range of 10000-12000 NIS were funded by donors, whereas projects with construction cost in the range of 5000-10000 NIS and 12000-15000 NIS were funded part on owners' expense and the other part on donors' expense.

According to interviewees' responses, follow up and taking samples by the responsible party was mostly during the first period of treatment unit installation and increase as construction cost increase.

GWTP construction cost also seemed to have an impact on treatment unit contribution in solving water shortage problem; most of responses were 'Partially contribute' and the percentage decrease as construction cost increase.

Table 4-20: Variation in respondents' answers based on GWTP construction cost

Question	Answer	Percentage of respondents (%)				Statistical parameters
		<5000	5000-10000	10000-12000	12000-15000	
Who has funded the establishment of greywater treatment plant?	At my own expense	4.8	1.3	0.0	0.0	Chi-Square = 39.747, p-value = 0.000, df = 6
	Donor	95.2	25.3	66.7	40.0	
	Part on my own expense and the other part on the donor	0.0	73.4	33.3	60.0	
Does the responsible party visit you to make sure that there are no problems at the treatment unit?	Yes continuously	4.8	5.1	11.1	36.7	Chi-Square = 25.190, p-value = 0.000, df = 6
	Only during the first period of treatment unit installation	52.4	62.0	66.7	53.3	
	No	42.9	32.9	22.2	10.0	
Does the responsible party take samples to ensure the effectiveness of the treatment unit?	Yes continuously	8.3	5.7	16.7	40.7	Chi-Square = 22.140, p-value = 0.001, df = 6
	Only during the first period of treatment unit installation	58.3	84.9	66.7	48.1	
	No	33.3	9.4	16.7	11.1	
Has the treatment unit contributed in solving the water shortage problem?	Yes	5.9	24.6	57.1	38.1	Chi-Square = 18.657, p-value = 0.005, df = 6
	Partially	76.5	75.4	42.9	57.1	
	No	17.6	0.0	0.0	4.8	
Do you use the treated greywater in the irrigation of the agricultural land?	Yes	95.2	98.7	55.6	90.0	Chi-Square = 25.445, p-value = 0.000, df = 3
	No	4.8	1.3	44.4	10.0	
What type of agriculture that is being used after the establishment of the treatment unit and is being irrigated by treated greywater?	Greenhouses	0.0	11.7	0.0	55.6	Chi-Square = 37.704, p-value = 0.000, df = 6
	Open cultivation	30.0	33.8	80.0	18.5	
	Fruitful trees	70.0	54.5	20.0	25.9	
What are the crops that are being irrigated by treated greywater?	Fruit trees	65.0	60.5	20.0	29.6	Chi-Square = 27.867, p-value = 0.000, df = 6
	Vegetables	10.0	35.5	80.0	66.7	
	Decorative plants	25.0	3.9	0.0	3.7	

Chapter Five

Conclusion and Recommendation

5 Chapter Five: Conclusion and Recommendation

Conclusion

There is a burden of water scarcity in many of the Palestinian rural areas where existing supplies are insufficient. Greywater reuse is an important issue that can be used towards the sustainable allocation of water resources as reuse of greywater for irrigation is practiced in many communities throughout the West Bank of Palestine

There is a common encouragement of treated greywater re-use among water and environmental experts as 91.1% of them supported that. In spite of that, up-to-date, there are no onsite treated greywater reuse standards and guidelines for Palestine and most of experts (95%) emphasized the importance of having Palestinian standards for treated greywater re-use. This percentage was higher among GWTPs beneficiaries as 97.5% of them confirm that it is important to have Palestinian standards for treated greywater reuse. Most of experts emphasized that there is health, social, environmental, economic and religious importance of such standards with percentages of 94.9%, 76.7%, 96.1%, 86.7% and 61.7% respectively.

Onsite greywater treatment plants follow-up is limited in the study area as 56.0% of the implementing agencies follow their projects just during the first period of the project implementation, 31.4% never monitor their projects, and only 12.6% continuously follow-up their projects.

