Chapter 16
Water Supply and Sanitation

Contents

Since good sanitation and hygiene are key to preventing contamination and good sanitation facilities give little benefit if the water remains contaminated, water supply and sanitation projects have come to be viewed as interdependent. Implementing them at the same time leads to the greatest benefit and is now considered ideal. However, this approach is not yet widely practiced.

Brief Description of the Sector

To remain healthy, human beings need an adequate, year-round supply of high-quality water. Many debilitating or even fatal illnesses are spread by contamination of the water supply with human fecal matter containing disease-causing viruses, bacteria, and parasites. Unfortunately, over one-third of the world's population, nearly 2.5 billion people, have inadequate access to sanitation, and over 1 billion people do not have access to enough safe water. These conditions, combined with poor hygiene, are largely responsible for the fact that 50 percent of the world's population suffers from debilitating diarrheal diseases (e.g., typhoid, cholera, dysentery) at any given time. Of those affected, 3 million die each year.

Overall, polluted water affects the health of 1.2 billion people every year and contributes to the death of 15 million children under five every year. Vector-borne diseases, such as malaria, kill another 1.5 to 2.7 million people per year, with inadequate water management a key cause of such diseases (*UNEP Global Environmental Outlook Report 2000*). Sub-Saharan Africa is by no means exempt from the problem: In Africa alone, over 300 million people lack either sanitation or adequate water, and frequently both.[1]

Disease and mortality are not the only consequences of polluted and scarce water. Less attention is paid to the fact that women and children bear much of the cost of dirty water and water shortages. Children are more likely to become ill, and women have to look after them. Women and girls carry out most water collection, and many spend long hours doing so. Time spent collecting water could be spent in more productive activity, such as food production or, especially in the case of children, education. As a result, there is a high opportunity cost to the lack of clean water. (When people are sick, they and their caregivers cannot carry out other tasks, so there are opportunity costs there as well.)

Guidelines Cover:

- Natural water supply projects
- Water distribution systems
- Complex water systems
- Latrines
- Septic tank and leach field systems
- Sewers
- Water stabilization ponds and constructed wetlands
- Water-borne sewage systems

[1] Based on a draft decision tree from Mario Pareja. Draft tree has been recommended for inclusion in Hruska and Gladstone (2000).

The YACUPAJ project: community participation promotes sanitation

The YACUPAJ project in Bolivia (1991–94) integrated many of the features analysts have found in successful sustainable projects:

Respond to demand. To participate in the project, communities had to ask for it. The first stage of the project in every community was to strengthen and expand this demand through a coordinated education and demonstration program.

Community management. Community members took part in managing the entire project. They defined their needs, set the level of participation, chose the project type, and shared costs.

Involve women. Steps were taken to engage women as active participants in every stage of the project.

Install appropriate technology. Facilities were simple, low-cost, and easily maintained by users.

Local construction and maintenance. Family or community personnel constructed household latrines. Local masons were trained in latrine construction and as hygiene promoters.

Promote hygiene. Hygiene was promoted through education and training. Promotion was [?] identified as a key activity for ensuring effective and sustained use of the services.

Monitor sustainability. State and private institutions remained involved after the project ended to monitor sustainability.

The results:

Communities provided over 50% of the funding, even though they were the poorest in the country.

A sustainability study in 1995 showed 82% of latrines still in use.

Trained masons continue to build latrines with direct responsibility to client families and no external support.

Attitudes toward latrine use have improved dramatically.

See Soto (1998).

Significant international focus and investment during the "Water and Sanitation Decade" (1981–1990) brought water to 80 percent of the world's population and sanitation to 50 percent. During the 1990s, however, no additional gains were made, and population growth led to an increase in the absolute numbers of people without safe water or sanitation. Water resources in general are poorly managed, especially in the developing world. For example, many urban areas lose more than 50 percent of distributed water through leaking pipes the water and sanitation technologies used in the developed world, such as extensive sewer systems and large wastewater treatment plants, are frequently too costly or impractical for developing countries, although this has not necessarily discouraged attempts to implement them. Rural populations and the rapidly growing peri-urban and urban poor are disproportionately under-served.

The Hakitagata Bakyara Twimukye Hot Springs near Kisoro, Uganda are believed to have special medicinal properties. Disease sufferers are living in makeshift huts at the source. Water quality downstream may be harmed by the effluent from this site. How might this impact be mitigated?

Since good sanitation and hygiene are key to preventing contamination and good sanitation facilities give little benefit if the water remains contaminated, water supply and sanitation projects have come to be viewed as interdependent. Implementing them at the same time leads to the greatest benefit and is now considered ideal. However, this approach is not yet widely practiced.

Over the past three decades, experience has shown that water and sanitation activities are most effective and sustainable when they adopt a participatory approach that (1) acts in response to genuine demand, (2) builds capacity for operation and maintenance and sharing of costs, (3) involves community members directly in all key decisions, (4) cultivates a sense of communal ownership of the project, and (5) uses appropriate technology that can be maintained at the village level. Also important are educational and participatory efforts to change behavioral practices.

These guidelines are designed for application to a variety of rural and urban water supply and sanitation systems that PVOs and NGOs may help design or manage. Water supply technologies covered by these guidelines include:

- progress made in providing safe water supply and sanitation for all during the 1990s;
- pond and spring improvements, hand-dug wells, small-diameter boreholes, wells with hand pumps, roof rainwater catchments, small dams and seasonal impoundments;
- showers, clothes-washing basins, cattle troughs, spring-fed gravity feed water distribution systems;
- more complex water systems, including well or surface water source pump, storage tank and distribution to standposts, individual yard taps or connections, extensions of existing urban water lines into unserved or under-served peri-urban zones.

Sanitation systems covered by this guideline include:

- individual latrines (ventilated improved pit, or VIP; composting; dehydrating; pour-flush);
- community latrines;
- small-scale septic and leach field systems;
- settled and simplified sewers;
- water stabilization ponds;
- constructed wetlands;
- water-borne sewage with disposal to surface waters.

Large-scale water projects are not considered here.

Potential Environmental Impacts of Development Projects

- Disease and death, loss of drinking water supply, increased costs
- Plants and animals harmed, ecosystems degraded
- Fresh water resources depleted
- Disease transmission from stagnant water

This well near Tamale, Ghana has poor drainage and thus significant potential for adverse health impacts.

Potential Environmental Impacts of Development Programs in the Sector and Their Causes

Debilitating disease and death, loss of drinking water sources, increased costs. Water supply and sanitation projects may cause increased incidence of infectious water-borne diseases such as cholera, non-infectious disease such as arsenic poisoning, and water-enabled diseases such as malaria.

- Especially serious is the contamination of surface and groundwater supplies with infectious organisms from human excreta. Contamination may be caused by poorly designed, operated or maintained sanitation facilities, such as sanitation systems that transfer sewage to receiving waters without treatment, or pit latrines located in areas with high water tables.
- Infectious diseases may also be spread by improper use of wastewater to grow food crops.
- Failure to test new sources of water, especially groundwater, for possible natural or industrial chemical contaminants, such as arsenic or mercury, can have devastating consequences.

