The use of greywater for irrigation of home gardens in the Middle East: Technical, social and policy issues

STEPHEN MCILWAINE AND MARK REDWOOD

The use of untreated household greywater for home garden irrigation is an increasingly common phenomenon in the water-stressed Middle East and North Africa (MENA) region, particularly among the poor. Most decentralized systems to date have proven to be relatively costly with doubts over their long-term financial viability. This paper describes some decentralized approaches to treating greywater and reducing health risk. It examines financial and social obstacles to wider greywater system uptake, and policy and regulatory incentives that are needed to allow water-stressed communities to use their greywater legally and with controlled risks. Comments are also included on the implications of the 2006 WHO guidelines for the safe use of wastewater, excreta and greywater. Policy makers also need to commit to either encouraging or discouraging greywater use as part of water resource optimization and demand management measures.

Keywords: greywater reuse, irrigation, Jordan, domestic water quality, scaling up, health impact

> Freshwater scarcity is an increasingly important issue in the Middle East and North Africa region

FRESHWATER SCARCITY IS AN INCREASINGLY important issue in the Middle East and North Africa (MENA) region. Home to 5 per cent of the world's population, the region only contains 1 per cent of accessible water resources. In 2005, annual per capita renewable water availability was only 255, 157, 442 and 106 m^3 in Israel and the Palestinian Territories, Jordan, Algeria and Libya, respectively, against a global average of 8,549 m^3 (World Resources Institute, 2008). Gulf countries such as Saudi Arabia, UAE and Kuwait have even lower figures of 96, 49 and 8 m^3, respectively, but their wealth allows them the more expensive option of desalination (ibid). When population growth is taken into account, per capita water availability will probably halve by 2050. In the MENA region, agriculture accounts for most water use (85 per cent), although an increasing proportion of freshwater is being used

Stephen McIlwaine is a chartered engineer and the Director of Center for the Study of the Built Environment. His experience and interests are primarily in the water and environment sectors, and he has carried out studies and projects in a number of countries in the Middle East. Email: mcilwaine@csbe.org. Mark Redwood is the Program Leader for the Urban Poverty and Environment (UPE) initiative at IDRC. He is a specialist on environmental issues with a specific focus on urban water management, urban agriculture and local government. Email: mredwood@idrc.ca
Most of the research presented here was organized for and presented at an international conference on greywater use in Aqaba, Jordan, in 2007, and published in book form in McIlwaine and Redwood 2010.

© Practical Action Publishing, 2010, www.practicalactionpublishing.org
doi: 10.3362/1756-3488.2010.011, ISSN: 0262-8104 (print) 1756-3488 (online)

for urban domestic supply (UN-Habitat, 2008). Access to improved sanitation in the region is fairly high, with 85 per cent benefiting. However, this leaves a total of 46 million people in the region without access to adequate sanitation (adapted data from World Bank, 2004). Most are the poor located in rural areas, but also in unserviced slum areas on the periphery of cities, and are exposed to considerable health risks from improperly disposed waste. The MENA region is also faced with geopolitical problems that significantly affect natural resource equity. For instance, water stress in the Palestinian Territories is compounded by problems associated with geopolitics (Homer-Dixon, 1994; Allen, 2001; Selby, 2004).

Untreated greywater use as a means of supplementing household water budgets in low-income areas

> Countries in the MENA region have been at the forefront of developing non-conventional sources

Given the general level of water scarcity, countries in the MENA region have been at the forefront of developing non-conventional sources. For example, the formal treatment and centralized management of wastewater for irrigation has become an important component of water policy in Jordan, Israel and Saudi Arabia. Desalinization, an expensive alternative, is widely used in Israel and the Gulf states. At the household level, greywater is often used. Greywater refers to any component of household wastewater from the kitchen, bathroom and/or laundry, but excludes toilet water which is known as 'black water'. Since greywater excludes sewage waste from toilets, it does not usually contain the same elevated level of pathogens as regular wastewater (WHO, 2006a). Given the assumed low level of risk and in the absence of any cross-contamination, greywater can be diverted and used to irrigate home gardens or to supplement other uses. Studies such as CSBE (2003) and Burnat and Eshtayah (2010), Suleiman et al. (2010) and Bino et al. (2010) have shown that, in particular, water-stressed households and communities are using their household greywater, often regardless of the legality or health risks. However, such informal greywater use often does not adequately manage the risks to health and environment, leaving water-stressed, low-income populations facing the possibility of associated health problems.

> Informal greywater use often poses risks to health and the environment

Benefits and risks of greywater use

Estimates of the amount of greywater used in households vary from 55 per cent to as much 80 per cent of volume (EAWAG, 2006). Although significant at the household level, given the size of the non-domestic water usage, greywater forms a very small portion of national water budgets. Nevertheless, for small-scale agriculture, the benefits to the householder from using greywater include the availability of additional water, and savings from reduced frequency of septic tank clearance where these exist. In the MENA region, many rural areas are not served by wastewater networks, and household septic tanks or cesspits are used to collect wastewater. An augmentation of the household water budget by up to 55 per cent would be significant in areas where the water supply to the household is intermittent (perhaps 12 hours per week or less in areas of rural Jordan and the West Bank). Greywater tends to be nutrient-rich and is a source of phosphorus (from laundry water) and nitrogen (from kitchen waste). If used for irrigation, these nutrients could help plant growth but when disposed of improperly or in large quantities these nutrients can cause eutrophication.

