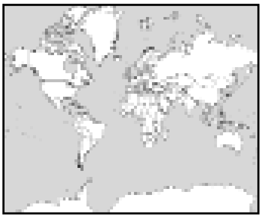

Decentralized wastewater management in peri-urban areas in low-income countries

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SUMMARY: *In peri-urban areas in low-income countries, conventional centralized approaches to wastewater management have generally failed to address the needs of communities for the collection and disposal of domestic wastewater and faecal sludges from on-site sanitation. There are opportunities for implementing wastewater management systems based on a decentralized approach that may offer opportunities for wastewater re-use and resource recovery as well as improvements in local environmental health conditions. Decentralized approaches may also offer increased opportunities for local stakeholder participation in planning and decision-making, and the paper emphasizes the importance of building the capacity of local organizations in all aspects of decentralized wastewater management. Using examples of functioning systems, the paper discusses the operational sustainability of decentralized technologies for wastewater management in peri-urban areas and their associated management requirements. The paper concludes that a concerted capacity-building effort is required to overcome the constraints that hinder the implementation and sustainability of decentralized wastewater systems, and proposes a framework for achieving this goal.*

I. INTRODUCTION

a. Urbanization and the growth of peri-urban settlements

URBANIZATION IS ONE of the most important demographic trends of the twenty-first century, and growth is particularly rapid in lower-income countries.(1) The majority of urban growth is associated with the rapid expansion of smaller urban centres and peri-urban developments.(2) Much of this growth is unplanned and informal, with community members and informal-sector developers taking advantage of the fact that the regulatory capacity of government authorities is weak, particularly in those areas that are outside official municipal boundaries.

Peri-urban areas are characterized by a mixture of land uses associated with a range of urban and rural livelihoods (Photo 1). Settlements are generally inhabited by communities of different economic status relating to land prices, which are affected by location in relation to the city, and which are considerably higher than in rural areas. Many industries locate on the edge of the city because land there is relatively cheap and not

1. United Nations (2001), *Population, Environment and Development: The Concise Report. Chapter VI: Population, Environment and Development in Urban Settings*, ST/ESA/SER.A/202, United Nations Population Division, Department of Economic and Social Affairs, New York.

subject to stringent development controls and, at present, the wastes they produce rarely receive adequate treatment. Due to ongoing development, peri-urban areas are generally in a state of rapid transition that may result in social and environmental tensions.

Photo 1: Peri-urban areas are characterized by a mixture of land uses, as in the outskirts of Faisalabad, Pakistan

The limited infrastructure facilities that are provided are often inadequate, and the result is a poor and often deteriorating environment. Provision of infrastructure and services tends to occur in a piecemeal fashion, either through the efforts of residents themselves or as a result of pressure from civil society on elected representatives and government officials. Electricity and water supply are usually provided first, with sanitation, drainage and solid-waste collection services following later. However, the majority of settlements in peri-urban areas, particularly those inhabited by poorer communities, do not have access to adequate water supply and sanitation facilities. Even where household sanitation and localized drainage facilities do exist, often there is a lack of a comprehensive system for the collection and disposal of wastewater.

b. Wastewater production, disposal and re-use in peri-urban areas

In peri-urban areas, increasing populations, combined with increasing water consumption and a proliferation of waterborne sanitation, create widespread wastewater disposal problems. In many cases, wastewater is discharged locally onto open ground and vacant plots, creating ponds of foul-smelling stagnant water (Photo 2). Children and others may come into contact with polluted water, especially as they often play in open areas where wastewater and refuse collects (Photo 3).

Health risks are increased by the fact that household and surface water

2. United Nations (1999), "World urbanization prospects: the 1999 revision. Chapter VI: population growth in cities", Working Paper No 161, Population Division of the Department of Economic and Social Affairs, United Nations Secretariat, New York.

