Perception of House Onsite Grey Water Treatment and Reuse in Palestinian Rural Areas

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Abstract: House onsite treatment of grey water and reuse of treated effluent for irrigating crops are increasingly accepted and practiced in Palestinian rural developments as more than 600 units are operational. The main goal of this research was to assess the impact of those systems on the environment, health, and the Palestinian society and economy through field survey in Qebia village where 47 house onsite sanitation systems were recently implemented. The results revealed that the biggest incentive for applying this system is the reuse of treated grey water for irrigation purposes, which is socially accepted. The application of those systems is currently limited and tied to the availability of external funds. The main concerns people have over the constructing of those house onsite systems are health risks, flooding, and odour emission. Accordingly, the concept of house onsite wastewater management systems is very promising, but provision of proper technical solutions is very important**.**

Keywords: grey water; source separated; onsite sanitation; reuse; perception

Introduction

Palestine is located in Southwest Asia on the Eastern shore of the Mediterranean, in the heart of the Middle East. Palestine, like most other mid-eastern countries, which are generally characterized by aridity, has very limited water resources. Therefore, pollution prevention of the sparsely available water and development of non conventional water sources like reuse of wastewater are receiving more recognition. Unfortunately, the status of wastewater management in Palestine is extremely critical. Of the total Palestinian West Bank population, only about 30% and 6% is served respectively by centralized sewerage and adequate centralized treatment facilities. The other major part of the population has cesspit sanitation. The situation is particularly critical in the rural communities (Mahmoud *et al*., 2003; Mimi *et al*., 2003).

Due to the problems experienced with cesspits and the need for irrigation water, around 600 non conventional house- onsite management systems had been introduced in the Palestinian rural areas since the late 1990s. Most of the implemented systems comprised of separate collection and treatment of black and grey water. The black water is disposed and stored in cesspits, and the grey water is treated in grey water treatment system (GWTS). The treated grey effluents are mostly disposed by means of drip irrigation systems for irrigating homes' gardens. Those sanitation projects have been financially supported mainly by international aid agencies, and implemented by local non-governmental organizations (NGOs).

Al-Sa'ed and Mubarak (2006) reported that a decision of installing a particular onsite treatment system in a Palestinian rural area is primarily made by the supporting NGO and its non-experienced developers. Those decisions are made according to the principles of low-cost treatment systems and NGOs profitability. The authors argued that in all Palestinian small communities, existing onsite sanitation facilities are inadequately designed, poorly sited, and rarely maintained over their service life cycle. Accordingly, the sustainability of those projects is questionable because every sustainable water resource should be environmentally friendly, socially acceptable, and financially viable. According to

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Al-Jayyousi (2003), grey water reuse has been practiced historically in many countries in the world, but social and economic constraints had prevented its further development and integration in the urban environment. Friedler and Hadari (2006) pointed out that in contrast to common perception, grey water may be quite polluted, and thus may pose health risks and negative aesthetics (odour and colour) and environmental effects. In addition, the adoption of non conventional sanitation system, which may be at odds with the prevailing cultural understanding and practices, may not be readily welcomed (Esrey *et al*., 2001). Therefore, one has to understand both people's attitudes and behaviour in order to help explain 'why' and 'why not' of denial and acceptability of proposed sanitation approaches (Nawab *et al*., 2006).

The main goal of this research is to assess at the household level (1) the impacts of house onsite source separated wastewater management systems on the environment, health, society and economy (according to beneficiaries' perception) and (2) the drivers and barriers of implementing those non conventional sanitation systems. Qebia village in the West Bank was chosen as a case study model where the most recent house onsite sanitation project was implemented.

Case Study Model

Qebia, with 5,300 inhabitants, is located west of Ramallah District in Palestine. It is considered to be one of the water stressed middle income localities that is not expected to be sewered for many years. The Qebia Women Cooperative (QWC) had initiated and implemented the project with financial aid from ACDIVOCA. The project consisted of 47 house onsite-source separated – grey water treatment and reuse units serving 48 houses in the village. Each of the served families was provided with a one treatment unit except two houses were provided with a one common unit. Each of the grey water treatment units is intended to treat about 0.5 cubic meters per day per family. The treated grey water is being reused for irrigating home gardens, fruit trees and vegetables.