The nutrients in greywater can help plant growth

The use of greywater, however, can entail risks to health since it can have a high bacteriological content. The new World Health Organization (WHO) guidelines on the use of wastewater note that with greywater 'microbial contamination … must be taken into account when calculating risks and selecting treatment methods' (WHO, 2006b, vol. 4). The WHO goes on to point out that 'bacterial indicators tend to overestimate the faecal load in greywater' due to the fact that regrowth of bacteria can occur. This 'overestimation' of faecal load can have important consequences in the development of risk-averse policy. In fact, this aversion has paralysed and prohibited many practical ideas to manage greywater safely. The WHO recommended approach, described in more detail below, has addressed this problematic feature of risk assessments and the resulting policy confusion about how to handle greywater.

Greywater can also present a risk to the environment

Greywater can also present a risk to the environment. Laundry detergents are a source of boron and surfactants. Boron can be toxic to plants in large quantities while surfactants can alter soil properties if highly concentrated. Some research has shown that greywater is high in concentration of these components (Gross et al., 2005). Surfactant content in greywater suggests that application of greywater – even if treated – can damage soil in the long term (Gross et al., 2008). The promotion of environmentally friendly detergents and/or the mixing of freshwater with greywater used in agriculture are some responses to this conundrum.

Most research suggests that household detergents and chemicals render greywater 'generally unfit' for use except when controlled, given the suggested long-term impact on soil (Carden et al., 2005; Wiel-Shafran et al., 2006). However, in developing country contexts and where household greywater is used to supplement the immediacy of a low-income household, this is not a particularly useful conclusion as, in and of itself, it is unlikely to influence behaviour. There is also a question of willingness to reuse wastewater. Some research shows that wastewater reuse is an accepted practice and receives official and

80 per cent of Palestinian farmers reported that they were willing to use wastewater

religious sanction (Faruqui and Bino, 2001). For instance, 80 per cent of Palestinian farmers in a survey conducted in 2001 stated that they were willing to use wastewater and, indeed, many were (Faruqui and Bino, 2001). Moreover, other authors have pointed to the very limited data on the long-term impact of greywater on soil and crops, which makes continued research necessary before drawing any concrete conclusions (Redwood, 2008).

Technical solutions developed in the MENA region

Various types of greywater treatment unit have been trialled in the MENA region. A number of donor-funded programmes in Jordan, Palestine and Lebanon were recently reviewed in McIlwaine and Redwood (2010). Three specific case studies from that book are summarized in Table 1.

Each of these schemes was based on a roughly similar concept of multi-chamber, multi-stage physical and biological treatment to reduce the suspended solids and organic material content, and consequently the BOD and bacterial load. Figure 1 is a simplified generic summary of the basic approach, synthesized from Bino et al. (2010) and Burnat and Eshtayah (2010). More complete technical details of the treatment units are provided in the references, together with an evaluation of each unit's performance in treating greywater. With the assistance of donor support, such greywater systems have been installed in a number of areas, and are providing additional water for use in irrigation of home gardens. The systems undoubtedly reduce

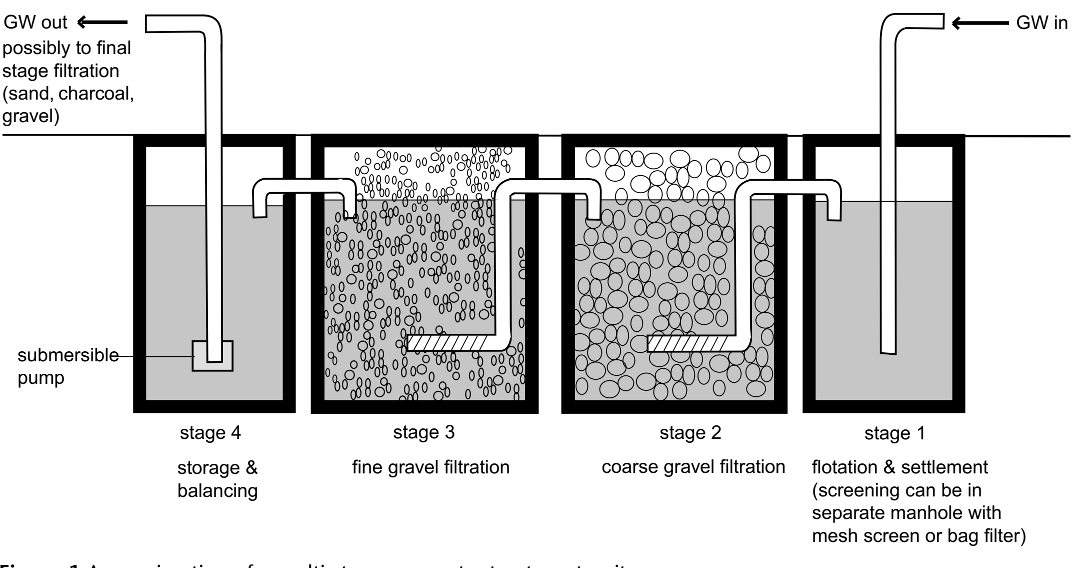

Figure 1 Approximation of a multi-stage greywater treatment unit
Source: Bino et al. (2010) and Burnat and Eshtayah (2010)

Table 1. Type, usage and funding mechanism for three greywater projects in the MENA region

