CHAPTER 6

# Comparative socioeconomic study of greywater and cesspit systems in Ramallah, Palestine

*Maher Abu-Madi, Rashed Al-Sa'ed, Nidal Mahmoud and Jamal Burnat*

*Palestinian rural and peri-urban communities represent more than 60 per cent of the total population but lack appropriate management of their wastewater. While most rural households are internally equipped with proper sanitation facilities, there is a problem with the way wastewater is discharged. Traditional cesspits are used for the collection of excreta, which often percolates into the surrounding soil and jeopardizes groundwater aquifers. Several non-governmental organizations (NGOs) promote on-site sanitation for rural communities with emphasis on separation of blackwater and greywater (GW) and utilizing treated GW in garden irrigation. However, the implementation of GW systems is often limited by the availability of external funding, and most Palestinian communities have not reached a stage where they are able to implement GW systems with their own funding.*

*This chapter studies the social and economic feasibility of existing GW systems and the public perceptions towards them in Western Ramallah villages. The researchers surveyed 30 households that use GW systems and 100 households that use traditional cesspits.*

## Introduction

The Occupied Palestinian Territories are facing a rapid population growth against a context of limited water-resources and poor wastewater management. The Palestinian rural and peri-urban communities represent more than 60 per cent of the total population. Most Palestinian households are internally equipped with proper sanitation facilities (plumbed toilets, sinks, drains, etc.), but lack means for proper collection and discharge. Only around 25 per cent of Palestinian households (35 per cent of the total population) are served by central sewerage systems, and a further 17 per cent of the collected municipal wastewater (from 6 per cent of the population) is partially treated (Abu-Madi et al., 2000; Mahmoud et al., 2003). The high percentage of unsewered areas and lack of treatment plants cause an over-reliance on traditional on-site systems for wastewater disposal, mainly cesspits and septic tanks.[1] Traditionally, each household has a cesspit for the collection of excreta, which often percolates into the surrounding soil. This is a disposal system fraught with disadvantages, since it jeopardizes groundwater and the environment (Plancenter, 1997). In addition, when the surrounding soil becomes saturated, cesspits require frequent emptying using expensive private tankers. Cesspit emptying is costly and disruptive and often causes additional environmental pollution. When cesspits become full, an unpleasant odour spreads around the area. The odour problems are exacerbated when the cesspits are emptied and often cause complaints from neighbours. Also, tanker operators who empty the cesspits often do not follow rules and regulations and discharge the emptied septage within the surroundings of the communities, especially in agricultural areas and open fields.

Substantial efforts have been made by Palestinian governmental and non-governmental institutions to improve sanitation services through centralized (off-site) and on-site wastewater treatment facilities. Nevertheless, the following major challenges are reflective of the current sanitation situation:

- The low-population densities and spatial expansion in rural and peri-urban communities, and the long distances from potential centralized wastewater disposal systems often mean that economies of scale do not exist. Therefore, centralized systems for wastewater collection and disposal require disproportionately large investments which are unaffordable to the majority of the rural and peri-urban poor (UN, 2001; Parkinson and Tayler, 2003).
- Limited funding is a major obstacle for the development and maintenance of water and wastewater services. Current wastewater treatment facilities are heavily overloaded, have inadequate maintenance and are of low cost recovery (World Bank, 2004; Al-Sa'ed, 2006).
- Some side effects of the Israeli occupation hinder the construction of wastewater treatment plants by Palestinians. These include imposing stringent effluent quality-standards and requiring the connection of Israeli settlements to Palestinian treatment plants. The Palestinian institutions, therefore, try to adopt on-site solutions that are environmentally-sound and opt for the treatment and use of household wastewater. Because of this, there is increasing interest in the separation of blackwater (toilet wastewater) and GW and the use of reclaimed GW in garden irrigation.

