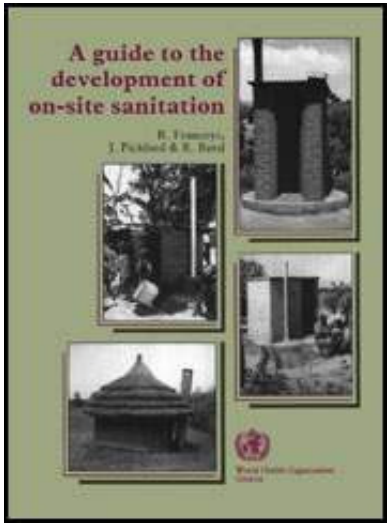



# A Guide to the Development of On-site Sanitation (WHO, 1992, 246 p.)

## Part III. Planning and development of on-site sanitation projects

### Chapter 9. Planning

- *(introduction...)*
- The demand for sanitation
- Project definition
- Background information
- Comparison and selection of systems

### Chapter 10. Institutional, economic and financial factors

- Institutional responsibilities
- Human resources development
- Economic factors
- Financial factors
- Examples

### Chapter 11. Development

- *(introduction...)*
- Implementation
- Operation and maintenance

# Evaluation

## A Guide to the Development of On-site Sanitation (WHO, 1992, 246 p.)

## Part III. Planning and development of on-site sanitation projects

## Chapter 9. Planning

**Many methods are used to provide or improve on-site sanitation. At one extreme, a project may involve detailed documentation (Grover, 1983) using the "project cycle" approach. At the other extreme, sanitation advances when individual householders build their own improved latrines, often because they have seen similar latrines built by neighbours. Many projects and programmes for improving sanitation lie between these extremes. Planning involves consideration of the local situation leading to selection of suitable types of sanitation. Designs are prepared and construction follows. On completion, and sometimes at intermediate stages, evaluation takes place.**

**With some projects, the form of planning and development is laid down by procedures which must be rigidly followed if external funds are to be released. However, in many successful programmes, development depends on the action of householders. Planning then leads to selection of appropriate forms of sanitation. Householders may be encouraged to adopt the selected types of sanitation by health education programmes, by technical or material support, or by other measures. The ways in which the different stages of planning and development may be regarded at various levels are shown in Table 9.1.**

### The demand for sanitation

**The initial demand for provision or improvement of sanitation in a particular area may come from the local people themselves or from a small group of active leaders in the community. Alternatively, the initiative may come from health officials, a government department, the organization responsible for water and sanitation, a bilateral aid agency, or a national or international voluntary organization. Ideally, sanitation improvements should be carried out in accordance with a national or regional sector plan and the adopted primary health care programme. A sector plan often covers both sanitation and water supply. It indicates the number of facilities to be provided, the number of people to be served in each district on a year-by-year basis during the planning period, and the resources needed. Particular attention is usually given to requirements for internal and external funding and to deficiencies in personnel of various categories.**

**There may be several reasons for a sanitation programme.**

- **There may be a genuine concern for health accompanied by an awareness that a high local level of disease is associated with existing sanitation practices.**
- **Household latrines may be called for because of the convenience they offer to users.**
- **Good sanitation may be a status symbol.**
- **Existing excreta disposal methods may result in unacceptable pollution of surface water, soil or groundwater.**
- **Sometimes a demand for improved sanitation is associated with water**

**supply. For example, a funding agency may require latrines to be constructed before it will provide piped water, or a water authority may wish to protect the catchment area for the supply to a nearby town by eliminating indiscriminate defecation. An increase in the amount of water provided to an area may lead to a demand for better wastewater disposal.**

## Table 9.1. The project cycle

| Government ministries and donor agencies | Implementing agency | Community |
|---|---|---|
| **Identification** | | |
| Definition of target population | | Felt need for improved sanitation |
| Determination of economic and health indicators, present service coverage and standards, objectives and policies, financial implications, staffing requirements, and training needs | | Exposure to health education |
| Assignment of planning responsibilities | | |
| **Pre-feasibility surveys** | | |
| Consideration of alternative projects to meet objectives taking into account technical, social, health, environmental, financial and economic criteria | Technical and social surveys | Response to questions by health workers and government officials about health, wealth, water and sanitation |

| | | |
|---|---|---|
| | Planning with the community | |
| **Feasibility demonstration** | | |
| Detailed design and analysis of preferred/chosen project | Proving of recommended range of technologies at affordable price to satisfaction of representatives of proposed target group | Discussion regarding experimentation with affordable means of improving sanitation |
| **Appraisal and approval** | | |
| Independent check on planning, usually by representatives of funding source | | |
| Investment decision | | |
| Release of funds for project implementation | | |
| **Implementation** | | |
| *Consolidation* | | |
| | Training, administrative support procedures, proving technology | Training of local people to assist with programme |
| | Determination of financial, material and technical | Invitation to local artisans and |

| | | |
|---|---|---|
| | support | contractors to participate |
| | | Drawings made available |
| *Expansion* | | |
| | Mass promotion in the community | Publicity about the programme |
| | Health education, use of media | Systems available to copy |
| | Demonstration units as "sanitation supermarket" | Drawings made available |
| | Financial, material and technical assistance where appropriate | Financial assistance available |
| | | Local artisans and contractors available to help with building |
| | | Household decision as to purchase of sanitation system |
| *Operation and maintenance* | | |
| | Advice on responsibility of household to use and care for on-site system | Use of facilities |

**Evaluation**

| **Evaluation** | | |
|---|---|---|
| Identification of further projects | Identification of positive and negative aspects; reformulation of design criteria | Comments regarding desired improvements |

## Project definition

## Scope

**Early in the planning process the extent of the programme or project must be assessed. This involves making an estimate of the number of people or households who will be covered. A house-by-house survey may be undertaken, or the necessary information obtained from health staff, government departments or local leaders.**

## Priority areas

**A list is drawn up comparing the needs of different areas. Priority should be given to people with especially poor facilities for excreta disposal and areas with a high incidence of diseases associated with poor sanitation. Areas with a high population density or congested housing may justify special attention. However, houses intended for temporary occupation may warrant less attention than permanent buildings.**

**Other factors that influence the selection of priority areas are the interest of the local communities in sanitation improvements and their record of participation in other projects. Ability and willingness to contribute financially may be other**

**criteria for the selection of priority areas. Projects generally depend on a financial contribution from householders; occasionally priority is given to people most likely to pay or those willing to try new ideas. For projects that are externally funded, the poorest people may be selected for preferential treatment, on the assumption that better-off families should pay for their own latrines.**

**Background information**

**Careful consideration should be given to all relevant factors in order to decide on the most appropriate form of sanitation and the most effective way of providing it. These factors include public health, socio-economic, cultural, financial, technological, institutional, and other considerations.**

**A large unified project may require several reports by agency officers or consultants. Long written reports are unnecessary for small projects and for programmes that consist of a succession of small schemes. However, whether a large or small scheme is planned, all relevant factors need to be carefully considered.**

**The responsible agency**

**The planning and implementation of a simple programme for a few households may be within the capacity of a small committee of interested people, preferably with an enthusiastic leader. Larger programmes may depend on government initiative, or on the support of an external body such as a bilateral agency, one of the international organizations, or a local nongovernmental organization. The degree of involvement of an agency varies considerably according to the nature of**

**the project, the type of agency and other national and local conditions.**

## Staff

**Staff employed to plan sanitation projects should be carefully selected and prepared. Unless they have previously worked on similar programmes, the people appointed should receive formal or informal training, preferably on site with an existing sanitation project. It cannot be too strongly emphasized that the staff involved in all stages of a low-cost sanitation programme should be familiar with technological, management and sociological issues. They should also be familiar with the local financial and socioeconomic conditions, i.e., the standard of living of the local communities, and be aware of the important role that women, social workers and nongovernmental organizations can play.**

## Community participation

**The involvement of the community in any project is essential for its success, because almost all on-site sanitation work depends on decisions made by individual householders. The extent of involvement will vary in different countries. Urban communities often play a role that is quite different from that undertaken by village people, and this is likely to be different again from that of those living in dispersed family units. Some groups of people are homogeneous; others comprise various cultures and socioeconomic levels.**

### *Key leaders*

**Early contact should be made with key leaders, who may sometimes be identified with the assistance of the local health officials. The key leaders may be the chiefs**

**and elders of villages, or people appointed by the government or political party. In some areas local schoolteachers or business people with education above the average may be useful as sources of local information and for an exchange of views.**

***Minority groups***

**Whoever are selected as key leaders, care must be taken to ensure that the views of all sections of the community are represented. It may be necessary to seek out leaders of minority groups and representatives of those without political influence. In particular, the views and support of women should be sought. These are often best obtained by women social workers.**

***Community needs and aspirations***

**Initial assumptions regarding the need for improved sanitation in the area as a whole and particularly in priority areas should be verified through contacts with key leaders and health workers. In particular, the incidence of excreta-related disease should be checked, as should awareness of relationships between sanitation and disease and of other disadvantages of existing excreta disposal practices, such as fly nuisance.**

**Care must be taken to avoid raising unreasonable expectations. At the same time, the local people should be made aware of the potential benefits of improved sanitation. When possible, even at the initial survey stage, key leaders should visit nearby completed projects to see good latrines in use. Simple drawings and models may also be used so that alternative technologies can be discussed.**

**Some idea of the readiness of the community to provide labour, money and materials for a latrine-construction programme should be obtained. Considerable skill is required to find out the true aspirations and priorities of the people. Answers to questions are often distorted because the interviewees wish to please the questioners. Small group discussions with minimum intervention by outsiders may be an effective means of finding out the true local opinion.**

**Survey of the area**

**The most appropriate sanitation is that which best meets the needs and aspirations of the people within all local constraints. In order to assess what is most appropriate, a survey of the district should be carried out.**

**The survey may include both secondary and primary data. Secondary data are obtained from existing reports, maps and statistics. These should be critically examined and due allowance made for possible inaccuracy. For example, the information may not be up to date, or it may have been obtained from unreliable sources or collected hurriedly. Study of the available secondary data will reveal gaps that need to be filled by primary data.**

**Primary data are obtained by direct and indirect observation, measurement, household surveys, interviews and informal conversations. Care should be taken to ensure that those carrying out the survey have been properly trained. Any questionnaires used should be carefully planned to ensure that the answers reflect the true opinions of respondents.**

**A survey for a sanitation project may include the items listed below. In addition to**

**information about the existing situation, any proposals for changes (and when they are likely to occur) should be noted.**

### *Physical factors*

**Of greatest importance is the local geology - the underlying rocks and the nature of the soil, in particular, how easy it is to dig and how stable the soil remains after excavation. It is also important to determine whether the soil is permeable so that water drains away, the depth of the top soil, how the soil varies with depth, the depth of hard rocks in which it is difficult to dig, and whether there are any fissures or boulders.**

**Natural gradients and the natural surface water drainage system should be noted, especially if there is much local variation. This may involve a study of the surface water hydrology and the climate, particularly the seasonal rainfall pattern. Areas that are subject to regular or occasional flooding should be noted. Any information that can be obtained about groundwater may also be useful, for example, the depth of the groundwater table, whether there is any seasonal variation or long-term change, the directions in which the groundwater flows, and its quality.**

### *Existing excreta disposal methods*

**It is essential to obtain as much information as possible about existing sanitation. A programme is usually intended to rectify an unsatisfactory situation and the extent of deficiency in sanitary provision is the baseline from which it starts. Any existing local sanitation that is satisfactory could give an indication of the most appropriate general solution. Improvements to existing systems are likely to be**

**more acceptable than completely new ideas. In addition, examination of existing sanitation may provide useful technical information regarding such matters as soil infiltration capacity and rates of accumulation of solids.**

**Another advantage of obtaining accurate and complete information about existing sanitation is that it can contribute to the evaluation of the completed programme.**