	Qebia Project, West Bank, Palestinian Territory, 2005–2006	*Karak Project, Jordan, 2004–2007*	*North-eastern Badia, Jordan, 2005*
Context	Rural area of low-income families and high unemployment (average family income < US$300/month), 90% of villagers found already using greywater without treatment, but with reported odour problems and suspected health issues	Rural area with low income levels (average family income < $300/month), greywater already being used routinely without treatment	Rural area with low income levels (average family income < $170/month), intermittent supply, greywater already being used routinely without treatment, but high levels of contaminants and coliforms render the greywater suitable only for restricted irrigation
GW unit type	Modified septic tank, up-flow gravel filter followed by an aerobic filter system	Four barrel type (4B) Confined trench type (CT)	Septic tank/sand filter system (STSF) Up-flow anaerobic sludge blanket (UASB) with zeolite filter
Study	Distribution and installation of 48 household units in Qebia district, followed by household survey and water quality sampling	Participatory distribution and installation of 110 household units, followed by water quality sampling, financial analysis and training	Participatory study, design, distribution and installation of 6 household units, followed by water quality sampling and financial analysis
Results	Greywater units reduced BOD, COD and coliform levels to allow irrigation of fruit trees and vegetables to be eaten cooked, measured against the 1989 WHO Guidelines	Provided greywater suitable for crops not eaten raw based on the 1989 WHO Guidelines, some increased soil salinity	BOD and TSS reduced by over 80% in both systems, coliforms reduced by 4 logs to below 1000 MPN/100 ml (in STSF system). Treated greywater suitable for crops not eaten raw when compared with the 1989 WHO Guidelines
Installation costs	NA	$300 (CT type) $260 (4B type)	$850 (USAB) $1,150 (SFST)
Operational costs ($/year)	20	40	NA
Benefits (average)	500 l/household/day treated greywater supplied, reduced cesspit pumping costs ($22/month), irrigation of fruit trees and vegetables	237 l/household/day of treated greywater supplied, sufficient for around 25 olive trees plus supplementary irrigation of other crops, reduced cesspit pumping costs ($22/month), irrigation of fruit trees and vegetables	150–200 l/household/day treated greywater supplied, sufficient or suitable only for restricted irrigation, i.e. of olive trees. Also reduced cesspit pumping costs, better quality water
Funding	Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance (ACDI-VOCA)	International Development Research Centre (IDRC)	International Development Research Centre (IDRC)
Implementation	Qebia Women's Cooperative (QWC)	Inter-Islamic Network on Water Resources Development and Management (INWRDAM)	Environmental Research Centre, Royal Scientific Society, Jordan
Discussed in	Burnat and Eshtayah, 2010	Bino et al., 2010	Suleiman et al., 2010

Notes: BOD, biochemical oxygen demand; COD, chemical oxygen demand; TSS, total suspended solids the contaminant loading in the water, and provide water of increased quality. These donor-funded projects include a degree of participation with the local communities, and training and awareness-raising regarding irrigation with greywater as, once the units are installed, ongoing operation and maintenance becomes the responsibility of the householder.

Cost-benefit imbalances of household greywater treatment systems

The above systems focus on the quality of the treated water as the main way to reduce health risks, exemplifying the engineering-dominated approach to greywater treatment. Such biological treatment systems produce relatively high quality water, but can be complicated and costly in comparison with the cost of water. These systems entail costs such as maintenance, replacement of filter media, and sometimes ongoing energy costs for pumping. Moreover, they are highly dependent on the attitudes of the user. While the high-quality water reduces the health risk to the user, it is arguable whether the vegetables and trees themselves need such high-quality water.

It is arguable whether vegetables and trees need such high quality water

A frequent assumption that the economic benefits arising from greywater projects are positive has been observed by the authors in many of the projects observed. This assumption was tested by the Karak greywater use project (Table 1), which found a cost–benefit ratio of 1 to 1.83 over five years assuming a discount rate of 3 per cent (Bino et al., 2010). While illustrating net positive benefits, it is our view that this is not an adequate short-term incentive that would alone entail widespread behaviour change. Memon and others (2005) point out that the slow uptake of greywater treatment systems is directly related to the poor cost–benefit ratio.

The economic feasibility of these schemes should be examined

There is therefore a strong need to further investigate the economic feasibility of such schemes. However, a full analysis would require detail on all types of associated costs and benefits. Some of these costs would include the costs of separation of greywater and black wastewater, construction costs of treatment units, operational and maintenance costs of these units, and the costs of agricultural inputs and infrastructure – drip irrigation systems, greenhouses, etc. The benefits would include the value of crops produced and any savings made from emptying cesspits and septic tanks. The costs and benefits should then be compared with the realistic alternatives to this type of greywater use. If such data were available, there would be more pressure on projects to deliver solutions for the lowest possible cost.

The use of treated greywater in home gardens will be economically viable under three conditions: 1) benefits exceed costs where 'time' is taken into consideration as a key variable; 2) the positive difference between benefits and costs is significant as a percentage of household income; 3) this difference is significantly higher compared with the difference between benefits and costs of the use of other water sources (e.g. water purchased from tankers). In future work, it will be important to investigate the economic viability of restricted irrigation (and corresponding treatment systems) versus unrestricted irrigation (and corresponding treatment systems), and the minimum land size needed at the household level to make the use of treated greywater for agriculture economically viable.

Without a compelling economic argument, widespread adoption of greywater treatment is unlikely

Without a compelling economic argument, it is unlikely that there will be widespread adoption of greywater treatment. This does not mean that greywater is not viable, only that more sophisticated economic models are required to understand the externalities associated with greywater disposal in order to factor in the full costs associated with waste versus reuse. Using a whole life cost model is the best way to help decision makers effectively implement and market greywater treatment and use (Memon et al., 2005; Redwood, 2008). The need for a comprehensive cost–benefit (C/B) analysis is acute as, to date, mostly descriptive economic data has been presented in the literature.

