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Barriers and strategies for dry sanitation in large-scale and urban settings

ANA CORDOVA*† and BARBARA A. KNUTH‡

†Instituto Nacional de Ecología, Periférico Sur # 5000, Mexico DF 04530, Mexico
‡118 Fernow Hall, Cornell University, Ithaca, NY 14853, USA

Centralized waterborne sanitation faces serious social, economic and environmental sustainability challenges. Dry sanitation (DS) may ease some of those, but it is not known whether DS can be a viable solution at large scales and in urban settings. We assessed DS viability in a broad range of large scale and urban contexts in Mexico. Here, we synthesize the operational and structural barriers encountered across a diversity of sites, provide an understanding of how and why those barriers arose and propose a set of strategies through which those barriers can be addressed. We include reference to other large-scale and urban experiences outside Mexico.

Keywords: Composting toilets; Dry toilets (DTs); Ecological sanitation; Mexico; Peri-urban; On-site sanitation

1. Introduction

1.1 *Lack of adequate sanitation*

Worldwide today, 2400 million people lack access to adequate sanitation (WHO and UNICEF 2000), causing serious problems of human dignity, public health and environmental health. Through illness and decreased productivity, lack of water and sanitation is intimately related to the perpetuation of poverty, and thus affects economic, social and human development (World Bank 1994, WHO and UNICEF 2000, Habitat 2001b). To meet the international target of halving the world's population without access to improved sanitation by 2015, adequate sanitation must be provided to 2200 million people. That would require annual investments of almost double those seen in the 1990s from now until 2015 (WHO and UNICEF 2000).

1.2 *Inadequacies of conventional sanitation*

Waterborne sewage has been conventionally accepted as adequate sanitation, but it is not certain that it is economically or environmentally feasible as a universal solution nor that it can be sustainable over long time-scales.

Waterborne sewage discharges, whether centralized or decentralized, regularly leach nutrients and pathogens into water resources. Only 35% of waterborne sewage in Asian, 14% in Latin American-Caribbean, and 0% in African cities were reported by those regions to be treated in wastewater treatment plants (WHO and UNICEF 2000). Even in urban areas of industrialized regions, such as Northern America and Europe, only 90 and 66%, respectively receive wastewater treatment (WHO and UNICEF 2000). Wastewater treatment plant failures, overloads and sewage system leaks are common worldwide (Costner *et al*. 1990, Otterpohl *et al*. 1997, Revkin 2002). Even in the best scenarios, treatment plants discharge nutrients (N, P, K) in their effluents (Otterpohl *et al*. 1997). Septic systems, which are also classified as adequate sanitation, are the third most common source of groundwater contamination in the US and known contributors of pathogens and nutrients to ground and surface waters (USEPA 2002). The liberation of pathogens into the environment constitutes a public health problem. The large amounts of nutrients discharged into water resources lead to anoxic aquatic systems, degrading and destroying habitat.

*Corresponding author. Email: ac58@cornell.edu

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Waterborne sanitation systems require large amounts of water that must be supplied to cities, treated, distributed to users, collected, and treated again. This is a hydrological burden on water-stressed areas (Córdova y Vázquez 2000), as well as a significant economic burden. Sewage networks have higher supply costs than the provision of drinking water (Habitat 2001b), water pumping and treatment are energy-intensive processes (Hellstrom and Karrman 1997, Otterpohl *et al*. 1997), and sewage treatment and collection are one of the greatest expenses of local governments (Van der Ryn 1995). The disposal of sewage sludge has become problematic as landfill space becomes scarce, incineration generates air pollution concerns, land application is thwarted by high levels of heavy metals and other contaminants and public health concerns regarding its reuse are growing (Rockefeller 1996, National Academies 2002). Finally, by not reintegrating human excreta into the soil, in what would be the natural cycle, soil nutrients are being depleted, soil structure is degraded and the alternative sources of plant nutrients either may be depleted in 10 human generations (P and K) or are highly energy-intensive to make available (N) (Otterpohl *et al*. 1997).

1.3 *Alternative sanitation*

For many years, the conventional understanding of adequate sanitation referred to the interruption of pathogen cycles in the immediacy of users, without necessarily considering effects on other human communities (downstream, for example) or on the environment. New definitions and criteria for sustainable sanitation are being developed which address these gaps. WHO and UNICEF (2000) propose that socially, economically and ecologically sustainable sanitation systems will incorporate equity, health promotion and protection from disease, and protection of the environment. Bracken *et al*. (2005) define sustainable sanitation as a system that 'protects and promotes human health, does not contribute to environmental degradation or depletion of the resource base, is technically and institutionally appropriate, economically viable and socially acceptable' (pp. 487–488).

Various sanitation systems, alternative or complementary to waterborne sanitation, could address many of these issues. Dry sanitation (DS) is one of them. Through waterless, on-site treatment of excreta, these systems reduce water supply needs for cities, protect water quality from high nutrient and pathogen-laden discharges and produce a soil amendment material, free from urban runoff and industrial contaminants, that can be reutilized in agriculture (Stoner 1977, Van der Ryn 1995, Esrey *et al*. 1998, Lenton and Thunberg 2000). DS systems also allow for economic savings, due to the volumes of water that are no longer necessary to supply, treat, distribute, collect and treat, and due to the lower capital investment costs that they can imply (Costner *et al*. 1990, Van der Ryn 1995, Otterpohl *et al*. 1997, Pollard *et al*. 1997, Esrey *et al*. 1998, Del Porto and Steinfeld 1999).

Thus, theroetically, DS might address excreta and water management problems that cities face today. Positive experiences exist and positive scenarios have been formulated (Esrey *et al*. 1998, Werner *et al*. 2005). The question is whether, in practice, this promise can hold true at a large scale, with DS as an effective complement or option for cities in developed and developing countries. Others have recommended the study of urban DS and the barriers to its wider application, both in developed and developing countries (Fittschen and Niemczynowicz 1997, Holmberg 1998, Niemczynowicz 1999, First International Conference on Ecological Sanitation 2001, Stockholm Water Front 2001). In this paper, we analyze the challenges and opportunities facing large-scale DS in urban areas, based on the study of current urban experiences, primarily from Mexico. We have reported some aspects of program success and user satisfaction elsewhere (Córdova y Vázquez 2000, Cordova and Knuth 2005). Here, we focus on the types of barriers large-scale and urban DS programs have faced and we suggest the types of policies needed to address them.

1.4 *Background on urban DS*

DS has been promoted in its modern form since the 1940s with the creation of the Swedish 'Clivus Multrum' and its commercialization, initially for remote and waterfront cottages (Costner *et al*. 1990, Esrey *et al*. 1998). It gained worldwide momentum during the 1970s, among individuals with 'back-to-the-land', self-sufficiency and environmental philosophies, as well as with the appropriate technology drive for low-income sanitation provision (Kalbermatten *et al*. 1980, Winblad and Kilama 1985, Van der Ryn 1995, Pollard *et al*. 1997, Esrey *et al*. 1998). During the 1970s and 1980s, DS was promoted in rural areas worldwide on small, medium and large scales. The larger-scale experiences were carried out predominantly in less-developed countries in Africa, Asia and Latin America. Its small-scale use in cities began in the 1980s. Larger-scale urban experiences of DS increased in the 1990s (Drangert 1997, Del Porto and Steinfeld 1999, Córdova y Vázquez 2000). These experiences are still experimental but provide insights into the barriers and opportunities facing this technology in urban settings.

Mexico has a large number of DS experiences, including some of the largest-scale urban experiences in the world. In addition to the high number of dry toilets (DTs) installed in the country, a large diversity of toilet models have been used in a wide variety of program modalities. The diversity of social, institutional, technical and climatic conditions covered increase the transcontextual relevance of the

Mexican experiences. For these reasons, Mexico provided a good context within which to study policy aspects of DS implementation.