### *Water supply*

**The service most closely related to sanitation is water supply, and careful note should be made of all water sources in the community. If possible, water sources should be visited and inspected. Claims by water authorities regarding the piped water supply service are often exaggerated, and the existence of water pipes and fittings should not be taken as evidence of satisfactory delivery of water. Pressure at the end of a long pipeline is often low, and the supply may be intermittent. Many people find it difficult to estimate distances in rural areas, so whenever possible the journey to collect water should be observed and timed.**

**Special care should be taken to check information relating to dependence on groundwater as a source of drinking-water. The depth of the water table and the location of wells and boreholes are particularly important because of the risk of pollution from pit latrines and soakpits. If possible, an analysis of the groundwater, including bacterial contamination and nitrate concentration, should be obtained. Comparison with analyses after the sanitation project has been implemented can then be used to monitor any groundwater pollution.**

### *Health and disease*

**The need for improved sanitation may be gauged from information about the prevalence of excreta-related diseases. Sometimes attendance records at local health centres yield this information, particularly in relation to diarrhoeal and parasitic diseases. However, the value of records depends upon the accuracy of diagnosis, the care with which records are kept, and the location of the health centre relative to the area served.**

**Data obtained in a health survey carried out before the start of a project may be compared with data from another survey after the project has been implemented as a means of assessing the effectiveness of improvements in sanitation. However, such baseline surveys are expensive and difficult to carry out successfully. They are normally only required where governments or donors require evidence of the efficacy of simple sanitation.**

***Population and dwellings***

**Information obtained previously about the number of people and the number of houses to be served by the project should be checked and supplemented as necessary. Detailed demographic data, such as age and sex distribution may be significant, especially if it is customary for workers to move away from the area temporarily or permanently. Trends in any migration patterns should also be noted.**

**Aspects of housing that most affect sanitation are density, quality and level of occupancy. While low densities overall are usual in rural areas, it is not uncommon for dwellings in villages, and even in isolated family compounds, to be clustered at high density. The most relevant statistics are the open space**

**belonging to each dwelling and the number of people occupying each dwelling. The quality of housing may indicate the economic level of the people and the efforts they are likely to put into improvements, including the construction of latrines. In many rural and periurban areas the majority of dwellings have been built by the occupants, who are therefore responsible for their own sanitation facilities. Improving the sanitation may be complicated where the occupant is not the owner, where a single dwelling is shared by several families, or where people occupy the upper storeys of multistorey buildings.**

***Culture and traditions***

**Customs that influence the selection of the most appropriate type of latrine include:**

- **the preferred method of anal cleaning (water or solid material such as paper, leaves, stones, grass or corncobs);**
- **whether it is customary to defecate squatting or sitting;**
- **the degree of privacy favoured;**
- **the preferred location of latrines in relation to dwellings;**
- **any preference for bathing in the latrine after defecating;**
- **traditional use of human excreta or compost derived from human excreta as a fertilizer;**

- **objections to handling excreta, even when they have completely decomposed;**

- **any restriction regarding the use of the same defecation place by different groups, for example a taboo on use of the same place by men and women, adults and children, or even more specific categories such as fathers-in-law and daughters-in-law;**

- **any objections to the use of communal or family defecation places by certain people at certain times, such as women while menstruating.**

### *Communication and education*

**The ability and willingness of communities to accept new ideas, including new ideas about excreta disposal, are likely to be influenced by the extent of their outside contacts. In many places there is regular exchange of information through meeting people from other areas at markets, or when attending social functions. Literacy levels may determine the extent to which written or printed advice or instructions can be understood. It may be useful to find out how many members of the community own radios and television sets and whether they are in working order, and how many people read newspapers or see film shows, and in which languages. Understanding local terminology and traditional modes of communication, such as drama and song, may also be useful.**

### *Employment*

**While full information about employment of the local people is useful as background, of particular importance to sanitation planning is the location of**

**workplaces. The practice of spending a high proportion of each day on farms that are distant from dwellings may influence the design of household sanitation. Similarly the extent of other activities away from home, such as attendance at markets or industrial employment, may point to a need to provide latrines at these places. Any seasonal variation in economic activity, income level, and location of workplace should be noted.**

### *The environment*

**Cleanliness of private dwellings and yards, and also of public roads, footpaths and open spaces, may give a good indication of the likely interest of communities in improving excreta disposal facilities. Methods commonly used for disposal of solid waste should be noted.**

### *Infrastructure*

**Ease of access by vehicles should also be checked, bearing in mind that many rural roads that are reasonably good in dry weather may be impassable for several weeks or months during the rainy season. Vehicular access to properties may affect the choice of type of latrine, for example, where full pits need to be emptied by vacuum tanker.**

### *Construction*

**While some householders may be able to build their own simple latrines, in many places construction will be undertaken by contractors or self-employed artisans. An assessment of the ability and reliability of local contractors and artisans is therefore required. The financial status of contractors may be relevant. Apart from**

**latrine construction, firms or individuals may be able to prefabricate components, such as slabs, blocks, pans and pipes.**

**The availability and market price of materials and components likely to be used in the construction of latrines should be ascertained as accurately as possible. For material that can be obtained locally, such as sand and gravel, the actual cost of extraction and transport may be more relevant than market prices. Wage rates for skilled and unskilled labour should be noted.**

***Availability of internal finance***

**An assessment should be made of the likely contribution that beneficiaries will make to the cost of latrine construction and maintenance. Money available in rural communities usually depends on the sale of agricultural produce and its seasonal variation; cash may only be available at harvest-time. In any community there may be income from wages and salaries, and from remittances received from absent members of families.**

**Attempts should be made to estimate willingness to spend money on sanitation, although it must be realized that statements made by individuals or community leaders regarding ability or willingness to pay are often unreliable. Responders usually answer questions in a way they think will give them greatest benefit. They may think that if they claim to be poorer than they are they will receive more outside help, Alternatively, they may exaggerate their ability to pay if they expect that this will ensure the implementation of outside-funded improvements.**

**Ability to pay may be based on the income of poorer sections of the community. In**

**some places it has been found that payments for improved sanitation by the poorest people should not exceed 1% of their income, but up to 3% is acceptable for other economic groups (Kalbermatten et al., 1982).**

***Availability of external finance***

**The fullest possible information should be obtained regarding grants, loans and subsidies likely to be available from local and central governments, bilateral donors, international and commercial banks, and other external sources.**

**Comparison and selection of systems**

**Careful consideration should be given to all the technical factors described in Chapter 5 in order to select a number of appropriate types of latrine from those described in Chapters 4 and 6. A decision tree, like that shown in Fig. 9.1, may serve as a framework for selection. In effect, use of such an approach may eliminate some forms of sanitation, leaving others for further consideration.**

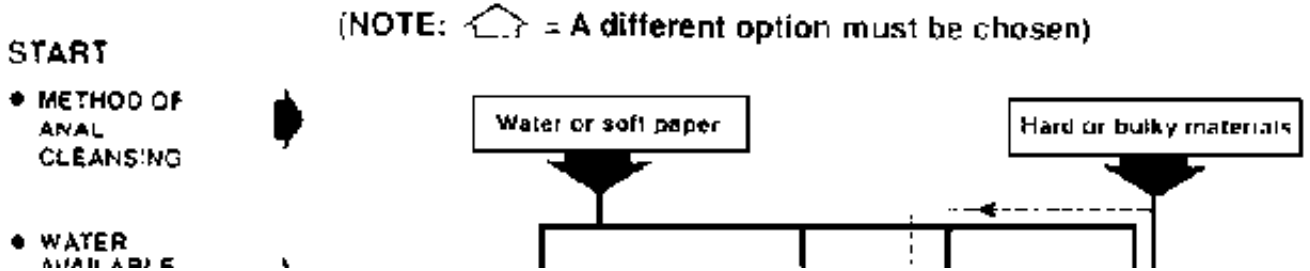
**Factors that are relevant in deciding whether a sanitation system that is technically feasible should be offered to householders and communities include the following:**

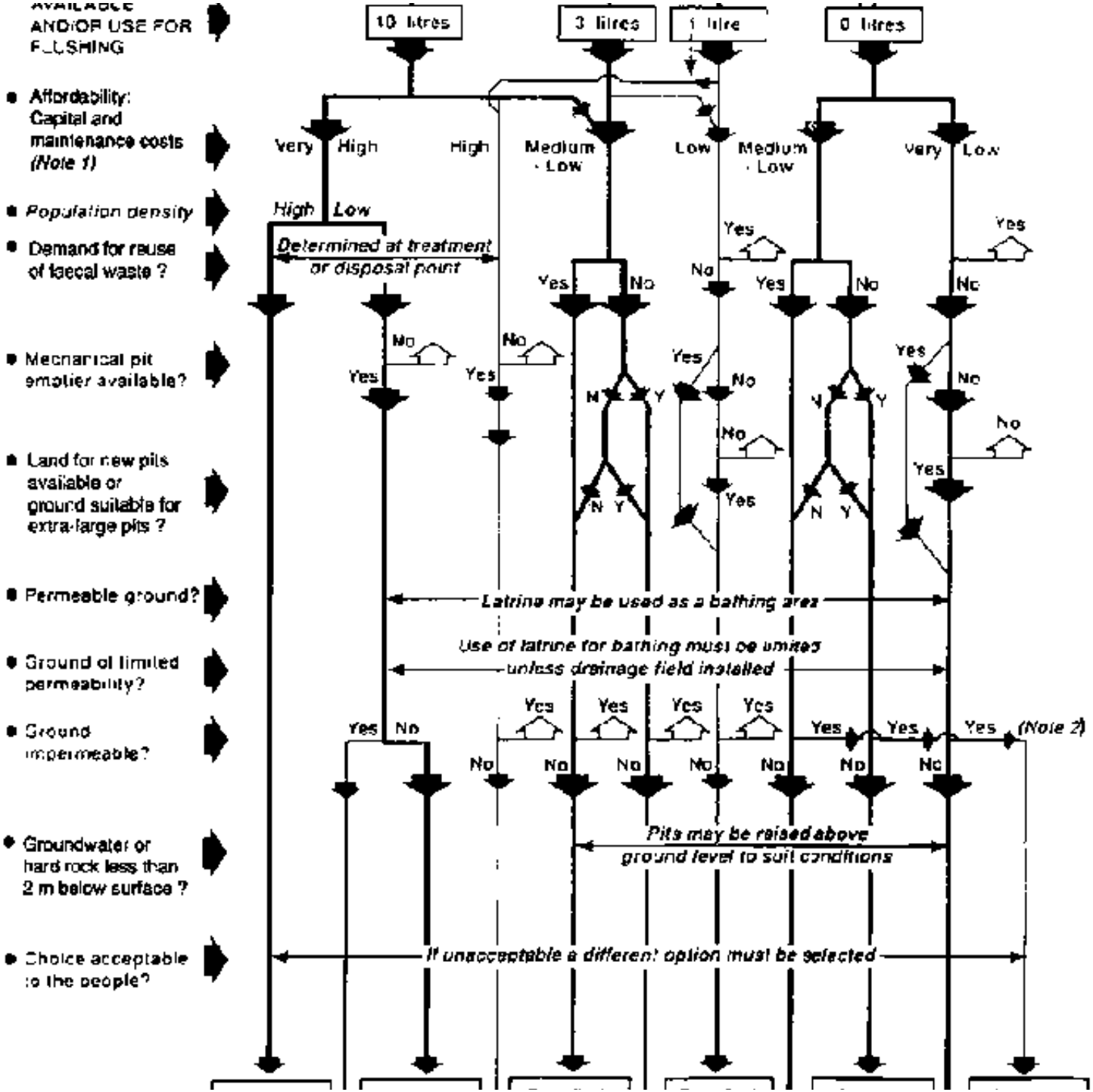
- **whether the system appears to be popular, as demonstrated by the number of householders who have already adopted it or by widespread interest in possessing it;**
- **the extent to which its use would fit in with local cultural and religious customs;**

- **the extent to which it would reduce pollution and health risks;**
- **the ease with which it can be provided by the people themselves, having regard to local skills and easily available materials;**
- **the cost, and particularly the cost of any materials, components and labour that cannot be provided by the householders;**
- **the ease with which it can be operated and maintained.**