Methodology

Questionnaire

A person from each beneficiary household was interviewed. The beneficiary's questionnaire was distributed and filled in by all of the 47 served houses. The questionnaire focused on the following main issues:

- Is the sanitation system socially and culturally accepted?
- Is the system affordable with respect to capital, operational and maintenance costs?
- What benefits have you gained from the house onsite source separated grey and black wastewaters management systems?
- Are there any problems experienced with the sanitation system?
- Is it safe to have a house onsite wastewater management system?
- Is it convenient to have an onsite sanitation system?
- What are the drivers and barriers of implementing a house onsite source separated sanitation system?

Effluent characteristics

Five grab samples from the effluent of a one treatment plant were collected over a one month period and analysed for COD fractions, BOD, NH_4^+, NO_3^-, PO_4^{3-}, SO_4^{2-}, TSS, VSS, TDS and FC. COD fractions were carried out as previously described by Mahmoud *et al*. (2003). All parameters were analysed according to standard methods (APHA, 1995).

Statistical Analysis

The data collected from beneficiaries were analyzed using SPSS (Statistical Package for Social Science) program for windows- Release 11.0.0, SPSS® Inc. (2001). The data collected from decision makers and sanitary experts were analysed and presented qualitatively.

Results and Discussion

General Information on Families and Houses

The survey results revealed that the average family size is 9.4 which entail a large family size, a typical characteristic of developing countries. The families in Qebia are poor with average monthly income of around 400 US Dollars, which represents almost 40 US Dollars per person per month. All houses have rather big gardens with an average area of 1,338 m^2. Of the all surveyed household gardens, 100%, 91.5%, 14.9% and 100% are planted respectively with fruit trees, vegetables, forestry trees and flowers. The percentage of families that use treated grey water in irrigating fruit trees, vegetables, forestry trees and flowers are respectively 97.9, 91.5, 4.3 and 95.7%. The produced crops are mainly used for household consumption (93.6%) and the other 6.4% is usually sold is the market. Thus the system had positive impact on food security.

Invisibility and User Comfort

People's satisfaction with the system is very promising as 74.5% of the beneficiaries are very satisfied, 21.3% are satisfied, and only 4.3% are not satisfied. People's satisfaction with the black and grey water collection/treatment systems expressed as very satisfied, satisfied and unsatisfied (respectively 66, 12.8 and 21.3%, for the black system and 80.9, 10.6 and 8.5% for the grey system). This shows that people are more satisfied with the grey water system than with the black. The aesthetic impact of the system is very positive. 97.9% of the interviewed people stated that it has a good impact, 2.1 % found it acceptable, and no one perceived it negatively. The produced noise from the system is rather negligible, as stated by 97.7 % of the people, and only 2.1 % stated that it is acceptable. 10.6% of the interviewed people stated that the system is not enhancing mosquito breeding, while 78.7% think that the system slightly enhances mosquito breeding, and 10.6% stated that it enhances remarkably mosquito spreading. The vast majority of the beneficiaries (95.7%) recommend the system to be applied for other non served houses. Of the total 47 beneficiaries, 16 reported 21 complaints about their system (Table 1).

Table 1. Complaints by 16 beneficiaries over their grey and back water management systems

Complaint	Black Water System	Grey Water System
Seepage/ flooding	4	2
Aesthetically unpleasant/ close to house	2	
Odour emission	6	5
cost	2	
Insects infestation/ close to house	2	
Sub-total	16	7

System Robustness

The robustness of the system is described in terms of system failure, operation, maintenance and effluent quality compliance with the effluent standards. The sanitation system as stated by 95.7% of the people had been monitored. The monitoring activities included routine work only, such as checking the treatment basins (fats removal; seepage, etc.), irrigation network, pump, and influent manhole. The maintenance activities included repair and cleaning. Both grey and black wastewater management systems have minor operational problems (Table 2). The applied wastewater management system requires very little

operational and maintenance efforts. Beneficiaries exert 0-200 hours/year for maintenance and operational work with an average value of 41 hours/ year. The sludge production from the system is rather low since the average yearly desludging rate is 1.6 and in the range of 0-12. The desludging cost of the existing wastewater management and the previously used cesspit system is in average 10 US Dollars/time but reached maximum values of around 30 US Dollars/round.