1.5 *Methods*

Between August 1999 and December 2000, we conducted field research on DS experiences in Mexico. Data collection included semi-structured, in-depth interviews with 50 practitioners and professionals associated with DS implementation in various regions of the country, collection of written and video documentation of DS projects, site visits, toilet inspections, informal conversations with DT users and a quantitative survey* among 284 DT users across the country. Themes covered in interviews, visits, and document analysis included: history of the project, implementer and user motivations, DT model selection, promotion strategies, user selection, training and follow-up support, DT operation, difficulties and success factors of the programs and appropriateness of DS. The initial stage of research included both rural and urban cases of DS, but site visits and interviews with users were limited to urban sites. The six urban sites were the largest-scale and most-recent urban experiences we had identified and included: Acapulco, Ciudad Juárez, León, Puerto Morelos, Cuernavaca/Tepoztlán and Xochimilco, Mexico City (figure 1).

This sample covered a wide range of climatic conditions across the whole country, large and small cities, and a diversity of program modalities. The sites shared being recent, urban initiatives, mostly under the auspices of an organization or government agency, yet differed in many aspects, including number of toilets, principal program promoter, user income level, toilet model, type of settlement, program motivation and philosophy and type of program (Cordova 2001). The analysis we present in this paper is based on the data collected on large-scale rural experiences and the six urban experiences visited, and is complemented, where appropriate, with reports of other large scale or urban experiences outside of Mexico.†

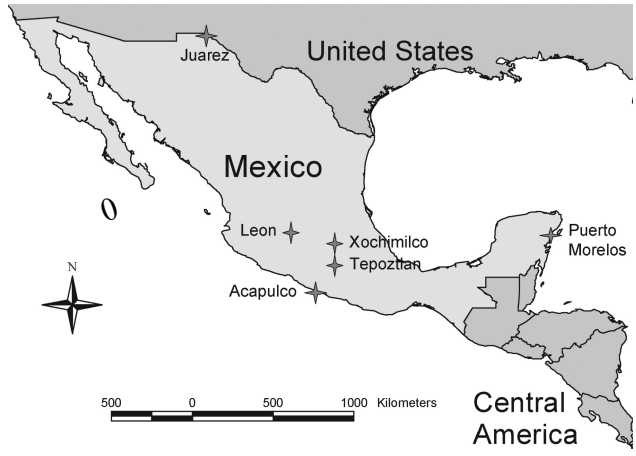

Figure 1. Large-scale, urban dry sanitation study sites.

2. Barriers to large-scale and urban dry sanitation success

Three levels of barriers were identified: (a) those relating to DS itself (as a technology with which users are initially unfamiliar); (b) problems encountered when increasing the scales of program operation in both rural and urban contexts; and (c) issues specific to urban settings—such as high density housing and urban expectations of modernity and reliable provision of public services. We discuss all three types of barriers, and in this sense, many of our results are relevant to both rural and urban DS programs (when the issues of large-scale operation are addressed), and to large-scale and small (when DS technology issues are under consideration). However, we have framed the discussion with an emphasis on urban large-scale implementation for several reasons. First, the urban arena is the most challenging one, and where most doubts about the viability of DS are raised (Pollard 1997, Stockholm Water Front 2001, Tiberghien 2002). In this sense, if DS can work there, 'it can work anywhere'. Second, the larger-scale urban programs are the newest experiences in modern DS, and the ones for which understanding is perhaps least well developed, thus they need specific research. Third, the urban programs have all three types of barriers, so studying urban experiences provides insight into the full set of problems. Fourth, urban areas tend to set the standard of what is socially acceptable and institutionally supported, so that if urban areas have effective and accepted DS systems, rural areas will likely also accept them. Finally, rapid urbanization coupled with population growth makes the need to provide for urban sanitation increasingly urgent.

We have grouped the barriers into two spheres, based on the set of social agents needed to address them (figure 2). What we call the operational sphere refers to the pragmatic, logistical or operational problems programs face, which are within the realm of program managers or community implementers to address. That is, with good program planning and implementation these barriers can be minimized. What we call the structural sphere refers to the contextual, sectoral, institutional and/or underlying constraints affecting DS programs that are not, for the most part, within the ability of individual program managers or community implementers to address. They require the concerted effort of a broader range of actors.

*Because this paper does not report detailed results from the quantitative survey, the survey methods are not detailed here. They are reported in Cordova and Knuth (2005).

†For more details on methods, see Cordova (2003).

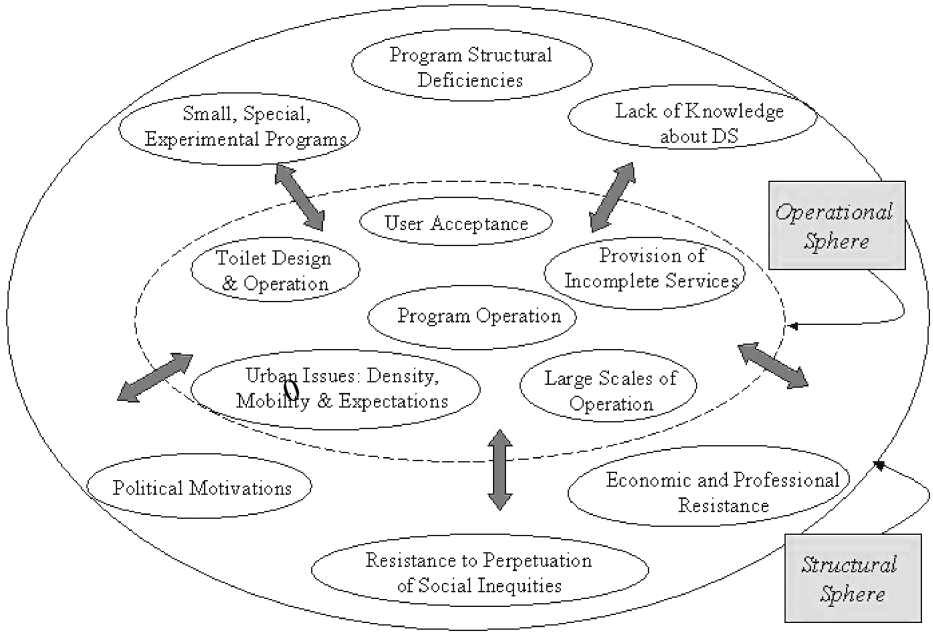

Figure 2. Barriers affecting dry sanitation programs. *Note*: Barriers in the operational sphere can be addressed by DS program managers whereas barriers in the structural sphere require broader concerted efforts. The dotted line between the spheres indicates that the distinction between operational and structural barriers may depend on the local context and thus is not rigid. Arrows indicate that barriers can influence one another, both within and across spheres.

This distinction between the operational and structural spheres is not rigid: some barriers may have aspects relating to both categories (e.g. user acceptance or urban expectations), some could be placed either in the operational or structural category depending on the local context (e.g. provision of incomplete services) and several barriers affect and are affected by others both within and across spheres. In this sense, both spheres function as dynamic systems, where system elements (barriers) interact with and influence one another, both within each system and between systems. The operational sphere is portrayed as embedded in the structural sphere because program operation takes place within a structural context. However, arrows between the spheres and a dotted line (permeable boundary) denote the reciprocal influences one can have on the other. This grouping of barriers provides a general sense of *how* and *who* can address each set of issues.

The sets of barriers and their components or dimensions are listed in tables 1 and 2. These sets represent a universe of barriers that DS programs have faced at a diversity of sites. Not all barriers were present in all programs. Solutions to each type of barrier have been devised, but not necessarily at all sites. Throughout the discussion, it is important to keep in mind that the barriers and their solutions are expressed on a surface of social relations and through the various organizational cultures of the interacting social agents (promoters, DT users, etc.). Hence, each local context adds social dimensions that are locally specific.

In the following sections, we refer to specific sites where certain problems were encountered with the intention to bring concrete examples to the discussion, and not to criticize specific programs. All programs were effective at developing solutions to several of the problems they encountered—albeit sometimes too late for program success, or at the expense of high investment. By providing detail of the barriers and problems faced, we do not imply that DS are overly problematic or doomed to be failures. The purpose of our analysis is to synthesize problems encountered across a diversity of sites, provide an understanding of how and why those problems arose, propose a series of strategies through which those problems can be addressed, and increase the potential for future success by reporting on collective learning.