**Having selected a number of options that are appropriate, the costs of each option can then be estimated. These should relate to a range of construction methods and materials. The total cost in both financial and economic terms of providing the required number of units for the project may then be calculated. Some agencies may favour least-cost solutions for externally funded projects, as discussed in Chapter 10.**

**When suitable options have been selected, the agency or the community itself must then go on to provide the latrines, giving each individual householder the maximum possible opportunity of choosing between alternative types, materials, finishes and other details. The stages in the implementation process are discussed in Chapter 11.**




AVAILABLE AND/OR USE FOR FLUSHING
10 litres
3 litres
1 litre
0 litres
Affordability: Capital and maintenance costs (Note 1)
Very High
High
Medium - Low
Low
Medium - Low
Very Low
Population density
High
Low
Demand for reuse of faecal waste ?
Determined at treatment or disposal point
Yes
No
Mechanical pit emptier available?
Land for new pits available or ground suitable for extra-large pits ?
N
Y
Permeable ground?
Latrine may be used as a bathing area
Ground of limited permeability?
Use of latrine for bathing must be limited unless drainage field installed
Ground impermeable?
(Note 2)
Groundwater or hard rock less than 2 m below surface ?
Pits may be raised above ground level to suit conditions
Choice acceptable to the people?
If unacceptable a different option must be selected

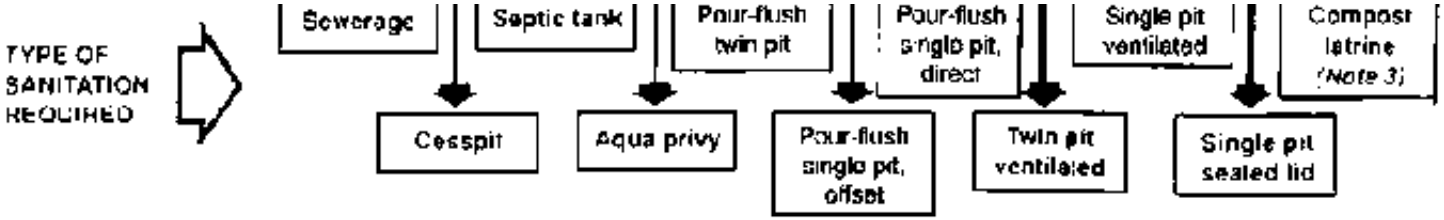



**Fig. 9.1. Decision tree for selection of sanitation**

***Note 1: Not all possibilities are illustrated as it is assumed that water availability is related to affordability.***

***Note 2: Use extra-large pits or consider composting.***

***Note 3: Also dependent on willingness to collect urine separately, demand for compost, availability of ash or vegetable matter, etc.***

***WHO 91381***

## Chapter 10. Institutional, economic and financial factors

### Institutional responsibilities

**Any work on sanitation improvement is carried out within a framework of household, community and governmental relationships, all of which affect the manner in which a programme is executed. Of major importance are the organizations or institutions that have been given responsibility for or have an interest in some aspect of sanitation improvement. Such bodies may be governmental ministries, departments of ministries, urban municipalities, rural councils, nongovernmental agencies or recognized organizations.**

**In this book, a body outside the local community which takes primary responsibility for initiating, promoting, supervising or otherwise supporting a sanitation improvement project is generally referred to as an agency in order to distinguish it from other interested institutions. This agency may be a sectoral institution or a part of an institution. It may also be a special multidisciplinary team drawn from several institutions or even a nongovernmental organization working under the authority of a governmental institution.**

**Projects or programmes**

**Improvements to sanitation practices involve projects and programmes. Projects are specific tasks with realizable goals within a specified time period. Programmes are continuous undertakings with long-term objectives. Protecting people and their environment from excreta-related disease and pollution is a continuous task which requires the responsible agency to take a long-term, programme approach.**

**Projects may be of vital importance to give a short-term boost to the sanitation programme and to enable people to make the next incremental improvement in their facilities. However, every project should be clearly related to existing sanitation programmes, with the relevant staff and institutions understanding its nature and objectives.**

**Governmental involvement**

***Allocation of responsibility***

**Government ministries of health, water supply, rural development, local government, agriculture, and social welfare, and local government councils may**

**all have an interest in sanitation. This concern may be at central, regional or local level. Ministries of finance and economic planning may also wish to exert some control. For a programme to succeed, there should be one lead agency, with a designated officer or management committee which has the responsibility and authority to take executive action.**

### *Integration of sectoral responsibilities*

**Nomination of a lead agency does not free other institutions from responsibility for a programme. Under their own terms of reference, they may want to play an active role in the promotion of sanitation, and may be able to provide specialist skills and inputs that are of vital importance. Consequently, it is necessary to define the responsibilities of all associated institutions, agencies and government officers at an early stage. The degree of involvement of any body will vary considerably according to the nature of the programme, the type of organization and other national and local conditions.**

**A forum or meeting for open discussion of needs and concerns may be of value. From this an intersectoral advisory committee can be drawn for more regular discussions of progress. However, it remains advisable to have a single lead agency responsible for decision-making rather than an intersectoral committee.**

### *Specialized sanitation support teams*

**Where a sanitation programme is being given a new impetus it is often found that the staff already have too many duties to be able to take on significant roles in a new project. Staff must either be released from other duties or new personnel**

**appointed. The creation of a multidisciplinary "sanitation improvement team" may be an effective means of encouraging progress. However, the relation of such a team to the existing organizational structure should be defined, particularly with regard to its eventual re-absorption as part of the overall programme.**

**Specialized teams or agencies, where properly constituted, are often able to bypass the bureaucratic procedures and delays that exist in all institutions. Particularly where unconventional, community-based approaches are used, considerable flexibility is required from the facilitating agency. For example, staff may need to attend community meetings in the evenings or extension workers may need to make home visits when householders are home from work. Extra payment for overtime, or time off in exchange for late working, may have to be arranged.**

***Flexibility within the institution and support team***

**As discussed in Chapter 11, there are considerable advantages in mobilizing the people, particularly with regard to the long-term sustainability of the improvements. However, in the short term there is no guarantee that the people will respond to the extent and at the rate desired by the agency.**

**The role of the agency may be made more difficult by non-acceptance of the preferred design standards, slow take-up of credits or materials, unfulfilled budgets, lengthy construction times and uncompleted objectives. Particularly where outside donors are involved, there will be a pressure to produce measurable results. The agency has to organize its budgets and work plans in such a way that donors and any sponsoring institutions are able to understand what is**

**happening and why, while retaining the flexibility required by the people.**

***Multilateral and nongovernmental organizations***

**Many aid and development organizations become involved in sanitation programmes with the aim of improving the health of the people. Some may be based within the country, while others are externally supported. Some are able to draw on considerable experience over many years in different parts of the world, with funds and skilled personnel from different countries. Others have limited experience and/or funds but demonstrate a strong desire to assist the people. Their enthusiasm and ability to respond quickly to new ideas may be usefully harnessed for the good of the project.**

**The sponsoring institution has to decide how best to use all offers of help. The crucial task is to integrate the multilateral and nongovernmental organizations and the sectoral institutions, where appropriate, into the long-term programme, with the objective of limiting any tendency the smaller organizations may have to promote one-off projects that are not sustainable.**

**Institution-householder linkage**

**To be effective, government institutions must have contacts with householders and the wider community that go beyond simply instructing the people what they must do. This is discussed more fully in Chapter 11. The lead agency should be constituted so that it can manage:**

- **community surveys, interviews, meetings, household visits;**

**- demonstration centres, sanitation "supermarkets", component purchase and/or production and sales;**

**- general or task-specific support staff, for example technical, social, financial and health staff;**

**- training of community members as facilitators;**

**- financial assistance; material assistance; technical assistance in construction;**

**- identification of contractors and skilled builders;**

**- standard specifications and target prices;**

**- ongoing support, in terms of technical assistance, and health education; and**

**- evaluation and monitoring.**

## Human resources development

**Human resources development includes the employment, supervision, continuing education and training, and occupational welfare of the people needed to do a job properly. The process should embrace planning, development of skills and training, and human resources management, with all aspects harmoniously geared to the achievement of specific goals.**

**Shortcomings in the preparation, implementation, operation and maintenance of sanitation schemes are often blamed on poor performance of programme staff and the ignorance of the people using the system. The usual response is to plan a training programme to educate all those involved in how to carry out their tasks correctly. However, such teaching may not in itself solve difficulties of performance. There are many factors to be considered in enabling people to perform to their full potential, and it is one of the roles of the programme manager to consider all aspects of human resources development.**

**Carefoot (1987) suggested that deficiencies in human performance, particularly with regard to water and sanitation activities, can generally be traced to one or more of the following: lack of skill or knowledge; environmental and/or management difficulties; or motivational, incentive or attitudinal causes. If lack of skills or knowledge is the primary cause of a problem, training is the likely solution. However, if problems stem from environmental and/or management causes, or from motivational causes, they will probably not be solved by training alone. In a number of surveys, managers involved with water and sanitation programmes have estimated that only 10-30% of performance difficulties are due to lack of skills or knowledge which can be rectified through training.**

**A "dual-focus" approach - on both the individual and the system within which the individual works - was therefore suggested by Carefoot in seeking solutions to performance problems. Development of skill should be complemented by the strengthening of the organizational environment, whether formal or informal, in which the person works.**

**Programme participants**

**Before looking at the requirements for human resources development in more detail, the people who might need to be involved in a programme must be considered.**

### *Householders*

**One of the advantages of many on-site sanitation systems is that much of the work can be undertaken by the beneficiaries. Householders can plan, design and construct many elements of a latrine. Support is therefore required both for the individual householders and for the community to impart the necessary confidence that they can complete the task.**

**The special role of women in many countries in running the home, collecting water, and managing the sanitation system should not be underestimated. Many training programmes are automatically biased towards men or, by including men, exclude women. However, women have a vital part to play in the appropriate design, construction, operation and maintenance of excreta-disposal systems. Any human resources development programme must cater for the particular needs of women. Some programmes have also benefited from paying particular attention to the needs and role of children, both within formal education and informally in the community.**

### *Community leaders and councillors*

**Community leaders have their own special interests, particularly where communal decisions have to be made about some aspects of a sanitation scheme or where leaders can set an example to other householders.**

### *Artisans*

**In many projects there is a need for masons, bricklayers, drain-layers, carpenters, plumbers and other artisans to carry out part of the work. These workers often have experience in construction of houses and other buildings. Special skills may be required for the construction of latrines and associated works.**

### *Local contractors*

**Householders may require local contractors to carry out certain tasks for them, such as lining pits or constructing slabs. Where new techniques are being introduced or new forms of project support and funding used, contractors and subcontractors will require support.**

### *Programme and project staff*

**The numbers and categories of people needed to prepare and implement a project are largely determined by the nature and size of the project, type of agency, involvement of central and local government, whether the project forms part of an ongoing programme, and the degree to which the community participates.**

**Government health officers often play an essential part in sanitation improvement schemes, especially where the ministry of health is responsible for sanitation. Where a technical arm of government (such as a public works department) or an independent agency is responsible, management and supervision may be in the hands of technical officers. In some countries, health assistants, community and development officers and extension officers may be the link between an agency and the community. There is considerable variation in the terms used for different**

**groups of workers and in the allocation of duties between these intermediate-level staff.**

***Professional staff***

**Several kinds of professional staff may be concerned with sanitation improvement projects:**

**- public health engineers who are employed by an agency or by consultants working for an agency, with primary responsibility for the technical aspects of the programme;**

**- architects, planners, medical officers and development staff who, because of their jobs with agencies or government departments, are involved with the planning and implementation of sanitation;**

**- behavioural scientists, anthropologists, health staff, geologists, economists and others having specialist expertise that can be beneficially employed at some stage of planning or implementation; and**

**- administrators.**

**Skills and knowledge training**

**If training is to be relevant and is to produce the desired results, it must be planned systematically. The objectives are to enhance people's breadth and depth of knowledge about their particular responsibilities, and to improve their ability to carry out particular tasks. In order to achieve these it is useful to follow a training**