Unfortunately, the treated grey water effluent is not suitable for unrestricted irrigation (Table 3). Striking that, the effluent quality in terms of BOD, TSS and FC is not complying with the worst effluent quality, viz. type D, imposed by the Palestinian Standards (PSI, 2003b). This implies that the applied treatment system should be modified or even changed.

Table 2. Problems experienced with the black and grey water systems and adopted solutions

		Solution					
	Problem↓	Not exist	Desludging	Fixation	Water pressure	Pipes cleaning	**Sub-total**
Black wastewater management part	Flooding		4				2
	Seepage	3		1			4
	Odour emission						
	Pipes blockage					3	3
	Pipes disconnection						
	Sub-total	3	4	1		3	11
Grey water management part	Flooding						
	Seepage			4			4
	Odour emission	1					1
	Pipes blockage				1	3	4
	Pipes disconnection	1					1
	Sub-total	2		4	1	3	10
All parts	Flooding		4				4
	Seepage	3		5			8
	Odour emission	1					1
	Pipes blockage				1	6	7
	Pipes disconnection	1					1
	Total	5	4	5	1	6	21

Table 3. Effluent characteristics of a house hold onsite GWTP[+]

COD	BOD	NH_4^--N	NO_3^- NO_3	PO_4^{2-}-P	SO_4^{2-} SO_4	TSS	VSS	TDS	FC	pH
205 (49)	107 (50)	30 (8)	3(0)	8(2)	2(1)	356 (254)	225 (119)	979 (110)	7 E+04 (2E+05)	8(1)

[+]average values for five grab samples collected over a one month period

Public Health

In terms of people exposure to wastewater, the system is rather safe as 38.3% of the beneficiaries stated that family member are never exposed to touching wastewater and 53.2% stated that such incidence is very rare. Nonetheless, the other 8.5% of them stated that they do touch the wastewater. The majority of the people believe that the introduced wastewater management system reduces diseases, and 10.6% have no clue, but no one worries that the grey water system might cause diseases. Most of the beneficiaries reported that the system is not causing any physical harm, and 14.9% stated that it is not very likely to do so.

Miscellaneous

The main benefits people gained from the systems are reusing of treated effluent for irrigation (97.9%), raising the hygienic status (97.9%) and reducing the cesspits desludging frequency (63.8%). The major problem experienced with the system is the odour emission (stated by 11 beneficiaries), seepage from the back water pits (stated by 6 beneficiaries), and to a lesser extent increased insects infestation (stated by 2 beneficiaries) and the small size of the black water pit (stated by 1 beneficiary). The desludging frequency has been reduced from 2.2 once/yr (range 0-20) for the previously applied cesspit to 1.6 once/yr (range 0-12) for the new system.

Drivers and Barriers

Environmental Drivers

The most important environmental issues of the system raised by the beneficiaries and other actors are presented in Table 4. All beneficiaries (100%) stated that all of the environmental aspects presented in Table 4 were important to them when they decided to equip the new sanitation systems, with the exceptions of nutrient recycling, and water sources protection.

Table 4. Environmental aspects of the source separated house onsite wastewater management system which were important for the beneficiaries and other actors when selecting the system in Qebia village/ Palestine

- Positive feeling about environmental behaviour
- Water saving
- Prevention of drying out of soil
- Reduction of water emissions
- Recycling of water
- Protection surface water
- Protection of ground water
- Recycling of nutrients
- Reduction of energy use
- Quality of neighbourhood landscaping

Environmental and Public Health Barriers

The barriers that stood in the way of incorporating non-conventional elements in the design and planning stage, and the percentage of people who considered those as barriers are presented in Table 5. The results reveal that the main obstacles in implementing the onsite sanitation system are health concerns, flood risks from effluent disposal and the potential of odour emission.

Table 5. The barriers that stood in the way of incorporating the non-conventional onsite wastewater systems in Qebia, and the percentage of people who considered those as barriers

Health risks (biological)	51.1
Health risks (chemical hazards)	44.7
Flood risks	48.9
Physical injury from householder access to equipment	36.2
Odour emission	46.8
Insects infestation	38.3

Separation (social/technical)

Separating black from grey water in existing houses could be a problem because of the possible need to destruct the tiles which causes extra cost and annoyance. No body stated that the separation was an obstacle. Even 18 beneficiaries stated that the separation was a driver because they intend to reuse the grey water (raw or treated) for irrigation but not the black. This is merely due to socio-cultural roots which are decisive in implementing sanitation system as pointed by (Nawab *et al*., 2006); and because the separation will reduce the desludging frequency of the cesspit (stated by 3 beneficiaries). For the other beneficiaries, the separation had no influence on their decision because the piping system in their houses was already separated before the project. Apparently, the people's socio-cultural heritage might be much stronger than the financial aspects of the sanitation system.