Recommendations

- Onsite treated greywater reuse standards and guidelines for Palestine should be developed as they are requested by experts and beneficiaries of GW treatment units.
- Monitoring mechanisms for the existing GW treatment units should be taken into account health and safety measures to be employed when GW is managed at the household level.
- A common understanding between local communities that have GW treatment units and the various responsible governmental agencies (mainly the environmental health department at the Ministry of Health) should be developed and should be considered as an important requirement to encourage taking responsibility and provide the users with the knowledge and support their needs.
- The sustainability of GW reuse projects should be proven by donor-funded projects through training and close collaboration with users in the selection, design, implementation, operation, and maintenance, and development process.
- Economic incentives should be emphasized at the household level for the establishment of new GW treatment units, as they are the main motivation to accept their establishment.
- Costs of long term field visits to beneficiaries for awareness, monitoring and sampling by NGOs involved in the implementation GW treatment units funded by donor projects should be part of the project to ensure the continuity and sustainability of the GW units.

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Appendix I

Questionnaire Forms

The first questionnaire form is for experts, and the second form is for the owners of onsite greywater treatment unit.

استمارة (1)

استمارة لجمع بيانات من الجهات الرسمية ذات العلاقة والخبراء

أخي الكريم / أختي الكريمة

تعتبر هذه الاستمارة أداة تجريها الطالبة "جمانة الخطيب" لنيل درجة الماجستير في جامعة بيرزيت في تخصص هندسة المياه والبيئة تحت عنوان " أهمية ايجاد مواصفات فلسطينية خاصة باعادة استخدام المياه العادمة الرمادية المعالجة" بإشراف الدكتور ماهر أبو ماضي

تعبئة هذه الاستمارة بدقة تعتبر مساهمة في إنجاح هذه الرسالة بإذن الله للوصول إلى الفائدة المرجوة. أشكرك سلفا على تمضية بعض من وقتك في قراءة وتعبئة هذه الاستمارة التي تم توخي البساطة فيها لاختصار الوقت في قرائتها وتعبئتها.

1 – معلومات الاستمارة	
G1	اسم الباحث ------------------
G2	رقم الاستمارة ------------------
G3	تاريخ تعبئة الاستمارة ------------------
2- معلومات عامة عن المبحوث	
V01	عمر المبحوث بالسنوات ------------------
V02	الجنس 1- ذكر 2- أنثى
V03	الدرجة العلمية للمبحوث 1- بكالوريوس 2- ماجستير 3- دكتوراه 4- غير ذلك حدد -------
V04	المؤسسة التي يعمل فيها 1- سلطة المياه 2 – سلطة جودة البيئة 3- وزارة الصحة 4- وزارة الزراعة 5- وزارة الحكم المحلي 6- مصلحة المياه 7- مؤسسة المواصفات والمقاييس 8- جامعة 9- مجلس تنظيم قطاع المياه 10- جمعية غير حكومية 11- غير ذلك حدد --------
V05	الوصف الوظيفي للمبحوث ------------------
3- أهمية المواصفة	
V06	هل تشجع اعادة استخدام المياه العادمة الرمادية المعالجة؟ 1- نعم 2- لا
V07	هل تشعر بضرورة وجود مواصفات فلسطينية لاعادة استخدام المياه العادمة الرمادية؟ 1- نعم 2- لا
V08	اذا كان الجواب نعم لماذا؟
V09	اذا كان الجواب لا لماذا؟
V10	من وجهة نظرك، هل ترى وجود أهمية صحية لوجود مواصفات فلسطينية لاعادة استخدام المياه العادمة الرمادية؟ 1- نعم 2- لا

