2.3 Health aspects

In the developing world inadequate water supply and sanitation facilities are the prime cause of widespread and serious health problems, but improvements in these services show few health benefits unless they are coupled to improved hygiene behaviour.

Inadequate water supply, poor sanitation, and poor hygiene all offer routes for transmission of faecally contaminated matter, the source of diarrhoea and many other diseases.

The main health benefits of both water supply and sanitation interventions lie in the reduction of faecal-oral diseases, of which diarrhoea, estimated to kill over three million people a year, is by far the most important.

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Health is one of the most important reasons for investing in water, sanitation, and hygiene. While the measurement of health improvements is extremely difficult, rigorous studies (Esrey et al., 1985, 1991) have demonstrated conclusively that well-designed projects can make important contributions to health. Experience shows that the provision of water and sanitation technology alone, without changes in hygiene behaviour, will usually achieve little or no significant health improvement. On the other hand, water and sanitation improvements can be the spur to changes in hygiene behaviour (see Section 2.8).

Principles

2.3.1 How water affects health

Water affects health in the developing world mainly through helping or hindering the transmission of communicable diseases such as diarrhoea, scabies, schistosomiasis, and malaria. These diseases are characterized by an infectious agent (e.g. bacteria or parasites), a human or animal host containing these agents, and transmission routes from old hosts to new hosts. Bradley (1972, 1977) and Feachem (1977) developed a useful classification of such communicable diseases affected by water (see Table 2.3.1). The system looks at the ways in which water affects infectious disease transmission, and thus the ways in which water interventions may reduce the burden of disease.

Faecal-oral diseases

This group includes cholera and other diarrhoeal diseases, typhoid, hepatitis A and E, and many other diseases which are spread by people swallowing faecally contaminated matter containing the organisms which cause these diseases. The main health benefits of both water supply and sanitation interventions lie in the reduction of faecal-oral diseases; of all of these, diarrhoeal disease is by far the most important.

Diarrhoea is estimated to kill over three million people every year, the overwhelming majority of whom are children. The toll is not just in mortality, but also in heavy morbidity (sickness); the median frequency of diarrhoea is 2.6 episodes of diarrhoea/child/year for those under five, while the median frequency among infants is five episodes/child/year (Bern et al., 1992). These are median rates, and vulnerable communities will experience much higher rates of attack. Many of these attacks are serious, and all demand time, care, and often money from the family.

Faecal-oral transmission can follow a number of routes as shown in the ‘F-diagram’ (see Figure 2.3.1). Water and sanitation affect transmission in a variety of ways. Sanitation, with good hygiene, acts as a fundamental ‘primary barrier’ by ensuring that faecal matter is disposed of safely, and does not spread in the environment. Once in the environment, however, there are many ways in which infected faecal matter can be spread. Good water supply can support a number

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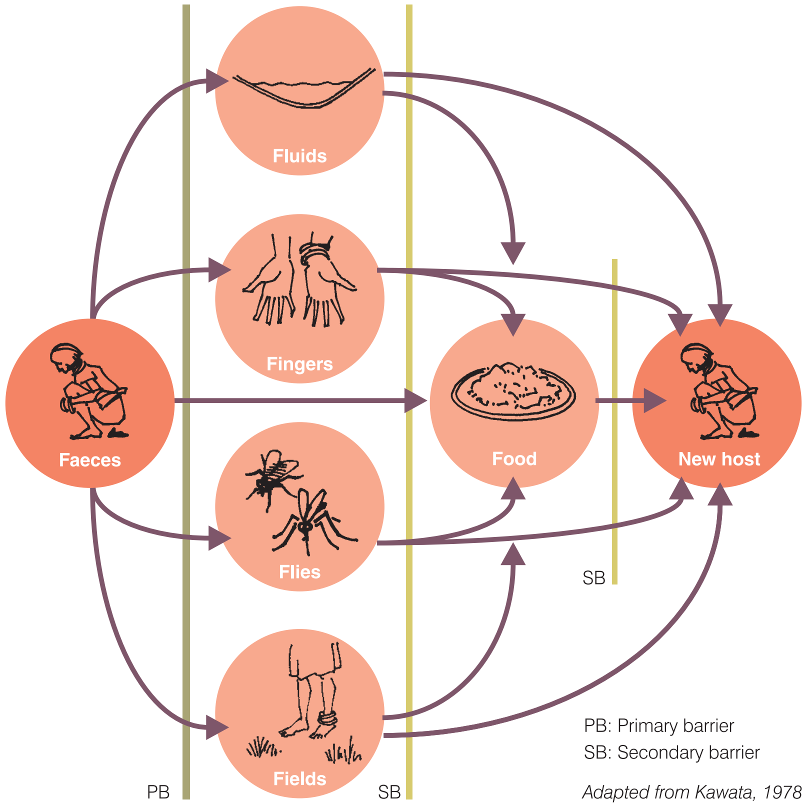
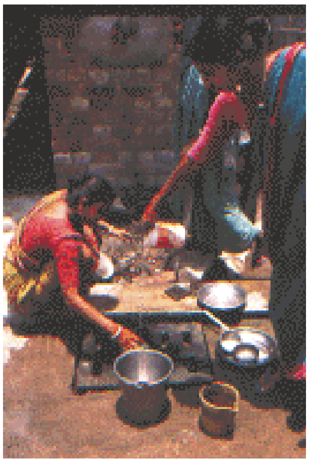


Figure 2.3.1. Transmission of disease from faeces



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of the 'secondary barriers', which prevent the further spread of contamination and infection to new hosts.