Overdrawing wells can alter groundwater flows or cause aquifers in coastal or island areas to experience salt-water intrusion, potentially leading to loss of drinking water sources locally or in downstream or down-gradient locations. Finally, if water is treated for domestic or industrial use, chemical and biological contamination may lead to increased treatment costs.

All of these impacts may strike both urban and rural areas. Increased population densities and the lack of facilities can increase the impact in peri-urban areas.

Native plants and animals harmed and associated land, water, and coastal ecosystems degraded. These impacts most often arise from water diversion, construction or decommissioning activities in or near a watercourse, or from fecal contamination of water. Numerous impacts on ecosystems are possible:

- Construction of facilities in sensitive areas (wetlands, estuaries, etc.) can destroy flora or fauna or their habitats, leading to loss of biodiversity, reduction of economic productivity and loss of aesthetics and recreational value.
- Water-supply projects can also deplete fresh water and can erode soil from pipe leakage or poor drainage at taps. Increased consumption of water can reduce water flows and cause loss of habitat, wetlands and wildlife downstream. Soil erosion may cause sedimentation in receiving waters, which may reduce the capacity of ponds and reservoirs, increase flooding, or substantially alter aquatic ecosystems by changing streambed, lakebed and estuary conditions.
- Contamination of receiving waters with human excreta or animal manure can cause nutrient enrichment, depletion of dissolved oxygen and other changes that disturb natural ecosystems and reduce the vigor, abundance, and/or diversity of plants and animals

that live either in the water or on land. Disease-causing microorganisms from excreta and manure may also contaminate fish or shellfish, creating health hazards.

Fresh-water resources depleted. This may occur when projects do not adequately assess the quantity of available surface and groundwater, historically and seasonally. Other causes include poor mechanisms for regulating withdrawals and use of water, and insufficient monitoring and maintenance of leaks.

- Depletion of surface water sources destroys the resource itself, damages aquatic life, reduces economic productivity, diminishes downstream use, and curtails recreational possibilities.
- Exhaustion of groundwater can lead to land subsidence (sinking of the land's surface), altered groundwater flow in other locations, and loss of economic productivity.

Both these situations increase the cost of future water supply systems. In addition, depletion of water resources may lead to poorer water quality, health impacts, and elevated costs of potable water supplies in downstream or down-gradient locations.

Increased disease transmission from standing, stagnant water. Poor design, operation and/or maintenance of water supply improvements can lead to pools of stagnant water near water taps, water pipes and storage tanks. Improper or ineffective practices for disposing of excreta and solid waste make this problem worse. These pools form an excellent breeding place for disease vectors (mosquitoes that carry malaria, etc.). They can also increase transmission of water-related diseases, especially when the wet spots are clogged or contaminated with solid waste or excreta.

Adverse environmental impacts of water supply projects and their causes are summarized in Table 1. Adverse environmental impacts of sanitation projects and their causes are summarized in Table 2.

Table 1: Potential Environmental Impacts of Water Supply Projects and Their Causes

Problems	Possible Impacts	Possible Causes
1. Depletion of fresh water resources (surface and groundwater)	Destruction of the natural resource Destruction of aquatic life Loss of economic productivity Loss of recreation areas Land subsidence Increased cost of water supplies in the future or in down-gradient locations	Overestimation of water supplies Underestimation of water demand Over-pumping of water resources Lack of information on resource yields Waste and leakage of potable water Poor water pricing policies and practices, leading to excessive use, waste and leakage
2. Chemical degradation of the quality of potable water sources (surface and groundwater)	Concentration of pollution in surface water sources Salt water intrusion Poorer quality water, with associated health problems Increased water treatment costs in the future or in down-gradient locations	Depletion of surface and groundwater resources (see above) Reduced stream flows Runoff/drainage from improper solid and liquid waste or excreta disposal
3. Creation of stagnant (standing) water	Increase in vector-borne diseases Contamination of standing water with fecal matter, solid waste, etc., leading to health problems Soil erosion/sedimentation	Drainage systems lacking or poorly designed Leakage from pipes/wastage from taps Lack of user/operator concern for stagnant water
4. Degradation of terrestrial, aquatic, and coastal habitats	Alteration of ecosystem structure & function and loss of biodiversity Loss of economic productivity Loss of natural beauty Loss of recreational values Soil erosion/sedimentation	Improper siting of facilities (within wetlands or other sensitive habitats, etc.) Poor construction practice Leakage/wastage from pipes and taps Increased population density/agricultural activity because of new water systems
5. Increased human health risks	Arsenic poisoning Mercury poisoning Water-related infectious diseases	Failure to test water quality before developing the water resource Lack of ongoing water quality monitoring Inadequate protection of wells and water supply points Biological contamination from inadequate protection of wells and water supply points

Source: Alan Wyatt, William Hogrewe and Eugene Brantly (1992). *Environmental Guidelines for PVOs and NGOs: Potable Water and Sanitation Projects.* Water and Sanitation for Health Project, USAID.

Table 2: Potential Environmental Impacts of Sanitation Projects and Their Causes

Problems	Possible Impacts	Possible Causes
1. Increased human health risks from contamination of surface water, groundwater, soil, and food by excreta, chemicals and pathogens	Increased disease transmission associated with excreta (diarrheal, parasitic, etc.) Malnutrition caused by above diseases High infant mortality Reduced economic productivity Poor quality surface and groundwater Health problems from use of chemically contaminated water Increased cost of down-gradient water treatment for domestic and industrial uses	Failure to use sanitation facilities Disposal of excreta or wastewater directly on land or into surface water without adequate treatment Improper siting of sanitation facilities near water supplies Inadequate protection of groundwater Improper operation of sanitation facilities Failure of sanitation facilities due to lack of maintenance Improper use of wastewater in food production
2. Ecological harm from degradation of stream, lake, estuarine and marine water quality and degradation of land habitats	Health problems from contact with contaminated water Fish or shellfish contamination Nutrient contamination (eutrophication) Alteration of ecosystem structure and function; loss of biodiversity Reduced economic productivity Soil erosion and sedimentation	Failure to use sanitation facilities Disposal of excreta or wastewater directly into sensitive areas without adequate treatment Improper operation of sanitation facilities Failure of sanitation facilities due to lack of maintenance Improper siting of facilities (within wetlands or other sensitive habitats, etc.) Poor construction practice

Source: Alan Wyatt, William Hogrewe and Eugene Brantly (1992). *Environmental Guidelines for PVOs and NGOs: Potable Water and Sanitation Projects.* Water and Sanitation for Health Project, USAID.