Greywater projects implemented in similar arid and semi-arid countries revealed that the use of treated GW in agricultural irrigation is a technically feasible and economically affordable alternative in several case studies. Jamrah and colleagues (2004) investigated the Omanis' perceptions towards the use of treated GW and found that about 82 per cent of respondents were in favour of GW treatment and use in agricultural irrigation. Nevertheless, Prathapar and colleagues (2005) identified several constraints for the application of GW systems in Oman, related to concerns over effluent quality and institutional, legal, financial, and social constraints. Greywater treatment and use within household irrigation projects implemented in Jordan showed reasonable ratios of benefits to costs ranging from 2.8 to 9.4 (Faruqui and Al-Jayyousi, 2002).

In general, water and wastewater services in the Palestinian urban and rural communities are characterized by poor cost recovery, where sustainability can only be maintained through external funding. The majority of implemented greywater systems (GWS) in the West Bank have been technically and financially supported by NGOs (e.g. PHG, PARC and PWEG) and aid agencies (e.g. IDRC, ACDI-VOCA, DFID and SC). Nevertheless, the rural and peri-urban communities have still not reached a stage where they can replicate such systems with their own funding. Many GW treatment-and-use projects failed, where planning, design, and implementation were based mainly on technical aspects, without adequate examination of the economic or socio-cultural issues. Therefore, a socio-cultural, ecological and cost–benefit analysis should be considered to ensure that on-site GW treatment-and-use schemes are designed to be sustainable, irrespective of the project size.

The development and performance of different treatment technologies and effluent-use schemes have been addressed by most past research efforts, whereas the socioeconomic aspects of GW use have been insufficiently tackled (Al-Sa'ed, 2000; Ogoshi et al., 2001; Dallas et al., 2004; Friedler and Hadari, 2005; Friedler et al., 2005). The lack of comparative studies on GW and traditional systems for domestic wastewater management and safe effluent disposal prompted this research study.

## Objectives

The main aim of this study was to compare the socioeconomics of GWS and common cesspits in five Western Ramallah rural and peri-urban communities: Bil'in, Deir Ibzi', Kafr Ni'ma, Kharbatha Bani Harith, and Ras Karkar. The specific objectives were to assess and compare the direct costs and benefits of existing GWS and traditional cesspits and to better understand the public perceptions towards GWS and use of treated GW in irrigated agriculture.

### *Methodology*

Field visits and a questionnaire survey were conducted in 2006 in Western Ramallah towns and villages. The total sample size was 130 households of which 30 had already constructed GWS while the other 100 relied on cesspits for disposal of their wastewater. The type of GWS observed in this study is the 'septic tank–up-flow gravel filter' (Burnat and Mahmoud, 2004). The owners of the GWS in each of the five villages had been pre-identified and selected for the survey. The households with cesspits had been randomly selected and equally distributed between the five villages with 20 cesspits in each. The questionnaires included sections about the interviewee, household, water, sanitation, land use and perceptions. The SPSS statistical program and excel spreadsheets were used for data manipulation and analysis. The original cost data was collected in the local currency (Israeli new sheqel) and converted to US dollars at a 2006 rate of US$1 = ILS4.3.

The cost calculations comprised investment/capital costs (CAPEX) and recurring/operational costs (OPEX). In addition to a separate cesspit for the blackwater, CAPEX covered the costs associated with excavation, construction, piping, pumps and labour. OPEX covered costs associated with electricity, labour, and emptying/de-sludging, sampling, checking and cleaning. Obviously, these costs varied according to the number of people served by each system. The financial valuation of GWS and cesspit systems was based upon the direct benefits and costs to households – mainly the water and sanitation expenditures. Lack of data prevented the researchers from assessing the indirect benefits and costs of both systems in relation to health, environmental and agronomic impacts. The benefit–cost ratio of GWS was calculated based upon the net present value of the total costs and benefits (Abu-Madi, 2006).

The contingent valuation method was used to elicit households' willingness to have a GWS as well as their willingness to use the produced effluent for garden irrigation, and to identify the reasons behind public decisions towards GWS and their effluent use (Abu-Madi et al., 2003; Hussain et al., 2001; Po et al., 2005).