Other barriers to social acceptance of greywater use

Other social issues are also critical to an understanding of whether household greywater use is to be included in an integrated water management policy. Haddad El-Hajj (2010) discusses the importance of the role of women in household management and argues that, by controlling greywater production and use in the household, women in conservative rural communities can manage some aspects of household economic production. There is widespread cultural reluctance to use greywater-irrigated crops, some from understandable wariness of the health risk, and some from a culturally conservative resistance to change. However, whereas some have suggested caution when applying a policy of wastewater use – even greywater – in Islamic countries, Al-Jayyousi (2010) points out that the use of greywater is not contradictory to the fundamental tenets of Islam. In fact, he suggests that the Islamic principle of *ijtihad* encourages innovation in finding acceptable solutions to new environmental problems.

Greywater is not contradictory to the fundamental tenets of Islam

Abu-Madi et al. (2010), Haddad El-Hajj (2010) and Bino et al. (2010) all note the common and significant problem of unpleasant odour that can emanate from poorly maintained systems. To an engineer, this problem seems facile since there are easy ways to manage odour, even in a low-income setting. However, this has proven to be a significant barrier to a more widespread adoption of greywater management solutions.

There has been an overemphasis on technical solutions

Many failures related to greywater treatment and use systems can be directly linked to an overemphasis on technical solutions that misunderstand local cultural and social realities. This is emphatically illustrated by the fact that, while greywater management systems seem to have more economic benefits in comparison to cesspits, they remain less popular with the public. Laban (2010) argues that our understanding of the social and economic issues associated with greywater use is limited, despite the considerable case examples that have been gathered. The promise of technology in the field of wastewater treatment and management has frequently failed to live up to expectations. Abu Madi also suggests that mobilizing education and training is fundamental to any further work on the subject in MENA (Abu-Madi et al., 2010). Education can reduce people's instinctive hesitation towards eating greywater-irrigated crops, and provide guidance on which crops can be eaten, and what type of preparation (e.g. cooking) is needed for each type.

Education can reduce people's instinctive hesitation towards eating greywater-irrigated crops

The management of health risks arising from greywater use

The 1989 WHO *Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture* have been the main benchmark guiding approaches to risk assessment and regulation related to wastewater irrigation. The guidelines offered a programming framework for management, as well as a straightforward set of numerical guidelines related to faecal coliform (FC) counts and helminth eggs (Mara and Cairncross, 1989). One limitation of the 1989 Guidelines was the translation of the numerical guidelines into water quality standards in many countries, in the absence of a comprehensive approach to risk management. This led to a reassessment of how to approach guidance on wastewater uses, culminating in the publication of new WHO guidelines (WHO, 2006b). These new guidelines differ from the 1989 ones in that they provide:

- evidence-based health risk assessment;
- guidance for managing risk, including options other than wastewater treatment;
- strategies for guideline implementation (including progressive implementation where necessary).

The 2006 WHO guidelines do not exaggerate concern about greywater. Their response is a pragmatic one, that policy and planning for greywater use must be done with consideration of the local health context in which greywater is being used. So, in a country where the major disease burden comes from failed sanitation or easy exposure to sewage, greywater use may be a moot point given the relatively low comparative risk since it ends up being mixed with far more potent black wastewater. The guidelines no longer look at water quality standards but, instead, look at health-based targets. For example, they permit questions such as what level of pathogens is it permissible to ingest in light of the possible risk of infection *given the health context where the wastewater is being applied* (Mara and Kramer, 2008). The incidence of disease caused by wastewater is not only related to exposure, but also to the degree of exposure, the health, and the age of those affected. As a result, controls related to the end-use of the recycled wastewater are most effective. The 2006 guidelines included specific information regarding greywater; a tacit acknowledgement that the risks associated with greywater are not as severe as those related to combined wastewater. In addition, the new guidelines use the 'Stockholm Framework' (Figure 2) which suggests that countries develop a risk management approach that is adapted to their own cultural, social, economic and environmental contexts, an important advance in approaching health risk management.

Controls related to the end-use of the recycled wastewater are most effective

The guidelines emphasize the need to develop a risk management approach that is adapted to the cultural, social, economic and environmental context (see Figure 2). This common-sense conclusion