V11	اذا كان الجواب نعم، لماذا؟
V12	من وجهة نظرك، هل ترى وجود أهمية اجتماعية لوجود مواصفات فلسطينية لاعادة استخدام المياه العادمة الرمادية؟ 1- نعم 2- لا
V13	اذا كان الجواب نعم، لماذا؟
V14	من وجهة نظرك، هل ترى وجود أهمية بيئية لوجود مواصفات فلسطينية لاعادة استخدام المياه العادمة الرمادية؟ 1- نعم 2- لا
V15	اذا كان الجواب نعم، لماذا؟
V16	من وجهة نظرك، هل ترى وجود أهمية اقتصادية لوجود مواصفات فلسطينية لاعادة استخدام المياه العادمة الرمادية؟ 1- نعم 2- لا
V17	اذا كان الجواب نعم، لماذا؟
V18	من وجهة نظرك، هل ترى وجود أهمية دينية لوجود مواصفات فلسطينية لاعادة استخدام المياه العادمة الرمادية؟ 1- نعم 2- لا
V19	اذا كان الجواب نعم، لماذا؟
4- دور المؤسسة التي يعمل فيها المبحوث	
V20	هل لمؤسستكم دور في مراقبة جودة المياه الرمادية المعالجة؟ 1- نعم 2- لا
V21	اذا كان الجواب نعم , فما هي طبيعة هذا الدور؟
V22	هل لمؤسستكم دور في مراقبة اعادة استخدام المياه الرمادية المعالجة؟ 1- نعم 2- لا
V23	اذا كان الجواب نعم , فما هي طبيعة هذا الدور؟
V24	في حال تم تشكيل فريق فني لوضع المواصفة الخاصة بالمياه العادمة الرمادية فهل ترى ضرورة لمشاركة مؤسستكم في ذلك؟ 1- نعم 2- لا
V25	هل لديك معرفة او اطلاع على المواصفات المستخدمة اقليميا وعالميا الخاصة باعادة استخدام المياه العادمة الرمادية المعالجة؟ 1- نعم 2- لا
V26	هل ترى أن المواصفات المستخدمة اقليميا وعالميا الخاصة باعادة استخدام المياه العادمة الرمادية المعالجة ملائمة للواقع الفلسطيني؟ 1- نعم 2- لا 3- لا أدري
V27	هل ترى ضرورة لمشاركة مؤسسات المجتمع المدني في اعداد المواصفات؟1 - نعم 2- لا 3- لا أدري

استمارة (2)

استمارة لجمع بيانات المستفيدين من محطات المعالجة

أخي المواطن / أختي المواطنة

تعتبر هذه الاستمارة أداة تجريها الطالبة "جمانة الخطيب" لنيل درجة الماجستير في جامعة بيرزيت في تخصص هندسة المياه والبيئة تحت عنوان " أهمية ايجاد مواصفات فلسطينية خاصة باعادة استخدام المياه العادمة الرمادية المعالجة" بإشراف الدكتور ماهر أبو ماضي

تعبئة هذه الاستمارة بدقة تعتبر مساهمة في إنجاح هذه الرسالة بإذن الله للوصول إلى الفائدة المرجوة

أشكرك سلفا على تمضية بعض من وقتك في قراءة وتعبئة هذه الاستمارة التي تم توخي البساطة فيها لاختصار الوقت في قرائتها وتعبئتها

1 – معلومات الاستمارة	
G1	اسم الباحث -----------------
G2	رقم الاستمارة -----------------
G3	تاريخ تعبئة الاستمارة -----------------
2 – معلومات عامة عن الأسرة المستفيدة من وحدة المعالجة	
V01	عمر المبحوث بالسنوات -----------------
V02	الجنس 1- ذكر 2- أنثى
V03	اسم البلدة -----------------
V04	عدد الأسر التي تخدمها المحطة -----------------
V05	عدد أفراد الأسرة المقيمين في المنزل والمخدومين بوحدة المعالجة -----------------
V06	الدرجة العلمية لرب الأسرة -----------------
V07	مهنة رب الأسرة -----------------
V08	معدل دخل الأسرة (شيكل/ شهر) -----------------
3- معلومات عامة عن وحدة المعالجة	
V09	نوع النظام المستخدم 1 –معالجة المياه الرمادية 2 –معالجة المياه العادمة (رمادية + سوداء)
V10	مصادر المياه العادمة الرمادية الناتجة عن المنزل 1- مغسلة للايدي 2- دش للاستحمام 3- غسالة الملابس 4- مغسلة حوض الجلي 5- مصارف في المنزل 6- غير ذلك ، حدد -----------------
V11	العمر الزمني لوحدة المعالجة (سنة) -----------------
V12	تكلفة إنشاء وحدة المعالجة (شيكل) -----------------