Photo 2: Poor drainage of wastewater in Andhra Pradesh, India

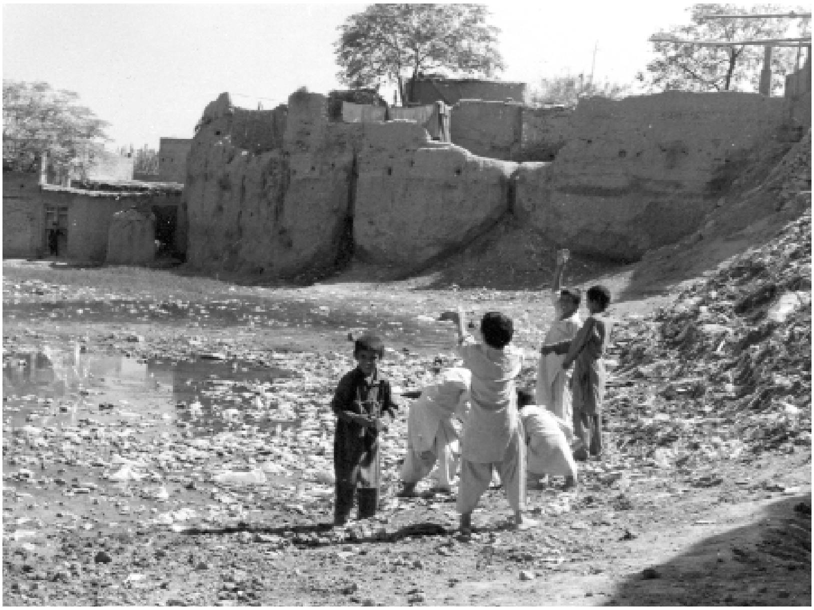

Photo 3: Children play in open spaces of land where wastewater drains

drainage systems are invariably combined, so that floodwater becomes contaminated with excreta. Mosquitoes and other pests breed in blocked drains and ponds, spreading diseases such as filariasis. This is a particular problem where piped water is provided before drainage infrastructure.(3)

The lack of infrastructure and services and effective systems for managing wastewater has led to widespread pollution of surface water and groundwater and a deterioration in environmental health conditions. The range of environmental health problems in peri-urban areas includes

3. Birley, Martin and Karen Lock (1999), *Health Impacts of Peri-urban Natural Resource Development*, Cromwell Press, Trowbridge, UK.

those associated with both urban and rural living and, as a result, the peri-urban poor "…*get the worst of both worlds*."[4] The greatest impacts are upon the health and livelihoods of poor communities, who often inhabit low-lying and marginal land, for instance wetlands and alongside drainage channels, which are polluted with excreta and other wastewater.

At the same time, increasing competition for limited water resources has resulted in a tendency for farming communities in peri-urban areas to use untreated wastewater for irrigation and aquaculture. Farmers often find it cheaper to exploit wastewater than to incur capital and recurring costs in pumping groundwater to irrigate crops. The re-use of wastewater for irrigation is likely to be most prevalent in regions where water from other sources is scarce for part or all of the year. The nutritional value of wastewater in terms of its nitrogen and phosphorus, which can increase the productivity of farming and thus contribute to the livelihoods of peri-urban communities,[5] provides another strong incentive for agricultural re-use. For instance, in Hubli-Dharwad in India, vegetables produced outside the *kharif* season (the normal growing season) can fetch three to five times the price obtained during that season.[6] It is estimated that 10 per cent of the world's population eats food produced using wastewater,[7] which may be used either directly for irrigation or indirectly where irrigation water is drawn from natural water bodies that receive wastewater flows.[8]

Whilst some wastewater re-use takes place in formal schemes, the majority is associated with informal re-use and the vast majority of wastewater is untreated (see Photo 4). There are potentially serious health consequences for both those who work in agriculture and aquaculture and those who consume produce which is irrigated with wastewater.

Photo 4: Informal wastewater re-use using untreated wastewater in peri-urban Faisalabad, Pakistan

4. Birley, Martin and Karen Lock (1998), "Health and peri-urban natural resource production", *Environment and Urbanization* Vol 10, No 1, April, pages 89–106.

5. Edwards, Peter (2000), "Aquaculture, poverty impacts and livelihoods", *Natural Resources Perspectives* No 56, Overseas Development Institute, London, June.

6. Brook, R and J Dávila (editors) (2000), "The peri-urban interface: a tale of two cities", School of Agricultural and Forest Sciences, University of Wales and Development Planning Unit, University College London.

7. Smit, Jac and Joe Nasr (1992), "Urban agriculture for sustainable cities: using wastes and idle land and water bodies as resources", *Environment and Urbanization* Vol 4, No 2, pages 141–152.

8. Westcot, D W (1997), "Quality control of wastewater for irrigated crop production", *Water Reports* No 10, FAO, Rome, 86 pages.

Diseases that can be transmitted via untreated irrigation water include helminth infections such as schistosomiasis, ascaris and hookworm, beef and pork tapeworms (where the irrigated land is used for grazing) and non-latent faecal–oral infections, particularly those that require a low infective dose. As a result, there are concerns about health problems associated with these practices and there is a need to introduce a range of preventive measures to mitigate health risks – including restrictions on the crops grown, a choice of methods for waste application to the crops, and control of human exposure to wastes – combined with wastewater treatment in order to provide comprehensive protection measures.[9]

9. Blumenthal, Ursula, Martin Strauss, Duncan Mara and Sandy Cairncross (1989), "Generalized model of the effect of different control measures in reducing health risks from waste re-use", *Water Science and Technology* Vol 21, pages 567–577.

c. Deficiencies of centralized approaches to service provision in peri-urban areas

The environmental problems associated with urban areas are a consequence of the number of people producing wastes, and their high concentration. On the other hand, the large concentrations of people would appear to offer greater opportunities for centralized approaches to the provision of infrastructure and services, which may actually reduce the per capita cost of service provision.[10] However, the population densities in developments in peri-urban areas, and the latter's distances from existing centralized wastewater disposal systems, often means that economies of scale do not exist, so that centralized systems for wastewater collection and disposal require disproportionately large investments which are unaffordable to the majority of the peri-urban poor.

