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Article

Cesspits as Onsite Sanitation Facilities in the Non-Sewered Palestinian Rural Areas: Users' Satisfaction, Needs and Perception

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Abstract: The main aim of this research was to assess the problems of using cesspits in the non-sewered areas in the West Bank of Palestine by the means of a questionnaire, with a sample size of 485 households, targeting the cesspits' owners. People who use cesspits for house onsite wastewater management are not satisfied with them, and most of them complain about high disturbance during discharge of the cesspits (75.5%). Emptying cesspits represents a financial burden, costing 6% of the households' monthly income. The frequency of cesspits' emptying decreases substantially when there are onsite GWTPs. People accept that constructing a house with an onsite GWTPs when supported by external funding, and to a much lesser extent when they need to fund them themselves. The majority of people prefer sewerage networks for wastewater management (74.8%), followed by onsite GWTPs (15.5%), and cesspits are the least preferable (9.5%). Therefore, a more technically sound individual home onsite wastewater management system should be applied to replace cesspits so as to solve their negative implications on the socio-economic, environmental, and health aspects in the Palestinian rural communities.

Keywords: cesspit; wastewater; rural areas; developing countries

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1. Introduction

1.1. General Information

Billions of people around the world suffer from poor access to water, sanitation, and hygiene [1]. In view of this, poor sanitation remains one of the greatest challenges of the twenty-first century, as nearly 90% of the generated sewage in less developed countries and 20% in more developed countries is disposed of untreated into nature [2]. Consequently, more than 80 % of all diseases in the developing world are caused by poor sanitation and contaminated drinking water resources [3]. Septic tanks and pit latrines are used to meet the sanitation needs of more than 2.7 billion people worldwide, especially in low-income countries [4,5]. Ensuring access to water and sanitation for all through sustainable management of water resources is the sixth of the 17 Sustainable Development Goals, developed by the UN General Assembly in 2015 [6]. Water, the most precious resource, is exploited mainly in agricultural production, and is elementary to achieve worldwide food security.

The overuse of water resources causes multifaceted problems, such as salinization that ultimately leads to depletion of groundwater resources [7]. The unsewered areas relying on cesspits or septic tanks are considered a major source of groundwater pollution [8]. On the contrary, the onsite sanitation systems, when properly located, designed, and constructed, pose a minimal threat to public health and natural resources, but when improperly located or designed, can pose significant threats [9]. Cesspits may have an important role in rapidly transferring various pollutants, such as nitrogen, to groundwater [10–12]. Nitrates can be a concern for drinking water if concentrations are greater than 45 mg/L NO_3, as it can interfere with the ability of red blood cells to carry oxygen, leading to methemoglobinemia (blue baby syndrome) [13].

Palestine is among the countries with the scarcest renewable water resources per capita due to both natural and artificial constraints [14]. The Palestinians' accessibility to renewable water of only 70 cubic meters per capita per year for all purposes makes Palestine among the poorest countries with water per capita in the Middle East and across the globe. At present, water demand exceeds the available water supply. The gap between water supply and water demand is growing due to population growth, a higher standard of living, and the need to expand irrigated agriculture and industrialization [15]. According to the Palestinian Central Bureau of Statistics [16], 25.9% of households in Palestine get water 3–4 days per week.

The sewers networks in Palestine had been absent from every agenda and had not been adequately developed. Although 70% of the West Bank households are served by cesspits [17], no regulations are imposed to govern cesspit septage disposal. The number of the population who use cesspits in the West Bank is around 1,600,000 people [18], with an estimated number of cesspits in the range of 200,000 to 350,000 units. Septage in cesspits might seep into groundwater, depending mainly on the surrounding hydrogeological conditions.

There is a growing number of studies on wastewater addressing socioeconomic and political issues associated with its use for agriculture [19]. In Palestine, gray water treatment and treated effluent reuse gained more acceptance than total sewage [15,16]. Gray water refers to domestic wastewater generated in households or office buildings from streams without fecal contamination, i.e., all streams except for the wastewater from toilets. Sources of gray water include sinks, showers, baths, washing machines or dishwashers. Japan, North America, and Australia rank globally the highest in applying decentralized gray water management [20]. A decentralized system employs a combination of house onsite and/or cluster systems to treat and dispose of wastewater from dwellings and businesses close to the source. Managed decentralized wastewater treatment systems are viable, long-term alternatives to centralized wastewater treatment facilities, particularly in small and rural communities, where they are often most cost-effective. They already serve a quarter of the population in the U.S., and half the population in other countries. These systems should be considered in any evaluation of wastewater management options for small and mid-sized communities [21]. Treated gray water typically has a much better hygiene quality than mixed wastewater. Clogging from fats is a potential risk in gray water systems that must always be considered, especially when the pipe system is enlarged and water cools in the ground [22,23].

The negative perceptions of onsite GWTPs in Palestine were due to the need to separate the house internal black and gray water (GW) conveying pipes; refusal to use the reclaimed GW in garden irrigation; non-availability of external funding; and unaffordable construction costs [24]. Problems related to cesspits are significant from the point of view of health, environment, as well as the social and economic aspects.

While scientific knowledge is important for knowledge-based policy development, combining science and local knowledge from stakeholders is necessary for developing more inclusive approaches and locally targeted solutions [25]. It is increasingly agreed that gray water can alleviate water shortage [20]. Gray water is a valuable water resource that can be utilized for irrigating home gardens or agricultural land [12]. The willingness of households to adopt a gray water treatment and reuse system depends on many factors such as socio-culture acceptance, public awareness, economic situation, and institutional capacity in the field of the on-site treatment [26]. The public perception of wastewater reuse is still suspicious, although generally gray wastewater reuse is more acceptable than black water reuse [27]. The Internet of Things-based platform has as a main objective the real-time management of wastewater flow, quality, and energy consumption can contribute in solving the operation and monitoring problems of the onsite wastewater treatment and reuse systems, where several sensing nodes can collect data from these systems [28].