2.1 *Operational problems*

2.1.1 Program operation. The problems associated directly with program operation dealt typically with user awareness, user training, technical support, cover material availability and/or end-product management. Often users

Table 1. Operational barriers to dry sanitation (DS) program success.

Barrier	Barrier elements
Program operation	• Insufficient awareness raising on dry toilet (DT) benefits • Insufficient user training • Poor follow-up and technical support services • Lack of convenient supply of cover material • Lack of convenient end-product management • Above issues lead to: toilet malfunction, user dissatisfaction, inappropriate disposal of end-product, decreased assurance of pathogen destruction, toilet abandonment, disrepute for the technology
Increased scales of operation	• Hasty promotion of DTs and attraction of beneficiaries • Decreased quality of awareness raising, training, and follow-up • Decreased quality control of DT production • Loss of balance between program software and hardware aspects • Inclusion of broader populations, with diverse needs and lower overall motivation
Urban issues	• High density housing intensifies need for: ◦ convenient access to cover/texture material ◦ off-site end-product management (long-term storage, secondary treatment, re-use) ◦ odor control in certain toilet models • Population high mobility implies need for periodic retraining at homes with DTs • Need DTs appropriate for apartment and high-rise buildings • Expectations of convenience, modernity and public service provision lead to resistance of residents to take on excreta management responsibilities and accepting 'backward' and/or incomplete services
Toilet design and operation	• Need to improve current designs and functionality • Poor DT design, incorrect application of DT design, or inadequate siting • Delivery of incomplete DTs • Use of poor quality materials or poorly constructed DTs • Incorrect user operation and maintenance
Incomplete service provision	• Lack of end-product management system (collection, re-use/disposal) • Lack of complementary graywater management systems • Lack of solid waste management systems • Provision of what users perceive as incomplete bathrooms
User acceptance (reasons for low acceptance)	• Behavioral changes require on-going education, training, follow-up and incentives • DTs require more user work and oversight than WCs • Perception of DT as a second-class, temporary, or 'backward' solution • Poor quality toilets offered in many low-income area programs • Lack of user choice in accepting the DT, selecting a DT model, siting the DT, or integrating DT inside the home • Users dissatisfied with program operation (poor training, poor technical support services, toilet malfunction, difficulty in obtaining cover material, and lack of end-product management support)

were not aware of dry toilet (DT) benefits; they had not been trained adequately in the operation and maintenance of the toilet, the program offered deficient or null follow-up or technical support services and the users had difficulties obtaining cover or texture material, did not know how/when to empty the DTs, and/or did not know how to safely and effectively manage the end-product. These problems caused toilet malfunction, user dissatisfaction, inappropriate disposal of end-product, decreased assurances of pathogen destruction, toilet abandonment and/or disrepute for the technology. These problems occurred in both rural and urban programs, but were compounded in large-scale and in urban settings as described below.

2.1.2 Increased scales of operation—focusing on quantity at the expense of quality. When programs have been small in scale, often in diffusion-style programs, users and promoters have typically had lengthy interactions discussing the benefits of DS, and/or the users have some (usually strong) degree of self-motivation that leads to dedicated maintenance of the toilet and to personal investment in trouble-shooting problems or seeking assistance when problems arise (e.g. Tepoztlán). If programs grow gradually, with this same level of interaction and motivation, they maintain high success levels, such as the rural case of Lismore, Australia (Pollard *et al.* 1997). Unfortunately, several large-scale experiences, both rural and urban, have

Table 2. Structural barriers to dry sanitation (DS) program success.

Barrier	Barrier elements
Program structural deficiencies	• Lack of program continuity • Uncommitted, non-continuous, and inexperienced promoters • Limited funding • Budgets emphasizing hardware over software • Promotion of DS as a magic bullet, one-stop solution • Little documentation and research on alternative sanitation systems and DS program lessons learned • Insufficient piloting and testing of different models at one site
Small, special, pilot, experimental programs	• Short funding cycles, need positive results and wrap-up in short periods (1–2 years) • Few, if any, provisions for program or support system continuity • Overworked promoters, understaffed programs • Dependence on highly motivated, charismatic program leaders • Lack of funding and human resources for innovation and diffusion • Lack of continuity repeated
Lack of knowledge	• Public officials not aware of DS, its advantages and disadvantages, or feasibility • Construction professionals cannot promote a technology they are unaware of and for which regulations/permits do not exist • Lack of citizen demand due to lack of knowledge • Political risk for elected officials to propose DS when it is an untested and unguaranteed technology • Insufficient documentation of experiences underway and insufficient research on the implementation of DS in a variety of settings limits understanding of DS potential • Collective creativity in implementation and innovation is thwarted by lack of exposure to DS
Political motivations	• Political vs. demand-based distribution of dry toilets (DTs) in a neighborhood • Withdrawal of political support to DS program when in conflict with current government administration • Introduction of CS when DS movement creates a threat to local government • Electoral value of CS, not yet seen for DS • Use of DS as a means to secure land-tenure by communities or to coopt social movements by local government, with little commitment to functional programs and eventual malfunction and abandonment of DTs
Economic and professional resistance	• Engineers and water/construction industry are resistant to accepting a technology they are unfamiliar with • Lower cost sanitation systems generate lower engineering and construction fees
Resistance to perpetuation of social inequities	• When provided to low-income settlements as a second-class, inconvenient, incomplete, burdensome services, DS is perceived as perpetuating social inequities and marginality

not maintained this quality interaction and motivation as the program grew. The problems encountered have been hasty promotion of DTs or hasty attraction of users/beneficiaries, deficient awareness-raising and user training, deficient follow-up and technical support services and decreased quality control of toilet production. When expanding rapidly to an unaware and non-demanding population, programs have begun incorporating a portion of users who were not individuals highly motivated about owning a DT, but people who were given one for free (e.g. Juárez), or sometimes even forced to have one because of the location in which they lived (e.g. León). At large scales, user populations become more diverse and it cannot be assumed that they will be self-sufficient in addressing problems, nor that they will all have the same training and awareness-building needs. Many large-scale programs have not made provisions for the increased and diversified training and follow-up needs of these larger and more diverse populations.

Lack of provisions for long-term follow-up support was almost universal in the sites we studied. In many cases, large-scale programs focused almost exclusively on the hardware aspects of construction and delivery of toilets, with very little or no attention to the software aspects of awareness building, training and follow-up (e.g. rural and peri-urban Oaxaca and rural Guanajuato, Mexico).

Large increases in scale have also led to decreases in quality control of toilet production and breaking of components during transportation. This has led to higher rates of toilet malfunction or delivery of incomplete toilets (e.g. Oaxaca, Juárez).

2.1.3 Problems associated specifically with urban settings—density, mobility, expectations. Program operation problems can be compounded in urban settings. Because of high-density housing, the common presence of asphalted surfaces, and little ground area on each household's plot, cover/texture materials needed for the DTs (such as dirt,

dry leaves or wood shavings) were not always easily accessible to users. Compared to rural areas, fewer wood stoves are used, if any, which also reduces this source of ash as a cover material. In addition, high density and little garden space per family reduce the possibilities of families re-using or storing their toilet end-product on-site. Thus, in high-density areas, users have increased needs for cover material provision and for end-product collection, which many programs failed to address institutionally. A question which arises frequently about the urban implementation of DS is whether DTs can be introduced in high-rise buildings. We saw two different toilet models in second and third story levels in Cuernavaca-Tepoztlán and Puerto Morelos, and DTs have also been installed in apartment buildings in Sweden (Ingvar-Nilsson 2001). In addition, several self-contained models, which can be installed in small spaces inside a dwelling, are available commercially (Del Porto and Steinfeld 1999). However, many program promoters were not aware of these possibilities.