10. See reference 1.

In the past, the conventional wisdom has been that centralized systems are easier to plan and manage than decentralized systems. There is some truth in this argument when municipal administrative systems are centralized. However, experience shows that centralized systems have been particularly poor at reaching peri-urban areas, particularly those that fall outside municipal boundaries and have not been responsive to local needs and resources. It has also been argued that they express power relationships within which service to the urban poor is always given a low priority.[11]

11. Swyngedouw, Erik A (1995), "The contradictions of urban water provision – a study of Guayaquil, Ecuador", *Third World Planning Review* Vol 17, No 4, pages 387–405.

II. DECENTRALIZED APPROACHES TO WASTEWATER MANAGEMENT

IN RESPONSE TO the deficiencies of centralized approaches to service delivery, in recent years there has been increasing emphasis on the potential benefits of adopting decentralized approaches to sanitation and wastewater management, which are considered to be particularly appropriate for peri-urban areas. According to the Environmental Protection Agency in the United States, decentralized wastewater systems may provide a cost-effective and long-term option for meeting public health and water quality goals, particularly in less densely populated areas.[12]

12. US EPA (1997), "Response to congress on use of decentralized wastewater treatment systems", EPA-832-R-97-001b, US EPA Office of Water, April.

Broadly speaking, the implications of decentralization on wastewater management systems relate to planning and decision-making, design of physical infrastructure, and management arrangements for operations and maintenance. More generally, decentralization is also seen as a way of strengthening the role of local government and democracy in general, and as an effective means of addressing environmental and health concerns.[13] The basic tenet is that local control, as opposed to centralized control, will result in more accountable service providers and better services.

13. Fragano, Frank, Carlos Linares, Harold Lockwood, Daniel Rivera, Andrew Trevett and Guillermo Yepes (2001), *Case Studies on Decentralization of Water Supply and Sanitation Services in Latin America*, edited by Fred Rosensweig, Environmental Health Project, Strategic Paper No 1, January, US Agency for International Development, Washington DC.

It is arguable that decentralized systems are more compatible with decentralized approaches to urban management than centralized systems. They are also compatible with the "unbundled" approach to service provision promoted by the World Bank. The Bank focuses on the financial aspects of unbundling, seeing it as a way of introducing private-sector investment and competition into service delivery and thus improving operational efficiency. However, the concept of unbundling can also cover the utilization of local resources through community-based and non-governmental initiatives.

There has also been an increased emphasis on a more holistic approach to waste disposal that stresses the benefits of reducing the strength or quantity of waste at source and, where possible, recycling or re-using it close to the point where it is produced. One conceptual model which incorporates these different aspects is the household-centred environmental sanitation approach,[14] which starts from the assumption that sanitation problems, including wastewater disposal, should be solved as close to their source as possible, with decisions and the responsibility for implementing them flowing from the household to the community to the city and, finally, to higher levels of government.

Although decentralized systems have yet to be widely accepted and implemented in practice, they do appear to offer a number of potential advantages. These relate to opportunities for greater stakeholder involvement in decision-making and planning, to financial advantages, and to the benefits of segregation of wastewater at source and compatibility with local demands for wastewater re-use.

a. Decentralized decision-making and participatory planning

Decentralized planning and decision-making in wastewater management offers potential benefits relating to increased responsiveness to local demands and needs and, hence, increased willingness of communities to pay for improved services. For example, an integrated environmental plan has been developed by the inhabitants of informal settlements in the peri-urban areas of Lima, Peru, and this has formed the basis for local action and also for negotiating support from external agencies.[15] Where poor people are already involved in local agricultural systems, there is a possibility that improving decentralized management systems will achieve a better distribution of benefits than more centralized management approaches.

Increased stakeholder involvement at the local level is often promoted by the non-governmental organizations (NGOs), which encourage a demand-responsive and participatory approach and often act as intermediaries to improve the flow of communication and broker agreements between communities and local government authorities. In relation to infrastructure provision, NGOs can play a key role in assisting communities to develop their basic services,[16] but it must also be recognized that NGOs, and indeed community involvement as a whole, do not offer a panacea to the deficiencies of the public sector. In particular, NGOs may lack the technical know-how required to plan and design effective decentralized schemes, whilst community organizations will not automatically provide the stability and reliability required to provide long-term management of those schemes.

14. Kalbermatten, John, Richard Middleton and Roland Schertenleib (1999), "The household-centred environmental sanitation model", SANDEC, Swiss Federal Institute for Environmental Science and Technology, Duebendorf, Switzerland.