Sector Program Design—Some Specific Guidance

As with other program and project development activities, potential environmental harm needs to be addressed early in the design process to avoid possible costly mistakes or project failure. Many environmental, social and cultural problems from water supply and sanitation projects occur

Best Design Practices For Water and Sanitation Projects

- Use others' experience
- Concentrate on the human component
- Use a promotional program
- Participatory approach
- Cost sharing
- Integrate water supply, sanitation and hygiene
- Use existing community organizations
- Economically self-sustaining design
- Provisions for operation and maintenance

A low cost alternative to a hand pump—a privately owned shallow well with a trap door cover near Segou, Mali.

when the improvement is not used, is used improperly, or is not maintained, or if people do not adopt necessary complementary behaviors, such as washing their hands after defecating. There are many lessons from water supply and sanitation projects over the past 30 years, a few of which are summarized below under best practices.

Best practices applicable to both water supply and sanitation projects

- **Take advantage of the experience of others**. Excellent and detailed guidelines, manuals, sourcebooks, and checklists provide clear and concise guidance on developing water supply and sanitation projects. In most cases these are available electronically. A number of these resources, most with URLs, can be found in the Resources and References section at the end of these guidelines.
- **Concentrate first on preparing and developing the human component of the project** and use a demand-focused approach. Projects will be welcomed and supported by the local community only when they perceive a need. At a minimum, people must commit to cost-share in operating and maintaining the systems before developing a project. Such commitment grows out of such genuine household-level demand, as does an interest in adopting hygienic behaviors.
- **A promotional program must accompany infrastructure development**. Community participation (discussed below) and joint understanding are essential. The focus on improved hygiene practices requires sensitivity to the community's cultural and social preferences. Realism must be applied in this process—it may take years for the community to adjust to new practices.

  Water supply and sanitation projects that fail to improve hygiene behavior generally show little or no improvement in public health.

Reaching school children is often an effective strategy, but efforts to bring about behavior change must focus on all other family members as well. Sanitation practices for infants, as well as those of pre–school age children, the elderly, the sick and the disabled, generally do more to contaminate water supplies and spread disease than those of healthy adults.

Understanding local hygiene behaviors and social-cultural beliefs that limit options is an essential first step in design. For example, in some cultures sanitation facilities for men and women must be strictly segregated even at the family level, so that a single latrine per family is inadequate. In other cases there may be the belief forbidding defecation in roofed structures. Materials have been developed to help promote the adoption of better hygiene behaviors. See *Sanitation Promotion* (Simpson-Hébert and Wood, 1998), *PHAST step-by-step guide: a participatory approach for the control of diarrhoeal disease* (Sawyer et al., 1998), and *Towards Better Programming: A Sanitation Handbook* (UNICEF, 1997), listed in the Resources and References section at the end of this guideline, for descriptions and access information.

- **Use a participatory approach, including choice of technology,** that actively engages the community in all stages of the project, including planning and development of management systems, establishment of user fees, construction, operation and maintenance, and possible future decommissioning. This will lead to appropriate design, enhance adoption of new behaviors and help generate the levels of community commitment and support needed for proper maintenance of the project.

  An essential part of the process is to give families and communities a selection of generally appropriate technology and design options to choose from, instead of beginning the project with a predetermined technology. Offer technology alternatives that can be operated and maintained locally/at the village level (VLOM). Confirm, however, that spare parts and necessary expertise are readily available. The VLOM approach has not worked well in practice for communal hand pumps. If other options are preferred by the community, these should be pursued.

- **Use some form of cost sharing**. When households share the cost of building latrines, overall costs drop, the sense of ownership and responsibility increases, usage is greater and maintenance improves.

- **Integrate water supply, sanitation and hygiene promotion**. If these elements are treated individually, the fecal-oral route of disease transmission will not be broken and public health benefits will be limited.

  If it is not possible to implement an integrated program, the first priority should be improving hygiene behavior and sanitation; next, improving increasing water quantity, and last, improving infrastructure for water quality. When programs are implemented independently, those that focus on improved sanitation, including the adoption of good hygiene behaviors, show the greatest reduction in disease transmission. Those focused exclusively on improving

water quantity show the next best performance and those focused only on improved water quality give the least benefit.

- **Draw upon existing community organizations instead of starting new ones.**
- **Design the program so that it will be economically self-sustaining**. Generally, this requires cost recovery mechanisms such as user fees, taxes or levies to finance operations, monitoring, maintenance and repairs, along with a sustainable management structure for collecting these monies and overseeing their use.
- **Include a system for sustaining operation and maintenance** as part of overall program design. The failure to ensure ongoing operation and maintenance is one of the most common reasons projects fail. The system should include a mechanism for training local residents to operate, monitor, maintain and repair the improvement and to keep up institutional memory, for example, maintaining a pool of community members trained in operation and maintenance.

Best practices for water supply projects

Best Design Practices – Water

- Calculate yields and extraction rates
- Appropriate scale and capacity
- Assess water quality
- Periodic testing
- Minimize downstream impacts

- **Calculate yield and extraction rates** in relation to other area water uses in order to avoid depleting the resource or damaging aquatic ecosystems or communities down stream/down gradient. These calculations should take into account historic and projected upstream/up-gradient and downstream/down-gradient supply and demand for water. Projects tapping groundwater should also consider depth to water table and groundwater hydrology.
- **Design improvements with an appropriate scale and capacity**. Estimate current and projected water quantity and availability based on current water sources and preferences, baseline measurements on quantity of water available including seasonal fluctuations, current and historic use data (household, agricultural, and institutional), population data and forecasts, current and projected demand up and down stream/up and down gradient, and actual water use for similar projects in the past. Data on typical water leakage rates in other existing water schemes should be examined. Demand projections should take into account the likelihood that the project will generate additional users.
- **Assess water quality** to determine if water is safe to drink and to establish a baseline so that any future degradation can be detected. Ideally, for these purposes, tests should be performed on the chemical, biological and physical quality of the proposed water source. At a minimum arsenic and fecal coliform tests should be conducted. USAID requires testing for arsenic for all USAID-funded water supply projects, as there is currently no way to determine which locations may contain natural arsenic deposits. (For international water quality standards on virtually any parameter, see *WHO Guidelines for Drinking-Water Quality* vols. 1 and 2 (1997). http://www.who.int/water_sanitation_health/GDWQ/GWDWQindex.html).

- **Maintain periodic testing**. *Ongoing testing is the only way to determine if a water supply is or has become contaminated* (other than by observing dramatic and sustained increases in water-borne disease).
- **Minimize downstream/down-gradient effects of intervention**, perhaps by establishing some form of communication with downstream parties.

Best practices for sanitation projects

- **Develop a hygiene promotion strategy** that takes into account the current hygiene behavior of all users, including women, infants, children, the elderly and the infirm and, as well as any social/cultural religious factors that may hinder changing behavior.
- **Design improvements to match demand, user customs and preferences, climate, and abundance of water**.
- **Test water quality downstream/down gradient** from the proposed site before construction of infrastructure to set a baseline . Elements to test for include fecal coliform, total suspended solids (TSS), biological oxygen demand (BOD) and nutrients. Maintain ongoing testing to monitor for contamination.
- **Minimize downstream/down-gradient effects of intervention**.
- **Consider appropriate natural treatment systems instead of mechanical systems**. These tend to be preferable for small-scale activities as they generally cost less, do not require highly skilled labor, and can frequently be manufactured locally. Also, supplies for maintenance and repair are likely to be more readily available.