There are two ways in which water can affect faecal-oral disease transmission. One is through *water-borne transmission,* in which faecally contaminated water transmits the disease-causing organisms directly to the new host. Contaminated drinking water can lead to dramatic epidemics, in which large numbers of people are simultaneously exposed to infection. The second way is through *water-washed transmission*, that is, transmission encouraged by poor hygiene due to insufficient quantities of water for washing. Where water is scarce, it is very difficult to maintain clean hands, clean food, and the clean household environment essential to control many of the other routes of faecal-oral transmission.

Water-washed transmission is not as dramatic as water-borne transmission, as it does not often affect so many people at the same time. On the other hand, the conditions for water-washed transmission are common, and exact their toll every day, whether or not an epidemic is in progress. Water-washed transmission probably contributes more to the endemic (continuous) toll of diarrhoea than does water-borne transmission.

The distinction between water-borne and water-washed is important, because while improving the *quality* of drinking water can reduce

Good water *quality* is important as a faecally contaminated water supply can lead to direct ingestion of disease-causing organisms by many, possibly causing an epidemic. An adequate *quantity* of water, however, is more important in controlling non-epidemic disease, which in fact exerts a higher toll. Increasing the quantity of water available allows better hygiene and can thus prevent disease transmission from faecal contamination of hands, food, or household utensils. Washing hands and utensils in dirty water can still reduce contamination, and is better than not washing them at all.

Adequate quantities of water are relevant to many other diseases. No mortality is generally associated with a range of skin and eye infections but some millions are blinded by the eye infection trachoma; many of these diseases can be reduced by increasing water quantity.

water-borne transmission, increasing the *quantity* of domestic water *used* is the most important way to reduce water-washed transmission. Where water use is low, water-washed transmission is widespread, and simply increasing the quantity of water used, *regardless of its quality*, can be expected to reduce the transmission of faecal-oral disease. Put very simply, washing faecally-contaminated fingers and utensils, even with dirty water, is better than not washing at all. Increasing the quantity of water used by households is probably more important than increasing the quality to reduce the day-to-day non-epidemic toll of disease. Of course, increased water use is not a goal in itself, but an indicator of changes in hygiene behaviour. Under certain conditions it will result directly from improved access to water (see Section 2.3.7). On the other hand, hygiene promotion efforts need to be directed at specific behaviour changes, rather than at an increase in water use *per se* (see Section 2.8.4).

Strictly water-washed diseases

These are the diseases, apart from the faecal-oral diseases, which can be reduced through increasing the *quantity* of water available to households, regardless of its quality. Skin infections (e.g. scabies, body lice, tropical ulcers) and several eye infections (e.g. trachoma, conjunctivitis) fall into this category. Thus, in addition to reducing faecal-oral disease, increasing the quantity of water used in the household will also reduce these infections. Improved sanitation would not be expected to have any effect upon strictly water-washed diseases, except through the control of flies, which have been incriminated in the transmission of eye diseases.

Water-based diseases

These are parasitic infections of humans in which the parasite spends a part of its life cycle in an intermediate aquatic host. The two most significant diseases within this category are schistosomiasis (bilharzia) and guinea-worm. Improvements in water supply can significantly reduce these infections; indeed, water supply is a major focus of the effort to achieve world-wide eradication of guinea-worm.

Water-related insect vector diseases

These consist of a number of insect-borne diseases where the insect (known as a vector) spends a significant portion of its life cycle breeding or biting around water. These diseases include malaria, filariasis, yellow fever, dengue, and onchocerciasis (river blindness.) Domestic water and sanitation projects are *unlikely* to influence such diseases, with the possible exception of filariasis. These diseases, however, should be considered in the planning, development, and execution of large-scale water-resources projects. Good management of urban infrastructure (e.g. solid waste management, drainage, and construction site management) can also can be significant in reducing urban breeding sites for malaria, yellow fever, and dengue vectors.