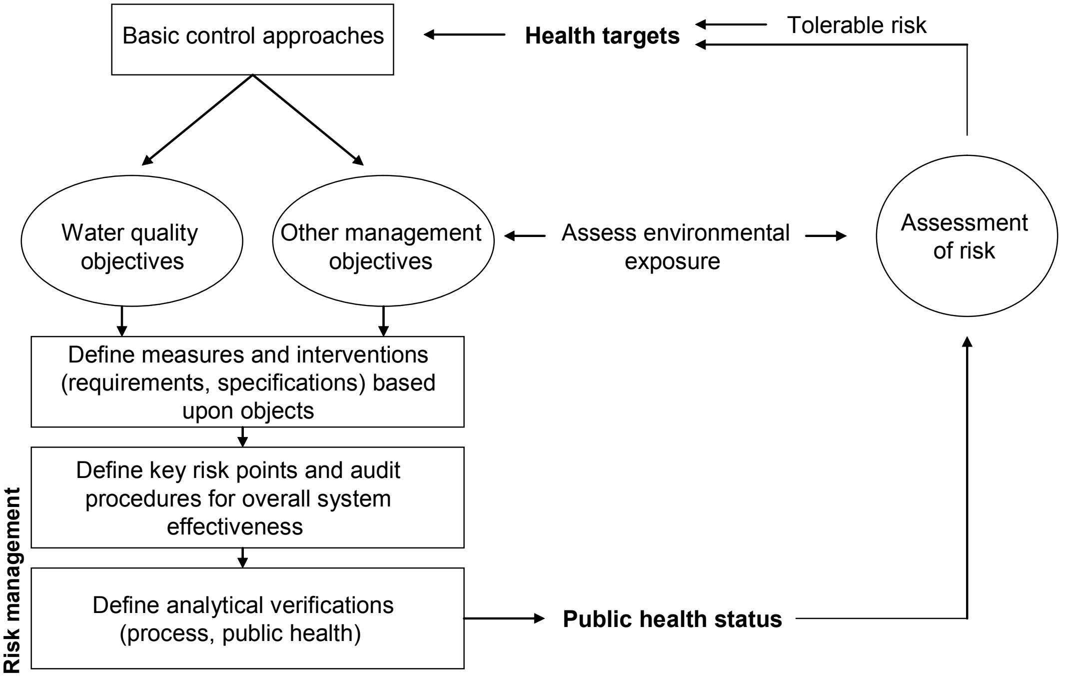

Figure 2 The Stockholm Framework for the assessment of health risk
Source: WHO 2006b

reflects a big change from the 1989 guidelines, which inadvertently appeared to suggest a 'one-size-fits-all' approach. Subsequent policy concentrated on the numerical water quality guidelines as opposed to a comprehensive management approach. Despite being a significant improvement in many respects, the new guidelines have not proven to be an easy sell as, in the drive to make the guidelines more context-specific, they have had to sacrifice simplicity. On the other hand, the guidelines are designed in a rolling fashion to be developed in accordance with the latest available data. Recent research has begun to examine the application of this approach in several developing country contexts (WHO, IDRC and FAO, 2008).

Contact avoidance and cessation of irrigation two days prior to harvesting can reduce risk

An important component of the 2006 guidelines is the notion of a multi-barrier approach to the mitigation of health risks. This approach suggests a series of barriers along the chain of use (both treatment and non-treatment) that can be used to reduce health risks. When applied to greywater, simple techniques such as contact avoidance and cessation of irrigation two days prior to harvesting can be effective at eliminating any potential risk (that might be caused by cross-contamination, for instance). The key point is that mitigation measures should be adapted in coherence with the potential risk. To use highly sophisticated measures to reduce health risks associated with greywater adds unnecessary cost.

There are other ways to control contact with greywater and/or treat effluent (Otterpohl, 2002; WHO, 2006b). EAWAG (2006) suggests that primary treatment is adequate, since irrigated soil acts as a good secondary treatment and can contribute to pathogen die-off. Some simple methods that will reduce risk at the household/farm level include systems such as sand filters, drip irrigation, soil infiltration and constructed wetlands (WHO, 2006b). The inclusion of kitchen water as greywater is debated since organic matter and soaps can lead to high BOD and COD, making treatment more complicated. Ashour and Jamrah (2008) illustrate that kitchen *Escherichia coli* survived in soil irrigated with greywater for longer than soil irrigated with greywater excluding kitchen waste. It is thus tempting to conclude that kitchen waste should simply not be used unless it is possible to significantly reduce or eliminate the entrance of organic matter.

MENA government policies on regulating greywater use are not adequately developed

The need for regulatory policy to incentivize practical greywater use while managing risks

Despite the donor-supported research and piloting efforts on the technical aspects of greywater use, especially among low-income rural communities, MENA government policies on regulating greywater use are not adequately developed. Countries adopting large, centrally managed wastewater treatment and use schemes may be hesitant to promote household greywater use which would reduce the amount of water reaching the treatment plants (CSBE 2003). Governments may also be wary of allowing too much household control of greywater because of health risks. No state has taken a clear view of the financial and economic benefits of greywater use in comparison with the alternatives. Even where there is an appreciation of greywater's usefulness, no MENA country has developed a *clear* approach (i.e. more than a mention) to greywater use that states the responsibilities of the users and the regulatory requirements. There is a need for policy and regulatory frameworks in the region to be examined in order to harmonize greywater policy with the wider water and water reuse policies and to encourage authorities to send out consistent messages on greywater with clear rules and regulations to ensure that the required protection to health, water resources, and the environment is provided, while allowing communities to make use of this valuable resource.

Greywater policy should seek to manage the various risks associated with greywater use. However, as well as examining and controlling risk, policy should also recognize the potential benefits from allowing greywater use. The risk–benefit relationship will be different in different areas, as will the cost–benefit ratio, and each of these must be interpreted within the particular social and socioeconomic context. Policies should take into account the different contexts and should develop a clear message to households, communities and potential greywater users.

When considering policy responses to the push for more greywater use, policy makers may decide that centralized collection and treatment of wastewater and distribution of the treated product is the best option and that the risks of household-managed greywater use are too high. Also, it may be reasonable for authorities to prohibit greywater use in urban areas – particularly areas of high density where there is insufficient area to use the greywater in irrigation. For instance, Carden et al. (2007) suggest that 50 development units per hectare be the limit for off-site disposal in order to avoid significant pollution problems or the accumulation of greywater in the soil. However, it may be more difficult to argue against allowing it in rural areas, where sewerage network coverage is low, and particularly given the abundant evidence that water-stressed communities are already using greywater. It can also be argued that water is a commodity, paid for by the householder and that the government has little claim on what the householder can do with that water. If consumers choose to water their own garden with water from their own shower, it is difficult to argue that this should be prohibited.