Financial Drivers and Barriers

The financial considerations of the sanitation system are presented in Tables 6 and 7. Results clearly reveal that the availability of external funds is a key issue in implementing the systems. The wide scale implementation of the system is apparently limited to the availability of external funds as 66% of the interviewees stated that they would not have constructed the system on their own expense. Financial revenues from implementing the system like reducing water consumption, garden irrigation, and nutrients recirculation were also very important elements for accepting the system.

Table 6. Financial considerations that were either drivers or a barriers in determining decisions to incorporate non-conventional elements in the design

Financial consideration	Driver	Neutral	Barrier
Capital cost as compared with the previously applied conventional cesspit system	12.8	12.8	74.5
Operating cost as compared with the previously applied conventional cesspit system	17	14.9	68.1
Availability of external funds	97.9	2.1	0
Beneficiaries financial contribution to the capital cost	0	76.6	23.4
Reduced drinking water consumption and thus lower bills	97.9	2.1	0
Separation of house internal grey and black water piping systems	70.2	29.8	0
Financial aspects of garden irrigation	97.9	2.1	0
Nutrients availability in monetary terms	74.5	25.5	0

Table 7. Extent of the financial considerations that played a role in the implementation of the non-conventional house onsite wastewater management system

Financial consideration	Important in accepting the system	Big role in hesitation	No role
Capital cost as compared with the previously applied conventional cesspit system	97.9	0	2.1
Operating cost as compared with the previously applied conventional cesspit system	91.5	0	8.5
Availability of external funds	97.9	2.1	0
Beneficiaries financial contribution to the capital cost	44.7	8.5	46.8
Reduced drinking water consumption and thus lower bills	95.7	2.1	2.1
Separation of house internal grey and black water piping systems	70.2	0	29.8
Financial aspects of garden irrigation	95.7	2.1	2.1
Nutrients availability in monetary terms	70.2	19.1	10.6

Social and Managerial Drivers and Barriers

The social aspects of the sanitation system those were important for realising the non-conventional house onsite sanitation system are presented in Table 8. Results clearly show that people's obligations to manage their household wastewater is the most important factor for opting for the system, followed by interest to improve the overall living conditions and reducing the nuisance caused to the neighbours by the previously applied sanitation systems and practices.

Table 8. Social aspects of the sanitation system that were important for the beneficiaries and other actors in realising a non-conventional design, expressed as percentage of the respondents out of the total beneficiaries

Aspects	Important (%)
Intensive contact with neighbours / Collaboration with neighbours	76.6
Involvement in sanitation / Taking responsibility for your household water management system, e.g. water saving, reducing emissions	100
Improves quality of living	97.9
Religion	0

The social and managerial considerations that hampered incorporation of non-conventional elements in the design are presented in Table 9. Results indicate that lack of experience and vision in the system's performance and operational requirements were among the most important factors which hampered the implementation of the system. This leads to the conclusions that the existence of successful pilot projects is essential for wide acceptance of the new sanitation systems. When beneficiaries were asked if they could do the project again and if they would do it the same way, they mostly answered yes (37 beneficiaries) and the rest complained about the smell and the plant's close distance to the houses.

Table 9. The social and managerial considerations that hampered incorporation of non-conventional sanitation system , expressed as % of the respondents out of the total beneficiaries

Aspects	Caused hesitation (%)
Difficult technology as compared with the previously applied system	42.6
Worries about the performance of the newly introduced sanitation system	48.9
Maintenance responsibilities unclear	38.3
Maintenance burden on householders	36.2

Conclusions and Recommendations

- The source separated house onsite wastewater collection, treatment and reuse systems are socially accepted in Palestine.
- The biggest incentive for applying this system is the reuse of treated grey water for irrigation.
- The application of the onsite system is tied to the availability of external funds
- Development of proper technologies to handle both grey and black water is very essential for the sustainable application of the system.
- The main worries people might have over the construction of those house onsite systems are health risks, flood concerns, and odour emission.

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