## Results and discussion

### *Construction cost (CAPEX) comparison of GWS and cesspits*

Table 6.1 shows the capital cost (CAPEX) data. The average CAPEX of the surveyed GWS and cesspits was US$1,212/household and US$1,405/household, respectively. The per capita CAPEX was within the range US$49–388/person (with an average of US$250/person) and US$74–581/person (with an average of US$180/person), for GWS and cesspits respectively. The costs varied between households even where the same types of GWS were used. These variations are attributed to: 1) variations in family size; 2) differences in the types of cesspits/tanks (three different types were noted); 3) variation in the excavation costs from one site to another due to different soil types; 4) modifications made by some households to their existing cesspits; 5) the use of family members and friends for construction labour; 6) the use of locally available materials; 7) the approximations made by some interviewees, some of whom were not directly involved in the construction. It is worth mentioning that households who had already invested in constructing cesspits would have to bear additional financial burden if they decided to shift to GWS.

**Table 6.1** CAPEX comparison of GWS and cesspits

| *CAPEX* | *N** | *Minimum* | *Maximum* | *Mean* | *Std. deviation* |
|---|---|---|---|---|---|
| **GWS** | | | | | |
| US$ | 30 | 488.4 | 2,325.6 | 1,212.4 | 527.1 |
| US$/person | 30 | 48.8 | 387.6 | 179.9 | 82.6 |
| **Cesspits** | | | | | |
| US$ | 100 | 465.1 | 3,604.7 | 1,405.1 | 611.4 |
| US$/person | 100 | 74.0 | 581.4 | 249.5 | 102.3 |

* N = number of households

### *Operation and maintenance costs (OPEX) comparison of GWS and cesspits*

Table 6.2 shows the operational expenditure (OPEX). These results show that operating and maintaining the GWS was cheaper than maintaining the cesspits. The OPEX of the surveyed GWS varied between US$23.3 and US$139.5/year (an average of US$65.7). The OPEX of the 37 cesspits that were emptied frequently was within the range of US$23.3–976.7/year (an average of US$151.6/year). The reason for this high variation is attributed to differences in the frequency of cesspit emptying, which ranged from 1 to 24 times per year (with a mean value of 6 times per year). This range depended on the cesspit type and volume as well as the permeability of the surrounding soil. The other 63 cesspits were not emptied, thus no operational costs were incurred. However, our cost comparison did not consider this as an option since it is not environmentally acceptable.

### *Benefits of GWS*

Table 6.3 illustrates the household expenditure on water during the study. Although no 'before-system' data is available, it can be provisionally inferred that one likely direct benefit of using GWS was the saving in the water bill, i.e., saving in potable water consumption as a result of substituting potable water

**Table 6.2** OPEX comparison of GWS and cesspits per household unit

| *OPEX* | *N** | *Minimum* | *Maximum* | *Mean* | *Std. deviation* |
|---|---|---|---|---|---|
| **GWS** | | | | | |
| US$/year | 30 | 23.3 | 139.5 | 65.7 | 26.2 |
| US$/person/year | 30 | 2.9 | 29.1 | 9.9 | 5.0 |
| **Cesspits** | | | | | |
| US$/year | 37** | 23.3 | 976.7 | 151.6 | 206.4 |
| US$/person/year | 37** | 2.6 | 203.5 | 25.2 | 38.8 |

* N = number of households

** Number of cesspits that are emptied at least once a year

**Table 6.3** Impact of GWS and cesspits on households' expenditure on water and wastewater

| | *N** | *Minimum* | *Maximum* | *Mean* | *Std. deviation* |
|---|---|---|---|---|---|
| **GWS** | | | | | |
| Water expenditure (US$/month) | 30 | 11.63 | 58.14 | 28.64 | 12.73 |
| Water expenditure (US$/person/month) | 30 | 1.94 | 11.63 | 4.22 | 2.17 |
| Water expenditure (% of income) | 30 | 1.25 | 18.00 | 6.48 | 3.90 |
| Wastewater expenditure (% of income) | 30 | 0.14 | 1.33 | 0.54 | 0.32 |
| **Cesspits** | | | | | |
| Water expenditure (US$/month) | 100 | 11.63 | 93.02 | 38.86 | 23.19 |
| Water expenditure (US$/person/month) | 100 | 1.45 | 23.26 | 7.24 | 5.39 |
| Water expenditure (% of income) | 100 | 1.14 | 35.00 | 8.47 | 6.94 |
| Wastewater expenditure (% of income) | 37** | 0.33 | 8.75 | 2.29 | 2.28 |