> It may be reasonable to prohibit greywater use in urban areas

> It is difficult to argue against household-managed greywater use in rural areas

In the current context of the water-scarce countries in the Middle East, it is difficult to argue against household-managed greywater use, at least in areas where there is sufficient planted area to make use of it. However, if large-scale wastewater collection networks (managed either by the authorities, or by communities) were to become widespread and provide usable water easily and cheaply to householders, then there would be arguments for prohibiting household greywater use, to allow all the wastewater resource to be captured and treated centrally.

Some important issues specific to the MENA region, which should be addressed in policy, are set out as follows.

Policy must balance the risks from controlled greywater use with the alternatives

Water policy makers in the MENA region have to address competing goals including increasing economic growth, reducing poverty, protecting and improving health, protecting environmental resources, addressing food security, and maintaining internal and external security. All of these have implications for water resource and supply management policy. While greywater use carries risks, there are also risks to communities with inadequate water supplies, including economic deprivation and malnutrition. The Stockholm Framework allows the concept of relative risk, whereby the risks of both using and not using a particular intervention are considered together. The 2006 WHO guidelines allow that the tolerable burden of disease may vary from one country to another. In other words, a practice which carries an unacceptable risk in one country, may actually reduce overall health risks in another country or at least carry a risk which is acceptable when balanced with the benefits that the practice brings. Each country must therefore address its own risk context and in fact, develop regionally and locally appropriate mitigation strategies. In some areas of MENA, this may mean that allowing greywater use is the lesser evil, when compared with the results of water poverty, particularly in low-income areas. The result may be that practices which are unacceptable in other countries are tolerated, even promoted, in some areas in the MENA region.

> The Stockholm Framework allows the concept of relative risk

> Allowing greywater use is the lesser evil, when compared to the results of water poverty

Policy must be integrated

A greywater use policy should be set within an integrated part of a comprehensive water resources management framework which includes policies on water supply, allocation, demand management, agricultural policy and wastewater use. A country which has accepted the principle of wastewater use must consider where household greywater use fits within this and decide how this particular wastewater resource can be used – at the household where it is produced or under the control of the authorities. Alternatively, a country with a highly developed wastewater treatment and use policy and practice may want to restrict greywater use in areas where total wastewater is captured and used centrally.

Policy should be simple so as not to impede greywater use

In 2001, the Arizona Department of Environmental Quality published regulations for residential greywater (Arizona Department of Environmental Quality, 2001). These regulations follow an interesting three-tiered approach whereby: 1) systems using under 1,500 litres per day are covered by a general permit without the need for the householder to apply for anything, provided they meet a list of reasonable conditions; 2) systems producing over 1,500 litres per day require a permit; 3) those over 13,000 litres per day are dealt with on a case-by-case basis. These regulations are risk-based and widely regarded as progressive (Oasis Design, 2005). The tiered approach makes greywater use easy for the ordinary householder and allows for innovation and flexibility of design. They do not prescribe particular design specifics and follow a performance-based approach, while the blanket prohibitions increase the protection of human and plant health.

The tiered approach makes greywater use easy for the ordinary householder

The principle of simplicity and ease of implementation adopted by Arizona is an example to be followed. Its policy is only several pages long and outlines broad recommendations and common-sense rules to follow. If complex application requirements – such as form filling, presentation of drawings, system inspection, or water quality monitoring – are placed on households, there is unlikely to be significant uptake of regulated greywater use. Particularly in countries with weak regulatory regimes and where local authorities have limited capacity, a realistic and workable regime should be adopted, whereby the requirements placed on local authorities should be minimized as far as possible. Following Arizona's example, information and guidance on risk management by householders should be well publicized and the responsibility placed with the householders to manage the system. Perhaps some pre-approved treatment systems, relevant to the MENA countries, could be suggested, removing the burden of seeking out professional advice from householders.

The responsibility should be on the householders to manage the system

Risk management should be behaviour based, rather than technology or water quality based

A realistic policy in a MENA country should follow the new WHO guidelines' move away from an exclusive focus on water quality, and encourage other means of risk mitigation such as drip irrigation, protective gloves for workers, and restrictions on greywater usage and permitted crops, and perhaps even include requirements for food preparation and cooking of produce irrigated by greywater. A policy which simply requires water quality to be of a particular standard will: 1) be too expensive to implement; 2) be too expensive to regulate; 3) not fully address all the important risks; and 4) likely be too restrictive. The evolution of experience in social marketing offers a useful method of behaviour influence that can result in behaviour change.

Policy development should include stakeholders

There is a need to consult with communities in developing policies

Care should be taken to consult with and involve communities in developing policies which are appropriate, understandable and workable at the community level. The context in low-income areas is likely to be different from that in which the (generally more well-to-do) policy makers have experience.

Policy must be clear regarding implementation

Codes should set out clearly what potential users should do to satisfy the regulatory authorities. In the case of some (e.g. California, see Buildings Standards Commission, 2007), an application is to be made, with supporting information, whereas in the case of Arizona, the user is automatically in compliance, provided certain basic conditions are met.