15. Hordijk, Michaela (1999), "A dream of green and water: community-based formulation of a Local Agenda 21 in peri-urban Lima, *Environment and Urbanization* Vol 11, No 2, October, pages 11–29.

16. Choguill, Charles (1997), "Ten steps to sustainable urban infrastructure", *Urban Age* Vol 5, No 2, pages 22–23.

b. Financial advantages of decentralized management

The capital investment for decentralized wastewater systems is generally less than for centralized systems in peri-urban areas, and they are also likely to be cheaper to construct and operate. By tackling wastewater problems close to source, the large capital investment of trunk sewers and pumping costs associated with centralized systems can be reduced, thus increasing the affordability of wastewater management systems. Decentralized approaches to faecal sludge collection and disposal are particularly appropriate for peri-urban areas, as they reduce haulage distances and thus reduce the cost of transportation.

In some cases, the investment may require little more than improvements to existing informal wastewater collection systems and the introduction of an appropriate form of treatment prior to disposal or re-use. Although economies of scale mean that decentralized treatment facilities will tend to have a higher cost per person served than centralized facilities, the incremental increase in per capita cost is likely to be fairly small where unsophisticated technologies are used.

c. Segregation of wastewater at source

Domestic wastewater consists of "black" water, the mixture of water and faeces flushed from WCs and pour-flush toilets, and "grey" water, the sullage from kitchens and bathrooms. Grey water contains much lower pathogen levels and has a lower oxygen demand than black water and therefore represents a much smaller health and/or environmental threat. Grey water and black water are produced separately, and ensuring that they remain separate can facilitate management of the two wastewater streams. This option may be considered where it is possible to dispose of black water to a leach pit or septic tank followed by a soakaway. Grey water can then be used for irrigation or discharged into a local watercourse with little or no treatment. This option creates the need periodically to remove and treat the sludge that accumulates in the leach pit or septic tank, and therefore tends to place greater demands on individual households than options that remove all wastewater from the house. However, it is arguably easier to ensure that households maintain their own facilities than to ensure effective management at the community level.

One example is provided by an initiative in the village of Yoff, on the outskirts of Dakar in Senegal, where the village association APECSY is working in cooperation with the NGO CRESP–Senegal to create and promote a sustainable strategy for environmental sanitation, focusing on the capacity of the local community to manage the systems. The sanitation system developed as part of the programme involves a pilot *cité écologique* to house about 1,000 people, which includes separate disposal of faecal wastes and sullage water. The sullage water is treated using reedbeds, and excreta is managed using either dry toilets with urine diversion or septic tanks. These facilities have been provided at the household level or, alternatively, as communal facilities to be managed by groups of residents.[17]

The segregation of industrial and commercial effluents from domestic wastewater at source is also an important benefit of decentralized wastewater management, in as much as wastewater from residential areas is less likely to receive highly polluted industrial flows, which is particularly important where wastewater is to be re-used.[18] It will therefore be

17. Weisburd, Claudia (2000), "Community sanitation in Yoff", *Waterlines* Vol 19, Intermediate Technology Publications, London, July.

18. Shuval, H I, A Adin, B Fattal, E Rawitz and P Yekutiel (1986), "Wastewater irrigation in developing countries – health effects and technical solutions. Integrated resource recovery", UNDP Project Management Report, World Bank Technical Paper 51, Washington DC.

necessary to introduce systems for regulating and treating wastewater discharges, and local communities can be an effective means of monitoring the activities of the commercial sector.

d. Compatibility with local demands for wastewater re-use

Decentralized wastewater systems are likely to be compatible with local demands for wastewater re-use in peri-urban areas where water and the nutrient content in the wastewater increase agricultural productivity and contribute to the livelihoods of peri-urban communities. Wastewater may also be re-used for aquaculture, in which aquatic plant biomass is used either directly or as an ingredient in a feed-mix to raise fish or livestock for human consumption. Wastewater re-use can promote incentives for local people to operate and maintain local systems, and thus help to ensure long-term operation and financial sustainability. The re-use of waste can increase local agricultural productivity, resulting in increased revenue for local producers. Whilst this argument is not absolute insofar as financial benefits can be obtained equally well from the re-use of effluent from centralized facilities, it implies that decentralized management systems may achieve a better distribution of benefits and thus have the potential to be more pro-poor than centralized management.

III. OPTIONS FOR DECENTRALIZED WASTEWATER TREATMENT

IN ORDER TO ensure that decentralized wastewater management systems protect against adverse impacts on health and the environment, some form of treatment will be required before effluents are discharged or re-used. The level of treatment is dictated by the disposal or re-use option, for example, pathogen reduction is important when wastewater is re-used but less important when it is discharged into a watercourse.