The aim of this research was to assess the problems of using cesspits in the non-sewered areas in the West Bank of Palestine, knowledge and acceptance of onsite GWTPs as an alternative house onsite wastewater management system in the rural areas, as well as availability and need for irrigation water at household level.

Cesspits and GWTPs are not only used in Palestine, but also in other neighboring countries, such as Lebanon, Syria, and Jordan. Therefore, the results of this study are not only relevant to Palestine, but also to other countries in the Middle East. However, this study deals with the existing houses, but not with the new houses that could include GWTPs during the construction phase. Another limitation for this study is that, in Palestine, so far only a one GWTP system has been applied, whereas other more efficient technologies could be installed that might lead to other results.

1.2. Description of Cesspits

Cesspits are unlined underground pits, similar to the pits used with pit latrine systems, that are used capture for wastewater collection and storage (Figure 1).

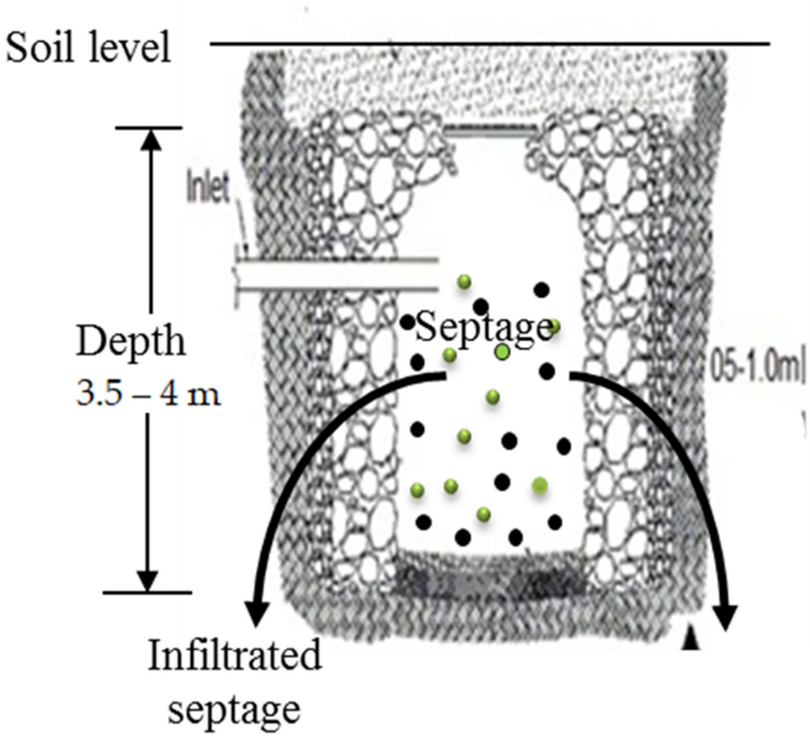

Figure 1. Cesspit schematic drawing [7].

1.3. Description of the House Onsite GWTP Used in Palestine

The house internal sewage piping systems are modified to separate the gray and black wastewater streams. The (black) toilet wastewater is disposed into the available cesspit. The gray wastewater (wastewater sources except toilet wastewater) is transported to the household gray water treatment plant (GWTP).

The onsite GWTP is comprised of a septic tank (first compartment) ahead of two up-flow gravel filters (second and third compartments), as presented in Figure 2. Grease is tapped in the septic tank using an outlet T-shaped pipe. The fourth compartment is a pumping wet well tank, where the anaerobically pre-treated wastewater is lifted to a multi-layer coal-sand filter. Afterwards, the treated wastewater is stored in an irrigation tank connected to the garden irrigation network. More details about the system can be found in Burnat and Shtayye [26]. The GWTP rough cost is USD 5 to 10 thousand.

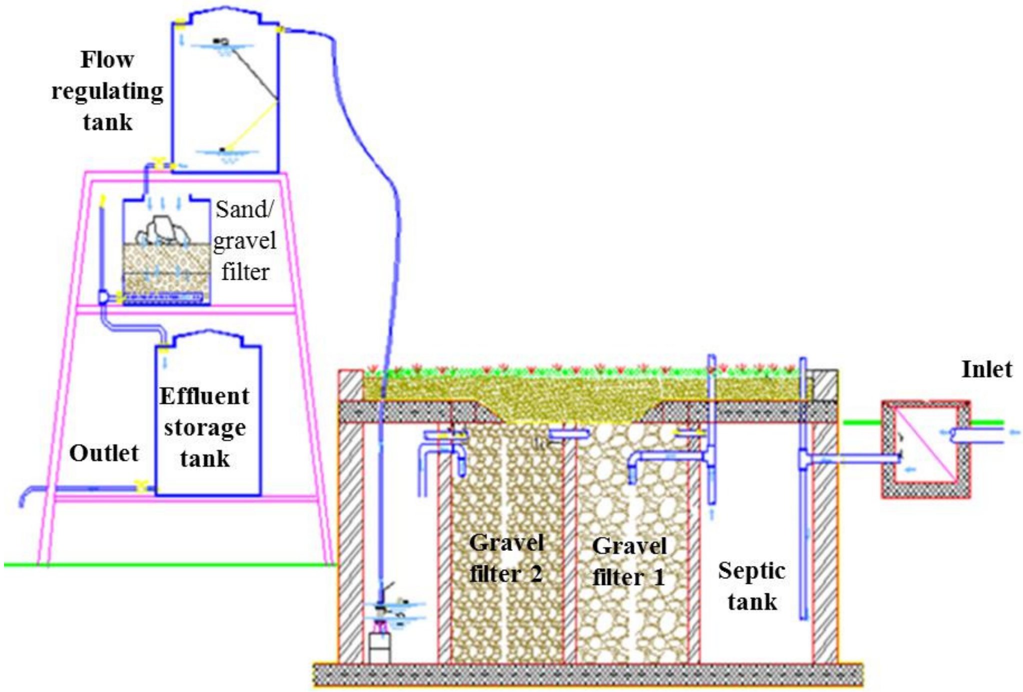

Figure 2. Onsite gray water treatment plant (GWTP) [23].