Policy should not place undue financial burdens on users

Neither expensive materials nor assistance should be necessary for using greywater

No one should be penalized for responsibly using greywater. Expensive professional assistance should not be required, nor should the use of expensive materials be mandatory. Application fees (if any) should take into account that the purpose of greywater policy is to provide additional water resources to water-stressed (and possibly low-income) populations, not as a revenue raiser for local government. The types of greywater treatment unit that are being proposed for the region are costly enough in themselves, without adding any extra expense.

Decentralized use should be considered for poor communities

A centralized approach to wastewater use conflicts with the idea of decentralized use of greywater (or blackwater) at household or even community level. Arguments against a decentralized approach include: 1) the need to control the treatment process to guarantee the treated effluent water quality and minimize health risks; 2) the need to control irrigation practices, also to minimize risk to both workers and end users of the irrigated product; 3) the need to maintain a certain flow in the wastewater network to transport the waste; and 4) the

Policy makers must not allow a centralizing tendency to overrule

need to maintain a particular concentration/dilution of effluent so as not to disrupt the wastewater treatment process. However, centrally treated wastewater is rarely returned and made available to the householders that produced it. In the context of alleviating community water scarcity, especially in low-income and rural areas, policy makers must recognize the importance of the locally managed greywater resource, and not allow a centralizing tendency to overrule.

Policy should differentiate with regard to scale

Jurisdictions that have drawn up legislation for greywater use have found it beneficial to differentiate between large users and small users, since the implications of greywater use and the cost and complexity of solutions are also different in each case. The case studies discussed above only address community use for agriculture, although other applications of greywater may also be addressed in a policy. Customers of a large hotel or high-rise building that uses the greywater from residents and staff will expect a higher degree of protection than a single household reusing its own greywater under its own control, where household pathogens are shared together anyway. One of the main purposes in large-usage regulation would be to provide for protection to health and environment and ensure the responsible design, installation and operation of the greywater system. Policy should clearly address these contexts separately.

Next steps

To conclude, it seems that, despite some professionally designed and implemented projects which have developed and installed greywater treatment systems in a number of areas of the MENA region, obstacles against the increased take up of greywater treatment systems remain. If safe greywater use is to be adopted more widely, it cannot be done so through case-by-case donor-funded projects. The sustainability of these projects is not proven despite the promising research results in some cases. It is essential that any further investments in this sector address a fundamental tenet of design: close collaboration with users in the design and development process.

Economic data are required for increased adoption of greywater at household and community levels

A second fundamental requirement is to better compile and assess the economic data required for increased adoption of greywater at household and community levels. Public investment in the development of a better understanding of the economic costs and benefits of greywater – specifically in the quantitative assessment of externalities – would likely help shift interest towards more action in support of the idea. Unfortunately, aside from case examples, to date there appears to be little peer-reviewed research that we could find in the

MENA region where a strong economic analysis had been carried out, taking into account externalities and a rigorous assessment of the social benefits. If household uptake of treatment is not self-financing, then a targeted subsidy is an alternative possibility. However, we would argue for a targeted subsidy only in the case where there is a clear societal benefit, something that has yet to be proven.

Third, renewed research is required, but we would argue not on technological options – there are many proven techniques – but rather on markets, attitudes, policy options and household requirements. What is then required are simple options that liberate home owners from overly restrictive policy while encouraging entrepreneurs to offer associated services for profit. These actions would be guided by locally appropriate and straightforward enabling policy and regulations following the revised 2006 WHO Guidelines. Technologists could then help promote this uptake in a feasible manner. It is far from certain, however, that this decentralized approach to operation and implementation of greywater would be welcome in the highly centralized political economy of the MENA region.

References

Abu-Madi, M., Rashed Al-Sa'ed, Mahmoud, N. and Burnat, J. (2010) 'Comparative socioeconomic study of greywater and cesspit systems in Ramallah, Palestine', in S.J. McIlwaine and M. Redwood (eds), *Greywater Use in the Middle East: Technical, Social, Economic and Policy Issues*, Practical Action Publishing, Rugby and CSBE, London.

Al-Jayyousi, O.R. (2010) 'Greywater use: Islamic perspectives', in S.J. McIlwaine and M. Redwood (eds), *Greywater Use in the Middle East: Technical, Social, Economic and Policy Issues*, Practical Action Publishing, Rugby and CSBE, London.

Allen, J.A. (2001) *The Middle East Water Question: Hydropolitics and the Global Economy*, IB Taurus, London.

Arizona Department of Environmental Quality (2001) 'Direct Use of Reclaimed Water (01/16/01), 7 AAR 758', http://www.azdeq.gov/function/laws/final.html#2001 [accessed 30 October 2009].

Ashour, J. and Jamrah, A. (2008) 'Survival of bacteria in soil subsequent to greywater application', *The International Journal of Environmental Studies* 65(1): 51–6.

Bino, M., Al Beiruti, S. and Ayesh, M. (2010) 'Greywater use in rural home gardens in Karak, Jordan', in S.J. McIlwaine and M. Redwood (eds), *Greywater Use in the Middle East: Technical, Social, Economic and Policy Issues*, Practical Action Publishing, Rugby and CSBE, London.

Buildings Standards Commission (2007) *California Code of Regulations, Title 24, Part 5 – California Plumbing Code, Graywater Systems for Single Family Dwellings*, State of California, Sacramento.

Burnat, J. and Eshtayah, I. (2010) 'On-site greywater treatment in Qebia Village, Palestine', in S.J. McIlwaine and M. Redwood (eds), *Greywater Use in the Middle East: Technical, Social, Economic and Policy Issues*, Practical Action Publishing, Rugby and CSBE, London.