We did not detect many instances of homes being affected by neighbors' DT odors, except in some highly malfunctioning cases (Juárez, Léon) and in a few cases where extraction fans shifted the smells to a neighbor's yard (Puerto Morelos). On this note, we point out that DT models which extract foul smells from the home will likely need to be fitted with odor control filters if there are other homes close-by and down-wind from the extractor.

Urban dwellers are often more mobile than rural residents. In our survey, we found several users had found the DT in the house when they moved there. Many of these people did not receive the original DT training and/or did not know whom to contact for toilet malfunctions.

Finally, urban dwellers have expectations of convenience, modernity, and reliable public service provision. In general they have less tolerance for providing services for themselves than may be the case for rural dwellers. They may also have less time to manage their DT, due to long commuting times and reduced time at home. Urban DS programs have encountered resistance due to the increased user responsibility they imply in comparison to flush toilets,* and the burden of being perceived as backward and incomplete services. Users at several urban sites said that they preferred conventional sewage because they wanted a 'normal' home or toilet, 'with the complete services', 'the way it's supposed to be' (survey open-ended responses).

2.1.4 Toilet design and operation, aesthetics and comfort. In many instances, toilets were poorly designed (e.g. small toilet chute in León, which consistently got dirty, small urine duct in Tepoztlán which clogged), inadequately finished or sited (e.g. permeable chambers in high water table areas in León, lack of toilet room walls/roof in Puerto Morelos and Acapulco, toilets with insufficient solar exposure in Juárez or Xochimilco, unfinished toilets in Cuernavaca (Clark 1997)), or built with poor quality materials (urine ducts consistently slipping out of place in Oaxaca, broken doors, handles and locks in Juárez and Xochimilco). These problems interfere with adequate toilet operation or utilization, leading again to malfunction, dissatisfaction, abandonment and disrepute.

Design issues and materials decisions also affected aesthetics and comfort, which in turn influenced user acceptance and satisfaction with the toilets. León toilet seats were made of cement, which was cold in the mornings; Juárez and Xochimilco toilet seats were too low to be comfortable for adult users and were in outdoor fiberglass booths that were too narrow, and too hot† or too cold; users mentioned difficulties for the elderly or handicapped using stairs to reach the toilet room in Juárez and Puerto Morelos.

In situations where users do not understand the operation of DTs, they cannot provide adequate maintenance. We observed toilet malfunction and user dissatisfaction increase in these situations; this has also been reported in Swedish cases (Fittschen and Niemczynowicz 1997).

2.1.5 Incomplete service provision. Conventional sewage has been a way to safely collect and withdraw both human excreta and graywater from households. When people are provided with DS, in many instances they have only been provided with a means to safely collect and process excreta, but they have not been provided with a service to manage graywater nor to dispose of the processed excreta. Of the urban sites we studied, only in León had users simultaneously been given graywater and DS systems,‡ and only in León and Puerto Morelos did program implementers offer to collect end-products from the household. Thus, in most sites, users had been provided with what many considered incomplete services. Consequently, many users aspired for the 'complete' set of services associated with sanitation through conventional sewage. It has been noted by other practitioners that DS will not be effective until garbage collection is also provided to communities, since some users dispose of garbage in their DTs when no other solid waste management option is available (Thompson 2001). As regards the toilet *room,* several of our survey respondents

*A classic urban amenity and aspiration.

†One user in Juárez light-heartedly joked that the DTs were dual-purpose: a toilet and a sauna all-in-one.

‡Unfortunately, due to poor siting and design, the graywater filtration system did not consistently drain into the soil, but frequently overflowed in people's yards.

expressed that they wanted washing and bathing facilities in the same room as the toilet, to have a 'complete bathroom' (survey open-ended responses). Finally, we observed some DTs used as storage space at several sites. This has also been observed elsewhere, where the DTs are sometimes the only concrete structure a peri-urban family may have and often more valuable to the household as storage space than as a toilet (e.g. Jamaica (Thompson 2001)).

2.1.6 User acceptance. User acceptance affects and is affected by many of the barriers described thus far. It has been hindered by toilet design and operation problems and by deficiencies in program operation as described above, in a vicious and compounding cycle, where poor technical support leads to dissatisfied users, lower motivation, less care in toilet operation and increased malfunction; where lack of toilet aesthetics compounded with lack of user awareness of the benefits of DTs lead to toilet abandonment; or where excessive effort invested in securing cover material compounded with frustrated expectations of urban conveniences lead to high user dissatisfaction. User acceptance is also strongly hindered by the changes in behavior required with DT introduction. Whether this represents a shift from a flush toilet, a latrine or outdoor elimination, the transition requires user attention, willingness, training, follow-up support and incentives. As we have discussed, many large-scale programs have not made sufficient provisions for the intensity and diversity of these needs.

The lack of user choice and decision-making has been a deterrent to user acceptance. In many large-scale, institutionally promoted programs, users were not involved in choosing DS over other sanitation options for their communities, they were not given options between various DT models that might be better adapted to their personal lifestyles, and they were not made aware of the possibility of integrating the DTs into the home.

In addition to being perceived as backwards and incomplete services, the DTs have also been perceived frequently as second-class or temporary solutions. The largest-scale urban DS programs we studied were directed to low-income, peri-urban dwellers (Acapulco, Juárez, León and Xochimilco). These programs did not emphasize aesthetics and in most cases were uncomfortable toilets, sometimes with high levels of malfunction (e.g. León). The toilets were seen as second-class or temporary solutions by many users, either because of the perceived vulnerability of fiberglass materials that 'probably won't last very long' (Juárez and Xochimilco), because of the incompleteness and inconvenience of the service, because promoters had mentioned that conventional sanitation would later be introduced (Acapulco), or simply because people knew that 'regular' urban residents did not receive this type of toilet. So long as DTs are perceived as second-class or temporary, people will aspire for first class, permanent services. In León, users fought hard political battles to get conventional sanitation introduced in their neighborhood, and eventually the city provided these services. A note of optimism: despite all these potential and possible deterrents to acceptance, users at four of the urban sites rated satisfaction with their DTs almost 9 on a 10 point scale, and 76–100% of users at those sites said they could accept DTs as long-term sanitation options if they were provided with certain services and incentives (Cordova and Knuth 2005).

2.2 *Structural problems*

2.2.1 Program structural deficiencies. Many of the operational and pragmatic problems discussed above have their roots in other (structural) program deficiencies. Numerous DS programs have suffered from inexperienced promoters, non-committed promoters, lack of continuity, limited and incorrectly structured budgets, promotion of DS as a magic bullet (one stop solution), and/or little documentation available on a range of alternative and dry sanitation options. Some DS programs have been affected by promoters who had economic motivations and were not necessarily committed to effectively solving sanitation problems (Clark 1997). When promoters were inexperienced, they did not assess a variety of sanitation options or a variety of toilet models. In many cases, they knew of one or two DT models and implemented a large-scale program without pilot testing or involving users in decision-making. Hastiness in decisions was often due to short funding cycles, as well as delays and unreliability in funding disbursements from donor agencies. Incorrectly structured budgets, which emphasized sanitation hardware over software, were due both to promoter inexperience as well as restrictions imposed by funders, who typically wanted to see hardware results in short periods. Lack of continuity affected the majority of large-scale urban programs. This was due to one-time grants/investments (Puerto Morelos, Juárez, Acapulco) and/or to changes in political administrations (León, Acapulco, Xochimilco). Promoters certainly tried to maintain some of these programs over time, but were able only to a limited extent, and eventually many programs suffered discontinuity. Many of these difficulties are typically encountered in sanitation or development programs worldwide (Vivian 1994, LaFond 1995, Black 1998), and have eluded solutions over many years.

2.2.2 Small programs, special programs, experimental programs. Several of the above distortions have resulted from DS programs being pilot, experimental or special programs, or from being small programs. If the programs have been promoted by non-governmental organizations (NGOs) they typically depend on grant monies that,

as discussed previously, have timing and structuring restrictions and occasionally are one-time events. Even when grant monies are renewable, NGOs may feel pressured to provide success stories rather than a more candid recognition of failures that would lead to collective learning about shortcomings of the development approaches used (Vivian 1994). Due to this tacit pressure, 'failures are repeated around the world until they become too obvious to ignore—at which time their wastefulness is deplored' (Vivian 1994, p. 189).