V13	من قام بتمويل إنشاء محطة معالجة المياه العادمة الرمادية ؟ 1- على نفقتك الخاصة 2- جهة مانحة 3- جزء على نفقتك الخاصة وجزء على الجهة المانحة
V14	مقدار المساهمة المالية من قبل المستفيد ان وجدت (شيكل) ----------------
V15	اذا كان تمويل محطة معالجة المياه العادمة الرمادية من قبل الجهة المانحة فمن هي ؟ ----------------
4- مراقبة نظام المعالجة	
V16	هل تقوم جهة رقابية بزيارتكم للتأكد من عدم وجود مشاكل في المحطة؟ 1 -نعم بشكل مستمر 2 -فقط في الفترة الأولى من تركيب المحطة 3 -لا
V17	اذا كان الجواب نعم، فمن هي الجهة الرقابية ؟ ----------------
V18	هل تقوم الجهة الرقابية بأخذ عينات للتأكد من فاعلية المحطة؟ 1 -نعم بشكل مستمر 2 -فقط في الفترة الأولى من تركيب المحطة 3 -لا
V19	هل تشعر بضرورة وجود مواصفات فلسطينية لاعادة استخدام المياه العادمة الرمادية ؟ 1- نعم 2- لا
V20	اذا كان الجواب نعم لماذا ؟
V21	اذا كان الجواب لا لماذا ؟
V22	ما مدى ثقتك بالمواصفات الفلسطينية والجهات التي تشرف عليها ؟ 1- أثق جدا 2- أثق 3- لا أثق 4- لا أدري
5- محطة المعالجة: سبب الانشاء، استخداماتها، مدى الرضى، المشاكل ذات العلاقة	
V23	ما هو السبب الرئيسي لقبول إنشاء محطة المعالجة؟ 1 -نقص المياه. 2 -لأنها ممولة من جهات مانحة. 3 -توفير تكلفة نضح حفرة الامتصاص. 4 -إعادة استخدام المياه المعالجة في الزراعة. 5 -التوفير في فاتورة مياه الشرب. 6 -غير ذلك /حدد----------------
V24	ما مدى رضاك عن محطة المعالجة؟ 1 -راض جداً. 2 -راض. 3 -غير راض.
V25	في حال عدم الرضى، ما هو سبب عدم الرضى؟
V26	هل كنت تعاني من نقص في كمية المياه قبل انشاء المحطة؟ 1- نعم 2- لا
V27	هل ساهمت المحطة في حل مشكلة نقص المياه؟ 1- نعم 2- جزئيا 3- لا
V28	هل تتوفر (حديقة منزلية) أرض زراعية ؟ 1- نعم 2- لا
V29	ما هي مساحة الحديقة المنزلية $م^2$ ؟ ----------------