**cycle. This same cycle may be followed for householders as well as for professional engineers (Fig. 10.1).**

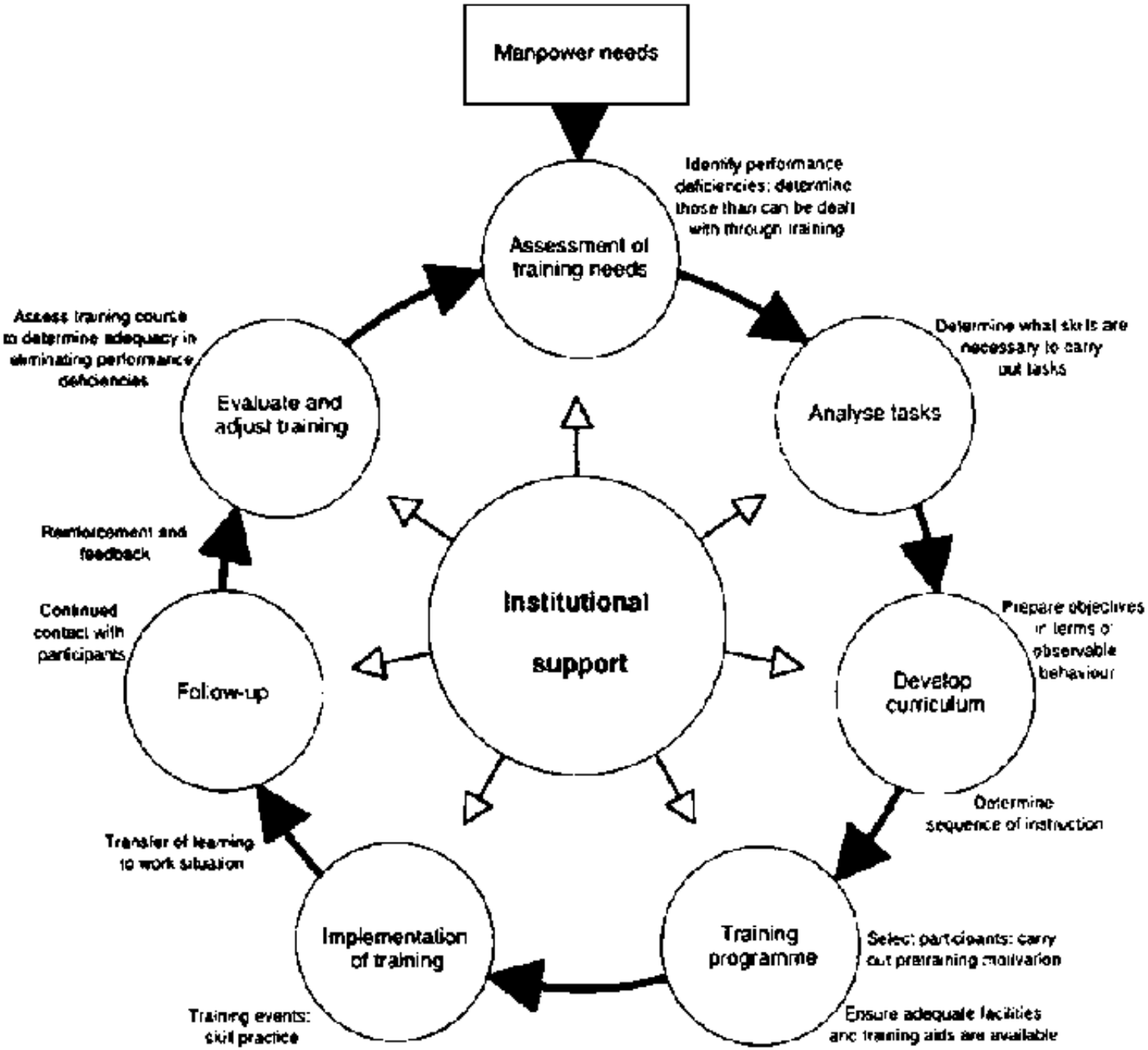



**Fig. 10.1. The training cycle**

***WHO 91366***

## *The training cycle*

**Preparation of any training programme begins with an assessment of training needs. This requires an organizational chart describing the different jobs to be carried out in order to complete the objective. The objective should not be limited to completion of initial construction but should also include operation and maintenance. Each of the jobs listed then requires a job description, that is, a detailed list of the tasks to be carried out by the person in that position (whether or not employed by the programme). Comparison of the job description with the knowledge and skills of people likely to be available to do a task leads to a list of training needs. A training plan is then prepared from the list of training needs, bearing in mind the priorities of the programme. The plan should specify the people to be trained, with target dates for completion and objectives for what the training should accomplish.**

**Implementation of training depends on whether the needs are for:**

- ***knowledge*** **- where lectures and books are particularly useful,**
- ***manual skills*** **- step-by-step development through demonstration, practice and correction of faults, concentrating on key areas;**
- ***social skills*** **- use of role-playing, case studies, discussion, practice under supervision;**
- ***attitude change*** **- group discussion, personal interview, case studies and**

**feedback; or for**

- ***systems*** **(for example clerical procedures and stock control) - checklists, demonstration and practice with correction.**

**The final phase of the training cycle is evaluation of what the participants have learned and determination of what they are able to do. This leads to a reassessment of training needs for the next training session or programme. Of course, training and education form a continuous process which starts from what people know and enables them to build upon that foundation of knowledge. There is always opportunity for further learning; it cannot ever be said to have been completed.**

**Management requirements**

**However well people have been trained, they will not be able to reach the objectives of effective sanitation unless their working environment is geared towards meeting those objectives. For example, if there is no transport for project staff to visit sites when required, the community will become disheartened when the expected visitors do not arrive. Similarly, if there is no money to disburse loans to householders when promised, or if there is a lack of supplies, materials and tools, the project will lose momentum. To overcome such problems requires a willingness on the part of management to use all possible means to overcome institutional difficulties.**

**In addition, project staff, particularly those working directly with the community, require constant encouragement and recognition of their contribution to the**

**project. Suggestions for improving work conditions include:**

- **regular visits by supervisors and colleagues to those working in isolated situations;**
- **regular meetings and seminars so that all staff on a project feel part of a team;**
- **the provision and maintenance of appropriate transport (car, van, motorbike or bicycle);**
- **alternation of work at rural and urban locations;**
- **payment of overtime where necessary; and**
- **ensuring that personnel have occasional postings near their home.**

## Motivation

**Adequate motivation of agency staff and householders is a prerequisite for successful training. Of particular importance to project staff is the possibility of future career development beyond the present project. If the staff can see a chance of transfer to other projects within a continuous programme, they are more likely to be prepared to learn and improve their skills, and to share their expertise with colleagues and householders. It is important that status, conditions of service and salary scales should compare favourably with those for other available employment. This is particularly important for senior posts where the holders have to work away from home.**

## Economic factors

## Choosing between alternatives

**Different sanitation techniques may be equally acceptable from the health, social, technical and institutional points of view. The final choice between different techniques is therefore often made on the grounds of cost.**

**Financial costs, that is, in general terms, what a householder or agency has to pay in cash for a sanitation facility, are discussed in the next pages. Economic costs represent the total resource cost to the national economy, that is, what the country as a whole has to pay in terms of labour, materials, health, environment and imports.**

**Economic comparative costing aims to assign a cost to all the elements that go to make up a system, thus enabling comparisons to be made between competing technologies. It is important for planners and project staff to consider all the alternatives in order to recommend the most economic systems for demonstration and promotion. This then allows the householders to make the final decision on grounds of affordability, convenience and attractiveness.**

**It should be noted that detailed economic analysis is normally undertaken only for large projects in high-density urban and periurban areas. Because of uncertainties in the basic economic data in many countries, it is inadvisable to make final decisions regarding sanitation technology on the basis of economic analysis alone. However, the discipline of thought required to carry out an analysis of the full life-cycle costs of any system can be of great benefit to the planning team by leading to a fuller understanding of all the issues involved.**

**Least-cost analysis of alternatives**

**It is difficult to quantify the benefits obtained from improvements in sanitation. Where there is a choice of technology available to achieve the objective of safe disposal of excreta in an acceptable manner, the benefits obtained from the different options may be presumed to be equivalent. Economic comparison of the alternatives may then be restricted to a "least-cost analysis", which focuses solely on the costs of providing sanitation. There may be variations in the convenience with which this is achieved. For example, a flyless, odourless improved latrine may be far preferable to a flush toilet and septic tank where the water supply is intermittent. However, such situations are so site-specific that it may be generally assumed that the systems outlined in this book (unless specified differently in Chapter 4) have similar benefits with regard to excreta disposal.**

**Each alternative should be considered according to consistent factors using economic analysis. Non-monetary contributions by householders, for example digging their own pits, should be quantified. Similarly, imported fittings for a pedestal toilet and septic tank should be recorded at their true cost to the national economy, taking into account "real" exchange rates. The values thus assigned may not directly reflect the financial cost involved.**

**Detailed information on economic analysis and methods of determining "real" values is given in the *Guide to practical project appraisal* (UNIDO, 1978). The main areas that need to be considered are outlined below.**

## Economic costs of sanitation systems

### *Labour*

**Where a householder is to contribute labour, e.g., by digging the pit or building the superstructure, this work should be costed at the shadow wage rate. This is the rate at which people would be hired to work if there were no artificially controlled wage rates. In a country with high unemployment, the shadow labour rate is likely to be between 40% and 70% of the government minimum wage. Similarly, where agency staff or direct labour is to be used for construction, the costs should be charged at the shadow rate rather than the amount actually to be paid to them. If a labour-only subcontractor is to be employed, the amount to be paid less profit to the subcontractor should be used. Profit represents a "transfer payment" and does not reflect any real transfer of wealth within the economy.**

***Building materials***

**The costs of both the superstructure and the substructure must be considered. Where a toilet is to be installed in part of a house, the proportion of the house value represented by the toilet (in terms of the proportion of the floor area) should be included in the calculation.**

**Building materials may be collected locally without financial charge. There is, however, a labour charge according to the time taken, based on the shadow labour rate. Where the materials to be collected are scarce and efforts are being made to renew them, for example through a reforestation programme, some costs should be assigned to these "free" materials.**

**For items manufactured in the country, the amount charged by the manufacturer, including transport to the site (less all profit margins), should be used. However, if the item is subsidized by the government, the subsidy should be added to the**

**total cost. Where an item carries a sales tax, the amount of the tax should be subtracted to reflect the real value of the item to the economy.**

**Where imported items are to be used, the total cost, including freight charges and insurance, should be used, but not including customs duties, local taxes or traders' profits. In some countries, the foreign currency exchange rate may be kept artificially high in order to reduce the financial costs of imports. To reflect the real value of any imported materials, a shadow exchange rate should be used, which is likely to increase the apparent cost of imports. The shadow exchange factor is often in the range 1.2-1.8.**

### *Water*

**Where water is to be used for flushing the sanitation system, the cost of this water has to be included. If it is to be obtained free of charge from an unimproved source, there is a labour charge for carrying the water to the latrine - calculated from the total time taken, costed at the shadow wage rate. If water is to be obtained from a standpipe or other improved source, the economic cost of delivering that water to the standpipe should be used, in addition to the labour cost of transfer to the latrine. Similarly, where a household has an individual water connection, the economic cost of delivering water to the house must be used. This economic or marginal cost of the extra water used for sanitation is normally higher than the actual tariff paid by the householder. The cost of any pipework and fittings to be used specifically to transfer the water to the toilet should also be considered.**

### *Land use*

**Where land is scarce, particularly in urban areas, there is a cost associated with it, which should be included in the analysis.**

***Cost of money and the timing of costs***

**In economic terms, there is a cost involved in using money for one purpose, such as sanitation, as opposed to using it for an alternative purpose. This cost of using money is known as the opportunity cost of capital, and may be defined as the return on an investment in the best alternative use, that is, what could be earned by that money if it was used elsewhere. This cost influences the choice between alternatives with regard to the balance between initial capital investment costs and recurrent operation and maintenance costs. For example, some facilities are expensive to build but cheap to run, while others cost very little to construct but have to be rebuilt and/or emptied at regular intervals.**

**The influence of the opportunity cost of money on the timing of payments for a sanitation scheme is determined through the mechanism of discounting. This is a technique whereby all future payments made are given a current value by discounting in order to assess fairly the different streams of payments.**

**In economic analysis, the discount factor is the opportunity cost of capital. Where money invested increases in value over a period of time, the technique of discounting quantifies the money required at the present time in order to obtain a given amount at a set time in the future. Discount factors are normally obtained from tables, but may be calculated directly from the formula:**

$$\text{Discount factor} = \frac{1}{(1+r)^t}$$

where $r$ = discount rate

$t$ = period in years.