The relative sophistication of conventional treatment processes presents difficulties for operation and maintenance at the local level,(19) and these technologies are unlikely to be appropriate for local use because they require careful and skilled attendance.(20) However, a range of alternative technologies are available which may be used for decentralized wastewater management systems, and these are briefly discussed below. Although these technologies are less dependent upon power for operation than more advanced technologies, they require increasing amounts of land, especially where wastewater is re-used. A potential constraint on localized management is therefore the limited availability of land for treatment facilities. This is particularly important in the case of simple options such as waste stabilization ponds and constructed wetlands, which require a large land area. Most land in urban and peri-urban areas is privately owned or privately controlled. Land ownership can constrain the implementation of decentralized wastewater management systems due to the ineffective planning and control over informal development.(21)

a. Anaerobic treatment

Anaerobic treatment of wastewater is considered to be an appropriate form of technology for the treatment of black water and faecal sludges

19. Blumenthal, Ursula, Anne Peasey, Guillermo Ruiz-Palacios and Duncan Mara (2000), "Guidelines for wastewater re-use in agriculture and aquaculture: recommended revisions based on new research evidence", WELL Study, Task No 68, Part 1, London School of Hygiene and Tropical Medicine and WEDC, Loughborough University, UK.

20. Sasse, Ludwig (1998), DETWAS: *Decentralized Wastewater Treatment Systems in Developing Countries,* Bremen Overseas Research and Development Association (BORDA), Bremen, Germany.

21. Allison, M, P J C Harris, A H Hofny-Collins and W Stevens (1998), "A review of the use of urban waste in peri-urban interface production systems", Henry Doubleday Research Association, Coventry, UK, published by DFID Natural Resource Systems Programme.

from household latrines, as it requires less land area and produces a well-stabilized sludge in lesser quantities than aerobic treatment. Anaerobic treatment may also be cheaper than most aerobic treatment processes because the process of anaerobic digestion produces energy and is therefore not dependent upon an external power source.(22)

The simplest form of anaerobic treatment is the simple septic tank, which both settles suspended solids and achieves some anaerobic digestion of those settled solids. In hot climates, septic tanks can remove 60 per cent or more of the organic load of "normal strength" sewage, but they achieve little in the way of pathogen reduction. Other anaerobic options include anaerobic waste stabilization ponds, anaerobic filters and upward-flow anaerobic sludge blanket reactors (UASBs).(23) Vieira et al.(24) provide information on a small community UASB treatment works in Sumare City in the state of Sao Paulo, Brazil, and propose that this form of technology has potential for widespread application. However, they also acknowledge the problems relating to financing, insecurity in using new technologies and constraints from the legislation relating to the quality of treated effluent discharges. UASBs also require careful management and therefore may not be applicable where technical skills and organizational systems for effective management are not well developed.

The German NGO BORDA has developed an alternative anaerobic treatment technology called the "baffled reactor", which it claims achieves similar results to the UASB but in a more robust and easily managed way.(25) In essence, a baffled reactor consists of a series of narrow chambers through which wastewater is passed. The wastewater is introduced to the bottom of each chamber and has to pass through the sludge that has accumulated there before passing on up through the chamber. After passing out from the top of the chamber, it is piped to the bottom of the next chamber. The theory is that passing the wastewater through the sludge at the bottom of each chamber achieves a similar effect to passing effluent through a UASB sludge blanket.

Anaerobic treatment systems such UASBs, baffled reactors and upward-flow anaerobic filters can provide an improved performance over simple septic tanks (85–90 per cent removal of the organic load), but this is dependent on adequate attention to operation and maintenance, and the issue for planners is whether this increase in performance over simple septic tanks justifies any additional capital and operational expenditure that they might require.

b. Waste stabilization ponds

Waste stabilization ponds include anaerobic ponds, facultative ponds that combine aerobic and anaerobic processes, and purely aerobic maturation ponds. The obvious advantage of pond systems is their simplicity. A second advantage is that their long retention time means that they are better than most treatment options at reducing pathogen levels. They can produce economic benefits in that maturation ponds provide a good environment for growing fish such as tilapia. The effluent from ponds has fairly high algae concentrations, so it is a good resource for irrigation. One of the disadvantages of waste stabilization ponds is that they require a relatively large area of land, especially when combined with wastewater re-use.

Wastewater stabilization ponds may be integrated with re-use systems

22. van Buuren, Joost (1996), "Anaerobic wastewater treatment in developing countries – a sustainable core technology", published in the proceedings of the Workshop on Sustainable Municipal Wastewater Treatment Systems, ETC/WASTE, Leusden, the Netherlands.

23. Chernicharo, C A L and R M G Machado (1998), "Feasibility of the UASB/AF system for domestic sewage treatment in developing countries", *Water Science and Technology* Vol 38, Nos 8/9, pages 325–332.