Carden, K., Armitage, N., Winter, K., Sichone, O., Rivett, U. and Kahonde, J. (2005) 'The use and disposal of greywater in the non-sewered areas of South Africa (1): Quantifying the greywater generated and assessing its quality', *Water South Africa* 33(4): 425–32.

Carden, K., Armitage, N., Winter, K., Sichone, O., Rivett, U. and Kahonde, J. (2007) 'The use and disposal of greywater in the non-sewered areas of South Africa (2): Greywater management options', *Water South Africa* 33(4): 425–32.

Center for the Study of the Built Environment (CSBE) (2003) *Greywater reuse in other countries and its applicability to Jordan* [online], available from: http://www.csbe.org/graywater/report/report_final.pdf [accessed 6 January 2009].

EAWAG (Swiss Federal Institute of Aquatic Science and Technology) (2006) *Greywater Management in Low and Middle-income Countries*, EAWAG, Dubendorf, Switzerland.

Faruqui, N. and Bino, M. (2001) *Water Management in Islam*, United Nations Press, Tokyo.

Gross, A., Azulai, N., Oron, G., Ronen, Z., Arnold, M. and Nejidat, A. (2005) 'Environmental impact and health risks associated with greywater irrigation: a case study', *Water Science and Technology* 52(8): 161–9.

Gross, A., Wiel-Shafran, A., Bondarenko, N. and Ronen, Z. (2008) 'Reliability of small scale greywater treatment systems and the impact of its effluent on soil properties', *The International Journal of Environmental Studies* 65(1): 41–50.

Haddad El-Hajj, N. (2010) 'Greywater use as a gender empowerment project in Tannoura, Lebanon', in S.J. McIlwaine and M. Redwood (eds), *Greywater Use in the Middle East: Technical, Social, Economic and Policy Issues*, Practical Action Publishing, Rugby and CSBE, London.

Homer-Dixon, T. (1994) 'Environmental scarcities and violent conflict: evidence from cases', *International Security* 19(1): 5–40.

Laban, P. (2010) Can local people accept greywater technology?', in S.J. McIlwaine and M. Redwood (eds), *Greywater Use in the Middle East: Technical, Social, Economic and Policy Issues*, Practical Action Publishing, Rugby and CSBE, London.

Mara, D. and Cairncross, S. (1989) *Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture*, World Health Organization, Geneva.

Mara, D. and Kramer, A. (2008) 'The 2006 WHO guidelines for wastewater and greywater use in agriculture: a practical interpretation', in I. Al Baz, R. Otterpohl and C. Wendland (eds), *Efficient Management of Wastewater: Its Treatment and Reuse in Water-Scarce Countries*, pp. 1–17, Springer, Berlin.

McIlwaine, S.J. and Redwood, M. (eds) (2010) *Greywater Use in the Middle East: Technical, Social, Economic and Policy Issues*, Practical Action Publishing, Rugby and CSBE, Jordan.

Memon, F.A., Butler, D., Han W., Liu, S., Makropoulos, C., Avery L.M. and Pidou, M. (2005) 'Economic assessment tool for greywater recycling systems', *Engineering Sustainability* 158(3): 155–61.

Oasis Design (2005) *Greywater Policy Packet* [online], available from: http://oasisdesign.net/downloads/GWPolicyPacket.pdf [accessed 6 January 2009].

Otterpohl, R. (2002) 'Options for alternative types of sewerage and treatment systems directed to the overall performance', *Water Science and Technology* 45(3): 149–58.

Redwood, M. (2008) 'The application of pilot research on greywater in the Middle East North Africa region (MENA)', *Journal of Environmental Studies* 65: 109–17.

Selby, J. (2004) *Water, Power and Politics in the Middle East: The Other Israel-Palestine Conflict*, IB Taurus, London.

Suleiman, W., Al-Hayek, B., Assayed, M., Dalahmeh, S. and Al-Hmoud, N. (2010) 'Greywater management in the northeastern Badia of Jordan', in S.J. McIlwaine and M. Redwood (eds), *Greywater Use in the Middle East: Technical, Social, Economic and Policy Issues*, Practical Action Publishing, Rugby and CSBE, London.

UN-Habitat (2008) *The State of African Cities Report*, UN-Habitat, Nairobi.

Wiel-Shafran, A., Ronen, Z., Weisbrod, N., Adar, E. and Gross, A. (2006) 'Potential changes in soil properties following irrigation with surfactant-rich greywater', *Ecological Engineering* 26(4): 348–54.

World Health Organization (WHO) (1989) *Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture* (Technical Report Series 778), WHO, Geneva.

WHO (2006a) *Overview of Greywater Management Health Considerations* (Report WHO-EM/CEH/125/E), WHO, Geneva.

WHO (2006b) *Guidelines for the Safe Use of Wastewater, Excreta and Greywater* (vols 1–4), WHO, Geneva.

WHO, IDRC and FAO (2008) *Non-Treatment Options for Safe Wastewater Use for Poor Urban Communities* [West Africa and Jordan] [online], available from: http://www.who.int/water_sanitation_health/wastewater/poor_urban_communities.pdf [accessed 27 October 2009].

World Bank (2004) *World Development Report: Making Services Work for Poor People*, World Bank, Washington, DC.

World Resources Institute (2008) EarthTrends: Water Resources and Freshwater Ecosystems [online], available from: http://earthtrends.wri.org/pdf_library/data_tables/wat2_2005.pdf [accessed 6 January 2008].