Best Design Practices – Sanitation

- Hygiene promotion
- Match demand, customs, preferences and ecosystem
- Know local water quality
- Minimize downstream impacts
- Consider natural systems before mechanical ones

An "enviroloo" (dry composting toilets) mandated by the Department of Public Works in the Northern Province of the Republic of South Africa (2002)

There are many proven natural treatment options. Examples include double-vault batch composting toilets, double-vault batch dry toilets, upflow anaerobic filters, biogas reactors, confined-space constructed wetlands, subsurface wetlands, floating aquatic macrophytes and stabilization ponds.

Process for evaluating potential environmental impacts

Potential environmental impacts of a project should be evaluated after the PVO/NGO and community have defined the project's objective, the types and extent of services, and the types of facilities that will provide the desired services in a way that fits the physical, social, and economic conditions of the community.

Appropriate options should have been identified for each "component" of the system. For a water supply system these would include the water source, storage facilities, the distribution system, and possibly treatment facilities. For a sanitation system they would include facilities for excreta, collecting, transporting, treating, and disposal or reuse of excreta or wastewater.

Once a set of appropriate options has been defined, a PVO/NGO can evaluate the potential environmental impacts of each option and identify appropriate mitigation measures. See the attached Environmental Impact Assessment booklet for more information on EIAs and assessments.

Environmental Mitigation and Monitoring Issues

Table 3: Environmental Mitigation and Monitoring Issues for Water Supply and Sanitation Projects

Activity/ Technology	Impact *The activity or technology may. . .*	Mitigation *Note: Mitigations apply to specified project phase: planning and design (P&D), construction (C), or operation and maintenance (O&M).*
General		
Site selection (P&D)	Damage sensitive ecosystems or endangered species (P&D)	Survey for, and avoid, wetlands, estuaries or other ecologically sensitive sites in the project area. Identify nearby areas that contain endangered species and get professional assessment of species' sensitivity to construction at site (P&D)
Construction of buildings and structures (C)	Damage sensitive ecosystems or endangered species (C) Cause erosion and sedimentation (C)	Follow guideline on Construction in this manual (P&D) (C) Train and monitor workers (P&D) (C) Gather data on soil type, slope and topography to determine the potential for significant erosion (P&D) Use silt screens, straw bales or similar erosion control measures (C) Avoid damaging vegetation (C) Revegetate areas damaged during construction. Do not remove erosion control measures until revegetation is complete (C) Use proper bedding materials for pipes (P&D) (C)
Soakways and drains	Cause erosion (O&M) Alter the natural flow of rainwater runoff (O&M) Create pools of stagnant water (O&M)	Use riprap (cobbled stone), gravel or concrete as needed to prevent erosion of drainage structures (P&D) (C) Monitor and keep drains and soakways clear (O&M)
Water Supply Improvements		
Hand-dug wells, seasonal ponds, improved springs, ground-level catchment and similar structures	Contaminate water with human pathogens (O&M) Contaminate water with animal manure (O&M) Create pools of stagnant water (O&M) Exhaust water supply (not applicable to improved springs or hand-dug wells) (O&M)	Include focus on proper use and maintenance of the improvement as part of behavior change and education program (P&D) Construct spigot or similar system that prevents people from touching impounded water with their hands or mouths (P&D) (C) Use fencing or equivalent that will keep live stock from grazing uphill or up gradient of the water supply improvement (P&D) (C) Do not allow animals to drink directly from the water source (O&M) Monitor drains and soakways and keep them clear of debris (see entry on soakways and drains above for more detail) (O&M) Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves and similar structures (O&M) Put in place a system for regulating use, such as a local warden or appropriate

Activity/ Technology	Impact *The activity or technology may. . .*	Mitigation *Note: Mitigations apply to specified project phase: planning and design (P&D), construction (C), or operation and maintenance (O&M).*
		pricing (P&D) Give the community training in operating the improvement (P&D) (O&M) Monitor water levels in wells or impoundment structures to detect overdrawing (O&M)
Wells	Contaminate water with nutrients and bacteria from animal waste (O&M) Create pools of stagnant water (O&M) Change groundwater flow (O&M) Create saltwater intrusions (O&M) Deplete aquifer (groundwater) (O&M) Cause land subsidence (impact from many wells) (O&M)	Don't let animals graze or be watered up-gradient from wellhead (P&D) (O&M) Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves and similar structures (O&M) On islands and coastal areas, keep withdrawals within safe yield limits to avoid overdrawing, possible salt water intrusion and contamination of the well (P&D) Put in place a system for regulating use, such as a local warden or appropriate pricing (P&D) Include a focus on proper use and maintenance of the improvement as part of the behavior change and education program (O&M) Monitor water levels (O&M)
Standpipes	Create pools of stagnant water (O&M) (This problem can be more severe when water table is high, clay soils are present, or population/tap density is high)	Ensure that spilled water and rainwater drain to a soakway or equivalent structure and do not accumulate and create stagnant standing water (C) Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves and similar structures
Treatment systems		
Pit latrine	Increase transmission of vector-borne diseases (O) Contaminate groundwater supply with pathogens (O) Contaminate water supplies, damage water quality and/or transmit disease at other locations if waste is not properly handled and treated during or after servicing (O)	Devote adequate attention to identifying and addressing social barriers to using latrine (P&D) Use the ventilated improved pit latrine design that traps insect vectors (P&D) Evaluate depth to water table, including seasonal fluctuations and groundwater hydrology. The size and composition of the unsaturated zone determine the residence time of effluent from the latrine, which is the key factor in removal and elimination of pathogens. Pit latrines should not be installed where the water table is shallow or where the composition of the overlying deposits make groundwater or an aquifer vulnerable to contamination (P&D) Ensure that a reliable system for safely emptying latrines and transporting the collected material off-site for treatment is used. This should include use of a small pit-emptying machine such as the vacutug that relies on an engine-driven vacuum pump. The vacutug was tested for UNCHS in low-income areas of Nairobi, Kenya, and was found to give workers much greater protection from disease than conventional methods. See Wegelin-Schuringa, *Small Pit-Emptying Machine: An Appropriate Solution in Nairobi Slum,* for more details) (O&M) Ensure that collected material is adequately treated and not directly applied to fields or otherwise disposed of improperly (O&M)