Chemical contamination

As stressed in the *WHO Drinking Water Guidelines*, many chemical water quality standards (such as those for salinity, iron, and hardness) have evolved in response to such real consumer concerns as taste, 2

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Table 2.3.1 Summary of Feachem-Bradley Classification of Water-Related Disease (after Cairncross & Feachem, 1993)

Type of water related infection	Examples	Water-related control measures
Faecal-oral diseases	diarrhoea, typhoid, hepatitis, cholera	• increase *water quantity used* • improve *water quality*
Strictly water-washed	scabies, trachoma, conjunctivitis	• increase *water quantity used*
Water-based (intermediate host)	guinea-worm, schistosomiasis	• restrict contact, provide alternative sources
Water-related insect vectors	malaria, filariasis, river blindness	• focus on insect breeding sites (not much scope in domestic water supply)

Table 2.3.2 Inorganic drinking water contaminants of public health significance

Substance	Maximum guideline concentration (mg/l)
arsenic	0.01 (P)
cadmium*	0.003
chromium*	0.05 (P)
cyanide*	0.07
fluoride	1.5
lead*	0.01
mercury* (total)	0.001
nitrate (as NO_3)	50
selenium*	0.01

* *contamination likely to be from artificial source.*
P *provisional guideline*

staining, and excessive soap requirements. These are important, as they will have a significant effect upon the consumer choice of water source, but they are not directly related to health.

The number of chemicals which are both widely distributed and which constitute a significant health threat is fortunately small. Nevertheless, natural contamination by such chemicals as arsenic and fluoride can contribute to very serious health problems.

The main inorganic chemical contaminants of public health concern are shown in Table 2.3.2, although the reader is referred to the *WHO*

As noted in the *WHO Guidelines for Drinking Water Quality,* microbiological contamination is by far the most widespread and serious threat to health from poor water quality. In some cases (e.g. where levels of arsenic and fluoride are naturally high) there may be chemical dangers to which programme planners must be alert, but in most cases a good water supply will benefit users without the need for refined chemical analysis.

An obvious example of the need for balance in this area is the interest in trace carcinogens that can be produced by the chlorination of some source waters; the protection chlorine affords against the deadly 'faecal peril' far outweighs any hypothetical increase in cancer risk.

Guidelines for Drinking Water Quality (1993a) for a complete listing. Those marked with an asterisk are unlikely to be found in these concentrations in natural waters, and usually occur only as the result of artificial contamination (e.g. industrial leachate, lead pipes).

There can be little general guidance on the vast variety of possible organic contaminants from agricultural herbicides and pesticides. Where these are suspected to be a problem, analysis is a worthwhile investment. Where there is no reason to suspect a problem, however, such analysis is unwarranted and far from routine. This point holds in general for chemical hazards. It is not realistic or worthwhile to propose chemical testing of all water sources, especially in rural areas, for possible contamination.

Most pesticides are insoluble emulsions, and tend to sink to the bottom of surface water bodies. They accumulate in the food chain, particularly in bottom-feeding fish. Long before pesticides reach concentrations which constitute a health hazard in water, therefore, they will have reached far greater and more hazardous levels in the fish, and in those who eat them.

Over the past twenty years there has also been growing concern in the engineering community about the formation of trace amounts of carcinogenic organic compounds (for example, carbon tetrachloride)

Table 2.3.3 Some orders of magnitude of the world-wide extent of water-related disease

	Morbidity	Mortality/year
1. Faecal-oral		
diarrhoeal disease	1,000 million episodes/year	3.3 million
cholera	>300,000	>3,000
enteric fevers	>500,000	>25,000
roundworm (Ascariasis)	20–40% rate of infection in developing countries	
2. Strictly water-washed		
trachoma	6-9 million blind	
skin infections	very common, millions	
3. Water-based intermediate host (parasitic)		
schistosomiasis	200 million	>200,000
guinea-worm	1989: 890,000 1996: 35,000 (and still dropping!)	
4. Water-related insect vector		
malaria	300-500 million cases	1.5-1.7 million
filariasis	128 million	
dengue	30-60 million infected/year	

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from the chlorination of drinking water. The risks from such compounds pale into insignificance compared with those from drinking water which is not reliably disinfected, and any claim that an alternative disinfectant to chlorine is safer on these grounds should be treated with suspicion.

2.3.2 How sanitation affects health

The cycle that leads to faecal-oral disease transmission begins with poor sanitation. Failure to dispose of human excreta safely can contaminate the environment and new victims through a variety of routes. While contaminated water supplies are one route, poor personal and household practices can spread disease in other ways. Even where acceptable sanitation facilities are installed, the risks are not eliminated, as poor hygiene can still spread disease through a variety of faecal-oral routes.

Sanitation, defined in these guidelines as 'the safe management of human excreta', naturally has its greatest impact on excreta-related diseases. The chosen definition of sanitation rightly includes both 'hardware' and 'software' components, as effective interventions need to stimulate both the construction of sanitary *facilities* for excreta management, and their hygienic *use*.

Understanding the health aspects of sanitation requires some understanding of the types of diseases involved, how they are transmitted, and how sanitation hardware and hygiene promotion are likely to affect them. The classification described below was developed by Bradley and Feachem (Feachem et al., 1983), and this summary follows closely that of Cairncross and Feachem (1993).