24. Vieira, S M M, J L Carvalho, F P O Barijan and C M Rech (1994), "Application of the UASB technology for sewage treatment in a small community at Sumare, Sao Paulo state", *Water Science and Technology* Vol 30, No 12, pages 203–210.

25. See reference 20.

for the production of plants (e.g. duckweed and water hyacinth). These plants grow prolifically in nitrogen-rich environments, and can be harvested and composted and subsequently used to fertilize and condition agricultural soils. The removal of the plant biomass stimulates the continued growth of the plants and also contributes to the removal of nutrients from the wastewater and reduces eutrophication in receiving waters.

These systems may also be combined with pisciculture (fish-farming). This technology has been implemented at the village level on a pilot scale in Bangladesh and consists essentially of duckweed, an aquatic plant grown in effluent holding ponds.(26) This type of integrated wastewater treatment and re-use system has been implemented on a pilot scale in Mirzapur by the NGO PRISM (Photo 5), where the production of fish provides income generation for local people. More recently, the system has been promoted in the city of Khulna, where community-based groups are responsible for operating and maintaining the service but where PRISM and Khulna City Corporation (KCC) are closely involved in the management side.

26. Iqbal, Sascha (1999), "Duckweed aquaculture potentials; possibilities and limitations for combined wastewater treatment and animal feed production in developing countries", SANDEC Report No 6/99, EAWAG, Switzerland.

Photo 5: Integrated wastewater treatment and re-use in aquaculture in Mirzapur, Bangladesh

c. Constructed wetlands

Constructed wetlands (reedbeds) can provide a low-cost and appropriate technology for the treatment of domestic wastewater and faecal sludges,(27) but will normally require pre-treatment and so can only be considered as a secondary treatment option. Like waste stabilization ponds, they are fairly good at removing pathogens, but facilities have to be designed and operated in a way that controls disease vectors, especially mosquitoes, and odours. Because of the problems with mosquitoes, it has been argued that wetlands may not be a suitable form of wastewater treatment for use in areas where malaria occurs.(28)

27. Denny, Patrick (1997), "Implementation of constructed wetlands in developing countries", *Water Science and Technology* Vol 35, No 5, pages 27–34.

28. Grau, Petr (1996), "Low-cost wastewater treatment", *Water Science and Technology* Vol 33, No 8, pages 30–46.

Shrestha et al. describe the application of constructed wetlands for wastewater treatment in the Kathmandu Valley.[29] A two-staged, sub-surface-flow, constructed wetland for hospital wastewater treatment, and constructed wetlands for the treatment of grey water and septage are now becoming a demonstration site of constructed wetland systems in Nepal. Five other constructed wetlands have been designed, and some are under construction for the treatment of leachate and septage in Pokhara municipality, and for wastewater at Kathmandu University, two hospitals and a school. Although there is considerable potential for utilizing constructed wetlands for wastewater as well as for faecal sludge treatment, the experiences from Nepal indicate the importance of the need for adequate attention to maintenance and proper supervision.

29. Shrestha, R R, R Haberl and J Laber (2001), "Constructed wetland technology transfer to Nepal", *Water Science and Technology* Vol 43, No 11, pages 345–360.

IV. CONSTRAINTS ON REPLICATION AND WIDE-SCALE IMPLEMENTATION

a. Lack of management expertise

EVEN WHERE POLICY makers accept the validity of the decentralized approach, a lack of capacity to plan, design, implement and operate decentralized systems is likely to be a severe constraint on efforts to ensure its wide adoption. Even in the United States, the Environmental Protection Agency concluded that lack of management was a major barrier to implementing decentralized systems.[30]

The management arrangements and responsibilities for operation and maintenance must be considered in relation to the capabilities of the individual householders, community groups or government departments. Therefore, where a system requires that ongoing operation and maintenance tasks are devolved to individual householders or community groups, it is essential that responsibilities are clearly explained at the outset. Planning and implementation of wastewater re-use systems at the neighbourhood/user level will only take place successfully when the need for improved systems has been "internalized" by members of households and communities.[31]

The sustainable operation of decentralized wastewater management systems must be compatible with the knowledge and skills available at the local level. Although even the simplest technologies often fail in practice due to a lack of attention to operational and maintenance requirements,[32] decentralized management may provide opportunities for these tasks to be carried out correctly by local stakeholders, who have a greater incentive to ensure that facilities continue to perform as intended.

30. See reference 12.

31. Khouri, N, J M Kalbermatten and C Bartone (1994), *The Re-use of Wastewater in Agriculture: A Guide for Planners*, UNDP–World Bank Water and Sanitation Programme, World Bank, Washington DC.