2. Methodology

The research methodology is presented in Figure 3, and elaborated in the following sub-sections.

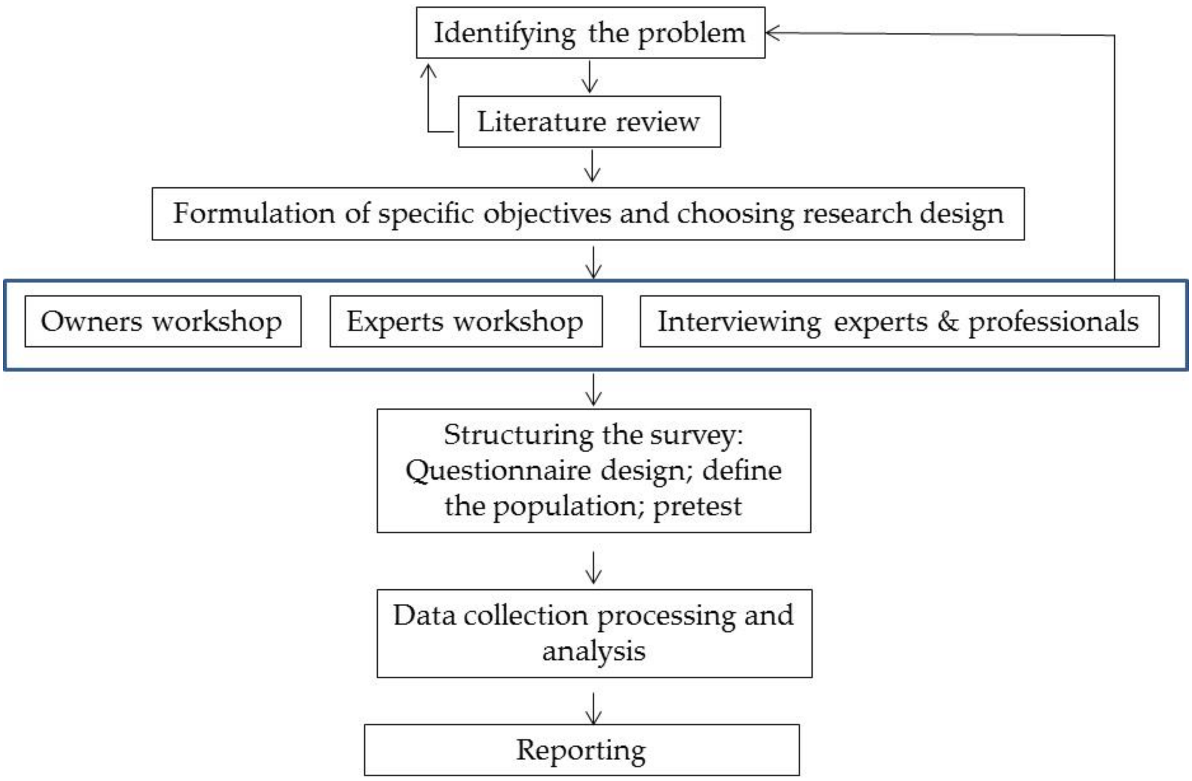

Figure 3. Block diagram research methodology.

2.1. Study Area

The study area included 19 different rural communities of around 160,000 inhabitants, distributed in eight governorates of the West Bank, namely Ramallah, Jerusalem, Bethlehem, Hebron, Jenin, Tubas, Tulkarem, and Nablus (Figure 4). The study area was selected according to the use of cesspits in the governorates of the West Bank. Palestine has unusual characteristics of great variation in terrain within a small area, from the coastal plain to the central mountain ridge ending with Al-Ghor at the Jordan valley, where the lowest point on earth is located at the Dead Sea [27].

Figure 4. Study area in eight governorates of the West Bank.

The results of the Housing Conditions survey in 2010 indicated that 0.9% of households in the Palestinian Territory live in a villa, 47.8% live in a house, while 50.2% live in apartments The percentage of households living in a house in rural areas in 2010 is 74.3%, while 41.9% of households in urban areas live in a house [29]. The West Bank and the Gaza Strip have a lower-middle-income economy with average per capita gross domestic product (GDP) of USD 4484. Total GDP grew by more than 3% in 2015, but agriculture—the main sector exposed to foreign competition and a major driver of inclusive growth—contracted by 25% between 2014 and 2015. The number of households with an employed person also increased by 5% [30].

Study area was selected according to availability of onsite GWTPs distributed mostly in all governorates of the West Bank.

2.2. Data Collection Tool and Sample Size

In this study, a survey by questionnaire (Table A1) was conducted, and a sample of 485 owner of cesspit was randomly selected and the questionnaire was distributed at a household level. The sample size was calculated based on the normal distribution using the software program "Sample size calculator Raosoft, Inc., 2004", at a confidence level of 95%, and a response distribution of 50%. The number of cesspits in the study area of 19 communities was estimated to be around 15,000 units. Prior to the questionnaire design, an inception workshop was arranged to gather the owners of cesspits and their users to reveal the concerns, opinions, views of the local community about the sanitation systems they use. Another workshop was carried out targeting key persons who work in the water and sanitation sectors. Furthermore, for the sake of designing the questionnaire, several interviews were conducted with several representatives of non-governmental organizations (NGOs), scientific and technical groups, professionals, and other associations working in water management and related environmental issues in Palestine. The questionnaire was piloted by interviewing 10 persons from different 10 households. The recovery was 95.9% as 465 questionnaires were filled. The questionnaire was finalized after consulting several experts who work in the water and sanitation fields in different institutions.