Faecal-oral diseases

These diseases, described earlier by the 'F-diagram' (Figure 2.3.1), are among the most obvious targets of sanitation for health; they are endemic throughout the developing world. The effectiveness of sanitation as an intervention in reducing faecal-oral diseases can vary substantially with the required dose for infection. Bacterial infections, such as cholera, often involve large infective doses, and these are naturally more susceptible to control through sanitation than other diseases, such as polio or hepatitis, which require only a small dose to spread the disease. Many of the faecal-oral diseases (e.g. salmonellosis) involve transmission cycles that can pass through animal hosts, which therefore limits the benefits of controlling only human excreta. Controlling human wastes will do little good if the disease can be spread by the excreta of chickens in the household.

Soil-transmitted helminths

Sanitation alone has its greatest impact on parasitic worm infections. These diseases, like the faecal-oral group, are endemic in the developing world and can be significantly reduced by eliminating excreta or sludge disposal on the ground around habitations, including areas accessed by pigs and cattle.

These are parasitic worm infections where the eggs, passed in human faeces, require some time in favourable conditions, usually moist soil, to mature and become infective. These diseases include roundworm, whipworm, and hookworm, which are debilitating diseases that can contribute to malnutrition and can become severe conditions in their own right. These diseases are widespread throughout the developing world. Good sanitation facilities, which are regularly cleaned, can make a significant contribution to the control of these diseases; a poorly maintained latrine, however, can actually become a focus of infection.

Beef and pork tapeworms

These tapeworms require a period in the body of an animal host before they re-infect humans when the animal's meat is eaten without being cooked sufficiently . Any system which prevents pigs and cattle from eating untreated excreta, or grazing on soil contaminated by fresh sewage or sludge, will therefore control the transmission of these parasites.

Water-based helminths

This group is the same as the 'water-based intermediate host' group described for water, with the exception of guinea-worm, which is unrelated to excreta management. The most important member of this group is schistosomiasis. Since one worm can multiply in the snail host to produce thousands of larvae each day for over a year, faecal contamination must be practically eliminated to reduce transmission. Under these conditions, restricting human contact with water (e.g. through provision of convenient water supplies) is likely to be far more effective than sanitation alone.

Excreta-related insect vectors

There are two groups to consider. Firstly, *culex* mosquitoes, which do *not* transmit malaria but can transmit filariasis, breed extensively in septic tanks and flooded latrines. Secondly, flies and cockroaches often thrive on excreta and have been implicated in some transmission of faecal-oral disease. Mosquitoes, flies, and cockroaches all constitute a great nuisance, and poor urban households have consistently been shown to spend substantial amounts of their scanty household income on using control coils and nets.

Table 2.3.4 Sanitation-related disease, and the likely effects of interventions (after Cairncross & Feachem, 1993)

Category	Examples	Dominant transmission mechanisms	Likely effect of sanitation hardware alone	Likely effect of hygiene promotion alone
Faecal-oral (non-bacterial)	Hepatitis A Amoebic dysentery Rotavirus Giardiasis	Person-to-person contact Domestic contamination	Negligible (as very low infective dose required)	Moderate
Faecal-oral (bacterial)	Cholera Salmonellosis Shigellosis Many forms of diarrhoea	Person-to-person contact Domestic contamination Water contamination Crop contamination	Slight to moderate	Moderate
Soil-transmitted helminths	Hookworm Roundworm Whipworm	Yard contamination Communal defecation areas Crop contamination	Great	Negligible
Tapeworms	Beef tapeworm Pork tapeworm	Yard contamination Field contamination Fodder contamination	Great	Negligible
Water-based helminths	Schistosomiasis	Water contamination	Moderate	Negligible
Excreta-related insect vectors	Filariasis Some faecal-oral diseases	Insects breed or feed in sites of poor sanitation	Slight to moderate	Negligible

Experience shows that WS&S hardware improvements, without effective hygiene promotion, are not enough to improve health significantly among poor communities. Making water available in or near the house leads to a natural increase in washing, but other beneficial changes to hygiene behaviour require other forms of promotion.

In 1992, an informal WHO working group reviewed epidemiological literature and field experience in hygiene promotion, and identified three areas where particular attention should be focused:

- the safe disposal of children's stools;
- the washing of hands with soap after defecation and before touching food; and
- the safe storage of water in the household.

WHO, 1993b

The above classification summarizes the various ways in which sanitation can affect health. The faecal-oral group exacts by far the heaviest toll in human health of all the sanitation-related diseases, followed by the soil-transmitted helminths. While the above discussions only promise 'moderate' success in their control, this is far more significant than much greater success in controlling much rarer diseases.

2.3.3 How hygiene affects health

Hardware by itself cannot improve health very much; what matters is the way in which it is *used*, and the ways in which it *may promote changes in hygiene-related behaviour*. In some cases this change is fairly automatic; people across the world need little encouragement to increase the amount of water they use for washing once it is readily available at the household level. In other cases, however, a significant amount of time and effort is required to alter hazardous practices which are considered 'safe', or are simply not thought about.