V30	هل يتم استخدام المياه العادمة الرمادية المعالجة في ري الحديقة المنزلية؟ 1- نعم 2- لا
V31	اذا كان الجواب نعم فما هي مساحة الارض المروية باستخدام المياه العادمة الرمادية المعالجة (م^2) ؟ ------------------
V32	نوع الزراعة المستخدم بعد انشاء المحطة والتي يتم ريها من المياه المعالجة؟ 1 - بيت بلاستيكي 2- زراعة مفتوحة 3- اشجار مثمرة
V33	ما هي المزروعات التي يتم ريها بالمياه المعالجة؟ 1 -أشجار مثمرة 2 -خضراوات 3 -نبات زينة 4 -أعلاف 5 -غير ذلك /حدد
V34	كيف تتصرف بمنتوج الحديقة؟ حدد النسبة(%) 1 - استهلاك ذاتي % ----- 2 - هدايا% ------ 3- تسويق% -------
V35	ما مدى ثقتك بنوعية المياه المعالجة وصحة المنتج؟ 1 -واثق 2 -متشكك 3 -غير واثق
V36	اذا كنت تبيع المنتج الزراعي هل تخوفت من حافز البيع او التسويق؟ 1- نعم 2- لا
V37	اذا كانت الاجابة نعم، ما هي النواحي التي تخوفت منها؟ ------------------
V38	هل تتقبل اعادة استخدام المياه المعالجة من ناحية دينية؟ 1- نعم 2- لا
V39	هل تخجل من الناس بسبب استخدام المياه المعالجة في المنزل؟ 1- نعم 2- لا
6- تأثير المحطة على الوضع الصحي في المنزل	
V40	هل تصدر روائح كريهة من محطة معالجة المياه العادمة الرمادية؟ 1 -غالباً 2 -أحياناً 3 -نادراً 4 -لا
V41	ما هي شدة هذه الروائح؟ 1 -قوية 2 -متوسطة 3 -خفيفة
V42	كيف أثرت محطة معالجة المياه العادمة الرمادية على انتشار الحشرات حول المنزل؟ 1 -انتشار كبير وبشكل ملحوظ 2 -انتشار قليل ومقبول 3 -لا يوجد تأثير
V43	هل لديك مشاكل مع الجيران بسبب المحطة؟ 1- نعم 2- لا
V44	هل تتعرض الأسرة لملامسة مباشرة للمياه العادمة الرمادية؟ 1 -كثيراً 2 -أحيانا 3 -نادرا 4 -لا تتعرض مطلقاً
V45	هل لاحظت انتشار أي مرض وبائي خلال ال 12 شهر السابقة نتيجة استخدام وحدة معالجة المياه العادمة الرمادية في منزلك ؟ 1- نعم 2- لا
V46	إذا كان الجواب نعم، ما هو نوع المرض؟ --------------

Appendix II

SPSS Results (Crosstabs)

Crosstab V01* V33

			V33 What are the crops that are being irrigated by treated greywater?			Total
			Fruit trees	Vegetables	Decorative plants	
V01 Interviewee age (years)	20-30	Count	3	0	3	6
		%	50.0%	0.0%	50.0%	100.0%
	31-40	Count	12	9	1	22
		%	54.5%	40.9%	4.5%	100.0%
	41-50	Count	30	20	3	53
		%	56.6%	37.7%	5.7%	100.0%
	more than 50	Count	42	20	2	64
		%	65.6%	31.3%	3.1%	100.0%
Total		Count	87	49	9	145
		%	60.0%	33.8%	6.2%	100.0%

Chi-Square = 23.014, p-value = 0.003, df = 6

V04*V16 Crosstab

			V16 Does the responsible party visit you to make sure that there are no problems at the treatment unit?			Total
			Yes continuously	Only during the first period of treatment unit installation	No	
V04 Number of families served by greywater treatment unit	1	Count	9	30	37	76
		%	11.8%	39.5%	48.7%	100.0%
	2	Count	5	21	10	36
		%	13.9%	58.3%	27.8%	100.0%
	3	Count	2	23	3	28
		%	7.1%	82.1%	10.7%	100.0%
	4	Count	0	14	0	14
		%	0.0%	100.0%	0.0%	100.0%
	more than 4	Count	2	1	0	3
		%	66.7%	33.3%	0.0%	100.0%
Total		Count	18	89	50	157
		%	11.5%	56.7%	31.8%	100.0%

Chi-Square = 38.634, p-value = 0.00, df = 8

V04*V18 Crosstab

			V18 Does the responsible party take samples to ensure the effectiveness of the treatment unit?			
			Yes continuously	Only during the first period of treatment unit installation	No	Total
V04 Number of families served by the greywater treatment unit	1	Count	9	21	9	39
		%	23.1%	53.8%	23.1%	100.0%
	2	Count	5	18	3	26
		%	19.2%	69.2%	11.5%	100.0%
	3	Count	1	23	1	25
		%	4.0%	92.0%	4.0%	100.0%
	4	Count	0	12	2	14
		%	0.0%	85.7%	14.3%	100.0%
	more than 4	Count	2	1	0	3
		%	66.7%	33.3%	0.0%	100.0%
Total		Count	17	75	15	107
		%	15.9%	70.1%	14.0%	100.0%