Activity/ Technology	Impact *The activity or technology may. . .*	Mitigation *Note: Mitigations apply to specified project phase: planning and design (P&D), construction (C), or operation and maintenance (O&M).*
	Cause injury to people or animals	Properly decommission pit latrines. Do not leave pits open. Fill in unused capacity with rocks or soil.
Composting toilets	Increase transmission of vector-borne diseases (O) Contaminate groundwater supply with pathogens (O) Cause disease transmission to field workers and consumers of agricultural products (O)	Maintain humidity of composting material above 60% and supplement excreta with generous quantities of carboniferous material (dry leaves, straw, etc.). The pile should then remain aerobic, odor-free and insect-free (O&M) Construct sealed vaults to hold composting material if using fixed-batch systems. If using movable-batch systems check removable containers for leaks before installing (O&M) Test samples from active chamber and mature chamber after fallow period for *Ascaris* eggs and fecal coliforms (O&M) Allow sufficient residence time in mature chamber. This may vary from 6 months in warm climates to 18 months in cooler climates (O&M) Ensure that the systems will be properly operated and maintained so that the soil amendment taken out after the treatment period is truly sanitized (O&M)
Dry toilets	Increase transmission of vector-borne diseases (O) Cause disease transmission to field workers and consumers of agricultural products (O)	Maintain humidity of composting material below 20% and supplement excreta with alkaline material (ashes or lime). The pile should then remain both odor free and insect free (O&M). Generous applications of ashes will help ensure that pathogens are destroyed. pH is the most important factor for sterilization (O&M) Construct sealed vaults to hold dehydrating and curing material (C) Ensure that the systems will be properly operated and maintained so that the soil amendment taken out after the treatment period is truly sanitized (O&M) Test samples from active chamber and mature chamber after fallow period for *Ascaris* eggs and fecal coliforms to assess level of sterilization (O&M) Allow sufficient residence time in mature chamber. This may vary from 6 months in warm climates to 18 months in cooler climates (O&M)
Septic tanks	Contaminate groundwater supply with pathogens (O&M) Contaminate surface water supplies with nutrients, biological oxygen demand (BOD), suspended solids (SS) and pathogens. (Septic tank effluent generally contains relatively high concentrations of pathogens, BOD, and SS) (O&M) Contaminate water supplies, damage water quality and/or transmit disease at other locations if waste is not properly handled and treated during or after servicing (O&M)	Evaluate depth to the water table, including seasonal fluctuations and groundwater hydrology. If water table is too high, line the tank with clay, plastic sheeting or some other impermeable material to prevent leakage (P&D) (C) Avoid direct discharge of effluent to waterways if possible. Direct discharge to waterways with sufficient volume and flow to assimilate the waste may be acceptable. It is better to add a secondary treatment, such as passing effluent through an anaerobic filter, followed by discharge to an absorption field, or better yet, a constructed wetland (P&D) Ensure that a reliable system for safely removing sludge and transporting the collected material off-site for treatment is available. This should include use of a mechanized (probably vacuum-based) removal system (P&D) (O&M) Ensure that collected sludge is adequately treated and not directly applied to fields or otherwise improperly disposed of (See Sludge management below)

Activity/ Technology	Impact *The activity or technology may. . .*	Mitigation *Note: Mitigations apply to specified project phase: planning and design (P&D), construction (C), or operation and maintenance (O&M).*
		(O&M)
Upflow anaerobic filters	Damage ecosystems and degrade surface water quality. Sludge has high concentrations of nutrients, BOD, and solids (O&M) Cause disease transmission to field workers and consumers of agricultural products (Sludge may still contain pathogens) (O&M)	Treat sludge before secondary use (see Sludge management below). Do not allow disposal in or near water bodies (O&M) Provide workers servicing, transporting, and otherwise exposed to sludge with appropriate protective clothing including, at a minimum, rubber gloves. Train workers to wash hands and faces frequently with soap and warm water and make both available. (See Wastewater and sludge use in agriculture and aquaculture below) (O&M)
Settled and simplified sewers	Damage ecosystems and degrade surface water quality (O&M) Transmit diseases to field workers and consumers of agricultural products (O&M)	Ensure that collected sewage will be treated, e.g., in a wastewater stabilization pond, and not simply discharged to a river or stream or used directly in agriculture or aquaculture. This is especially important for simplified sewerage, since there is no interceptor tank (P&D) (O&M)
Biogas reactors	Damage ecosystems and degrade surface water quality (O&M) Transmit diseases to field workers and consumers of agricultural products (O&M)	Do not allow disposal of digested slurry in or near water bodies (O&M) Follow WHO or other national or international guidelines for use of sludge in wastewater in agriculture and aquaculture (see Sludge and wastewater reuse below) (P&D) (O&M)
Wastewater stabilization ponds (anaerobic, facultative, aerobic)	Damage ecosystems and degrade surface water quality (O&M) Transmit diseases to field workers and consumers of agricultural products (O&M)	Avoid discharging single (facultative) pond systems directly into receiving waters. If this is unavoidable, construct hydrography-controlled release lagoons that discharge effluent only when stream conditions are adequate. Install secondary treatment such as a constructed wetland, if possible (P&D) (C) (O&M) Use two-, three- or five-pond systems if possible (anaerobic, facultative, (maturation)) (P&D) Allow only restricted uses for agriculture and aquaculture of effluent from all but five-pond systems (O&M)
Reed bed filter	Contaminate groundwater or surface water (O&M)	Evaluate depth to the water table, including seasonal fluctuations and groundwater hydrology. If water table is too high, line tank with clay, plastic sheeting or some other impermeable material to prevent leakage (P&D) (C)
Subsurface wetland	(See reed bed filter above)	
Free water surface wetland Floating aquatic macropytes	Provide breeding ground for disease vectors (O&M) Introduce invasive non-native species (O&M)	Use plant and animal species that are native to the region. Avoid introducing water hyacinth, water milfoil, or salvinia, which have proven extremely invasive outside of their natural range (P&D) If using water hyacinth, maintain dissolved oxygen at 1.0 mg/L, frequently harvest and thin plants and/or add mosquitofish (*Gambusia affinis*) to the wetland or use other plant species such as duckweed, water lettuce (*Pistia stratiotes*), water milfoil, or salvinia (*Salvinia spp.*) (O&M)
Slow-rate overland flow	Contaminate groundwater or surface water (O&M)	Use where growing season is year round. Requires vegetation (P&D) (O&M)