Even after substantial investments have been made in water and sanitation hardware, hygiene behaviour in these areas often remains a substantial risk to health. In many cultures, for example, the excreta of young children are considered safe, and are thus not treated with the same hygienic concern as the excreta of adults. In fact, as children are the main victims of faecal-oral diseases, they are consequently the main reservoir of infection. This means that the faeces of children are more infectious than those of adults, as they are more likely to contain the disease-causing organisms.

The practice of washing hands with soap after defecation is another example of a behaviour that does not follow 'automatically' from the provision of hardware, and yet which has major health implications. A classic study by Khan (1982) in Bangladesh showed that the simple practice of washing hands with soap after defecation was sufficient to reduce the secondary attack rates of dysentry within participating families by 85 per cent. Similarly, B.C. Deb et al. (1986) examined transmission within families with one proven case of cholera. Some families were provided with a traditional *sorai* water storage container with a small diameter inlet and outlet which does not permit users to dip into the storage container; control families used the more widespread practice of dipping into a common bucket. The rate of cholera transmission within the families with the *sorai* was 75 per cent lower than that in the families using conventional water storage and dipping. While such an intervention may not have much impact on transmission *between* families, it is a simple, effective, and low-cost intervention to reduce transmission within the family (see Section 2.8.7).

2.3.4 Epidemiological summary of WS&S interventions

Esrey and colleagues (1985, 1991) have been involved in a number of reviews of the epidemiological literature of water and sanitation. These reviews have demonstrated a wide range of results for superficially similar interventions. Some discrepancies may arise from poor study design and an inability to control for such variables as hygiene and socio-economic status, while others may stem from the very complexity of the problem and the variety of transmission routes and disease-causing organisms. Esrey's results for the relatively few rigorous studies which were felt to be relatively free of methodological error are summarized below.

Table 2.3.5 Diarrhoeal morbidity reduction from WS&S (Esrey et al., 1991)

	Rigorous studies	
Type of intervention	No. of studies	Median % reduction
Water and sanitation	2	30
Sanitation	5	36
Water quality and quantity	2	17
Water quality	4	15
Water quantity	5	20
Hygiene	6	33

Looking at the effects of water supply improvements on other diseases, Esrey found the following:

Table 2.3.6 Effects of improved water supplies on non-faecal-oral disease

Disease	No. of rigorous studies	Median reduction in morbidity	Range
Guinea-worm	2	78%	75-81%
Schistosomiasis	3	77%	59-97%
Trachoma	7	27%	0-79%

Adding good hygiene to WS&S interventions is not the end of the story. Lack of attention to other aspects of community environmental health can detract from or nullify the intended benefits. Poor solid waste management encourages rats, flies, cockroaches, and other vectors of disease. Uncontrolled waste tips in poor areas often contain faecal matter and are fertile breeding grounds for pests. Indiscriminate rubbish dumping can lead to blocked drains and overflows.

Note that guinea-worm is the only one of these water-related diseases where water-quality was significant to the intervention; the benefits of water supply improvements in reducing schistosomiasis stem from reducing contact with infected bodies of surface water, and the reduction in trachoma resulted from increased quantities of water allowing better personal hygiene.

2.3.5 Health aspects of other components of environmental sanitation

There is more to environmental health than water supply, sanitation, and hygiene. In developing countries, the other main environmental health measures include drainage of surface water and sullage, solid waste management, and vector control. These will only be discussed in these guidelines as they relate to water and sanitation interventions.

Drainage

No sanitation system can be considered 'safe' if the area it serves is poorly drained. *Any* sanitation system (sewer, septic tank, pit latrine, or other) can become a source of faecal contamination when flooded, as the flood waters will mix with the excreta and spread the

In adequate drainage of surface water and sullage can lead to local flooding and spread of waste from foul sewers, septic tanks or latrines.

Sometimes the best investment in drainage is better solid waste management.

Where improving community health is a major objective for a WS&S intervention, appropriate health specialists need to be involved from the beginning. Unless health issues are properly reflected in the project design from the start, technical planners are unlikely to achieve significant improvements in community health.

contamination wherever the water flows. 'Sullage' consists of domestic water exclusive of toilet waste, but this does not mean that it is safe; water used for cleaning clothes and nappies can be heavily contaminated with the same disease-causing organisms that sanitation is intended to control. 'Runoff' consists of the portion of rainfall that runs off the surface during or after a storm. Sewers are often designed to drain all three liquid wastes (toilet wastes, sullage, and runoff) but they can be very expensive. Regardless of the technical option chosen for sanitation, both runoff and sullage need to be disposed of safely if a sanitation system is to be considered complete.

Solid waste management

Piles of rubbish in the streets or at dump sites can provide a habitat for rats and flies, and thus contribute to the spread of a number of diseases; rats are major vectors of plague, leptospirosis and other infections, and flies are one of the transmission routes in the F-diagram for faecal-oral disease. In addition, tin cans and tyres can contribute a significant breeding ground for *Aedes* mosquitoes, which transmit dengue and yellow fever. Apart from these direct health impacts, solid waste is also linked to the faecal-oral transmission route in a number of ways.