* N = number of households
** Number of the cesspits that are emptied at least once a year

with GW for irrigation purposes. The results of the study showed that the households' average expenditure on water supply was about US$28.6/month (US$4.2/person/month) and US$38.9/month (US$7.2/person/month) in the cases of GWS and cesspits, respectively. The average share of the water supply expenditure as a percentage of the households' income was lower for GWS users (6.5 per cent and 8.5 per cent for GWS and cesspit cases, respectively). The results also showed that the average share of sanitation expenditure as a percentage of the households' income was lower for GWS users (about 0.5 per cent and 2.3 per cent for GWS and cesspit users, respectively). These figures could be considered high when compared with the international affordability level (4 per cent of the annual income) for water supply, and wastewater services (DANCEE, 2002; World Bank, 2004). However, the figure for GWS (about 7 per cent) is lower than that for cesspits (about 11 per cent).

### *Benefit–cost ratio of GWS*

The direct benefit–cost ratio of GWS was calculated based on the net present value (NPV) of total costs and benefits according to the equations listed below, taken from Abu-Madi, (2006). The following assumptions were made:

- discount rate of 7 per cent;
- life time of the GWS is 30 years;
- constant annual OPEX and constant annual water saving;
- 70 per cent of the households' total water supply that enters the GWS and used in garden irrigation;
- annual benefits (B) = annual value of water saving + annual avoided cost of cesspit emptying;
- value of each cubic meter of reused water is US$1;
- avoided cost of cesspit emptying is US$150/year/household.

$$NPV = C/(1+i)^n \quad (6.1)$$
$$NPV = C_1/(1+i) + C_2/(1+i)^2 + C_3/(1+i)^3 + \ldots + C_n/(1+i)^n \quad (6.2)$$

In case of equal annual operation and maintenance costs (i.e., $C_1 = C_2 = C_3 = \ldots = C_n = C$), a simple equation for NPV is derived:

$$NPV = C.\sum_{t=0}^{n} [1/(1+i)^t]$$

or

$$NPV_{OPEX} = OPEX \cdot \{1-(1+i)^{-n}\}/i \quad (6.4)$$
$$NPV_{TOTEX} = CAPEX + NPV_{OPEX} \quad (6.5)$$
$$NPV_{Benefits} = B \cdot \{1-(1+i)^{-n}\}/i \quad (6.6)$$
$$B/C\ ratio = NPV_{Benefits} / NPV_{TOTEX} \quad (6.7)$$

The net present value benefit–cost ratio analysis for the studied GWS is shown in Table 6.4. This analysis shows that the direct benefit–cost ratio ranges between 1.2 and 4.2 (mean 2.2). These results support the findings published earlier by Faruqui and Al-Jayyousi (2002) on benefit–cost ratios of Jordanian GW use in agricultural irrigation ranging from 2.8 to 9.4. The results show that the direct benefits of using GWS were high even before considering the indirect benefits associated with preventing groundwater pollution, safeguarding public health, and the nutrient-rich irrigation water.

### *Public perceptions towards GWS and use of reclaimed greywater*

Despite their high cost cesspits are often constructed by rural households with the household's own funds. On the other hand, the available GWS were mainly constructed with external funding, except for a very few cases. One of the study objectives was, therefore, to better understand this phenomenon, by examining public perceptions of the establishment of GWS with and without external funding. The results showed that about 72 per cent of the surveyed households were willing to implement GWS with external funding while 17 per cent would be willing to fund a GWS themselves. These results were in harmony with the findings of other research studies in the same study area. A study by Al-Sa'ed (in press) conducted on the socioeconomic aspects of decentralized sanitation in