Activity/ Technology	**Impact** *The activity or technology may. . .*	**Mitigation** *Note: Mitigations apply to specified project phase: planning and design (P&D), construction (C), or operation and maintenance (O&M).*
		Use only where soil textures are sandy loam to clay loam (P&D) (O&M) Use where groundwater is >3 ft. below surface (P&D) (O&M)
Slow-rate subsurface flow	Contaminate groundwater or surface water (O&M)	Use only where soil textures are sand to clayey loam (P&D) Use only where groundwater is >3 ft. below surface (P&D)
Rapid infiltration	Contaminate groundwater or surface water (O&M)	Use only where soil textures are sandy to loam (P&D) Use only where groundwater is >3 ft. below surface (P&D)
Sludge management	Damage ecosystems and degrade surface water quality (O&M) Cause disease in handlers and processors (O&M)	If possible, choose treatment technologies that do not generate sludge, such as wastewater stabilization ponds (P&D) Compost sludge, then use as soil amendment for agriculture (O&M) Provide workers with appropriate protective clothing, including rubber gloves, boots, long-sleeved shirts and pants. Train workers to wash hands and faces frequently with soap and warm water and make both available (O&M)
Wastewater use in agriculture and aquaculture	Cause disease in field workers and consumers of agricultural products (O&M)	WHO guidelines recommend (1) treat to reduce pathogen concentrations, (2) restrict use to crops that will be cooked, (3) use application methods that reduce contact with edible crops, and (4) minimize the exposure of workers, crop handlers, field workers and consumers to waste (P&D) (O&M) Wastewater used in aquaculture should have $<10^3$ fecal coliforms per 100 ml to minimize risk to public health. (*See Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture: Measures for Public Health Protection*, 1989, WHO, Geneva (P&D) (O&M) http://www.who.int/environmental_information/Information_resources/documents/wastreus.pdf

Resources and References

General Resources

- *Sanitation promotion* (1998). Mayling Simpson-Hébert and Sara Wood, eds. Water Supply and Sanitation Collaborative Council (WSSCC) Working Group on Promotion of Sanitation. Geneva: World Health Organization (WHO). http://whqlibdoc.who.int/hq/1998/WHO_EOS_98.5_pp1-140.pdf and http://whqlibdoc.who.int/hq/1998/WHO_EOS_98.5_pp141-277.pdf

  A valuable resource consisting of a number of short sections that can be used independently. A "Checklists" section (pp. 141–153) includes checklists for planning better sanitation projects, sanitation in emergency situations, hygiene behavior-change, and suggestions for addressing gender issues. Other sections focus on building political will and partnerships and on conducting promotional programs including subsections on principles and guidelines, empowerment, checklists, and promotion through innovation.

- *DFID guidance manual on water supply and sanitation programmes* (1998). United Kingdom Department for International Development (DFID). http://www.lboro.ac.uk/well/gm/contents.htm.

  An excellent general resource designed to assist DFID staff and partners in developing effective and sustainable water supply and sanitation programs. Comprising three chapters and appendices, it takes the reader from an overview of the sector, through specific development perspectives, to detailed recommendations for each stage of the project cycle.

- *PHAST step-by-step guide: a participatory approach for the control of diarrhoeal disease* (1998). R. Sawyer, M. Simpson-Hébert and S. Wood. Geneva: WHO.
  English: http://whqlibdoc.who.int/hq/1998/WHO_EOS_98.3.pdf
  French: http://www.who.int/water_sanitation_health/Environmental_sanit/PHAST/phastf.htm

- *Operation and maintenance of rural water supply and sanitation systems*: *a training package for managers and planners* (2000). Prepared by François Brikké. WSSCC Operation and Maintenance Network and IRC International Water and Sanitation Centre. Geneva: http://www.who.int/water_sanitation_health/wss/O_M/Rural.htm

- *Towards better programming: a sanitation handbook* (1997). UNICEF Programme Division and USAID. Water, Environment and Sanitation Technical Guidelines Series No. 3, Environmental Health Project, New York. http://www.dec.org/pdf_docs/PNACB124.pdf

- *Sanitation for all* (2000). UNICEF. http://www.unicef.org/sanitation/sanitation.pdf.
  Good overview of key issues. Offers a short set of recommendations for better programming.

- C*ommunity-based technologies for domestic wastewater treatment and reuse: options for urban agriculture* (1999). G. D. Rose. International Development Research Centre (IDRC). http://www.idrc.ca/cfp/rep27_e.html.

  This document provides information on urban wastewater management. It specifically discusses issues involved in wastewater resource recovery, wastewater management, project planning and implementation. It also includes a good discussion of wastewater treatment technologies such as on-site treatment, anaerobic treatment systems, water-based treatments and sludge management.

- *PROSANEAR: People, poverty and pipes a program of community participation and low-cost technology bringing water and sanitation to Brazil's urban poor* (1998). Y. Katakura and A. Bakalian. UNDP-World Bank Water and Sanitation Program. www.wsp.org/pdfs/working_prosanear.pdf.

  This report is a description of a water supply and sanitation project in the urban slums of Brazil. Includes participation strategies, design costs and listings of different technologies. A good discussion of solutions to specific urban problems, such as the condominial sewage system that created shared access to sewers for clusters of closely located houses.

- *Best-practice sourcebook on water, sanitation, and environmental health* (2000). CARE (in press).
- *AQUA PLUS guidelist: appropriate technology for water supply and sanitation in the developing countries* (2002). UNICEF Supply Division. Can be ordered at http://www.irc.nl/products/publications/descr/aqe.html. (997 pp., 91 euro)

  A catalogue of appropriate equipment, tools, and materials for water supply and sanitation projects in developing countries. Prepared in consultation with WHO, the World Bank and IRC. Targeted at UNICEF field staff and government technical staff at the central and local level.
- *Learning what works: a 20-year retrospective view on international water and sanitation cooperation* (1998). Maggie Black. World Bank. English:. http://www.wsp.org/English/lww.pdf: French: http://www.wsp.org/French/lww_fr.pdf: Spanish: http://www.wsp.org/Spanish/lww_sp.pdf; or contact the World Bank Water Help Desk (see Web sites section below for contact information).

  A more detailed history of water supply and sanitation programs and lessons learned.
- *WHO guidelines for drinking water quality: training pack.* (2000). World Health Organization, Protection of the Human Environment. Geneva: WHO. http://saturn.who.ch/uhtbin/cgisirsi/K7nEEzh07Y/23602116/9
- *WELL studies* (see Web site section below for description of WELL [Water and Environmental Health at London and Loughborough])**.**

  Practically oriented review of studies relating to water supply, sanitation, solid waste disposal and related issues in the developing world.

See http://www.lboro.ac.uk/well/studies/contents.htm for links to full text of the following studies:

- *Assessing demand for water supply and sanitation projects.* (2000). Sarah Parry-Jones. An exploration of the issues surrounding a demand-responsive approach to water and sanitation service provision, with a discussion of the relative merits of the most commonly used demand assessment tools.
- *Sanitation programmes revisited* (1999). Darren Saywell and Caroline Hunt. A comparative analysis of two notable African sanitation programs, focusing on a historical analysis (investigating how, when and why the programs developed in the way they did) and an understanding of critical issues common to each program, including demand assessment, sanitation promotion, community participation, responsibility for service provision, finance and cost recovery, and health aspects of promotion.
- *Groundwater, latrines and health* (1999). Ben Cave and Peter Kolsky. A review of the risks to health posed by groundwater contamination from on-site sanitation. The study focuses on microbiological contamination because this is the most widespread and direct threat to health from on-site sanitation. The risks from nitrate contamination (the most frequent chemical contaminant of concern from pit latrines) are summarized in the report.
- *Review of safety in construction and operation for the water supply and sanitation sectors,* (1999). Paul Larcher and M. Sohail. *Part 2: literature review* (1999). M Sohail. A critical literature review of construction safety in developing countries, highlighting the most relevant and useful publications and identifying possible areas for future work or research. The report is accompanied by a brief summary note for policy-makers and practitioners.
- *Lessons learned from village-level operation and maintenance (VLOM)* (1999). Jeremy Colin. A literature review of sector experience of the Village Level Operation and Maintenance Management (VLOM) approach to rural water supply.
- *Private sector participation in the water and sanitation sector*: *public-private partnership and the poor* (1999). Mike Webster and Kevin Sansom. A review of existing work examining the impact of Public-Private Partnerships (PPP) in the water and sanitation sectors on service delivery to the poor. Important gaps in current knowledge are also identified.