The questionnaire was written in the Arabic language, and included questions about family size, employment, income, general information about the problems of using cesspits, availability of water for domestic use and irrigation and cost, knowledge and acceptance of onsite GWTPs, drivers and barriers of applying onsite GWTPs, and preferred systems for irrigation. The surveyors were educated about cesspits and GWTPs, their operation and maintenance methods, and the environmental, economic, and agriculture values that the treated gray water might provide. The obtained data was analyzed using the Statistical Science Software Program (SPSS), version 20 [31]. Acceptance of providing onsite GWTPs was statistically tested by Logistic Regression Analysis using "Backward Stepwise (Conditional)", which reduces the variables of each step in regression to finally produce the significant variables to build the equation.

3. Results and Discussion

3.1. General Information on Households

The survey results revealed that the average family size varied in the governorates from 2 to 15 persons per household, with an average of 7 persons. Indeed, the family size in the rural areas is higher than in the whole West Bank, with an overall average family size of 5 persons [29]. The families in rural communities are considered to be poor with monthly income in the range of USD 285 to 570, while the last official Palestinian statistics reveal that 13.9% of the West Bank population are below the national poorness standard, as their average income is less than USD 580 [32]. The unemployment rate was 11.7%, 48% of the interviewees were daily workers, 22.5% were full time employed, and 5.1% were farmers working on their own farms. The average monthly water bill per household varied in the range USD 14–30, with a maximum value of USD 120 per month.

The water price varied between USD 1.2 and 6/m^3. The highest price of USD 6/m^3 was in case of purchasing from the water tankers, with four times the network water price, especially during summertime, due to the frequent intermittent water supply. However, the majority of the households (61.7%) paid USD 1.2–1.5/m^3 for network water.

3.2. Cesspit Characteristics

The majority of households (87.3%) used cesspits for onsite wastewater disposal, and only 12.1% used septic tanks. The cesspits were constructed over more than 60 years ago, since 1960. The average volume of cesspits was 60 m^3. Most of the cesspits (92%) were covered with concrete roofs, but only 6.7% of the pits were sealed by having concrete floors, walls, and roofs. Thus, most of the house-onsite collected wastewater might impose threats to groundwater quality by percolation through the soil. This was evident, as 50.8% of the cesspits were never discharged since being constructed, and 49.2% were emptied after 1 to 40 years.

3.3. Cesspits' Owners' Satisfaction

The owners' satisfaction with using cesspits for wastewater disposal was assessed in terms of system's acceptance, disturbance, social problems due to odors emission and the high frequency of cesspit emptying, affordability, and noise pollution. People's satisfaction with using cesspits was not promising, since 49.2% of the cesspits' owners expressed their dissatisfaction with the applied sanitation system. The dissatisfaction was due to (1) financial burdens of the high cesspits' emptying cost, (2) the cesspits were adjacent to rainwater harvesting cisterns and so were a potential for water pollution, (3) health concerns, (4) pollution of environment and ground water, (5) leakage of the cesspits and so causing social problems with the neighbors, (6) odor emission, (7) insects infestations such as mosquitoes, and (8) separation of house internal gray and black wastewater piping system.

The average frequency of cesspits' discharge was 7 times per year, but astonishingly the very high emptying frequency of some cesspits was as high as 6.7%, since the cesspit's owners discharged the cesspits 24 times per year. The cesspits' users pay USD 15–86 each time of the cesspit is emptied, with an average of USD 35. This imposes a big financial and social burden on the users to operate these systems. The families spend in average 6% of their monthly income on cesspit emptying, and this percentage can be as high as 20% of some families' income.

The majority of the respondents (75.7%) complained about from the high disturbance when the cesspits were emptied; moreover, 68.5% of the neighbors were disturbed. Specifically, 74.3% of the respondents complained about the high noise of the discharging pump, and 10.4% had problems with neighbors during emptying of cesspits. Therefore, it can be concluded that people who use cesspits are not pleased with these systems.

3.4. Availability of Water for Irrigation

More than half (54.9%) of the interviewed persons had home gardens with an average area of 600 m^2. Moreover, 76.7% of the houses had rainwater harvesting systems, of which 63.7% were made of concrete, and 18.7% excavated in rocks. The rainwater harvesting systems were located at a distance ranging from 7 to 100 m, with an average distance of 31 m from the cesspits. According to the Palestinian Standards Institution the distance between the cesspit and the cistern should be more than 15 m, with the cistern located upstream. Thus, there is a risk of harvested rainwater pollution by the cesspits, especially those located at a distance of less than 15 m apart.

The households' gardens were mostly cultivated as 51.7%, 44%, 1.7%, and 2.6% were planted respectively with fruit trees, vegetables, flowers, and fodders. The used sources of irrigation water were the public water networks, rainwater cisterns, and untreated gray water of 25.8%, 32.8%, and 16.4%, respectively. The majority of the respondents (66.1%) reported that the available water was not sufficient for plants irrigation, and 32.2% stated that there was sufficient water for irrigation. This indicated that there was a shortage in the irrigation water, to the extent that there was a significant percentage of people who used untreated gray water for irrigation. Therefore, since people are willing to use untreated gray water for irrigation, there is no doubt they will accept using treated gray water, once it is available.

3.5. Acceptance of Gray Water Systems

The possibility of applying a more proper wastewater management system, such as a gray water treatment system, replacing the existing cesspits in the rural communities, was investigated. The findings revealed that 46.3% of the interviewees had previous information about gray water treatment systems, while 52.6% had no idea. The majority of the interviewed persons (74.8%) preferred sewerage networks for wastewater management, 15.5% preferred onsite GWTPs, and 9.5% preferred cesspits (Table 1). This is due to people not preferring to take responsibility for managing wastewater systems. In addition, people agreed to have decentralized wastewater management facilities, providing that their financial contribution would be minimal by receiving financial and technical support from donors. Apparently, the governorates with comparatively more water scarcity preferred GWTPs due to the need for irrigation water. For the respondents who favored cesspits, this might be because people are used to conventional methods, and they did not have enough information about the GWTPs.