First, where sanitation is poor, faecal matter can often be a significant fraction of 'solid waste'. In Lucknow, for example, DFID-funded studies of sanitation and solid waste estimated that the contents of 'dry latrines' contributed 30 to 40 tonnes/day or five per cent of the total mass of the solid waste chain; this excludes the faeces discharged to the small and large drains of the city. Given the lead time required for replacement of dry latrines with more sanitary options, it was clear that attention had to be directed to the solid waste system in the short run to address the inherent health risks.

Secondly, unmanaged solid waste usually ends up blocking surface water drains or sanitary sewers, and thus contributes to flooding and the faecal contamination described earlier. Sometimes the best investment in drainage is better solid waste management.

Vector control

Many municipalities have a group that is responsible for pest and vector control. These operations are primarily aimed at reducing the hazards from mosquito-borne and rat-borne diseases. As mentioned earlier with regard to excreta-related insect diseases, septic tanks and flooded latrines can become a focus of *Culex* mosquito breeding, and construction sites can become 'temporary' (but dangerous) breeding grounds for malaria-carrying *Anopheles* mosquitoes. Consultation with the vector control staff at the municipal level can help to establish how serious these problems may be on a given project, and may forestall the possibility of water and sanitation 'improvements' actually making the situation worse.

Public and domestic domains

In thinking about environmental health, it is helpful to distinguish between the *public* and *domestic* domains of transmission. The domestic domain is defined as the area normally occupied and under the control of a household, while the public domain includes public places of work, schooling, commerce, and recreation, as well as public infrastructure, streets, and fields (Cairncross et al., 1996). Whereas transmission in the public domain can allow a single case to cause a large epidemic, transmission in the domestic domain, while less dramatic, can account for a substantial number of cases and a significant fraction of endemic disease. Infection in the public domain is relatively widespread and indiscriminate, whereas infection in the domestic domain is characterized by clustering around those households where sanitary conditions, for whatever reason, are poor.

Work done in Brazil (Moraes, 1996) studying ascaris (roundworm) and other worm infections found that the provision of drainage (which also acted as sanitation) reduced the overall level of infection. The work also suggested that as the infection level dropped, it tended to become more clustered by household. The results thus suggested that drainage made wastewater contamination of the streets less common, and reduced infection in the public environment. Once the public transmission had been reduced, however, the residual transmission between household members in the domestic environment became relatively more important.

There is a temptation when dealing with public services and public health to focus on the public domain, and this may well be a suitable first priority. The studies showing the benefits of hygiene in improving health, however, illustrate the critical role of promoting health at the household level as well as in the public environment.

Practice


DFID/Howard J Davies

How do the above principles translate into practice? What are the aspects of water and sanitation projects and programmes that are most important to consider in practice to maximize health? As shown above, the requirements for improved health involve good hardware and good software; providing reliable, effective, and low-cost hardware are described in Sections 2.5, 2.6, and 2.7, while the application of health principles to hygiene and sanitation promotion is described in Section 2.8. Given the detailed coverage in these specific areas, there are only a few fundamental points of practice to reiterate here.

2.3.6 Think about health from the start

A common difficulty in any multidisciplinary activity is the temptation for members of one discipline with a strong interest to develop most of the project, while involving the other disciplines only in the later stages of the work. This can be particularly troublesome when activities with a substantial lead time (such as the data collection and training of hygiene promoters, or the establishment of systems to develop and market low-cost sanitation options) are ‘invited’ into the project only in the later stages, when fundamental decisions about the level of service and the types of intervention have already been made by the 'lead' stakeholders. If health benefits are likely to be a major justification of the project, it is critical that competent public health specialists be involved from the outset to assess the scope and plausibility of these health benefits. These specialists can then contribute to the development of relatively low-cost project or programme activities which can ensure that such benefits are maximized. As with any discipline, it is easier to contribute when involved from the beginning than if added in as a 'bolt-on.'

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2.3.7 Focus on quantity as well as quality of water supply

Quantity, as well as quality of water must be a focus of attention.

When water is brought within easy reach of the household water use increases dramatically. When water is further away or involves a return trip travel time exceeding half an hour water consumption drops off. (Note that queuing can be a significant contribution to this time.) Between these two extremes, however, water consumption is surprisingly constant and does *not* vary substantially when the return trip travel time is in the approximate range of three to thirty minutes. Reducing tap spacing in this range reduces drudgery and work and saves time but will not lead to increased water consumption and resultant health benefits.