- *Promoting change in environmental health behaviour* (1999). Ben Cave and Valerie Curtis. A literature review focusing on the potential effectiveness of approaches to environmental health promotion in developing countries, and appropriate expectations and targets for change in health behavior.
- *A review of policy and standards for wastewater reuse in agriculture: a Latin American perspective* (1999). Ursula Blumenthal, Anne Peasey, Guillermo Ruiz-Palacios and Duncan Mara. This document aims to assist in the development of appropriate wastewater reuse policies, including the formation of guideline standards for effluent destined for agricultural irrigation and the implementation of health protection measures, including wastewater treatment, crop restriction, selection of irrigation technique and community intervention programmes.
- *Guidelines for wastewater reuse in agriculture and aquaculture: recommended revisions based on new research evidence* (1999). Ursula Blumenthal, Anne Peasey, Guillermo Ruiz-Palacios and Duncan Mara. The implications of some new studies for the setting of international guidelines for using wastewater in agriculture and aquaculture are considered, along with the wastewater treatment and other health protection measures needed to achieve these guidelines.
- *Learning lessons from sector studies* (2000). Paul Deverill. A synthesis of lessons learned from donor-funded programmes, in water supply, sanitation and environmental health. Reviews sector study reports in Uganda, Nigeria, Tanzania and Kenya.
- *Health aspects of dry sanitation with waste reuse (*2000). Anne Peasey. A review that collates current knowledge of health risks associated with dry sanitation technologies and the problems associated with their use and maintenance.
- *Provision of water and sanitation services to small towns* (2000). Jeremy Colin and Joy Morgan. This report describes and analyzes the findings of rapid investigations in two small towns in Uganda and two in the Southern Indian state of Kerala.

Operation and maintenance, practical tools

- *Operation and maintenance of rural water supply and sanitation systems*: *a training package for managers and planners* (2000). Prepared by François Brikké, Geneva: WSSCC Operation and Maintenance Network and IRC International Water and Sanitation Centre. http://www.who.int/water_sanitation_health/wss/O_M/Rural.htm

See http://www.who.int/water_sanitation_health/wss/o_m.html for links to the following guides:

- *Selected case studies on operation and maintenance of water supply and sanitation systems.* These case studies describe different operation and maintenance (O&M) experiences in a variety of countries, in both rural and urban settings. They are a useful source of information for improving O&M practice.
- *Tools for assessing operation and maintenance status of urban and rural water supply* (2000). These comprehensive guidelines show how to assess O&M performance in both rural and urban areas.
- *Operation and maintenance of urban water supply and sanitation systems: a guide for managers.* This publication examines factors which may prevent existing urban water supply systems from working efficiently, and provides guidelines and solutions for optimization.
- *Leakage control: source material for a training package.* Materials trainers can adapt for use in local training courses, covering all aspects of leakage control, divided into individual modules for ease of use.
- *Upgrading water treatment plants (2001)*. Summarizes many different field experiences with efforts to improve the quality of water and to upgrade the capacity of water treatment plants. It provides a practical approach to improving the performance of water treatment plants.
- *Management of operation and maintenance in rural drinking-water supply and sanitation: a resource training package.* This package contains resource material for training courses aimed at improving the management of O&M in rural areas.

- *Models of management systems for the operation and maintenance of rural water supply and sanitation systems.* This document evaluates the factors which influence the development of O&M management systems for rural facilities. It describes models in eight representative countries and offers guidance to planners and designers in selecting the best approach.
- *Linking technology choice with operation and maintenance.* This document helps users make more appropriate technology choices by providing information on the O&M implications—particularly the costs—of selecting a specific technology.

Detailed Technical Resources

- *WELL technical briefs.* A selection of recommendations made by WELL (Water and Environmental Health at London and Loughborough), primarily in response to immediate technical assistance. Answers to commonly asked questions as well as information of particular interest to water and environmental health practitioners, updated regularly. http://www.lboro.ac.uk/orgs/well/services/tecbriefs/contents.htm.
- *Engineering theme W4: executive summaries.* DFID. Covering topics including water supply, water treatment, sanitation, wastewater, drainage, project cycle and others. http://www.lboro.ac.uk/well/themew4/contents.htm
- *Water for the world* (1982). USAID Development Information Center. A series of 160 technical notes covering all aspects of rural water supply and sanitation. Out of print but available online through Lifewater International. http://www.lifewater.org/wfw/wfwindex.htm
- *A guide to the development of on-site sanitation* (1992). R. Franceys et al. Geneva: WHO.
- *Standard methods for the examination of water and wastewater*, 20th ed. (1995). Washington, D.C.: APHA.
- *Guidelines for drinking-water quality,* vols. 1 and 2 (1997). Geneva: WHO http://www.who.int/water_sanitation_health/GDWQ/GWDWQindex.html

  Volume 1 sets out guideline values for a large number of water contaminants relevant to the quality of drinking water. The book also provides an explanation of how the guideline values should be applied, the criteria used in selecting the various chemical, physical, microbiological and radiological contaminants considered, a description of the approaches used to derive the guideline values, and brief summary statements supporting the values recommended or explaining why no health-based guideline value is necessary at present.

  *Volume 2 r*eviews and interprets the extensive toxicological, epidemiological and clinical evidence that shaped the determination of guideline values for drinking-water quality. Organized to parallel and extend the coverage of Volume 1, which presented the recommended guideline values and brief summary statements supporting these values. This volume communicates the scientific rationale for individual recommendations, based on a critical review of data linking health hazards to specific exposure levels. In so doing, it aims to establish an authoritative basis for national water-quality standards that are consistent with the goal of providing sufficient quantities of wholesome, safe drinking water. Well over 3,000 references to the literature are included.
- *WHO guidelines for drinking-water quality 2nd ed, volume 3: Surveillance and control of community water supplies* (1997). Geneva: WHO. http://www.who.int/water_sanitation_health/GDWQ/pdF_docs/gdw3.pdf

  A comprehensive guide to all practical procedures and technical measures required to ensure the safety of drinking-water supplies in small communities and peri-urban areas of developing countries. Now in its second edition, the book has been vastly expanded in line with broadened appreciation for the many factors that influence water quality and determine its impact on health. Revisions and additions also reflect considerable new knowledge about the specific technical and social interventions

that have the greatest chance of success in situations where resources are scarce and logistical problems are formidable.