**Table 6.4** Benefit–cost ratio of GWS

| | *Capita per house* | *CAPEX (US$)* | *Annual OPEX (US$/yr)* | *NPV of total OPEX (US$)* | *NPV TOTEX (US$)* | *Annual benefits (US$ yr)* | *NPV of total benefits (US$)* | *Benefit–cost ratio* |
|---|---|---|---|---|---|---|---|---|
| Mean | 7.1 | 1,212.4 | 65.7 | 815.7 | 2,028.1 | 331.4 | 4,112.4 | 2.2 |
| Minimum | 4.0 | 488.4 | 23.3 | 288.6 | 1,088.8 | 252.2 | 3,129.6 | 1.2 |
| Maximum | 11.0 | 2,325.6 | 139.5 | 1,731.5 | 3,335.6 | 431.1 | 5,348.9 | 4.2 |
| Std. deviation* | 1.9 | 527.1 | 26.2 | 324.7 | 622.1 | 48.1 | 596.6 | 0.8 |

* Number of GWS = 30

small Palestinian communities revealed that about 60 per cent of people were unwilling to consider small on-site sanitation systems. The major reason behind these findings was that most (80 per cent) of the respondents did not show a willingness to pay or contribute to the construction costs. Another study by Al-Sa'ed and Mubarak (2006) showed that more than 50 per cent of the respondents in Ramallah and Al-Bireh district were against having new on-site treatment systems and favoured centralized wastewater collection and treatment options, while only 18 per cent showed a willingness to contribute partially to the construction costs. Published data on public attitudes towards GW use in Oman supports these results (Jamrah et al., 2004).

From the survey of 83 households in Western Ramallah villages, it appears that the major reasons behind the resistance to self-fund the implementation of GWS were:

- unwillingness to restructure their internal piping systems in order to separate blackwater from GW (53 per cent);
- unwillingness to use the reclaimed GW for garden irrigation (33 per cent);
- belief in the availability of external funding for GWS (21 per cent);
- inability to afford the construction costs (17 per cent).

For those households who were unwilling to implement GWS even with external funding, (28 households), the reasons stated were:

- satisfaction with their existing cesspits that required no emptying (90 per cent);
- unwillingness to use reclaimed GW for garden irrigation (86 per cent);
- unwillingness to restructure their internal piping systems in order to separate blackwater from GW (63 per cent).

It is worth noting that health risks were not a feature of the replies, and that the literature reports that there are no recorded cases of anyone falling ill as a result of household recycling of GW (Marshall, 1996; Baker and Jean, 2000), although more work needs to be done on health risks.

## Conclusion

This work, though based on a small sample size, indicates that GW systems are superior to traditional cesspits in terms of: 1) construction costs; 2) operation and maintenance costs; 3) contribution to households' water consumption and expenditure reduction. In addition, the ratio of direct benefits to costs of GWS is high even without considering the indirect benefits. Nevertheless, the public perceptions were positive only towards externally-funded GWS and negative towards self-funded ones. The negative perceptions were attributed to: 1) refusal to restructure their internal piping systems to separate blackwater from GW; 2) refusal to use the reclaimed GW in garden irrigation; 3) availability of external funding; 4) unaffordable construction costs.

Under the prevailing conditions of the Israeli occupation and restrictions on the implementation of centralized wastewater treatment plants, GW treatment and use could be a potential partial solution for water shortage and wastewater-associated problems in Palestinian rural and peri-urban areas. The Palestinian Water Authority should consider developing, in cooperation with relevant institutions, strategies and standards that encourage GW treatment and use while limiting the application of cesspits.

Greywater development projects in the study area are characterized by an over-reliance on donor funding, despite the widespread willingness to self-fund traditional cesspits and septic tanks. This suggests that there is an awareness gap about the virtues of GWS and the drawbacks of cesspits. More efforts are, therefore, needed by the local and international concerned institutions to change these perceptions through participatory awareness campaigns that would make use of the existing GWS as demonstration sites. Donors also should consider providing technical and financial support only to poor families and providing only technical assistance to those who are willing to fund GWS themselves.