Chi-Square = 19.625, p-value = 0.014, df = 8

V04* V22 Crosstab

			V22 How much confidence do you have about the Palestinian standards and the authorities that oversee them?				
			Very confident	I am confident	I do not trust	I do not know	Total
V04 Number of families served by the greywater treatment unit	1	Count	1	50	16	9	76
		%	1.3%	65.8%	21.1%	11.8%	100.0%
	2	Count	3	26	6	0	35
		%	8.6%	74.3%	17.1%	0.0%	100.0%
	3	Count	0	26	1	1	28
		%	0.0%	92.9%	3.6%	3.6%	100.0%
	4	Count	2	11	0	1	14
		%	14.3%	78.6%	0.0%	7.1%	100.0%
	more than 4	Count	1	1	1	0	3
		%	33.3%	33.3%	33.3%	0.0%	100.0%
Total		Count	7	114	24	11	156
		%	4.5%	73.1%	15.4%	7.1%	100.0%

Chi-Square = 28.198, p-value = 0.005, df = 12

V04*V40 Crosstab

			V40 Are there foul odors from the greywater treatment plant?				Total
			Often	Sometimes	Rarely	No odors	
V04 Number of families served by the greywater treatment unit	1	Count	25	27	13	12	77
		%	32.5%	35.1%	16.9%	15.6%	100.0%
	2	Count	5	10	6	14	35
		%	14.3%	28.6%	17.1%	40.0%	100.0%
	3	Count	1	13	11	3	28
		%	3.6%	46.4%	39.3%	10.7%	100.0%
	4	Count	2	10	2	0	14
		%	14.3%	71.4%	14.3%	0.0%	100.0%
	more than 4	Count	0	0	1	2	3
		%	0.0%	0.0%	33.3%	66.7%	100.0%
Total		Count	33	60	33	31	157
		%	21.0%	38.2%	21.0%	19.7%	100.0%

Chi-Square =38.331, p-value = 0.000, df =12

V04*V41 Crosstab

			V41 What is the severity of these odors?			Total
			Strong	Medium	Light	
V04 Number of families served by the greywater treatment unit	1	Count	20	28	17	65
		%	30.8%	43.1%	26.2%	100.0%
	2	Count	4	12	5	21
		%	19.0%	57.1%	23.8%	100.0%
	3	Count	0	11	14	25
		%	0.0%	44.0%	56.0%	100.0%
	4	Count	4	3	7	14
		%	28.6%	21.4%	50.0%	100.0%
	more than 4	Count	0	0	1	1
		%	0.0%	0.0%	100.0%	100.0%
Total		Count	28	54	44	126
		%	22.2%	42.9%	34.9%	100.0%

Chi-Square =18.679, p-value = 0.01, df =8

V04*V42 Crosstab

			V42 How does the greywater treatment plant contribute in the spread of insects around the house?			
			Large and significant spread	Low and acceptable spread	Has no effect	Total
V04 Number of families served by the greywater treatment unit	1	Count	26	34	17	77
		%	33.8%	44.2%	22.1%	100.0%
	2	Count	6	18	11	35
		%	17.1%	51.4%	31.4%	100.0%
	3	Count	3	16	9	28
		%	10.7%	57.1%	32.1%	100.0%
	4	Count	6	5	3	14
		%	42.9%	35.7%	21.4%	100.0%
	more than 4	Count	0	0	3	3
		%	0.0%	0.0%	100.0%	100.0%
Total		Count	41	73	43	157
		%	26.1%	46.5%	27.4%	100.0%

Chi-Square =17.525, p-value = 0.021, df =8

V04*V44 Crosstab

			V44 Is the family exposed to direct contact with treated greywater?				
			Lot	Sometimes	Rarely	Not exposed at all	Total
V04 Number of families served by the greywater treatment unit	1	Count	2	27	16	32	77
		%	2.6%	35.1%	20.8%	41.6%	100.0%
	2	Count	0	13	8	14	35
		%	0.0%	37.1%	22.9%	40.0%	100.0%
	3	Count	0	1	17	10	28
		%	0.0%	3.6%	60.7%	35.7%	100.0%
	4	Count	1	4	4	5	14
		%	7.1%	28.6%	28.6%	35.7%	100.0%
	more than 4	Count	0	0	0	3	3
		%	0.0%	0.0%	0.0%	100.0%	100.0%
Total		Count	3	45	45	64	157
		%	1.9%	28.7%	28.7%	40.8%	100.0%