**The example 10.1 demonstrates how the technique might be applied to the practical problems of judging alternative systems.**

### *Design life of the system*

**As different facilities are designed to last for different periods, the principles of discounting may also be applied to differing design lives so as to give a fair comparison.**

### *Emptying and disposal*

**Pits and tanks may be emptied by hand, for which there are shadow labour charges, or by vacuum tankers, for which there are hourly running costs, including labour, fuel and maintenance. In addition, replacement costs have to be considered, allowing for shadow exchange rates where the machine and spare parts are imported. There is also a cost relating to the disposal of the sludge, whether it is to be discharged to land or to a wastewater treatment plant.**

### *Groundwater pollution*

**Wastes that drain through the soil may cause pollution, leading to the need for an alternative water source. If this possibility only applies to one alternative, the possible costs should be estimated and allowed for.**

### *Sullage disposal*

**Some systems accept sullage water as well as excreta, thus obviating the need to invest further in sullage removal. This difference should be included where necessary.**

***Waste reuse***

**If the waste products can be reused, for example, sold to farmers as fertilizer or used in a biogas plant, the benefit to be gained should be offset against the costs.**

***Governmental and agency management***

**Most sanitation schemes bear some hidden costs of agency management and promotion. Where alternatives have markedly different charges associated with them, these should be included.**

***Analysis***

**The economic cost of each alternative is determined by calculating all the costs involved in the construction, operation, emptying and maintenance of a particular system over a specified period of time, modified by any appropriate shadow factors. All costs are then discounted by multiplying by a discount factor according to the year in which they will be incurred. This gives the present value of those costs. The present value represents the amount of money required now to be able to pay all expected costs in the future. The present values for each year are then summed to give a single figure of the total present value of the entire life-cycle cash flow, that is, the economic cost for each alternative.**

**Where alternative systems being compared are expected to last for different**

**periods of time (that is, they have different design lives), it is necessary to take a standard duration in order to make a fair comparison. For on-site sanitation, periods of 10 or 15 years are appropriate. All the costs likely to be incurred during this period for each alternative should be calculated. If the time period is longer than the design life of a system, it is necessary to include rebuilding costs. For a fair comparison it is advisable to choose a standard time that best fits the design life or as nearly as possible a whole multiple of a design life of the alternatives.**

**Least-cost analysis may be used to compare on-site sanitation with a conventional sewerage system. The nature of the discounting technique, where future costs have a much lower economic impact, tends to favour systems with low initial investment and higher recurrent costs.**

**Total annual cost per household**

**An extension of the least-cost analysis approach is to consider the total annual cost per household (TACH) (Kalbermatten et al., 1982). The initial construction costs are calculated as described above. Because the maintenance costs of most on-site sanitation systems are dependent on the number of people using the system, an average household size appropriate to the area should be selected, usually in the range 6-10 people.**

**The TACH is calculated by considering the total present value (PV) of the life-cycle cash flow (as described above) as the equivalent of a loan which has to be paid back over the design life of the system at constant, non-inflated prices. The value of yearly repayments, including interest, is obtained by multiplying the present value by a capital recovery factor. This factor is taken from capital recovery factor**

**tables which are based on the equation:**

$$\text{Capital recovery factor} = \frac{r(1+r)^t}{(1+r)^t - 1}$$

where $r$ = discount rate

$t$ = design life in years

**An example of a TACH calculation may be found at the end of this chapter (example 10.2).**

**Analysis by TACH may be used to compare on-site sanitation systems with conventional sewerage systems. Kalbermatten et al. (1982) calculated that the cost of on-site sanitation was between 5% and 10% of that of conventional waterborne sewerage systems.**

**Cost-benefit analysis**

**Having determined by least-cost analysis the present values of alternative systems, it is normal practice to compare the costs with the present values of the expected benefits. Investment appraisal requires that the present values of benefits should be greater than the present values of the costs. Where alternatives are being considered, the system with the highest margin of benefits over costs should be chosen.**

**Benefits to be considered include enhanced privacy and convenience for the users, and environmental protection, as well as the reduction and anticipated eventual elimination of excreta-related diseases. Multiple benefits from a single**

**intervention are extremely difficult to isolate and determine, especially where benefits such as improvements in health are interrelated with other basic needs such as nutrition and water supply. Quantification of the benefits of sanitation therefore tends to focus on the more readily measurable reduction of disease and the subsequent increase in productive life expectancy, increase in work capacity, and the reduction of demand for medical facilities and drugs.**

**Quantification of perceived improvements in the quality of life (for example, not having to squat at the edge of the street before dawn) is based on the value attached to the improvement by the users. Logically this can only be measured by considering the amount people are prepared to pay for those elements of a sanitation system that are most closely related to comfort. However, in most cultures, the investment decisions will be made by men according to their priorities, whereas the greatest benefit is likely to be felt by women who may be unable to declare their preferences.**

**There are other sanitation benefits to be added, such as reuse of composted or digested excreta for agricultural purposes, or production of biogas for energy needs. However, the benefit to be obtained from this reuse is only occasionally significant.**

**Quantification of the benefits to be derived from sanitation is extremely difficult. Low-cost sanitation is usually considered as a basic human need, required for human dignity and development as a whole. Economic analysis is therefore best used to compare alternative techniques to determine the least-cost method. This approach is particularly necessary where many of the anticipated environmental or public health benefits will not be realized immediately owing to the necessarily**

**slow pace of community involvement.**

**A suitable approach to economic analysis is described in the *Guide to practical project appraisal* (UNIDO, 1978) in which it is stated that the literature of project (economic) appraisal commonly gives the impression that the goal is to produce a set of numbers that show whether a project is good or bad but that in reality it is not the numbers themselves that are important, but rather the appreciation of the project's relative strengths and weaknesses that is gained. The numbers are simply an instrument that forces analysts to examine all relevant factors, and a means of communicating their conclusions to others.**

**Financial factors**

**Financial costs represent the money or cash that has to be paid by householders and donor agencies to build and operate a sanitation system (together with allowances for depreciation and bad debts). Financial costs are the main concern of householders and donor agencies whereas economic costs are of greater interest to project planners.**

**Financial costs of sanitation systems**

***Labour***

**Although it is often assumed that the householders can provide much of the labour themselves, this is usually only correct in rural areas. Particularly among disadvantaged groups, such as the disabled, the elderly, and households headed by women in urban areas, skilled and unskilled labour has to be paid for.**

### *Building materials*

**Most items, such as concrete blocks or bricks for pit linings or superstructures, cement for the slabs, water seals, vent pipes, fly screens, roof sheeting and doors, have to be paid for. Only in the rural areas are timber and other materials normally free of cost. Routine maintenance, such as repair of superstructures and renewal of fly screens, will involve costs in the future.**

### *Water*

**For septic tank systems in particular, but also for pour-flush latrines, an allowance must be made for extra payments for the water required for flushing.**

### *Cost of money*

**Interest rates may be payable on loans either at market rates or at subsidized project rates.**

### *Emptying and disposal*

**Allowance should be made for possible future hiring of labourers for the emptying of double pits and the removal of digested sludge, or for the hiring of a vacuum tanker for sludge disposal.**

### *Waste reuse*

**In certain limited situations there may be a cash income from selling sludge to farmers.**

### *Governmental and agency management*

**Management costs are not normally passed on to householders but remain as a hidden subsidy. Mara (1985b) suggested that the institutional and project delivery costs may be assumed to be about 45% of the sum of labour and material costs.**

### Affordability and financial assistance policy

**Economic analysis of development projects attempts to show where scarce resources such as capital might be used to best effect. Economic theory requires that, to maximize the benefit to a nation, the financial costs charged to the users should reflect economic costs as closely as possible. However, if the users cannot afford to pay the recommended costs, they will never install a sanitation system and the society as a whole, as well as individual households, will fail to receive the anticipated benefits.**

**The general policy of international lending agencies is that if the cost of the minimal sanitation facility necessary to ensure adequate health is more than a small part of the household income, then the central or local government should subsidize its construction to make it affordable. Any operation or maintenance costs should be borne by the beneficiary. If, however, some consumers wish to have better or more convenient facilities, they should pay the additional cost themselves. Similarly, if more affluent communities decide that, beyond meeting basic health needs, they wish to safeguard the cleanliness of their rivers or more general environment by building a more expensive sanitation system, they should pay for that system either through direct user charges or through general municipal revenues (Kalbermatten et al., 1982).**

**Affordability is generally believed to be in the region of 1.5-3% of total household income, that is, total financial costs incurred in a year (initially high investment costs may be spread over a period by use of loans) should not be higher than 3% of total household income for that year. Among the poorest in a poor community, this figure of affordability falls to 1-1.5% of household income.**

**In many countries, any subsidy of costs over and above this level of affordability has to be rigorously controlled. Development budgets are normally insufficient to subsidize to any significant extent a large number of latrines. There is a danger that small-scale pilot projects with external donor assistance might be given a large subsidy, on the basis of the need to promote the concepts of effective sanitation, when such subsidies could not be extended to a larger scale during expansion of the implementation programme.**

**There are two other reasons for carefully controlling the level of any subsidy. (1) In some countries, private enterprise can become involved in making and selling the components for sanitation on a large scale. Any subsidy to government projects reduces the profit potential and, therefore, the incentive for private contractors to become involved. Direct subsidies to nongovernment enterprises are usually unacceptable in countries where there is a risk of poor administration. (2) Where a system is not affordable it is usually not maintainable, that is, where the people cannot afford the technology chosen, it is likely that they will also not have the funds to maintain the structure and empty the pits or tanks. The system will then quickly fall into disrepair and the investment will be wasted.**

**The financial costs of any proposed sanitation system therefore need to be examined very closely. If necessary, installation of pit linings, water seals, vent**

**pipes, cement slabs and superstructures may have to be postponed in order that, at the initial stage, the maximum number of people may benefit from a system which, however simple, leads to a reduction in excreta-related disease.**

**Where financial subsidies are employed, they should not favour one sanitation system over another in such a way that the economic ranking of alternatives is changed (Kalbermatten et al., 1982).**

## Financial assistance

**Financial assistance may be necessary to start a sanitation programme and, in countries with appropriate resources, subsidies may be a useful means of quickly propagating public health improvement. Where people cannot afford even the simplest form of sanitation, particularly in urban areas, society as a whole has to pay for the required social benefits through general taxation. However, the use of direct grants is not recommended because of the danger of funds being diverted for purposes other than sanitation.**

**From India, Roy et al. (1984) suggested that if a programme is designed to serve the poorest groups, a subsidy has to be provided. One method of determining the extent of the subsidy is to use a means test. This may be based on the public utilities (water, electricity, etc.) available in the household. For example, households with no utilities might receive a 75% grant and a 25% loan. Where more utilities are available, the proportion given as a grant decreases. However, even for the poorest households, a small loan component requiring repayment is generally recognized as being vital to ensure effective care and use of the latrines, which only occurs when ownership is clearly vested in the householder rather**