The implementation of GWS is more likely to be successful in new premises where separation of blackwater from GW is technically feasible. The use of GWS would be further encouraged by integrating GWS requirements in the national building codes and by aiming at effective promotion of legal GW use on a large scale. However, before GWS can become a common feature in residential buildings, more field testing is essential to ensure safe treatment and use practices.

More research is needed on the economics of the existing GW treatment-and-use systems in Palestine and other countries of the region.

## Notes

1 Traditional cesspits were excavations in the ground, preferably (from the households' perspective) in permeable soils to reduce emptying costs. This system is still common in rural areas that are not controlled by local authorities. In peri-urban and urban communities, another system – the septic tank – is applied. This consists of an excavation in the ground with concrete walls on all sides, except for the base which is left permeable. The wastewater (combined) discharged into these two systems might therefore reach the groundwater. The environmentally-sound cesspit/septic tank approach which is now required by the Palestinian Authority must be confined and impermeable to avoid infiltration of pollutants to the surrounding soil and the aquifer. This type of system implies frequent emptying from residents at costs higher than they can afford. Typical volumes of the three types of cesspits/tanks vary between 20 to 60 $m^3$.

## References

Abu-Madi, M. (2006) 'Political economy for environmental planners' [lecture notes WEEN630], MSc Programs, Faculty of Graduate Studies, Birzeit University, Palestine.

Abu-Madi, M., Al-Sa'ed, R., Braadbart, O. and Alaerts, G. (2000) 'Selection criteria for appropriate sanitation in the Palestinian rural and semi-urban communities', *The International Symposium on Water Sector Capacity Building and Research in Palestine*, Birzeit University, Birzeit, West Bank.

Abu-Madi, M., Braadbart, O., Al-Sa'ed, R. and Alaerts, G. (2003) 'Willingness of farmers to pay for reclaimed wastewater in Jordan and Tunisia', *Water Science and Technology: Water Supply* 3: 115–22.

Al-Sa'ed, R. (2000) 'Wastewater management for small communities in Palestine', *The Technical Expert Consultation on Appropriate and Innovative Wastewater Management for Small Communities in EMR Countries*, Centre for Environmental Health Activities (CEHA), World Health Organization (WHO), Amman, Jordan.

Al-Sa'ed, R. (2006) 'Technical and socio-cultural assessment of urban and rural wastewater treatment facilities in Palestine', MSc Report, Institute of Environmental and Water Studies, Birzeit University, Palestine.

Al-Sa'ed, R. and Mubarak, S. (2006) 'Sustainability assessment of onsite sanitation facilities in Ramallah-Albireh district with emphasis on technical, socio-cultural and financial aspects', *International Journal of Management of Environmental Quality* 17: 140–56.

Barker, A. and Jean, E. (2000) 'Recycling gray water for home gardens' [online], University of Massachusetts Cooperative Extension Service, Amherst, MA, available from: http://umassgreeninfo.org/fact_sheets/plant_culture/gray_water_for_gardens.html [accessed 18 January 2009].

Burnat, J. and Mahmoud, N. (2004) 'Evaluation of on-site grey wastewater treatment plants performance in Bilien and Biet-Diko villages, Palestine', *Bridging the Gap Conference*, Dead Sea, Jordan.

Dallas, S., Scheffe, B. and Ho, G. (2004) 'Reedbeds for greywater treatment – case study in Santa Elena-Monteverde, Costa Rica, Central America', *Ecological Engineering* 23: 55–61.

Danish Cooperation for Environment in Eastern Europe (DANCEE) (2002) *Water Prices in CEE and CIS Countries: A Toolkit for Assessing Willingness to Pay, Affordability and Political Acceptability* (vol. I), DANCEE, Ministry of the Environment, Copenhagen.

Faruqui, N. and Al-Jayyousi, O. (2002) 'Greywater reuse in urban agriculture for poverty alleviation', *Water International* 27: 387–94.

Friedler, E., Galil, N. and Kovalio, R. (2005) 'On-site greywater treatment and reuse in multi-storey buildings', *Water Science and Technology* 51: 187–94.