32. Yhdego, M (1989), "Waste stabilization ponds in Tanzania", *Waterlines* Vol 8, No 1, pages 10–12.

b. Institutional constraints

In the majority of countries, there is a lack of suitable institutional arrangements for managing decentralized systems and a lack of a suitable policy framework that encourages a decentralized approach. There is a danger that decentralization will lead to fragmentation and a failure to address overall problems adequately. Without technical assistance and other capacity-building measures, problems of institutional capacity that existed under a centralized operation are simply passed on to the new structures.[33]

Decentralized management may be a problem in peri-urban areas in which the boundaries between different communities may be very loosely

33. Campbell, T, G Peterson and J Brakarz (1991), *Decentralization to Local Government in Latin American Countries: National Strategies and Local Response in Planning, Spending and Management*, LAC Technical Department No 5, The World Bank, Washington DC.

drawn. Also, without a formal institutional framework within which decentralized systems can be located, efforts to introduce decentralized management are likely to continue to be fragmented and unreliable. Experiences from Malang, in Indonesia, show how efforts have been made to institutionalize an essentially decentralized approach.

A number of local wastewater management schemes were developed in the 1990s to serve individual *kampungs*.(34) Most served between 60 and 150 households and included both sewerage and simple ponds for treatment. Since then, efforts have been made to encourage communities to implement similar schemes. All these schemes operate at the lowest levels in the Indonesian government's formal system for organizing community efforts. Simultaneously, efforts are ongoing to introduce a scheme covering a whole *kelurahan*, the next level up in the hierarchy and the lowest level at which government officials are stationed (Photo 6). It remains to be seen whether this initiative will work, but the possibility of introducing it has been assisted by Indonesia's strong, if top-down, system of community organization.

Photo 6: Wastewater treatment system at the *kelurahan* level in Malang, Indonesia

34. Foley, Sean, Anton Soedjarwo and Richard Pollard (1999), "Community-based sewer systems in Indonesia: a case study in the city of Malang", WSP–EA Learning Note, Jakarta.

35. Edwards, D B, F Rosensweig and S Edward (1993), *Designing and Implementing Decentralization Programmes in the Water and Sanitation Sector*, WASH Technical Report No 89, Environmental Health Project, US Agency for International Development, July.

36. UNESCAP (1997), "Wastewater management policies and practices in Asia and the Pacific", *Water Resources* Series No 79, UNESCAP Publications, Bangkok, Thailand.

Decentralization requires greater coordination between government, the private sector and civil society, and there is a need to look at the most appropriate institutional arrangements for managing decentralized wastewater systems and for monitoring and regulating those organizations that are responsible for their monitoring. One of the consequences of decentralization may be a lack of attention to pollution control,[35] and it is therefore necessary to consider the regulation of wastewater discharges, which may prove difficult where there are many smaller decentralized systems.

In relation to this, although the majority of countries recognize the need to implement improved systems for wastewater management, and have developed a basic wastewater management policy[36] together with supporting legislation governing water-resource protection, these policies are generally not well defined, and may be inappropriate for decentralized wastewater systems and prove to be difficult to implement due to an overall lack of resources and management capabilities.

c. Economic constraints

Decentralized systems may reduce the cost of investment required for wastewater management, but the majority of local government agencies and departments lack the resources to invest in new infrastructure and rely on grants from higher levels of government to finance improvements in service provision. Many poor communities lack the financial resources to invest in improved infrastructure. Lack of access to credit may also be a critical factor, inhibiting communities' ability to invest in improved services.

Those with a lack of secure tenancy also lack the incentive to invest in infrastructure to improve wastewater management practices. The acquisition of land for the more extensive forms of treatment that are effective in removing pathogens may prove difficult for those with limited financial resources. In the absence of adequate cost-recovery mechanisms, investments in wastewater management may become a financial liability and this may constitute a major hindrance to the sustainable operation of decentralized wastewater management systems. Cost recovery in wastewater management is generally very poor and, even where sufficient monetary resources exist, there is often little willingness to pay for improved wastewater disposal.

Wastewater re-use is widely practised in the informal sector but is limited to a few official schemes, and benefits are not widely recognized in the wider macroeconomy. In many parts of Asia, traditional farming practices involving re-use of excreta and wastewater have provided an economic incentive for implementing localized wastewater management systems, especially where other sources of water are scarce. However, economic pressures from the competitive marketing of fertilizer can constrain the re-use of excreta, particularly where cheap alternative nutrient sources in the form of inorganic fertilizer are available, which may negate the incentive for wastewater re-use. Where transportation systems have been improved, locally harvested produce has to compete with imported products.