Table 1. Preferred systems of sanitation per governorate.

Governorate	Central Sewerage Network (%)	Gray Water Treatment Plant (%)	Cesspit (%)
Ramallah	82.2	14.3	5.0
Jerusalem	83.3	16.7	0.0
Bethlehem	81.3	18.8	0.0
Hebron	66.1	15.2	18.2
Nablus	85.7	14.3	0.0
Tulkarem	80.0	20.0	0.0
Jenin	72.6	19.8	7.5
Tubas	96.0	4.0	0.0
Total	74.8	15.5	9.5

The findings of this research revealed that the financial aspects and affordability were significant issues for construction of onsite GWTPs in the Palestinian rural communities. Of the interviewees, 55.4% accepted construction of onsite GWTPs subject to the availability of external funding, but 94.3% of them rejected the construction of onsite GWTPs if they had to pay for them. This highlights that the financial aspect is a major factor that influences people's acceptance of any new wastewater management system. Thus, people did not show a willingness to pay or contribute to the construction costs. On the other hand, 43.9% of the respondents refused construction of onsite GWTPs even being supported by external funding. This finding was in line with the finding that the majority of people (74.8%) preferred sewerage networks for wastewater management. Furthermore, 52.6% had no idea about gray water treatment systems. The main reasons for not accepting gray water treatment systems were the non-availability of agricultural land, perception that the systems were not convenient, followed by the technical difficulty of separating the gray and black water conveying pipes inside the house, and then health concerns (Table 2).

Table 2. Reasons for not acceptance of gray water systems.

Reasons for Not Accepting	%
Land availability for agriculture	27.3
Not convenience, no need for the treatment plant	27.2
Technical difficulty of separation	22.7
Health risks and worries about water quality	13.6
Cost of separation	4.5
Operation and maintenance burden on householder	4.5

3.6. Acceptance of GWTPs Construction with External Funding

The "logistic regression analysis" revealed that the significant variables for acceptance of onsite GWTPs by the cesspits' owners, in case external funding was available, were

(1) garden availability, (2) water source for irrigation is untreated gray water, (3) preference system of sanitation is central wastewater network, (4) acceptance of separation of house internal sewage piping system, and (5) knowledge of sanitation systems (Table 3).

Table 3. Acceptance of construction GWTPs in rural areas.

Independent Value	Acceptance of GWTPs Asymp. Sig. (2-Sided) Value *
Water source for irrigation: untreated gray water	0.025
Knowledge of gray water treatment systems	0.009
Acceptance of separation of house internal sewage system	0.012
Preferred system of sanitation: Central wastewater network	0.006
Garden availability	0.025

*: Significant value, if Asymp. Sig. (2-sided) Value is ≤0.05.

Social aspects of the sanitation systems are important for the acceptance of onsite GWTPs as, similar to any other wastewater management system, especially in the planning phase. The people acceptances to construct GWTPs varied among people based on the different source of irrigation water they use (Figure 5). However, the majority of the farmers were positive regarding the acceptance of GWTP, regardless of the source of irrigation water. The highest percentage (85.7) was by the farmers who utilized untreated gray water in irrigation due to of water scarcity, while the least (56.3) was by the farmers who had a water network, indicating fresh water was abundant.

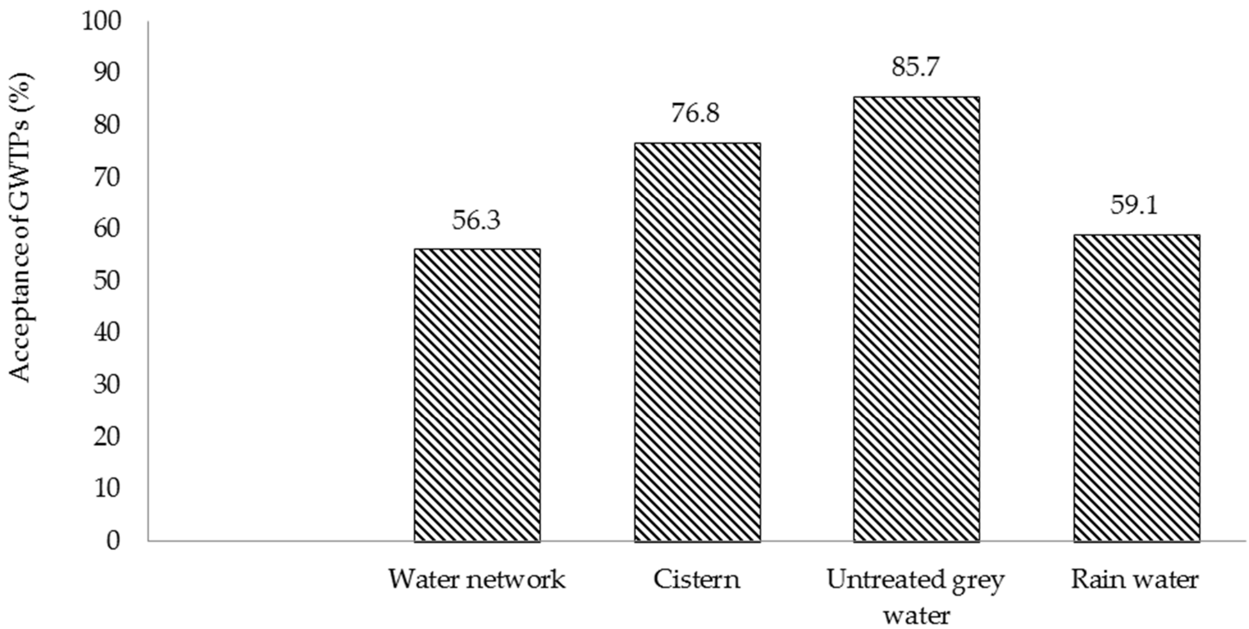

Figure 5. Acceptances of GWTPs relative to water source of irrigation.