Friedler, E. and Hadari, M. (2005) 'Economic feasibility of on-site greywater reuse in multi-storey buildings', *Desalination* 190: 221–34.

Hussain, I., Raschid, L., Hanjra, M., Marikar, F. and Hoek, W. (2001) 'A Framework for analyzing socioeconomic, health and environmental impacts of wastewater use in agriculture in developing countries' [online], available from http://www.lk.iwmi.org/pubs/working/WOR26.pdf [accessed 15 October 2006].

Jamrah, A., Al-Futaisi, A., Prathapar, S., Ahmad, M. and Al Harasi, A. (2004) 'Evaluating greywater reuse potential for sustainable water resources management in the Sultanate of Oman', *The International Conference on Water Demand Management*, Dead Sea, Jordan.

Mahmoud, N., Amarneh, M., Al-Sa'ed, R., Zeeman, G., Gijzen, H. and Lettinga, G. (2003) 'Sewage characterisation as a tool for the application of anaerobic treatment in Palestine', *Environmental Pollution* 126: 115–22.

Marshall, G. (1996) 'Greywater re-use: hardware, health, environment and the law', *The Sixth International Permaculture Conference and Convergence*, Perth and Bridgetown, Western Australia.

Ogoshi, M., Suzuki, Y. and Asano, T. (2001) 'Water reuse in Japan', *Water Science and Technology* 43: 17–23.

Parkinson, J. and Tayler, K. (2003) 'Decentralized wastewater management in peri-urban areas in low-income countries', *Environment and Urbanization* 15: 75–90.

Plancenter (1997) 'Conceptual master plan for sewerage management at Ramallah District', Plancenter and Center for Engineering and Planning, Ramallah, Palestine.

Po, M., Nancarrow, B., Leviston, Z., Porter, N., Syme, G. and Kaercher, J. (2005) 'Predicting community behaviour in relation to wastewater reuse: what drives decisions to accept or reject?', Water for a Healthy Country National Research Flagship, CSIRO Land and Water, Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO), Perth.

Prathapar, S., Jamrah, A., Al-Futaisi, A., Ahmad, M., Adawi, S., Al-Sidairi, S. and Al Harasi, A. (2005) 'Overcoming constraints in treated greywater reuse in Oman', *Desalination* 186: 177–86.

United Nations (UN) (2001) 'Chapter VI: Population, environment and development in urban settings', in *Population, Environment and Development: The Concise Report* (ST/ESA/SER.A/202), Population Division, Department of Economic and Social Affairs, UN, New York.

World Bank (2004) *West Bank and Gaza: Wastewater Treatment and Reuse Policy Note*, Water, Environment, Social and Rural Development Department, Middle East and North Africa Region.

## About the authors

Dr Abu-Madi works with the Environmental and Water Studies Institute where he is involved in academic research and training activities, as well as community services. He holds a BSc in Chemical Engineering and Technology from the Institute of Technology, Banaras Hindu University in India; a diploma in Water Supply and Environmental Sanitation from Birzeit University in collaboration with IHE-Delft in the Netherlands; an MSc in Sanitary Engineering from IHE-Delft; and a PhD in Water and Environmental Engineering from the UNESCO-IHE Institute for Water Education and the Technical University of Delft. He has worked with many water and environmental organizations. Dr Abu-Madi is the research coordinator of PoWER (Global Partnership for Water

Education and Research), which has partnership with 18 leading institutions from all over the world.
Email: abumadi@birzeit.edu

Dr. Rashed Al-Sa'ed is an associate professor and a staff member at the Institute of Environmental and Water Studies, Birzeit University whose main research fields are wastewater treatment and appropriate sanitation.

Dr. Nidal Mahmoud is an associate professor and a staff member at the Institute of Environmental and Water Studies, Birzeit University, whose main research field is anaerobic digestion with emphasis on decentralized sanitation concepts.

Jamal Burnat is a water and environmental sanitation specialist in a food security programme at ACDI-VOCA.