In the case of local government involvement (Acapulco, Xochimilco, León), discontinuity has arisen with changes in administration because the project was associated with the previous administration and the new administration either did not have interest or did not want to support previous programs. Interestingly, this lack of support has occurred whether the administrations were both from the same political party or not. In addition, most promoting governments did not make arrangements to either institutionalize the programs or to ensure continuity independently of the local government. In one city, the DS project was a 'special' project of the municipal health agency, with an independent and large budget, from which the rest of the agency felt left out. When the 'special' funds ended, the agency as a whole, which could have provided continuity, did not feel ownership or responsibility towards the program and let it dwindle. In another city, the promoting government originally had the idea of instituting a revolving fund, which would continually provide for new DTs as users paid off their toilets, but one year after initiation of the program and towards the end of the administration's term, the promoters made the decision to not charge the DTs after all and thus eliminated this continuity arrangement. Whether the decision was made on administrative, electoral or other grounds is not clear.

Other problems small programs and organizations face—including grassroots programs independent from external funding—are dependence on one or more highly driven individuals, few and overworked staff, excessive responsibilities and few economic resources. In many cases, the few staff must be seeking funding, resolving logistical and organizational issues, fighting political resistances, while they develop toilet models, promote them, train users and attempt to provide follow-up. Frequently, excessive responsibilities make program promoters unable to adapt the program or the toilets to user needs, and innovation and improvement are thwarted. When the burning souls burn out, the programs that depended on them risk becoming extinguished as well. When programs depend on one or two individuals, the personal shortcomings those individuals may have (unreliability, disorganization, overcommitment, etc.) also risk becoming associated with the programs or the technology themselves.

2.2.3 Lack of widespread knowledge about DS. Lack of knowledge about DS by government officials, construction professionals and communities themselves constitute a barrier for the wide-scale implementation of these types of systems. Public officials cannot promote DS if they do not know what it is, what advantages and disadvantages it has, and how and when it is feasible to implement. Citizens and communities cannot express demand for a technology they have never seen or used, and construction professionals cannot invest in technologies they do not know if they will be able to sell or obtain permits for. Insufficient documentation of the experiences underway and insufficient research on the implementation of DS in a variety of settings and contexts currently limits our understanding of the potential of DS. A great variety of sanitation systems—both wet and dry—may be combined in effective ways. However, if individuals and institutions related to urban development, construction, and water management do not have access to information abot them, this collective creativity is being lost.

2.2.4 Political motivations, irregular settlements and citizen rights. Political motivations have contributed directly to program failure in several ways: in some cases they have influenced who in a neighborhood/community receives the DTs, without regard to actual beneficiary interest or need; in other cases electoral competition or political cooptation have been the catalysts to introduce conventional sanitation into an area with DS; and in yet others, political differences among stakeholders have been the cause for lack of institutional support for the DS program. The political and social value that the provision of water and sanitation services represents for local governments has been well documented (Bennett 1995, Pezzoli 1998, Keck 2002). Large-scale programs whose goal has been political control (of a constituency or community) have limited themselves to delivering toilets and have lacked serious training and follow-up (Clark 1997). The high political value of water and sanitation provision directly affects the political will to experiment with alternatives to conventional sanitation. Sometimes decisions have been made to supply a community or neighborhood with conventional sewage despite the fact that DS was an effective alternative from an economic, environmental, and even social, point of view.

A related issue has been the use of DS (and other alternative sanitation options) as a means to secure land tenure and citizen rights in irregular settlements. Local governments do not provide public services to these communities either because they do not have the funds or they do not wish to legitimize the settlements. Obtaining services for such communities can become a first step in achieving land-tenure security or other sorts of legitimization. This has been common in Mexico City, for example, where the City government has tried to limit peri-urban

growth in ecological reserve areas under environmental arguments and citizens have been able to secure the right to settle in these areas by using environmentally-friendly sanitation systems, among other strategies.* However, DS is often only a means to the end of securing certain citizen rights, and as soon as citizens or communities can afford it, or politically obtain it, they abandon alternative sanitation for conventional sanitation (e.g. León (Pezzoli 1999)).

DS has thus been used both as a means for irregular settlements to obtain legitimization and for local governments and political parties to co-opt communities with promises for later provision of conventional sanitation. Both strategies may have important political value, but they have perpetuated the notion that DS is a temporary, second-class solution, and they have fostered poor government and community commitment to the technology, which has led to poor program implementation, semi-functional toilets and eventual abandonment of the technology.

Economic motivations and corruption in public officials or private entrepreneurs has negatively affected large-scale DS programs in several Mexican cases by emphasizing toilet production over training and follow-up, and by underdelivering materials and construction services, which has led to unfinished and incorrectly built toilets (Clark 1997).

2.2.5 Economic and professional resistance to DS. The high cost of waterborne sewage and treatment infrastructure, and the resulting lucrative professional fees paid to engineering and construction firms, have long been cited as a barrier to the broad-based introduction of alternatives to conventional sanitation (Van der Ryn 1995, Rockefeller 1996, Black 1998). The personal benefits accrued to government officials through the development of costly water and sanitation projects—both in developing and developed nations—have also been cited (Nugent 2001, Habitat 2001a, Habitat 2001b, Tiberghien 2002).† Professional, industry and government resistance to accepting and promoting alternative sanitation options may be as much due to these economic motivations as to the lack of knowledge about alternative sanitation and a fear that alternative sanitation will threaten their profession. If a set of major decision-makers feels threatened by the technology, this represents a very important obstacle to large-scale DS implementation.

2.2.6 Perpetuation of social inequities. When DS is promoted only to the peri-urban or rural poor, it perpetuates social inequities and marginalization by (a) creating a two-tiered sanitation system (first class for the wealthy and legal, second class for others); and (b) providing incomplete, short-term, low-status, inconvenient services with more management and cost responsibilities to those least capable of assuming them and for whom the marginal costs are higher. If communities and social organizations associate DS with the perpetuation of social inequities, this is another great barrier to the large-scale implementation of the technology.

3. Addressing the barriers

We suggest that operational solutions will not have a major impact on the large-scale dissemination and effectiveness of DS unless and until the structural issues are addressed, and that DS cannot be part of a structural solution to sanitation problems until and unless it is operationally functional. Thus, both sets of barriers must be addressed. We propose a set of structural strategies that, jointly, can address effectively a multiplicity of structural and operational problems currently facing large-scale and urban DS programs. With these in place, the equally important operational strategies we recommend will have a greater impact. As in the case of barriers, the strategies in each sphere are interrelated and the effects on each other may cross sphere boundaries. It is therefore advisable to implement the strategies in parallel.

3.1 *Structural strategies*

3.1.1 Formalizing DS as mainstream, institutionally-supported infrastructure. Currently, conventional sanitation (CS)‡ is formal, institutionally supported, state-subsidized, convenient and high status. Most citizens, and particularly marginalized, disempowered communities, aspire for formal, institutionally supported, state facilitated, convenient, high-status, functional services. The question is whether CS is the only system that can take that role. Other sanitation systems might have the appropriate characteristics to do so. It is important to identify the sets of sanitation options that may offer high quality services for large numbers of people in a socially, economically and environmentally sustainable way. DS may be able to take part of that role.

If DS were to gain formal, state-supported status, paid through the regular tax base, with the institutional support and public coordination afforded to CS, many issues that are now problematic with DS would be solved. It would no longer be an indirect way of perpetuating social inequities by establishing a dual sanitation system in cities where increased labor, responsibilities and costs are given to the

*We found this to be the case for several Xochimilco residents, and Pezzoli (1999) describes in detail a case in the Ajusco area of Mexico City.

†DS programs have not been immune to private and public corruption, but the sums involved are lower than in conventional sanitation by virtue of the lower overall investment costs.