The separation of black and gray water conveying pipes existing in the houses could be a problem due to the need to destruct the tiles, which causes extra cost and annoyance, as 35.5% considered it as a barrier for construction GWTPs. However, 64.5% of the respondents accepted a separation of the house internal piping system for the sake of construction onsite GWTPs. Since the majority accepted the pipes separation inside their houses, it can be concluded that separation of plumping systems was not a significant barrier for accepting the house onsite sanitation system. Results showed that 71.1% of cesspit owners accepted using treated gray water in irrigation without condition.

The acceptance of using treated gray water in irrigation varied among the rural communities in the surveyed governorates (Table 4). The highest acceptance of treated gray water reuse in agriculture were found in Nablus, Tulkarem, and Jenin, with acceptance percentages of 100, 93.3 and 87.0%, respectively. The least acceptance was found in Ramallah governorate of 49%, probably since Ramallah is not an agricultural area.

Table 4. Acceptance of using treated gray water in irrigation per governorate.

Governorate	Acceptance of Using Treated Gray Water in Irrigation (%)
Nablus	100.0
Tulkarem	93.3
Jenin	87.0
Tubas	84.0
Bethlehem	81.3
Jerusalem	68.4
Hebron	67.9
Ramallah	49.5
Total	71.1

3.7. Drivers and Barriers of Onsite GWTPs

3.7.1. Drivers of GWTPs

As reported by 50% of the respondents, the main driver for accepting to construct GWTP was the intention to reuse treated water in agriculture, followed by financial saving of cesspit discharge, as well as reducing water bills and saving fresh water for domestic use. A smaller percentage accepted to construct GWTPs so as to enhance public health and reduce pollution, and only 7.4% perceived availability of funds as a driver for providing GWTPs (Figure 6).

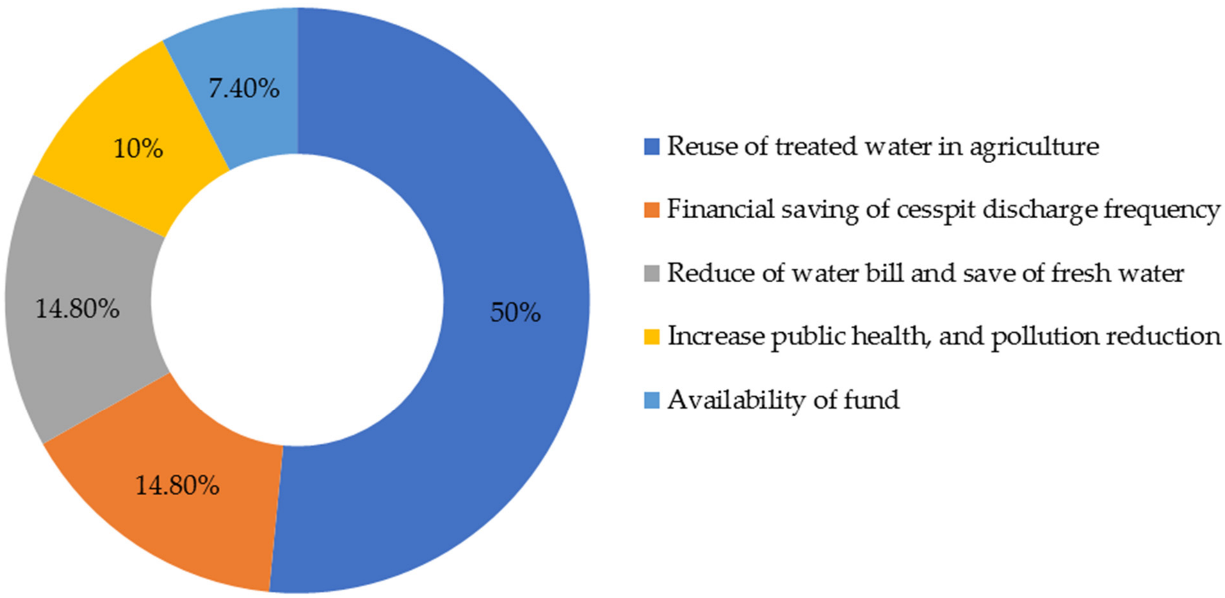

Figure 6. Drivers for accepting onsite GWTPs by the cesspits' owners.

3.7.2. Barriers of Construction Onsite GWTPs

The main barriers of constructing GWTPs, with the highest percent of 35%, were worries of health risks and non-confidence of treated water quality compliance with irrigation requirements. Other constraints were reported, such as land availability for agriculture. With a smaller percentage, other constraints of accepting GWTP's included odor emission, environmental pollution, and insect infestation (Figure 7).