It is intuitively clear that the quantity of water a household will actually use must somehow be related to its distance from a water source; we would all expect households with house connections to use more water than households an hour away from the nearest source of water. While this intuitive perception is certainly true, detailed water use studies carried out in the 1970s and 80s have reached a surprising consensus on water-use patterns between these extremes. Cairncross (in Cairncross & Feachem, 1993), developed the diagram below as a summary of the results of these water-use studies in East, West, and Southern Africa, Nicaragua, India, Sri Lanka, and Bangladesh. (While the exact levels of the graph vary from site to site, the shape and 'turning points' are similar at all sites. It has been noted — e.g. by Thompson (1998) — that the 'water consumption versus tariff' graph is conceptualy similar, and in fact has been observed to have a similar shape.)

Schemes which increase the number of public taps, in either rural or urban settings, but only move residents 'along the plateau' of the consumption vs. travel time graph, will *not* increase water consumption at the household level, regardless of how much water is available at the tap. Such an intervention cannot be expected to reduce water-washed transmission of disease, and therefore can claim relatively few direct health benefits. By contrast, schemes which permit more house connections, or which reduce long travel times to below half an hour, can be expected to lead to increased water

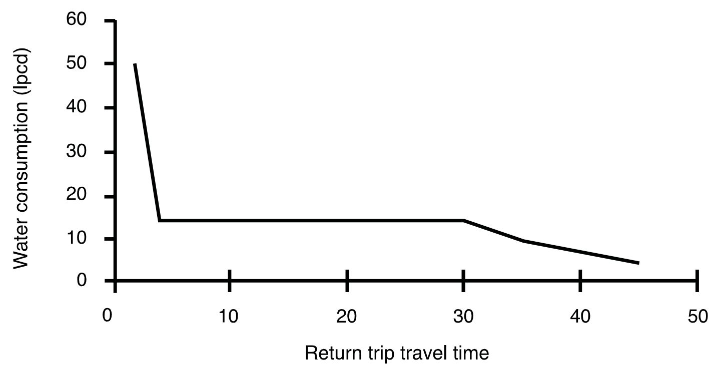

Figure 2.3.2. Water consumption vs travel time

consumption, and a reduction in water-washed disease. This principle is reflected in the policies of a number of organizations; WaterAid, for example, has as one of its main criteria for appraisal of rural water schemes the reduction of travel times from very distant sources.

2.3.8 Focus on changes at the household level

Programmes intended to improve environmental health must be driven by the impact they have at the household level. This is where most people (especially children) spend most time, and are most vulnerable to contamination. Unless improvements can be shown to have an impact at the household level, they are unlikely to improve health.

Changes to centralized infrastructure are unlikely to improve health unless they reduce contamination at the household level. People are likely to be most at risk from contamination when it is present in places where they spend the most time. One way to see this in an urban context is to think about the environmental priorities of many city-dwellers. The first environmental priority for most families is a clean and pleasant household, followed by a better environment in their street, followed next by a cleaner neighbourhood; only after these are all satisfied can there be much real concern over the city-wide environment and beyond (see Figure 2.3.3). This ranking is similar to the priorities from a public health perspective, which stresses the need for a clean and hygienic environment where people spend most of their time. In particular, the age distribution of sickness and death associated with poor water and sanitation stresses the need to look at where *children* become infected, and where *children* spread infection.

The health benefits of sanitation also reflect a household focus. A number of studies have shown that health benefits accrue to families who have latrines, even where neighbours do not. So, there is no minimum threshold of coverage required to achieve health improvements. The improvements are synergistic, however; additional benefits will accrue if the whole community is covered. ‘Coverage’ here, however, refers to household sanitation. Communal or public latrines are invariably either poorly maintained or else too costly to attract the most vulnerable; poorly maintained public latrines are a definite health hazard.