**than the agency.**

**A revolving fund or loan scheme, whereby money is lent at normal or subsidized interest rates for varying periods of time, may be of great importance. Monthly repayments on loans should be fixed at an affordable level. It is recommended that, if possible, loans for latrines should have a shorter repayment period (for example two years) than loans for housing. This is because benefits perceived by the householder are often limited and they may therefore lack motivation to continue payments over a longer period. Where the people have been fully involved in the construction of their latrines, small loans are usually repaid. If a programme is pushed through by an agency without effective community participation, it is likely that there will be a low return.**

**Revolving funds are a particular form of loan scheme where initial finance from government or a donor is distributed. The fact that there is only a certain amount of money available provides added incentive for borrowers to repay their loans, since other borrowers may have to wait for a loan while their neighbours repay.**

**There are many possibilities for combining the different types of financial assistance. A government agency might implement and maintain a sanitation system with full or partial cost recovery through tariffs or local taxation. This is more usually the case with a waterborne sewerage system than with on-site sanitation. The householders might do all the work themselves, assisted by grants or loans. They may achieve viable systems simply by accepting advice from external sources. Or the substructure might be constructed by an agency with costs recovered through a tariff, and with the householders building the superstructure with the help of a loan.**

**Wherever possible, financial assistance should be kept to a minimum, with design and technology appropriate to affordability in the various income groups targeted.**

## Costs of sanitation systems

**A survey of sanitation by WHO (1987c) suggested that funding limitations are still the most serious constraint on achieving the goal of sanitation for all. The costs of different sanitation systems vary greatly according to country, current exchange rates, and skills needed for designing and implementing on-site technology. The figures given here (from WHO, 1987c, and other sources) are an indication of current costs per person served. However, it should be recognized that these costs are liable to considerable change, even over a short period. The WHO survey discovered increases in median figures between 1980 and 1985 of 131% for individual urban household sanitation in the least developed countries. The survey also noted a 30% decrease in per capita costs for rural sanitation in one region.**

**In South-East Asia, the per capita cost of sewer connections in urban areas in 1985 varied from US$ 45 to US$ 400 with a median cost of approximately US$ 80. To this must be added an annual water charge in the region of US$ 5 per person served. Low-cost on-site alternatives were costing US$ 13-30 per person in urban areas, and US$ 5-20 per person in rural areas.**

**In Africa south of the Sahara, sewer connections were reported to cost US$ 120-300 with accompanying water costs in the region of US$ 8 per year per person. The median sewer connection cost was US$ 150, with urban on-site alternatives ranging from US$ 25 to US$ 70. Rural sanitation costs were in the range US$ 10-45 with a median of US$ 25 per person.**

**In Central and South America, sewer connection costs varied from US$ 120 to US$ 235 with a median cost of US$ 150, the same as for Africa. Urban on-site sanitation cost US$ 20-80 and rural sanitation ranged from US$ 10 to US$ 50, with an average of about US$ 25 per person served.**

## Examples

### Example 10.1. Least-cost analysis

**Two alternative on-site sanitation systems (A and B) are to be considered. The discount rate is taken to be 10%, the shadow exchange factor (SEF) for imported goods is 1.3, the shadow wage rate (SWR) for labour is 0.6, and the institutional and promotional costs are 30% of the initial capital cost. All costs are in dollars.**

**System A costs $ 71.80 at the initial construction stage and $ 10 for the use of a vacuum tanker every 5 years. The anticipated life of the system is 20 years. Note: the effects of inflation may be ignored.**

| | | | Materials | | | Labour | | |
|---|---|---|---|---|---|---|---|---|
| | | | Cost | SEF | Shadow cost | Cost | SWR | Shadow cost |
| Costs of pit: | excavation | | | | | 5.00 | 0.6 | 3.00 |
| | lining | - bricks | 15.50 | | 15.50 | | | |
| | | - cement | 5.00 | 1.3 | 6.50 | | | |
| | construction | | | | | 2.00 | 0.6 | 1.20 |
| Costs of slab: | cement | | 10.00 | 1.3 | 13.00 | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Costs of slab: | cement | 10.00 | 1.3 | 13.00 | | | |
| | steel reinforcing bar | 3.00 | 1.3 | 3.90 | | | |
| | aggregate | 0.50 | | 0.50 | | | |
| | construction | | | | 2.00 | 0.6 | 1.20 |
| | | 34.00 | | 39.40 | 9.00 | | 5.40 |
| Total economic cost | | | | 44.80 | | | |
| Cost of superstructure (calculated in a similar manner) | | | | 27.00 | | | |
| Subtotal | | | | 71.80 | | | |
| Cost of institutional support and sanitation promotion (at 30%) | | | | 21.50 | | | |
| Total economic investment cost | | | | 93.30 | | | |

**System B costs $ 55 for pit, slab and superstructure at the initial stage, with the same amount for a new pit and superstructure after 10 years, at the end of the original design life.**

| | |
|---|---|
| Total economic cost | 55.00 |
| Total economic investment cost | 71.50 |
| (calculated in a similar manner to System A above) | |

***Least-cost analysis***

| **System A** | | | | **System B** | |
|---|---|---|---|---|---|
| **Costs** | **Discounted costs** | **Year** | **Discount factor** | **Costs** | **Discounted costs** |

| (a) | (a) × DF | | DF | (b) | (b) × DF |
|---|---|---|---|---|---|
| 93.30 | 84.80 | 1 | 0.909 | 71.50 | 65.00 |
| 10.00 | 6.20 | 5 | 0.621 | | |
| 10.00 | 3.90 | 10 | 0.386 | 55.00 | 21.20 |
| 10.00 | 2.40 | 15 | 0.239 | | |
| 123.30 | 97.30 (present value) | | | 126.50 | 86.20 (present value) |

**By least-cost analysis, the present value of system B is slightly less than the present value of system A. However, the difference is not enough to allow one system to be chosen in preference to the other on economic grounds alone.**

**Example 10.2. Total annual cost per household**

**The total annual cost per household (TACH) is determined by multiplying the present value of each system by the capital recovery factor (CRF). Using the formula given in the text, and at an interest rate of 10% over 20 years, CRF = 0.118.**

**From the figures calculated in Example 10.1:**

*System A*
Present value = $ 97.30
TACH = 97.30 × 0.118
= $ 11.50 per household per year

*System B*
Present value = $ 86.20
TACH = 86.20 × 0.118
= $ 10.20 per household per year

**Example 10.3. Financial and affordability analysis**

**Using the figures given in Example 10.1 for system A, it is assumed that the householder is contributing time to excavate the pit and to construct the slab and superstructure.**

Financial costs to be paid by household

| | $ | |
|---|---|---|
| Labour | 0.00 | (given by household) |
| Bricks | 15.50 | |
| Cement | 5.00 | |
| | 10.00 | |
| Steel | 3.00 | |
| Aggregate | 0.00 | (collected by household) |
| Total | 33.50 | |
| Superstructure | 14.50 | (assumes household labour contribution of 12.50) |
| Total | 48.00 | |

***Determination of repayments***

**Assuming a subsidized interest rate of 5% with the loan to be paid off over two years:**

Capital recovery factor = 0.538

Annual loan repayments = 0.538 × $ 48.00

Annual loan repayments = 0.330 × $ 48.00

= $ 25.80

**Check on affordability: annual average household income estimated for this example as $ 380.**

$$\text{Repayment as percentage of annual income} = \frac{25.80 \times 100}{380} = 6.8\%$$

**This would normally be too high for a household to pay, so repayments over four years at a subsidized rate of interest of 3% should be considered:**

Capital recovery factor = 0.270

Annual repayments = 0.270 × $ 48.00

= $ 13.00

$$\text{As percentage of annual income} = \frac{13.00 \times 100}{380} = 3.4\%$$

**This may be acceptable, depending upon the cost of living, and repayments would be completed before the first pit-emptying cost is incurred. As an alternative to subsidizing the rate of interest, it might be possible to sell the latrine slab at a reduced cost. It would be unwise to sell the cement or steel at reduced cost because of the dangers of the materials being used for other purposes. Another alternative is to encourage the use of different building materials to reduce the cost of the superstructure.**

**Affordability with loan at full rate of interest, repayable over 4 years, slab sold at half price and reduced cost superstructure:**

Financial costs to be paid by household

| | $ | |
|---|---|---|
| Labour | 0.00 | |
| Bricks | 15.50 | |
| Cement | 5.00 | |
| Cement as half price slab | 6.50 | |
| Steel | | |
| Aggregate | 0.00 | |
| Total | 27.00 | |
| Superstructure | 9.50 | (reduced-cost design) |
| Total | 36.50 | |

Capital recovery factor = 0.315

Annual loan repayments = 0.315 × $ 36.50

= $ 11.50

$$\text{Repayment as percentage of annual income} = \frac{11.50 \times 100}{380} = 3\%$$

***Determination of subsidy***

**With subsidized rate of interest: assuming a real interest rate of 10%, capital recovery factor = 0.315 for four years. Without subsidy, annual repayments would be $ 15.10. With a subsidized rate of interest of 3%, subsidy = $2.10 annually for four years in addition to the institutional and promotional costs paid by the agency**

**of approximately $ 22.**

**With subsidized slab cost: the subsidy represents half the cost of a householder making a slab. Therefore the agency has to pay labour charges as well as half the material costs. Subsidy = $ 2.00, labour and materials = $ 6.50, total subsidy = $ 8.50, in addition to the institutional and promotional costs.**

## Chapter 11. Development

**Implementation of a successful sanitation project usually follows a recognizable pattern. After the initial surveys, as described in Chapter 9, a demonstration or experimentation phase is required. The demonstration phase is a practical test of the feasibility of the recommended options. This is followed by a consolidation period (Glennie, 1983), primarily to organize the institutional aspects of the project, leading on to the mobilization or expansion phase, when most of the sanitation facilities are constructed.**

**For the benefit of the agencies involved, it is always advisable to conclude the project with some form of monitoring or evaluation in order to determine how effective it has been. The time scale can vary according to the size of population to be served, its receptivity to development ideas and the financial resources available. However, it is usual to find that the whole sequence takes years rather than months.**

### Implementation

**The purposes of the preliminary surveys are to determine the extent to which a sanitation programme might be effective and to begin to determine the most**

**appropriate means of meeting public health needs. If the surveys indicate that there is a possibility of a programme being successful, a demonstration phase is required. This phase has three main objectives:**

**- to identify the techniques and materials that will be most cost-effective;**
**- to demonstrate the resulting sanitation systems to the community and the government;**
**- to begin to stimulate demand for sanitation from individual householders.**

**Experimental period**

**An experimental period is normally required for a new sanitation project, during which field staff investigate whether the proposed combination of materials and techniques will work effectively at an affordable level in the particular sociocultural and geographical situation. For example, different systems may need to be compared, and certain elements, such as pit linings, concrete slabs or water seals, may need to be adapted in order to use locally available materials.**

**Particularly where new techniques or materials are being introduced, the initiators need to carry out a pilot project to work out the technical details to their own satisfaction before promoting the idea to others. Low-income communities cannot afford the risk of installing an unproved system at their own expense.**

**The period of experimentation also provides an opportunity for informal training of field staff. Those involved in trying out the various alternatives learn the advantages and disadvantages of many different techniques. They can then subsequently explain in convincing detail and from first-hand experience why**

**certain options are being recommended to the prospective users.**

**If an affordable design is already well recognized and accepted by the prospective users, the experimental phase may be omitted.**

***Demonstration***

**As the project staff gain confidence in the technologies they are promoting, the experimentation period will merge into the demonstration phase, when all interested parties can see the proposed facilities and make their own recommendations and decisions. This enables the promoters to ensure that the technology selected is socially and culturally acceptable to the people. In particular, community representatives and leaders should be given the opportunity to see and discuss the proposals. Results of surveys (which respondents may not always have understood) can be checked against the reality of a demonstration unit.**

**Government officials from both the sponsoring ministry and related departments and ministries should be encouraged to participate in discussions about the demonstrated systems. Particularly where officials believe that the only acceptable form of sanitation is a high-cost waterborne sewerage system, it is necessary to show that low-cost on-site systems are viable alternatives. Where nongovernmental organizations are involved in the provision of sanitation, it is important that the appropriate government departments have the opportunity to comment at this stage.**