Chi-Square = 28.285, p-value = 0.005, df = 12

V12* V24 Crosstab

			V24 How much are you satisfied with the treatment unit?			Total
			Very satisfied	Satisfied	Not satisfied	
V12 The cost of establishing treatment unit (NIS)	5000-10000	Count	10	61	8	79
		%	12.7%	77.2%	10.1%	100.0%
	10000-12000	Count	0	7	2	9
		%	0.0%	77.8%	22.2%	100.0%
	12000-15000	Count	6	21	3	30
		%	20.0%	70.0%	10.0%	100.0%
	less than 5000	Count	2	11	8	21
		%	9.5%	52.4%	38.1%	100.0%
Total		Count	18	100	21	139
		%	12.9%	71.9%	15.1%	100.0%

Chi-Square = 13.455, p-value = 0.036, df = 6

V12* V35 Crosstab

			V35 How much confidence do you have about the product and treated greywater quality?			Total
			Confident	Skeptical	Not confident	
V12 The cost of establishing treatment unit (NIS)	5000-10000	Count	61	16	1	78
		%	78.2%	20.5%	1.3%	100.0%
	10000-12000	Count	8	1	0	9
		%	88.9%	11.1%	0.0%	100.0%
	12000-15000	Count	25	3	2	30
		%	83.3%	10.0%	6.7%	100.0%
	less than 5000	Count	4	15	2	21
		%	19.0%	71.4%	9.5%	100.0%
Total		Count	98	35	5	138
		%	71.0%	25.4%	3.6%	100.0%

Chi-Square = 35.697, p-value = 0.000, df = 6

V12*V38 Crosstab

			V38 Do you accept the reuse of treated greywater from religious aspect?		
			Yes	No	Total
V12 The cost of establishing treatment unit (NIS)	5000-10000	Count	78	1	79
		%	98.7%	1.3%	100.0%
	10000-12000	Count	9	0	9
		%	100.0%	0.0%	100.0%
	12000-15000	Count	28	2	30
		%	93.3%	6.7%	100.0%
	less than 5000	Count	17	4	21
		%	81.0%	19.0%	100.0%
Total		Count	132	7	139
		%	95.0%	5.0%	100.0%

Chi-Square = 11.613, p-value = 0.009, df = 3

V12*V39 Crosstab

			V39 Are you ashamed from people as a result of using treated greywater in the house?		
			Yes	No	Total
V12 The cost of establishing treatment unit (NIS)	5000-10000	Count	1	78	79
		%	1.3%	98.7%	100.0%
	10000-12000	Count	1	8	9
		%	11.1%	88.9%	100.0%
	12000-15000	Count	4	26	30
		%	13.3%	86.7%	100.0%
	less than 5000	Count	1	20	21
		%	4.8%	95.2%	100.0%
Total		Count	7	132	139
		%	5.0%	95.0%	100.0%

Chi-Square = 7.365, p-value = 0.05, df = 3

V12*V40 Crosstab

			V40 Are there foul odors from the greywater treatment plant?				Total
			Often	Sometimes	Rarely	No odors	
V12 The cost of establishing treatment unit (NIS)	5000-10000	Count	8	35	25	11	79
		%	10.1%	44.3%	31.6%	13.9%	100.0%
	10000-12000	Count	1	4	0	4	9
		%	11.1%	44.4%	0.0%	44.4%	100.0%
	12000-15000	Count	3	9	5	13	30
		%	10.0%	30.0%	16.7%	43.3%	100.0%
	less than 5000	Count	7	9	3	2	21
		%	33.3%	42.9%	14.3%	9.5%	100.0%
Total		Count	19	57	33	30	139
		%	13.7%	41.0%	23.7%	21.6%	100.0%