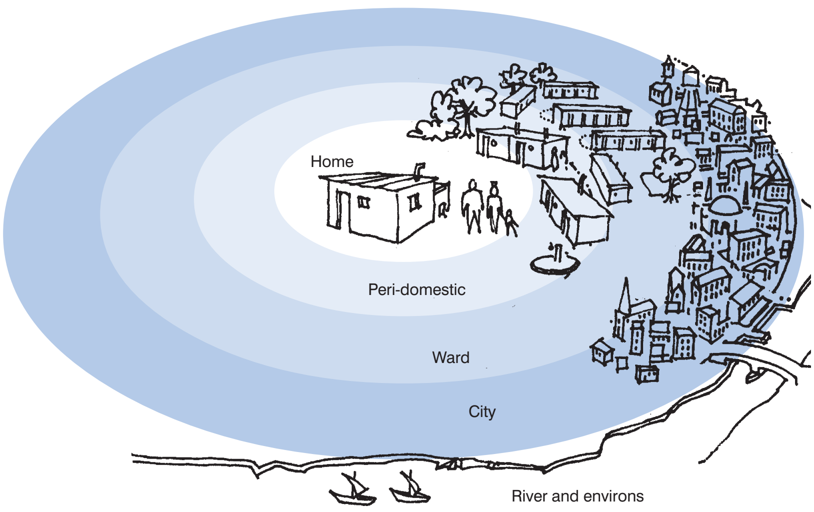

Figure 2.3.3. Environmental priorities of city-dwellers

2

2.3

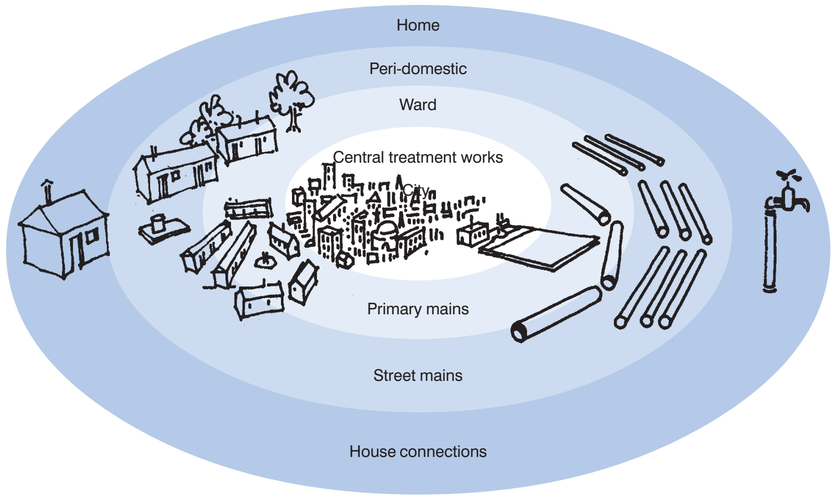

Figure 2.3.4. Environmental priorities of engineers and planners

This focus on the household can seem odd at first glance to the professional engineer, who may see instead that the whole system is dependent upon the centralized treatment works, or the functioning of the primary mains or sewers (see Figure 2.3.4). It is fair to say, however, that unless investments in such centralized resources reduce risk at the household level, they will not contribute to health. Investing in a water treatment system where intermittent distribution could result in re-contamination before water reaches the household, for example, offers little hope of improving health. A focus on the need to change practices at the household level also means that more effort must be spent on hygiene and sanitation promotion, and on ensuring that the services offered are what individual householders want (see Section 2.8.2).

2.3.9 Seek improved health indicators, rather than improved health statistics

Health impacts from WS&S interventions are notoriously difficult to assess. There are too many random variables to gain reliable information from statistics-based surveys. Better results come from observing practical outcomes such as the use and maintenance status of facilities, or improvements in hygiene practice.

Esrey's studies cited above, and earlier work by Blum and Feachem (1983), stress the enormous difficulty of managing rigorous studies that *prove* a health improvement is attributable to a water and sanitation intervention. Seasonal effects, the community-wide nature of the intervention (variations between health statistics in villages may well be due to chance), the difficulty in establishing controls, the epidemiologically short timeframe of most development projects, and the ever-present risk of confounding, make the epidemiological 'proof' of health benefits a far larger task than should be reasonably attempted in a development project. (For example, what kinds of people build latrines? Those who are more concerned about hygiene. It may not be surprising that they are therefore healthier than those who do not.)

Instead, it makes sense to look for practical indicators that point the way to changed health. Are the facilities in good order? If so, are they being used? If they are being used, have they contributed to changes in hygiene? The answers to these questions are much more reliable and sensible than most health statistics, especially where most diarrhoea goes unreported, and variations between seasons and years (with the odd epidemic) may contribute too much confusion to the analysis.

The logical frameworks for urban and rural projects in the Appendices include appropriate proxy indicators for health.

Further reading

Cairncross, S. and Feachem, R. (1993) *Environmental Health Engineering in the Tropics*, 2nd edition, Wiley, Chichester.

The first chapter of this book presents, in clear and simple terms, the basic issues of environmental health in developing countries, particularly those associated with water and sanitation. The remainder of the book describes the variety of engineering interventions developed to control these problems, and makes the necessary link between engineering intervention and health. Practical issues of management, institutions, and cost are also described.

Feachem, R., McGarry, M., and Mara. D.D. (eds.) (1977) *Water, Waste, and Health in Hot Climates*, Wiley, Chichester.

Although slightly dated, this book still has much to offer in its broad interdisciplinary perspective, and its realistic recognition of the financial, institutional, and economic constraints upon the improvement of water and sanitation in developing countries.

Hardoy, J.E., Cairncross, S. and Satterthwaite, D. (eds.) (1990) *The poor die young*, Earthscan, London.

An integrated review of the relationship between housing, infrastructure, and health among the poor in urban areas of the developing world. The book explores both the housing and health conditions in which the urban poor find themselves in different parts of the world, and the types of interventions most realistic for improving these conditions. The book is written for the general interested reader, and no previous technical knowledge is assumed.

Webber, R. (1996) *Communicable Disease Epidemiology and Control*, CAB International, Wallingford.

A clear and complete introduction to the issues of communicable disease control from the perspective of a public healthworker. Although this book was principally written for doctors working in rural areas in developing countries, the approach, text, and drawings are clear enough for the interested non-specialist; no engineer should be afraid to read it! The roles of water and sanitation are clearly recognized and explained.