**The experimental trials are most effective when carried out within the target area**

**at a workshop belonging to the agency or a sympathetic institution, and where prospective users can see the alternatives being tried. The subsequent demonstration sanitation system may be a completed experimental unit or a new system at a new location. The demonstration unit is best installed where local people can try it out in something approaching normal conditions. This may reveal further problems or limitations.**

**Pilot projects or demonstration systems should be located where people who are committed to the programme can regularly monitor and maintain the latrines. Because a demonstration unit, used by different people, can so easily become fouled, locations that may seem suitable, such as health centres, schools or community buildings, are not always effective sites. More usefully, a health worker's home or the compound of a community development officer who is prepared to care for and maintain the system can be used. Alternatively, the home of a motivated member of the community might be suitable. Where there are village development committees, and particularly where there are water and sanitation committees, prominent members may host demonstration units.**

**The experimental phase may produce several designs that appear to be suitable for a particular project area. Alternatively, one option that can use a range of different materials may be viable. Variety of design should be encouraged if it enables householders of differing income levels to participate. For example, a ventilated pit latrine can work equally well with a concrete slab or a maintained earth and pole slab. The demonstration phase should show how each solution can be used within the community and at the same time draw attention to possible ways of upgrading the system when financial circumstances permit.**

### *Stimulating demand*

**The selection of an appropriate sanitation system should be the responsibility of the people who will ultimately use it. The demonstration phase may be considered as a shop window where potential consumers can see what is on offer at a particular price and determine the model they require. Although most of the selling will go on during the full implementation phase, it is useful, even at this preliminary stage of the project, to begin to stimulate demand.**

**In many sanitation projects, the public health professionals take a strong lead in initiating the feasibility and demonstration phases. However, the responsibility for successful construction, operation and maintenance should be transferred to the community at the earliest opportunity, preferably before the full implementation or expansion phase starts. Experience has shown that the most successful sanitation projects involve a partnership between the people who will use the scheme and an assisting agency. The agency may be tempted to take too strong a lead role and to attempt to move the programme along too quickly. Working without adequate community involvement may appear to achieve progress in the short term, but it is often to the detriment of the project in the long term.**

**Wherever possible, low-cost on-site sanitation should be planned and built by the people, operated by the people and maintained by the people. The aim is for minimal agency participation in a community project. As described above, the agency can significantly assist with experimentation and demonstrations to aid people in the decision-making process. The agency can attempt to ensure that the right people have visited demonstration projects. It can help local organizations and government bodies to be aware of the issues by preparing clearly presented**

**documentation. However, to be certain that the people know that the project belongs to them and is under their control, it is important for the agency to restrict its role and not try to direct the project. The community and particularly the individual householders have to sort out their own priorities and move forward at their own pace. This may appear to delay progress and it may frustrate helpers, but true community decisions take time.**

**Glennie (1983) commented that programmes in which people have been forced to build latrines or where latrines have been provided free of cost have generally failed. "It is essential that a villager builds a latrine only as a result of a conscious decision that he wants to use one. It is the use, rather than the construction, of the latrine that is crucial. The strategy to be adopted therefore, is to encourage at least some villagers to decide that they want to use latrines, thereby stimulating a genuine demand."**

**In terms of the project cycle, information derived from the demonstration phase concludes the feasibility stage. At this stage, some governments and donor agencies may require an appraisal of the proposals, in the form of an independent check on the work that has been carried out. This appraisal normally covers technical, social, health, environmental, institutional, financial and economic criteria to determine whether the project is well planned and worthy of further investment. On the basis of the appraisal, the donor or government ministry may subsequently approve the decision to proceed with the project. This enables the consolidation phase to commence.**

**Consolidation**

**At the community level the distinction between the demonstration phase and the consolidation phase may appear blurred. However, there comes a point where the basic technology has been proved to be feasible and the project is generally acceptable. Before widespread implementation can begin a period of consolidation is required, primarily to organize the institutional aspects of the project. The demonstration units should continue to be operated and cared for, but the primary thrust at this stage is to determine the support (technical, financial, material and administrative) that the agency will have to provide in order to enable householders to build their own latrines. Training of community personnel and technicians, identification of community leaders, involvement of staff from the health, education and other sectors, confirmation of sanitary codes and regulations, testing of promotional materials, and general administrative support all have to be considered.**

***Governmental approval***

**The agency should finalize, as far as possible, the recommended designs for latrines, and seek the widest possible governmental acceptance for the programme. This approval should be sought not only from the institution directly responsible for sanitation but from all interested ministries, councils and committees. However, following on from the demonstration phase and initial contacts with community leaders, the agency and other institutions have to recognize that householders are unlikely to come to a clear-cut decision. Unless the community is unusually homogeneous, it is probable that the people will want a range of options at varying costs. For example, at the simplest level a lined pit could be constructed with a wood and mud slab and only a screen for privacy. At a later date, the household may be able to afford a concrete slab to replace the**

**timber and mud, and then later still a permanent superstructure could be built. On the other hand, some families may be able to afford a concrete slab from the outset.**

**In certain situations, some latrines may later be upgraded by connection to a main sewerage system, but it is normally impracticable to make specific plans for such improvements in the early stages.**

***Institutional support***

**The flexibility required to meet the differing expectations of householders makes the agency's work more difficult. The assistance proffered has to take into account the various income levels and preparedness of the different groups to invest. The agency therefore needs to focus on the aspects of the programme that are crucial to its success. These may be technical, financial, institutional, social or promotional, but the agency would do well not to be diverted into trying to enforce one set solution. In many projects this means that the superstructure, design and construction are left to individual householders, while the agency concentrates on general promotional work and helping with slabs and linings along with the water seal (and connecting pipe) or vent pipe, where required.**

**The approach adopted by the agency must be worked out in advance of widespread promotion within the community so as to minimize any confusion. Whichever approach is taken, standardized procedures should be fixed during the consolidation period. Agency staff can then be trained in these procedures to enable them to give clear and coherent advice to householders.**

**Any necessary administration required to support the field staff should also be determined on the understanding that it will be there to assist rather than to restrict or limit.**

### *Training*

**Sanitarians and technical staff who were not involved in the demonstration phase should be told about the results and techniques developed earlier. Related staff, such as health workers and sociologists, should also be given an introduction to the programme. The extent of training needed will depend on their proposed role within the programme, but at the least they should be fully informed as to what is expected of the householders.**

**Similarly, teachers in local educational establishments should be introduced to the programme and ideally provided with suitable educational material to use with their students. Artisans not directly responsible to the agency but who may become involved as small contractors should be trained in any specialized techniques that may have been developed during the experimentation. Training programmes for householders should be prepared and tested for later use.**

### *Pre-testing of promotional materials*

**Any leaflets, plans, posters or other explanatory or promotional material should be pre-tested during the consolidation phase to ensure that the message being received by the readers is the one intended by the promoters. Similarly any teaching materials for schools should also be tested.**

### *Sanitary codes and regulations*

**Basic legislation is necessary to enable a public health agency to initiate and develop activities in the field of public health and sanitation. Enabling legislation is normally confined to statements of broad principles, responsibilities and penalties. On the basis of such legislation, the public health agency concerned is in a position to formulate more detailed rules, regulations and standards.**

**Any existing sanitary code may exert a strong influence on the nature and content of an excreta disposal programme. If the sanitary regulations are outdated, or too elaborate or exacting, they may restrict both the technical and the administrative aspects of the project. Such regulations may defeat their own purpose and are often ignored by the population. When suitably drafted, regulations are useful in helping to ensure a basic minimum of sanitary safeguards and the elimination of potential health hazards, especially in densely populated communities. They usually deal with and prescribe standards for such matters as: the prevention of soil and water pollution, the disposal of human and animal wastes; the hygiene aspects of housing; the protection of food supplies; the control of arthropod, rodent and mollusc hosts of disease; and the use of surface water.**

**When elaborating sanitary regulations it is important to keep in mind the following principles:**

- **No regulation should be made that cannot be enforced.**
- **No law can be enforced without the cooperation of most of the people concerned.**

**Rules and regulations applying to excreta disposal in low-income areas should be reasonable and no stricter than necessary; above all they should be in accordance**

**with the basic principles of sanitation. It is important to consider every contigency that may occur within the foreseeable future, and the best way to do so is to consult the people for whose benefit the regulations are formulated. While the experience of others may be useful in drafting new regulations, it is always a mistake to adopt the regulations of another country without making necessary modifications.**

**On the need for the cooperation of the people in the enforcement of legislation, Lethem (1956) wrote, "No form of control can be effective without the support of most of the people concerned, backed by an enlightened public opinion. Hence, education must precede legislation; in fact it might be described as the father of legislation. The lower the standard of education, the greater the need for careful preparation before new regulations can be introduced and enforced. It is better to start in a small way and work up, than to introduce a multiplicity of rules and raise a wall of opposition, which makes enforcement difficult. Legislation alone cannot improve hygiene. To launch regulations without first preparing the way, is like sowing seed without first ploughing the ground. Old traditions die hard, and bad habits are not easy to change."**

**This statement is particularly applicable to excreta disposal programmes, which are designed to bring about changes in people's attitudes and practices. In this field, public health instruction is more important than compulsion, and sanitary inspection should not have as its primary aim the enforcement of regulations by means of sanctions.**

**There may be particular areas of concern in existing by-laws which may limit the freedom to introduce low-cost sanitation programmes. For instance, regulations**

**may specify that only water closets connected to a sewer or septic tank are acceptable in urban areas. Other rules may specify a minimum depth for pit latrines which would be unrealistic in particular ground conditions. It is important that these points are amended after full consultation. The most suitable time to make changes is during the consolidation phase, after the various technologies have been tested but before the expansion phase.**

**Other points to be considered for legislation include the following:**

- **Defecation in streets and public places should be illegal once sanitary facilities have been made available. Households should be required to install sanitation systems within a specified time of the sanitation programme commencing.**

- **No new housing developments should be allowed to proceed without suitable sanitation provision.**

- **The letting of any house or part of a house or household plot for residential purposes without sanitation facilities should be illegal.**

- **Where a landlord fails to provide sanitation within a specified time, tenants should be empowered to construct facilities and deduct the expense, as agreed with the agency's officers, from the rent payable to the landlord.**

- **In certain circumstances, local authorities may be empowered to recover loans for construction of latrines from the beneficiaries through local taxation (Roy et al., 1984).**

## Mobilization or expansion

**The mobilization or expansion phase aims to encourage and enable every householder and institution in the target area to acquire satisfactory sanitation facilities within a certain period of time. This period of expansion may be considered in terms of promotion and construction. Promotion consists of convincing individual householders that they need to improve their sanitation and have the capability to do so. Once the householders make their decision, the individual construction phase begins with particular requirements for support.**

### *Promotion*

**The mobilization phase is a time of mass communication. It is an opportunity to share information and lessons learnt from the preceding stages with the target group for the programme. Health education to explain the need for sanitation usually has to be stressed as strongly as the proposed solutions. Until people understand the objectives of the project and why sanitation is so important to them, they are unlikely to be fully committed to it. However, in considering the methods of health education and promotion listed below, it is helpful to remember that the primary motivation for sanitation is often the desire for privacy and convenience. Ultimately it has been found that most people choose to improve their sanitation when they see that their neighbour has a clean affordable system which is pleasant to use.**

**Sanitation may therefore be seen in certain circumstances as a consumer product. The technology that is successful in terms of user take-up has to have some of the attractiveness of any consumer product in addition to being effective and of good**

**value (Franceys, 1987). A valid approach to the promotion of latrines is to consider them as products to be marketed to individual households using all the skills of the advertising and marketing industry.**

**This approach has been taken in programmes where the experimentation or demonstration workshops have been turned into sanitation centres. These are effectively shops where prospective customers can come to inspect the options available in the various price ranges. They can then discuss with a "salesman" the possibilities of purchasing a system and hear of the special offers open to them regarding technical assistance and financial help. This approach is particularly appropriate for on-site sanitation where each system stands on its own, unconnected to any sewer lines or communal facilities.**