- *Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture: measures for public health protection* (executive summary) (1989). D. Maraand and S. Cairncross. Geneva: WHO. http://www.who.int/environmental_information/Information_resources/documents/wastreus.pdf
- *Water quality assessments: a guide to the use of biota, sediments and water in environmental monitoring*, 2nd edition (1996). Deborah Chapman, ed. Published on behalf of UNESCO, WHO and UNEP. London: E & FN Spon.
- *Multi-stage filtration: an innovative water treatment technology* (2000). Gerardo Galvis, Jorge Latorre and Jan Teun Visscher. Technical Paper no. 34. IRC International Water and Sanitation Centre.
- *Cholera and other epidemic diarrhoeal diseases control* (1996). Prepared by the Robens Institute, University of Surrey, UK. Geneva: WHO. http://whqlibdoc.who.int/hq/1996/WHO_EOS_96.4_1.p1-52.pdf
- *On-line bore-well and hand-pump installation tutorial.* Lifewater Canada. http://www.lifewater.ca/ndexdril.htm.
- *Tecnología manual de vaciado de pozos negros (manual pit latrine emptying technology (MAPET)), Dar es Salaam (Tanzania)*. Habitat. United Nations Best Practices Database. In Spanish: http://habitat.aq.upm.es/bpn/bp271.html

  The Manual Pit Latrine Emptying Technology (MAPET) is a neighborhood-based service for the emptying of pit latrines in Dar es Salaam, Tanzania. The service is carried out by independent, informal sector micro-enterprises (MAPET teams). The teams use MAPET equipment that is specifically developed to suit the technical, planning and economic conditions in the low-income neighborhoods.
- *Small pit emptying machine: an appropriate solution in Nairobi slum*, Madeleen Wegelin-Schuringa, IRC International Water and Sanitation Centre, and Manus Coffey, Manus Coffey Associates (MCA) for UNCHS (Habitat). http://www.irc.nl/themes/sanitation/smallpit.html

  This article describes the results of the trial period of a pedestrian-controlled pit emptying machine. The 'vacutug' has been tested for UNCHS (Habitat) in a low-income settlement in Nairobi, Kenya, through a local NGO. The trial confirmed the viability of the principle of the vacutug, as the machine has been in operation for two and a half years. Repairs have been made locally out of income from the service, spare parts can be obtained and demand for the service is high.

Web sites

- *Water Supply and Sanitation Collaborative Council.* http://www.wsscc.org/
- Water and Environmental Health at London and Loughborough (WELL). *http://www.lboro.ac.uk/well/index.htm*

  WELL offers technical expertise in response to specific requests from the British Government Department for International Development (DFID) staff and works closely with the Department's overseas partners. WELL also supports development of technical manuals and guidance notes designed to reduce short- and long-term problems through better documentation and dissemination of existing knowledge and understanding. WELL offers technical assistance and support to representatives of developing countries, UN agencies and UK non-governmental organizations.
- *The interWATER Guide to Organizations.* http://www.wsscc.org/interwater/organizations.html

  A resource provided by the International Water and Sanitation Centre. Provides the addresses of selected organizations concerned with water supply and sanitation in developing countries, organized by country. The list includes organizations able to provide additional information in various forms,

including newsletters, reports and publications, technical expertise, products, training courses, Internet sources, etc.

- *Water Supply and Sanitation Collaborative Council* (WSSCC) http://www.wsscc.org/index.html Established in 1990 at the end of the International Drinking Water Supply and Sanitation Decade. Its purpose is to maintain the momentum of the Decade, by providing a regular way for water and sanitation sector professionals to exchange views and experiences and develop approaches to foster more rapid achievement of the goal of universal coverage.
- *Vision 21: Water for People.* http://www.wsscc.org/vision21/wwf/index.html WSSCC's vision for solving the water supply and sanitation crisis. Brings together all of the approaches and insights to date. A roadmap for countries. Home page contains links to main document and supporting articles. A pilot program testing the vision recommendation is under implementation in the Indian state of Gujarat.
- *The International Training Network for Water and Waste Management* (ITN). http://www.wsp.org/English/itn.html A network of regional and international training institutions, launched in 1984 by the World Bank's Water and Sanitation Program to support training in low-cost water supply and sanitation. ITN Centers provide training, disseminate information and promote local applied sector research on low-cost water supply and sanitation options. The Network links affiliated institutions serving Asia and Africa in Ouagadougou, Burkina Faso (serving countries in francophone West Africa); Kumasi, Ghana (Ghana); Harare, Zimbabwe (Zimbabwe); Nairobi, Kenya (Ethiopia, Kenya, Tanzania, and Uganda); Dhaka, Bangladesh; Calcutta, India (India); and Manila, Philippines (Philippines). New centers are under development.
- *The World Bank and the Water and Sanitation Program Help Desk.* Global contact information: http://www.worldbank.org/watsan or http://www.wsp.org/ E-mail: whelpdesk@worldbank.org; Washington, D.C. Telephone: 202-473-4761; Fax: 202-522-3228.
- Regional contact information. New Delhi, India Tel: (91-11) 4690488; Nairobi, Kenya Fax: (254-2) 260386.

  A 24-hour advisory service for global and regional requests in the water supply and sanitation sector.

Other References

- *Drinking water and disease: what healthcare providers should know* (2000). Physicians for Social Responsibility. Washington, D.C. http://www.psr.org/dwprimer.pdf
- *Environmental sanitation from eco-systems approach* (1999). Steven Esrey and Ingvar Andersson. Vision 21. http://www.wsscc.org/vision21/docs/doc39.html
- *Household-centered environmental sanitation* (1999). Roland Schertenleib. Vision 21. http://www.wsscc.org/vision21/docs/doc09.html
- All Vision 21 Thematic Papers: http://www.wsscc.org/vision21/docs/index.html
- *Participation in the water and sanitation sector.* World Bank Dissemination Note based on Environment Department Paper No. 002. Written by Gabrielle Watson and N. Vijay Jagannathan as a contribution to the Participation Sourcebook. Copies of the full paper are available from the Environment Department, Social Policy and Resettlement Division, World Bank, Washington, D.C. 20433, fax (202) 522-3247. http://www-esd.worldbank.org/html/esd/env/publicat/dnotes/dn150695.htm
- *WHO catalogue 1991–2000*. http://www.who.int/dsa/cat98/zcon.htm See: http://www.who.int/dsa/cat95/zhow.htm for details regarding ordering WHO publications.
- *Environmental guidelines for PVOs and NGOs: potable water and sanitation projects* (1992). Alan Wyatt, William Hogrewe and Eugene Brantly. Water and Sanitation for Health Project, USAID.

A guideline designed to assist PVOs and NGOs in identifying and mitigating environmental impacts of water supply and sanitation projects. The guideline outlines a process for conducting an environmental evaluation of proposed projects.