‡For the remainder of the discussion we use the term conventional sanitation to denote centralized, waterborne sanitation.

poorest residents. By becoming mainstream, DS would no longer be associated with experimental or second-class solutions. Formalizing and mainstreaming DS would decouple the search for citizen rights (and access to state services) from the exclusive focus on CS. It would topple the notion that CS is the 'right' thing and the citizen 'right' and thus decrease the level of political conflict and toilet abandonment surrounding some DS contexts. It would also encourage the notion that DS is a long-term, established sanitation option.

By formalizing the provision of DS, the discontinuity, short funding cycles, dependence on few individuals, and other barriers facing experimental, 'special' and small programs would also be circumvented. Finally, the permanence of the service and the institutionalization of both system maintenance and end-product collection/management would address the pervasive problems of lack of follow-up and technical support.

3.1.2 DS as part of a repertoire of sanitation options in 'modular' cities. To suggest that DS should be the only sanitation option would perpetuate the pitfalls of emphasizing magic bullets as 'simple, neat and comprehensive solutions to complex development problems' (Vivian 1994). No solution can be a magic bullet, particularly in situations where environmental and social variability are involved. Thus, we do not suggest DS as the sole alternative to CS, but rather a component of what would be a repertoire of socially accepted, convenient, first-class, institutionally-provided solutions.

Water management and sanitation in urban settings are prime examples of cases where a modular approach would be useful. Soil, topography, hydrological, and geological variations within urban limits justify the use of different water management strategies across different sections of the city. In Mexico City, for example, while some areas are appropriate for CS, others are not due to volcanic bedrock (Pedregal) or high water-tables (Xochimilco). In addition, topography and city lay-out can make the existence of one large network of pipes less desirable than a set of compatible modular subsystems. Collections lines can represent up to 80% of the total cost of a conventional sewage system (English and Yeager 2002). In many cases, several wastewater treatment plants and smaller collection systems can be more cost-effective for a city, particularly if large central pumping systems and larger collection pipes are thus avoided (Casey 2002). If small modular systems can be recommended, there is no reason to limit the modules to CS. Once smaller-scale systems are in place, it would be advisable to use the sanitation system that is best adapted to that area—whether conventional or alternative.

Socially, user preferences and capabilities to support various technologies might also justify various water and sanitation strategies in different city sectors. Alternatively, new urban developments might integrate alternative sanitation options, while older developments would use CS at least through the end of its useful life cycle. Adopting water and sanitation approaches that acknowledge and adapt to environmental variability within cities would lead to a 'fluid mosaic' view that would lay the city down as a well-fitted, flexible mantle adapted to the local variability, rather than as a rigid, solid slab that 'imposes' itself on the environment. This would certainly require some level of uniformity within sectors, and water management compatibility and coordination between city sectors. Research and experimentation would be necessary, but a modular approach should not be unduly difficult either technically or logistically.* What would be important is that all sanitation options be equally well supported, and perceived similarly as socially acceptable.

3.1.3 Changing perceptions and raising the status of DS. We have discussed that so long as DS is perceived as a temporary, partial, low-status, 'backward' solution for the poor, people will abandon it as soon as they can afford other options. Therefore, raising DS status is imperative to its social success. Formalizing its implementation and making it part of the mainstream repertoire of sanitation options, as was discussed earlier, is one step in this direction. Another is to provide DS as part of a complete set of urban domestic services (including graywater management and solid waste management) which users demand (Habitat 2001a). Finally, a very important step is promoting DS among both the rich and the poor within a community, among urban and rural communities, as well as among more developed and less developed countries. We often encounter water and sanitation professionals who still perceive DS as a solution for poor countries—presumably because poor countries do not have the economic resources to provide CS. However, we have already discussed that high economic costs are problematic for both less and more developed countries (Van der Ryn 1995, Revkin 2002) and that water scarcity, nutrient loading, and geological and soil conditions unsuitable to CS, affect communities in rich and poor nations alike. When DS is seen as a technology useful to the 'rich' and the 'poor' (be these countries, communities or households), and used by both the rich and the poor, it is more likely that the poor will accept it and want it.†

3.1.4 Transforming economic and professional resistance into support. The suggestion of widespread introduction of alternative sanitation technologies may raise concerns in certain industries, such as wastewater treatment, water

*English and Yeager (2002) propose Responsible Management Entities as a means to manage decentralized sanitation systems with diverse modules.

†An excellent illustration of this concept would be Del Porto and Steinfeld's (1999) vision of DTs installed in World Bank and WHO office buildings.

supply and construction industries, which may find their current activities threatened. For a number of reasons, this concern is not necessarily warranted, and it is important to communicate clearly these reasons to those who feel threatened. Many sewage systems that currently exist will need maintenance, repair and operation for at least the next 50 years. A very high number of sewage systems worldwide do not provide adequate or any treatment and wastewater treatment plants must be built to service them. Even in situations where all sanitation became dry, there would be wastewater treatment needs for industrial water, stormwater and domestic graywater; some of these needs may be speciality niches and some may be large-scale. Large-scale water supply and stormwater management infrastructure will still be required, even in a modular water management scheme. Within a modular approach to sanitation, waterborne systems will likely still prove valuable options in many settings. Thus, there will be a continued demand for water supply, wastewater treatment, and the construction of large and small public works that water and construction industries can continue to service.

In addition, the broader introduction of alternative sanitation systems will create a new niche for the development of excreta management systems. DT models need much further research and development. End-product collection, secondary treatment, and reuse will also need research and development. Investments in these areas will broaden the service capabilities of current industries and professionals, and may also allow for the growth of other industries and services, such as appliance manufacturers and secondary composting or nutrient reuse centers. Drangert (1997) reports 22 manufacturers of 42 DT models in Swedish markets. He indicates that most of these were small, specialized companies, but two were well-established white-ware manufacturers.

If the international sanitation targets are to be met, highly increased investment will have to be made in the sector, and with the new environmental and social criteria for sanitation, it is likely that a variety of sanitation systems will be in order. Water and sanitation practitioners, professionals and industries will broaden their capabilities by incorporating alternative systems into their own repertoires.

3.1.5 Knowledge about these systems. In addition to sector professionals, other groups such as public officials, regulatory agencies, and citizens-at-large need to be aware of dry and alternative sanitation systems. These groups must have access to information and examples of a variety of sanitation systems and understand the technological, economic, managerial, social and environmental implications of each. In order to make effective choices about sanitation systems (whether at the household, neighborhood, community or city level), the assessment should include a discussion about the purposes the sanitation system is desired to fulfill in each context: water savings, energy savings, nutrient recovery, water quality protection, population coverage, economic savings, low-maintenance, user convenience, etc. With a consideration of the purposes to fulfill, an understanding of the contextual constraints, and knowledge about a variety of options, communities and individuals can likely make more effective sanitation decisions and investments than in the scenario of singular solution options.

3.2 *Barriers requiring broader social action*

There are some structural problems that affect DS implementation, which cannot be directly addressed by actions surrounding water management and sanitation alone. These include political motivations surrounding services provision, and inherent social inequities in access to services, land-tenure, adequate housing and other human needs. Corruption, inequity, poorly planned urban development and insufficient provision of services need to be addressed directly through a combination of social, economic and institutional measures, the discussion of which is beyond the scope of this paper. New technologies will, by themselves, not address these social ills. However, certain technologies and ways of implementing them can ease, or at least not contribute to, the manifestation of those social problems.

Instituting DS as an option used by the rich and the poor would eliminate one more way social differentiation is constructed and reproduced. Because DS can be cheaper and less resource intensive than CS, it might increase the ability of local governments to extend urban services (and thus some degree of citizen rights) to a broader proportion of the community.* Perhaps by being *able* to offer public services in a formal way, with lower-cost but socially acceptable functional technologies, local governments would not have to close their eyes to the emergence of irregular/illegal settlements and could actually facilitate their development in an orderly fashion. Politically, having a larger repertoire of socially acceptable sanitation options may provide more bargaining and negotiation space between citizens and local governments, move tensions away from a CS-or-nothing realm of decision-making, and decrease the tensions and manipulation potential that exist when only one, relatively high-cost, acceptable option exists. Additionally, a lower cost set of sanitation options may provide a means by which politicians actually *do* service the full electoral base they would hope to; this may aid in decreasing the common and vicious cycle of unfulfilled electoral promises.