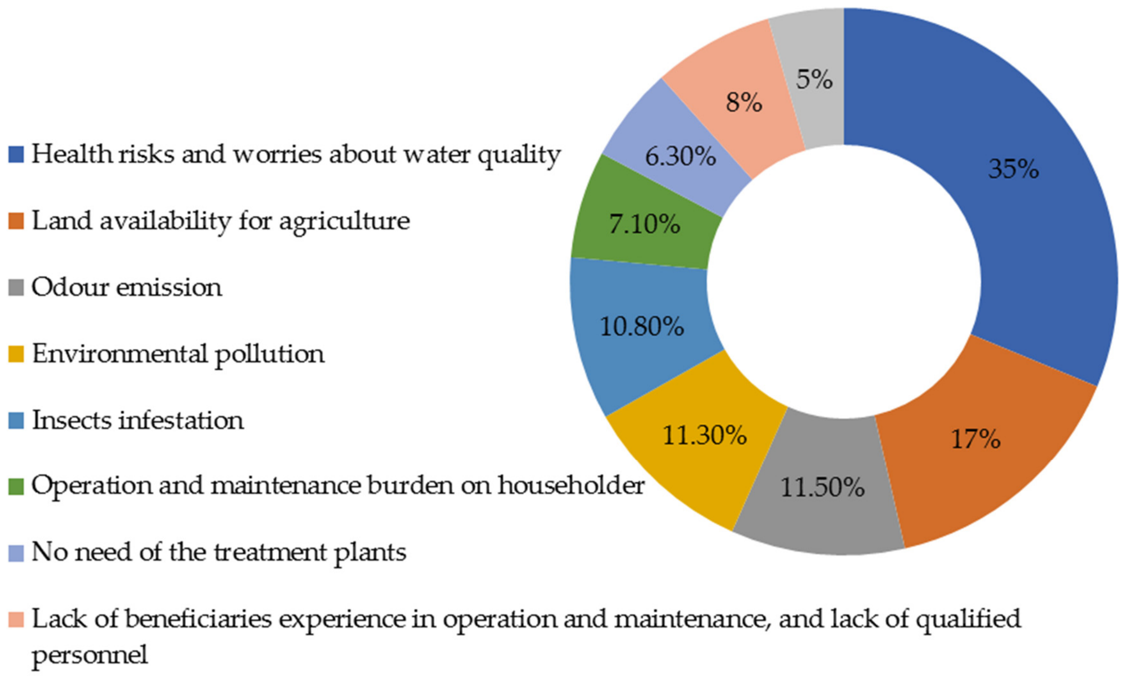

Figure 7. Barriers for accepting onsite GWTPs by the cesspits owners.

3.8. Separation of House Internal Pipes

The separation of houses' internal sewage pipes was a main issue for the acceptance of GWTPs construction. Some people did not accept the separation of the house's inside sewage piping system (Figure 8). Some respondents (27%) did not accept the piping system separation since they had no agricultural land to be irrigated, and others stated that there was no need for the treatment plant (27.2%). Some of them believed it was technically difficulty to have internal plumping works inside their houses.

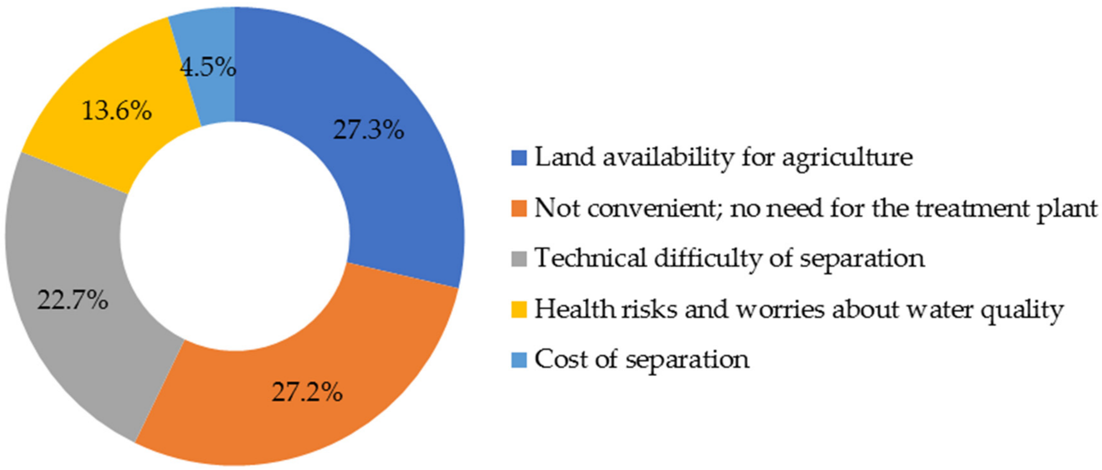

Figure 8. Reasons for non-acceptance of house internal sewage pipes separation.

3.9. Miscellaneous

A total of 54.5%. of the cesspits owners who frequently empty their cesspits were willing to construct GWTPs paid for by external funding, while 45.5% who never emptied their cesspits were not willing to have GWTPs. A total of 71.2% of cesspits owners accepted using of treated gray water in irrigation; 92.7% of the respondents who used untreated gray water in irrigation accepted the use of treated gray water without restrictions, followed by 74.4% of cesspit owners who depended on a cistern accepting the use of treated gray water in irrigation, while 57.1% of those who depended on water network for irrigation accepted using of treated gray water. The findings revealed that water shortage was a main driver for construction of GWTPs, since the vast majority of those who used untreated gray water were willing to use treated gray water in irrigation. On the other side, people who had a continuous source of water (water network) for irrigation were less willing to reuse treated gray water in irrigation.

3.10. Comparison of Cesspits for Total Wastewater and Cesspits for Black Wastewater

Around 50% of the interviewed persons in the rural communities were not satisfied with using cesspits as a main system for wastewater management. This percentage increased to 80.8% after providing onsite GWTPs, which revealed that people were satisfied with the GWTPs system due to the significant reduction of wastewater discharge to the cesspit. Consequently, the cesspits' emptying frequency was reduced, resulting in reducing the operation cost. A total of 60.2% of the interviewees paid USD 14–30 each time the cesspit was emptied, which caused them financial and social burdens. The results showed that the average number of cesspits' emptying per year before construction of onsite GWTPs was 6.9; 6.7% of the cesspits owners discharged the cesspits 24 times per year, but this number decreased to 4.1% after providing onsite GWTPs.

Most people in the rural communities were willing to have onsite GWTPs, but the majority were not able to afford them, as stated by 94.3% of the respondents. Furthermore, 55.4% of the respondents accepted construction of onsite GWTPs in the case that they were being supported by external funding.