However, the experiences of the NGO Waste Concern in Bangladesh show that there is widespread demand for organic fertilizer and that there are considerable benefits when partnerships are developed with commercial companies that manufacture and distribute fertilizer products to the agricultural sector. However, demand for wastewater re-use may be seasonal, which may inhibit the sustainability of wastewater re-use and, wherever there is a demand for the re-use of untreated wastes, there is unlikely to be a demand from farmers to treat wastewater.[37]

d. Social constraints

This brings us to perhaps the key constraint, the fact that there is currently no real demand for implementing effective systems for wastewater and faecal sludge management and, partly as a result of this, there is generally little willingness to pay for services, particularly for wastewater treatment.[38] This may relate to a lack of concern or awareness of environmental pollution and of the health implications relating to wastewater disposal and re-use.

Cultural factors may influence the way in which people view the re-use of excreta in food production, and the attitudes of the public and the policy makers towards the perceived risks to public health play a role in the adoption of wastewater management systems in which wastewater is used for irrigation or aquaculture. Although informal systems for wastewater and faecal sludge management and re-use have existed for many years, government public health authorities often oppose excreta re-use because of the health risks involved.[39] Also, traditional excreta re-use practices are generally not recognized or accepted by government authorities and are likely to be seen by officials as being archaic and redundant, especially when alternative technologies, which require less land, exist.[40] At the same time, the lack of government commitment to address wastewater-related problems creates a political and institutional environment that offers little incentive to manage wastewater effectively. This lack of commitment is reinforced by a lack of financial resources to develop and implement effective policies and programmes for managing wastewater.

V. CONCLUSIONS AND RECOMMENDATIONS FOR CAPACITY BUILDING

THERE ARE A range of technologies for the treatment of wastewater that are suited to decentralized management systems and which may be adopted for use in low-income peri-urban communities. However, most of these have not been utilized widely and remain in localized areas and pilot projects. The constraints to sustainability of these systems and the opportunities for replication have been described. In order to overcome these barriers to widespread implementation, a concerted capacity-building strategy is required. As proposed below, this is based upon four targeted levels associated with advocacy, development of appropriate policies, institutional strengthening, and training.

a. Advocacy

Due to the limited demand for improved wastewater management, the main challenge for planners and practitioners is to create informed demand for improved systems, focusing not only on health but also on the improvements in the local environment and in household finances that may be achieved through improved wastewater management. Advocacy at the political level is required and, at the community level, awareness campaigns to promote the benefits of improved wastewater management, involving extensive social communication and mobiliza-

37. Bunting, S W, P Edwards and J F Muir (1999), "Constraints and opportunities in wastewater aquaculture", Working Paper, Institute of Aquaculture, University of Stirling, Stirling/Asian Institute of Technology, Thailand.

38. Linares, C and F Rosensweig (1999) *Decentralization of Water Supply and Sanitation Services in El Salvador,* US AID Environmental Health Programme (EHP) Activity Report No 64, Washington DC.

39. Edwards, P (1985), "Aquaculture: a component of low-cost sanitation technology. Integrated resource recovery", World Bank Technical Paper No 36, Washington DC.

40. See reference 37.

tion, are necessary. This advocacy must be based on applied research on what can and cannot be achieved by decentralized management systems. This suggests a need to document experience and encourage the implementation and monitoring of additional demonstration projects in order to stimulate a wider interest in the benefits of decentralized wastewater management.

b. Policy recommendations

There is a need to incorporate wastewater management systems within an integrated framework of water resource management and other services of water supply and solid waste management. Official design standards may not be framed in a way that supports the development of decentralized systems. There is therefore a need to develop appropriate standards to be utilized for the design and construction of decentralized wastewater systems, and also to promote realistic and acceptable standards for treatment where wastewater is re-used.[41] The policy needs to be based upon practical experiences and realistic objectives, and should be developed in close collaboration with organizations involved with those communities that the decentralized wastewater systems are designed to serve.

41. See reference 19.

c. Institutional strengthening

This involves a change of focus of activities, whereby traditional centralized agencies take on a different role, focusing on the need for capacity strengthening to develop new skills to respond to the needs and demands of communities. This places greater emphasis on the role of centralized agencies as facilitating organizations, providing technical assistance and focusing on improved systems for coordinating the activities of different stakeholder groups involved in decentralized wastewater management. It also requires that these institutions develop capacities for monitoring and regulation, and effective systems for enforcing appropriate policies.

d. Training and dissemination of technical information

The choice of technology is limited by the need to ensure that the operation and maintenance requirements of the chosen technology are compatible with the levels of knowledge and skills available at the local level. There is often a lack of knowledge of decentralized options and a shortage of qualified workforce and skills for operation and maintenance. The management requirements in terms of the local availability of skills and knowledge to operate and maintain technologies and services for wastewater and faecal sludge management are therefore critically important. There is therefore a need to focus on the training of local stakeholders, to enable them to understand how various technologies operate, their operational and maintenance requirements, and the implications in terms of possible effluent re-use. There is also the need to disseminate technical information in appropriate forms and languages, in ways that are understandable and relevant to the needs of those who are responsible for the design and operation of decentralized wastewater and faecal sludge collection and disposal systems.