Chi-Square = 26.100, p-value = 0.002, df = 9

V12*V44 Crosstab

			V44 Is the family exposed to direct contact with treated greywater?				Total
			Lot	Sometimes	Rarely	Not exposed at all	
V12 The cost of establishing treatment unit (NIS)	5000-10000	Count	0	12	34	33	79
		%	0.0%	15.2%	43.0%	41.8%	100.0%
	10000-12000	Count	0	2	2	5	9
		%	0.0%	22.2%	22.2%	55.6%	100.0%
	12000-15000	Count	1	2	7	20	30
		%	3.3%	6.7%	23.3%	66.7%	100.0%
	less than 5000	Count	0	14	1	6	21
		%	0.0%	66.7%	4.8%	28.6%	100.0%
Total		Count	1	30	44	64	139
		%	0.7%	21.6%	31.7%	46.0%	100.0%

Chi-Square = 41.595, p-value = 0.00, df = 9

V11*V23 Crosstab

			V23 What is the main reason for the establishment of the treatment unit?					
			Lack of water	It is funded by donors	The cost of cesspit wastewater evacuation	Reuse of treated water in agriculture	Savings in the drinking water bill	Total
V11 Age of treatment unit (year)	1-3	Count	8	21	4	9	3	45
		%	17.8%	46.7%	8.9%	20.0%	6.7%	100.0%
	4-6	Count	5	4	0	5	0	14
		%	35.7%	28.6%	0.0%	35.7%	0.0%	100.0%
	7-9	Count	29	18	8	4	1	60
		%	48.3%	30.0%	13.3%	6.7%	1.7%	100.0%
	10-12	Count	2	0	0	1	0	3
		%	66.7%	0.0%	0.0%	33.3%	0.0%	100.0%
	more than 12	Count	0	1	1	0	0	2
		%	0.0%	50.0%	50.0%	0.0%	0.0%	100.0%
Total		Count	44	44	13	19	4	124
		%	35.5%	35.5%	10.5%	15.3%	3.2%	100.0%

Chi-Square = 28.135, p-value = 0.03, df = 16

V11*V44 Crosstab

			V44 Is the family exposed to direct contact with treated greywater?				
			Lot	Sometimes	Rarely	Not exposed at all	Total
V11 Age of treatment unit (year)	1-3	Count	0	4	9	32	45
		%	0.0%	8.9%	20.0%	71.1%	100.0%
	4-6	Count	0	1	2	11	14
		%	0.0%	7.1%	14.3%	78.6%	100.0%
	7-9	Count	1	11	29	19	60
		%	1.7%	18.3%	48.3%	31.7%	100.0%
	10-12	Count	0	0	3	0	3
		%	0.0%	0.0%	100.0%	0.0%	100.0%
	more than 12	Count	0	0	0	2	2
		%	0.0%	0.0%	0.0%	100.0%	100.0%
Total		Count	1	16	43	64	124
		%	0.8%	12.9%	34.7%	51.6%	100.0%

Chi-Square = 28.458, p-value = 0.005, df = 12

V08*V44 Crosstab

			V44 Is the family exposed to direct contact with treated greywater?				
			Lot	Sometimes	Rarely	Not exposed at all	Total
V08 Average household income (NIS / month)	less than 1000	Count	0	3	0	1	4
		%	0.0%	75.0%	0.0%	25.0%	100.0%
	1000-2000	Count	1	19	7	16	43
		%	2.3%	44.2%	16.3%	37.2%	100.0%
	2000-3000	Count	2	17	17	21	57
		%	3.5%	29.8%	29.8%	36.8%	100.0%
	3000-4000	Count	0	6	17	13	36
		%	0.0%	16.7%	47.2%	36.1%	100.0%
	more than 4000	Count	0	0	3	13	16
		%	0.0%	0.0%	18.8%	81.3%	100.0%
Total		Count	3	45	44	64	156
		%	1.9%	28.8%	28.2%	41.0%	100.0%

Chi-Square = 30.447, p-value = 0.002, df = 12