4. Conclusions and Recommendations

4.1. Conclusions

The main conclusions of this study are:

- People who use cesspits for house onsite wastewater management are not satisfied with them, and most of them complain about high disturbance during discharge of the cesspits.
- Emptying cesspits represents a financial burden, costing 6% the households' monthly income.
- The frequency of cesspits' emptying decreases substantially when there are onsite GWTPs. People accept the construction of onsite GWTPs in their homes when supported by external funding, and to a much lesser extent when have to be funded by themselves.
- Majority of people prefer sewerage networks for wastewater management, followed by onsite GWTPs, and cesspits are the least preferable option
- Some people use untreated gray water for irrigation when irrigation water is not available. They will accept using treated gray water, once available.

4.2. Recommendations

For the non-sewed areas in Palestine, the following issues are recommended:

- A more proper system is required to handle the wastewater and replace cesspits, and which has positive implications in environment, ground water, and health in rural communities.
- Development of public awareness programs is recommended in order to better understanding and improve public knowledge of wastewater systems, as well as perception toward reuse schemes, in parallel with field visits of local people to other wastewater treatment, and reuse for sharing knowledge and ideas.

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Appendix A

Table A1. Cesspits Survey Questionnaire.

1. Questionnaire Information		
Researcher name		
Questionnaire number		
Date of filling out the questionnaire		
2. General information about the household		
No.	Question	Answer
2.1	Governorate name	
2.2	Village name	
2.3	What is the number of family members?	
2.4	Profession of the family head	
2.5	Average household income (NIS/month)	
2.6	What is the current water bill? (NIS/month)	
2.7	What is the price per cubic meter of water? (NIS)	
3. Information about the cesspit used in the home:		
3.1	Which year was the cesspit created?	
3.2	What is the type of cesspit?	1—Perforated hole. 2—Solid hole (impermeable). 3—Other/specify
3.3	What are the dimensions of the cesspit in meters?	1—Height: 2—Width: 3—Depth:
3.4	What was the geological nature of the hole when it was excavated?	1—100% rock + 0% soil 2—75% rock + 25% soil 3—50% rock + 50% soil 4—25% rock + 75% soil 5—0% rock + 100% soil
3.5	Where was concrete used during the construction of the cesspit?	1—In creating the cesspit cover. 2—In constructing the sides of the pit. 3—In constructing the bottom of the pit.
3.6	What is the cost of constructing the cesspit? (in NIS)	
3.7	Do you empty the cesspit?	1—Yes 2—No

Table A1. *Cont.*

If the answer is 3.7 yes, answer 3.8–3.14		
3.8	In which year did the cesspit emptying start?	
3.9	How many times does the cesspit emptied during the year in the current period?	
3.10	What is the cost of cesspit emptying each time? (NIS)	
3.11	How annoyed the family is from the process of cesspit emptying?	1—Too much 2—Medium 3—Little 4—Not annoyed
3.12	What is the level of noise produced within the surrounding the house from the process of emptying the cesspit?	1—Low noise 2—Acceptable noise 3—A loud noise—not acceptable
3.13	How annoyed are the neighbors from the process of cesspit emptying?	1—Too much 2—Medium 3—Little 4—Not annoyed
3.14	Do you have problems with neighbors due to the cesspit emptying process?	1—Yes 2—No
3.15	Is the cesspit content discharged by a method other than emptying by the hauling tank?	1—Yes 2—No
3.16	If the answer to 13.15 is yes, then what is this method?	
3.17	How much are you willing to pay to get rid of the cesspit and find a replacement for it? (NIS/month)	
4. Information on the home garden and satisfaction with the sewage disposal system:		
4.1	Is there a home garden (farmland)?	1—Yes 2—No
4.2	What is the home garden area? (m^2)	1—Yes 2—No
4.3	Is there a rainwater harvesting cistern adjacent to the house?	1—Yes 2—No
4.4	What is the construction material of the rainwater harvesting cistern?	1—Concrete 2—Rock 3—Mixed
4.5	How far is the cesspit from the rainwater harvesting cistern? (m)	
4.6	What are the crops available in the garden? Write down in the box any of the following answers:	1—Fruit tree 2—Vegetables 3—Forest trees 4—Flowers and roses 5—Other:
4.7	What is the source of irrigation of crops in the garden?	1—Water network 2—Rainwater cistern. 3—Untreated gray water (laundry and 4—Kitchen sink water) 5—Do not need water
4.8	Is the amount of water available to irrigate crops sufficient?	1—Yes 2—No

Table A1. *Cont.*

4. Information on the home garden and satisfaction with the sewage disposal system:		
4.9	What is the used irrigation method?	1—Drip irrigation 2—Other methods/specify:
4.10	How satisfied are you with the current sewage disposal system?	1—Highly satisfied 2—Satisfied 3—Not satisfied
4.11	In case of dissatisfaction. What is the reason for the dissatisfaction?	
4.12	Do you know about gray wastewater treatment systems?	1—Yes 2—No
4.13	Do you accept the construction of a gray wastewater treatment plant at your own expense?	1—Yes 2—No
4.14	Do you accept the construction of a donor-funded treatment plant?	1—Yes 2—No
4.15	Which systems would you prefer to get rid of wastewater?	1—Sewerage network 2—Gray water treatment plant 3—Cesspit.
4.16	Do you accept the separation of the internal sewage pipes in the house as a condition for separating the gray water for the construction of the treatment plant?	1—Yes 2—No
4.17	If the answer is no. What are the reasons for this?	
4.18	What are the incentives for the construction of a gray wastewater treatment plant?	
4.19	What are the future worries of the construction of gray wastewater treatment plants?	
4.20	Do you accept the reuse of treated gray water in irrigating crops in the home garden?	1—Yes 2—No
4.21	If not, what are the reasons that you did not accept the construction of gray water treatment plants?	
4.22	Are you ashamed of people for reusing treated gray water at home?	1—Yes 2—No
5. Information of the respondents		
5.1	Respondent's name	
5.2	Phone number	

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