*In addition to providing sanitation to broader populations, the water saved through dry sanitation could be provided as drinking water to un(der)served populations as well.

In conjunction, the structural strategies we have discussed thus far would address a large number of problems facing large scale and urban DS programs today. Most structural problems would be addressed, some would be partially addressed but would need broader societal action to be fully taken care of, and some operational problems would be partially addressed as depicted in figure 3.

3.3 *Operational strategies*

The attention to the structural strategies discussed above might lead to great optimism and enthusiasm, perhaps to an unbridled adoption of the concept of DS, and the desire to promote it large-scale immediately. Such immediate but uninformed enthusiasm has led to great investments and low success in many of the sites we studied. A number of pragmatic issues must be attended to if large scale and urban DS is to be successful. In this section, we provide some guidelines, informed by the analysis of many experiences, which can avoid the pitfalls encountered in those cases. Many of the strategies we present have been implemented at one or more sites; other strategies derive directly from seeking a solution to the pragmatic barriers listed above. Again, many of the strategies relate to one another, so that parallel implementation would be advisable.

3.3.1 Program operation. In order to be effective, a DS program should be understood to include several elements: toilet model(s) selection; promotion/dissemination; toilet production/construction; toilet delivery; user training; follow-up and support services; end-product management; evaluation and feedback; and well-planned program management. These elements, which we describe below, need not be implemented in a linear fashion or through a top-down approach; they may be implemented iteratively, in parallel, and through adaptive management and participatory approaches (Cordova and Knuth 2003).

- Toilet model selection. Toilets must be designed correctly and selected adequately for cultural, lifestyle, and site conditions. Several DT models should be piloted at each site to identify those that are best adapted to the local social, environmental and climatic context. The testing of various models has been done in Skaneateles, USA (Abbott 2001) and in the second phase of the UTEP-promoted program in Juárez, Mexico (Graham 2001). This avoids the investment in models that would not perform optimally at the site. The adaptation of the designs to homes of different social-economic levels or different ethnic traditions, and integrating the toilet to the construction of the house (rather than in a separate out-building) can improve

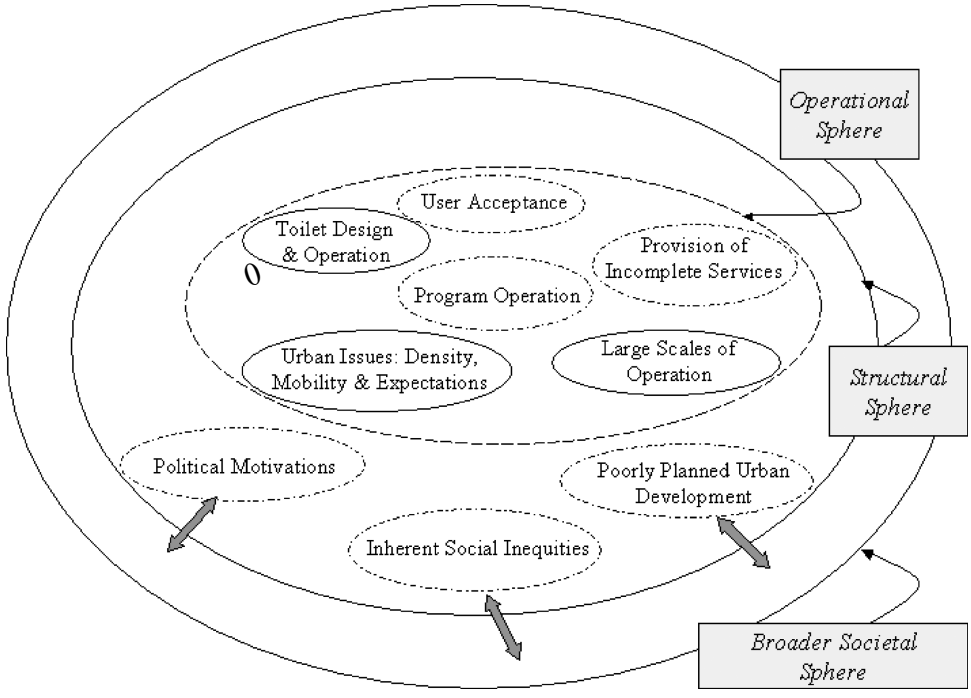

Figure 3. Barriers affecting dry sanitation programs once structural strategies are in place. *Note*: Dotted ovals around barriers indicate that the barrier has already partially been addressed by structural strategies. Two-way arrows indicate that solutions to these problems are partially dependent on broader societal action.

program success significantly. When possible, promoters should attempt to discuss DS options before the house is designed and built (as in Puerto Morelos and Tepoztlán sites). Efforts should be made to foresee all family members' needs (including children, elderly, gender-sensitive issues, etc.).

- Promotion/dissemination. This stage includes demand creation and the provision of information to users. Demand can be created through social marketing, health and environmental awareness building, and/or economic and regulatory incentives (Cordova 2003). The types of information users need to make knowledgeable decisions include the range of DT models available, suppliers, costs, responsibilities, existing support services, and the experiences of other DT users.
- Toilet production/construction. DTs and their components can be built on-site or prefabricated. They may be produced locally or imported, in both non-profit and commercial operations. Locally-appropriate decisions must be made regarding these alternatives and foresight should be given to production expansion (see increased scales of operation section below). Because toilets are intensely used equipment, attention to quality and durable materials is important.
- Toilet delivery. Programs have had most success when toilets were delivered soon after users' request (expressed demand) and in a complete and fully functional condition. When the users provide part of the DT cost (e.g. labor, materials or parts of the superstructure such as roof, walls, and door), it is paramount that the users' contribution be completed prior to final toilet delivery. In many cases, low-income users have not had the means to provide their part of the contribution and half-completed, idle toilets resulted (e.g. Acapulco, Puerto Morelos). When dealing with very low-income users, a revolving fund or some other financial scheme must be set in place to ensure that their contribution will indeed be met.
- User training. Training should identify direct and indirect benefits of the DT to users and should include all family members or toilet users. Training should address different needs based on age groups, gender and other categories. The toilet operation must be transparent to users: users must understand how and why the DT works (Fittschen and Niemczynowicz 1997, Del Porto and Steinfeld 1999, Thompson 2001). Users must also understand the time and labor involved in operation and maintenance (which is not necessarily much, but is important). The technology is simple, but the necessary change in habits is only consolidated over time (Añorve 1994), hence training should take place on a continuing basis, until toilets are consistently operating well.
- Follow-up and continuing support. A follow-up program should include: resolving doubts, providing technical assistance, fixing DT malfunctions, assisting users for the first few times in any new toilet operation step (mixing, shifting, emptying, etc.). In some cases, the first time the toilet is emptied can be 2–5 years after toilet installation. This means the follow-up program should be in place at least that long. Additionally, new users who move into homes with DS systems at later dates will need the same assistance, so some type of permanent follow-up system is necessary. Continuity and support are as essential for success in DS as plumbers and utility operators are in CS success. Support can likely be provided by a variety of actors including DT producers, promoters, or service providers for a diversity of DT systems (analogous to car mechanics and auto dealerships for auto owners).
- Other support services. Provision of cover material, collection of end-product, and servicing malfunctions are services that must be provided for the full lifetime of the DS system. These can be provided for free or for a fee, and by public, private or community/non-profit organizations.
- End-product management. Provisions should be made not only for end-product collection from households, but also for its further treatment and use. Due to non-ideal operating conditions, household DTs do not always destroy all the pathogens that laboratory settings claim (Redlinger *et al.* 2001). Therefore, it would be beneficial to consider central or neighborhood-level secondary treatment centers for end-products. The type and level of treatment will depend on the application they will be given. The re-use of nutrients from excreta should ideally not create more environmental impact than it avoids and thus the distance at which the nutrients are reused should be relatively close to the point of production.* Ideally, the full cycle of the DS process—including final use/disposal of the end-product (secondary treatment, burial and/or reuse)—should be demonstrated and made transparent to the community (Del Porto and Steinfeld 1999).
- Evaluation and feedback. Feedback systems should exist at all stages of the program, to improve or make local adaptations to toilet design, delivery, training, follow-up and support services needs. Toilet designs need to be continually improved or adapted for aesthetics, comfort and good excreta processing.

*Drangert (2001) reports the distance should be less than 200 km. This figure, of course, depends on the type of transportation used (solar-powered would have less impact than internal combustion vehicles), the weight and volume of the end-product, and other contextual factors such as the impact of the current sanitation technology (including sewage sludge transportation impacts).

Baseline monitoring of variables important to the program will also be essential in later determining program impact. Which variables are important (toilet use, hygiene behavior, water use, user satisfaction, etc.) will depend on program motivations and objectives.

- Well-planned program management. Budgeting and planning for a DS program must include material costs of production, transportation, and installation of the toilets, as well as dissemination, training, follow-up and support services costs. These program elements must be contemplated in timing, budget and personnel calculations. Sources of funding for all project phases should be contemplated and ensured before program initiation. The sources of cover material and the management of end-products must be worked out at the time of program inception.

3.3.2 Increased scales of operation. When increasing program scale, it is important to maintain program balance between three elements: a) interaction with users (creating demand, providing training, providing follow-up support); b) production capacity (capital, infrastructure, materials, and labor capacity); and c) organizational capacity to conduct the program (human resources, feedback systems, and hardware and software improvement capabilities). Additionally, it is important to take into account that larger scales bring new needs to the program.

a) As scale increases, the user population becomes more diverse and may need differential training, different incentive systems, and different demand creation techniques (e.g. some users may be more responsive to health or environmental education, others to economic or regulatory incentives). Special attention should be paid to identifying and addressing the needs of users that are slow adopters or less motivated.
b) As scale increases, production issues that arise are devising effective ways to produce/build the DTs at several sites and/or of transporting them effectively over long distances. The availability of additional raw materials and final products is not obvious (many programs use recycled materials or products from small suppliers who might not have the immediate capacity to produce larger quantities). Thus, a clear production expansion plan needs to be in place. When any of these factors has lacked (because programs promoted more than they were able to produce, or accepted increased demand too rapidly) toilet quality has decreased.
c) In a small program, one person may be able to address all promotion, training, and technical support needs, but in a large program teams for each type of activity will likely be necessary for effective program support. Enough human resources for program implementation and improvement are necessary.

3.3.3 Urban implementation. In urban settings, it is essential to strive for high user-friendliness and low user-labor involvement. It should be assumed that the majority of users will need a reliable and accessible supply of cover material, as well as a collection service for the end-product. Both of these services could be provided by one entity, be it a public, private or community service, or cover material might be sold at accessible locations (preferably walking distance from homes, as not all users have access to vehicles). Maintenance services would also increase urban acceptability of DS (Cordova and Knuth 2005). Secondary treatment of end-product and provisions for end-product reuse must be planned for, especially in urban settings. A diversity of DT models, including models that are adapted for small dwellings and higher stories, needs to be offered. Simple fanning of odors out of the DT may not be appropriate for dense settings—in DT models where excreta are not immediately covered, filters or other odor control systems may need to be included. Urban dwellers in many cases move often, so periodic retraining of households must be contemplated.

3.3.4 Complete set of services. Proper use of DTs depends to a certain extent on the availability of effective graywater and solid waste management systems and user acceptance of DTs depends to a certain extent on users' perception of having a complete set of services. In many cultures, bathroom 'completeness' includes having both toilet and washing/bathing facilities in the same room. Therefore, DS programs should try to make provisions both for effective graywater and solid waste management systems as well as for complete bathroom arrangements, when these are expected culturally.

3.3.5 User acceptance and incentive systems. User acceptance derives from several of the strategies, both structural and pragmatic, that we have described so far. Critical to user acceptance and matching services with their expectations of modernity or urban quality of life are: status, aesthetics, proper functioning, convenience, effective support services, and choice (ranging from having DS at all, to type of DT, to specific colors/shapes/location of the DT in their home (Cordova and Knuth 2005)). Affordability and cultural acceptability will also be important.

Incentives for DS will be necessary for at least two reasons: (a) because DS is to be introduced in societies that currently know and aspire for CS; and (b) because DS can require retraining and somewhat more user involvement than CS. We have mentioned the importance of demand creation, familiarity with alternative sanitation systems, and users' awareness of the social, personal,

direct and indirect benefits DS provides for them. Formal institutional support, regulatory sticks and carrots, and economic incentives systems, which correctly convey to individuals and communities the social, environmental and economic costs of different sanitation options, will also be important.

4. Who and how? Agents and format of strategy implementation

We do not suggest that there is one *who* or one *how* to implement the operational strategies we have presented. They could be initiated by one or more types of entities, including local governments, international agencies, water utilities, professional associations, private service providers, non-governmental organizations, community-based organizations, or any combination of these entities. The structural strategies, on the other hand, do require broader societal and sectoral involvement and support. It is likely that decision-makers, elected officials, professionals from the water, urban planning and construction sectors, funders, international agencies, communities and DT users will be involved. Depending on the local context, social relations, and users' interest, the process of strategy implementation may be more or less participatory or collaborative. Clear regulations and effective incentive systems need to be developed and user input will be crucial. Regulations and standards would be needed to guarantee uniformity, good quality performance, public and environmental health and compatibility between various excreta management systems within a modular framework. The exchange of experiences between DS programs has the potential to accelerate learning and development of the field. Approaches to implementing the strategies presented in this paper and to facilitate the exchange of experiences between DS programs have been presented in Cordova and Knuth (2003).

5. Conclusions

Dry sanitation (DS) is an option that might provide sanitation to large numbers of people and relieve environmental problems, if it is viable at large scales and in urban settings. However, many operational and structural barriers limit probabilities for program success. The former include: problems associated with program operation or with increased scales of operation, problems specific to urban settings, toilet design and operation deficiencies, incomplete service provision and conditions for low user acceptance. Structural problems include: program structural deficiencies, small, special and experimental program problems, lack of widespread knowledge about DS, political motivations, struggles surrounding irregular settlements and citizen rights, economic and professional resistance and association of DS with the perpetuation of social inequities.

Improving DS programs requires addressing both sets of problems. Structurally, bringing DS into the mainstream, making it formal infrastructure within a modular system that contemplates a repertoire of both wet and dry sanitation approaches, and increasing its social status are paramount. It is also important to disseminate information among professionals and policy-makers to counter the professional and economic resistance to alternative sanitation options. Operationally, an effective DS program should include: toilet model(s) selection, promotion/dissemination, toilet production/construction, toilet delivery, user training, follow-up and support services, end-product management, evaluation and feedback, and well-planned program management. Large-scale program balances between hardware, software and operational capacity must be maintained. Urban area programs should strive for maximum user-friendliness, low user labor, effective support systems, and periodic user (re)-training. DS programs will be more successful if promoted within the context of appropriate graywater and solid waste management systems provision, and will likely require incentives to encourage user acceptance and adoption. DS will be more readily adopted by poor households, communities or countries when they are shown to be acceptable and beneficial among rich households, communities and countries.

The strategies can be implemented by a diversity of entities, public, private, non-profit or community-based—but will likely need coordination and a regulatory framework that ensures minimum standards and compatibility of approaches. DS, considered as part of a repertoire of formal sanitation options, may be critical in achieving the international targets of halving the world population without access to improved sanitation by 2015, and providing improved sanitation for all humans by 2030. Whether DS can meet the challenge of large scale and urban implementation can only be tested in practice. We believe the analysis made in this paper provides a framework within which DS may prove its potential.

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