**A more conventional approach is to consider initial promotion as part of a health education programme which has the following purposes:**

- **to demonstrate the possibility of improving the health status of the individual and the household;**
- **to demonstrate the link between well-being, health and sanitation practices;**
- **to create a desire for improvement in sanitary habits;**
- **to help determine what changes are needed and desirable for improving sanitation and how they can be implemented;**
- **to encourage people to put into practice good habits of personal hygiene,**

**and measures to improve personal, home and community sanitary conditions;**

- **to secure sustained interest and participation in a community programme of environmental health improvement.**

**There are many methods of promoting health and improved sanitation as a means to health. The ideas listed below should be used in a mixture that suits the culture and aspirations of the people at the time of the programme. It is important to note that the extent of promotional activities should be linked to the agency's capacity to assist with construction of sanitation systems. Otherwise considerable frustration may build up which could be counterproductive.**

***Meetings and visits***

**Various types of meetings can be used, for example, individual discussions with community leaders, house-to-house visits by community development officers or sanitarians, visits by women health workers to the women in the community, and general public meetings where the wider issues can be discussed by the whole community.**

***Role of schools and teachers***

**Schoolteachers, especially at primary level, should be trained to prepare the children to use sanitation facilities correctly at school and to understand the need for hygiene and latrines at home. Special lessons should be given to help children understand that a clean water supply with effective sanitation can lead to improved health. This will not only be of benefit to the children but will also serve**

**to reinforce the health message to the community as the children report back to their parents.**

***Demonstrations and mass treatment***

**Demonstrations may be held using microscopes to show what can be seen in apparently clean water. This is most effective when what is seen can be shown to result from inadequate sanitation. Where such demonstrations can be linked with special clinics to treat people who are ill from excreta-related diseases, a powerful lesson can be provided.**

***Community groups***

**Selected target groups within the community may be invited to participate in drama or role-playing related to health education and the need for sanitation. Stories and songs can also be effective ways of communicating ideas.**

***Leaflets***

**Simple technical information leaflets are required, containing illustrations and drawings that have been pre-tested. The leaflets should describe the different parts of the system, and explain how they work together and how they can be constructed. Written information may also be supplied detailing the help that each household can obtain from the agency. Even if householders are illiterate they are likely to be able to call upon others to explain. It is important that everybody has equal access to details of assistance. Vague promises given at public meetings are not sufficient.**

**The information given should stress that any solution can eventually be upgraded. Even if householders find that they do not have the required piped water or that they cannot immediately afford the type of sanitation they desire, they should be able to see that there are ways to upgrade their facilities in stages while enjoying the benefits of improved sanitation.**

### *Training*

**Ideally, the skills that may be required by local artisans or technicians should be transferred during the consolidation stage. However, where training is also required during the expansion phase, simple practical sessions or demonstrations, where participants construct components and complete systems in selected households in the target area, are effective as a form of promotion as well as training.**

### *Use of the mass media*

**There are many forms of the mass media that can be used for promoting specific sanitation options as well as for health education. Their use and the balance between them will depend on the size of the target group, the relative wealth of the people and the availability of funding. Posters, billboards, newspapers, radio, loudspeaker trucks, slides, flip-charts, film, video, and broadcast television have all been used successfully in differing mixes. Careful planning is necessary, as too much information and health education coming too soon may lead to a build-up of resistance against the ideas. Karlin & Isely (1984) considered in detail the use of audiovisual materials for use in sanitation programmes.**

**Care should be taken to ensure that all the agencies, institutions and health-related bodies have prepared their staff to give the same message. Any conflict between them will lead to mistrust on the part of prospective users.**

## Construction

### *Selection of system by householders*

**In the majority of cases individual householders will be responsible for organizing the building of sanitation systems at their own houses. Having chosen the system they feel best fits their needs, they will benefit from continued assistance and support during the construction period.**

### *Technical assistance*

**Technical advice regarding the choice of system, the best site for a unit, the depth to which any pit should be dug, and requirements for lining, ventilating, sealing and covering the pit should be available from technicians who can visit the household for detailed discussions. This information should also be available in the form of a written leaflet.**

**Where required, an auger kit for drilling trial holes may be used by the technical staff to determine the best place to dig the pit.**

### *Training for householders*

**Short training sessions may be held at the demonstration workshop to teach householders how to dig and line pits and how to make slabs, vent pipes or seals.**

**Alternatively, householders may be helped to make their own components at the demonstration site.**

### *Identification of contractors and artisans*

**Although the skills required for latrine construction are relatively simple, many householders may prefer to pay others to carry out the work. A project can assist by identifying pit excavators, masons or contractors who are trained and able to carry out the work to a satisfactory standard. Agreements and pricing levels may also be negotiated by the agency on behalf of the householders.**

### *Tools and moulds*

**Special tools, such as iron bars, pickaxes, spirit levels, or plumb-bobs, that are not normally available in the community, may be provided, for loan, hire or sale. Similarly, reusable moulds for concrete lining rings, slabs or water seals may also be made available by the agency.**

### *Materials*

**Where the cost or a shortage of materials necessary for construction causes difficulties, the agency may help with procurement. There is, however, a danger that such materials will be misused, either by incorporation in nonsanitary household building work or through resale to traders. Because of this, materials support is often limited to the provision of precast components of a sanitation system, such as slabs, seals and vent pipes. These may be sold at commercial rates to encourage their production by local businesses, thus fostering industrial development (International Development Research Centre, 1983). Another**

**alternative is to sell at cost price to ensure that people are paying the real cost of their sanitation and to enable a revolving fund to be set up to help others.**

**Where ventilated pits are recommended, PVC-coated glass fibre or stainless steel fly screens should be readily available from the agency. It is unlikely that householders will be able to purchase such material from local merchants. The alternative mild steel fly screens corrode quickly, giving rise to a significant problem with flies.**

***Finance and subsidies***

**As discussed in Chapter 10, the financial costs to be paid by the householder usually reflect the economic costs (that is, the overall cost to the nation) as closely as possible. However, where it is considered necessary for reasons of social welfare, subsidies may be employed.**

**Subsidies may be used where the poorest people in the community would not otherwise be able to afford a sanitation system, though care must be taken to ensure this is not simply an excuse to promote inappropriate technology (e.g., to use a more expensive alternative). Subsidies may also be employed where people are unwilling to invest in sanitation because they remain unconvinced as to the benefits to be gained, or where householders are reluctant to invest in what is perceived to be a temporary form of sanitation which does not confer the desired benefits of status and convenience. Finally, subsidies may be used where the agency desires to speed up the development process, to encourage more people to install systems at a faster rate than would otherwise be possible.**

**The methods used have included subsidized (low-interest) loans for construction of the complete system or loans for the purchase of specific materials or components. These loans usually form part of a revolving fund, set up by a donor, a proportion of which is made available for further projects in other areas. Loans may be totally free of interest or may include a nominal rate of interest to pay overhead charges. Where loans are charged at full commercial rates of interest there is no direct subsidy involved.**

**A subsidy may also be in the form of a grant for materials or components or as materials or components provided at reduced cost. One approach has been for grants to be made to householders on completion of an acceptable latrine, as an added incentive. Indirect grants may be given in the form of technical assistance or general project assistance which is not charged to the householder. Similarly, some projects may establish shops to sell building materials at cost price, avoiding normal trader profits. There is, however, a subsidy in the form of the overhead costs of the materials store.**

**The aim of subsidies is to enable householders to construct an acceptable sanitation system at the earliest opportunity. The resultant system has to be at a level where the householder can afford the recurrent costs of operation and maintenance. The level of the subsidy is gauged as the level that enables a sustainable system to be built which is still perceived by the householders as being under their ownership and control.**

**In India, experience suggests that if a programme is designed to serve the poorest of the poor, a subsidy has to be provided (Roy et al., 1984). But even for the poorest households, a small loan component requiring repayment is recognized as**

**being vital to ensure effective participation and use of the latrines.**

### *Site supervision*

**Information leaflets and training courses alone are not sufficient to ensure that latrines will be built correctly. Technical helpers need to pay visits to households where latrines are being constructed to advise and check on the technical details. Such personnel should provide constructive suggestions and encouragement, rather than negative comments and criticism.**

### *Institutional support*

**The lead agency which is promoting sanitation has the major role. However, other government departments, councils, health and educational establishments can also support the project. They should ensure that their own sanitation facilities are adequate for the use of their staff, students and visitors. Such institutions can also assist by providing space for temporary storage of materials.**

**There are various other forms of institutional support. Government employees have been given time off from work to construct their own sanitation systems as a model for their neighbours to copy. Similarly, it has been known for a government to declare a public holiday for all employees, both private and public, to spend time building latrines. However, there is a strong likelihood that the results of such special events will be less than hoped for unless the correct preparation (surveys and demonstrations) has been done.**

### *Loan repayments*

**Monthly instalments to pay back loans should be fixed at levels that are affordable rather than at rates designed to ensure quick repayment. However, this has to be balanced by the need to ensure that repayment periods are not excessive, since householders may be reluctant to continue paying over a long period for a facility such as sanitation.**

**Where the people have been fully involved in the construction of their latrines, it is usual to find that small loans for latrine construction are repaid. If a programme is forced through by an agency without full community involvement, it is likely that there will be a low return rate on loans.**

***Completion of the programme***

**Within most programmes, the rate of completion of individual sanitation units tends to follow an "S" curve (Fig. 11.1). In the initial demonstration and consolidation phases there is little progress in terms of numbers of systems completed. During the expansion phase the majority of the population are expected to install latrines. However, the rate of installation normally falls as the 80% completion level is neared. During the completion stage additional positive inducements should not be used, since this would be unfair to those who have already constructed their facilities on their own. Unless the failure to complete is due to particular social disadvantage, in urban and periurban areas legal action may have to be taken to ensure completion by all households. As the health benefits cannot be fully realized unless all members of the community use improved sanitation (particularly in areas of high population density), it is reasonable to expect substantial compliance.**

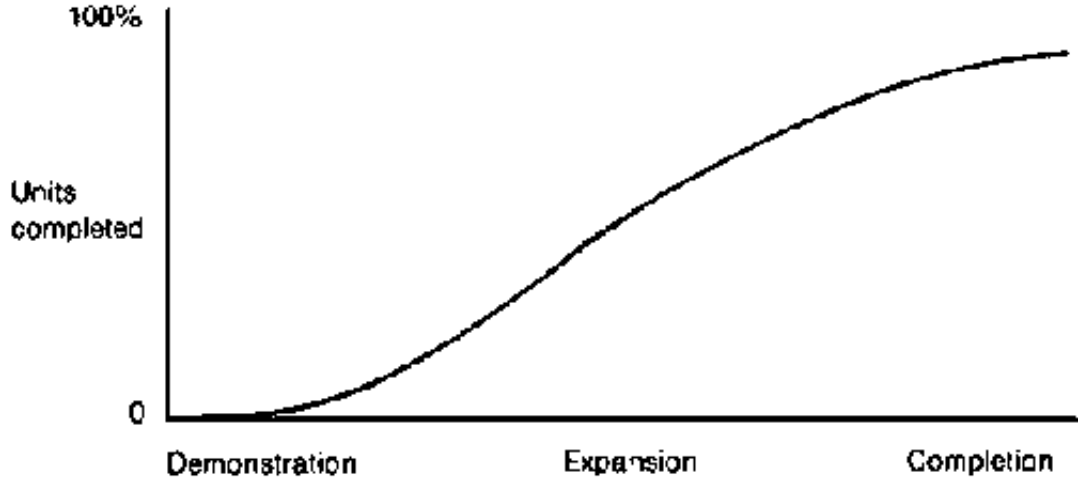



**Fig. 11.1. Pattern of installation of latrines in a sanitation programme**

***WHO 91500***

**There are many different approaches to assisting householders to construct their own sanitation facilities. For each project the right mix of assistance, motivation and legislation has to be determined in order to produce the desired results.**

**Operation and maintenance**

**Household responsibility**

**Completion of latrine construction marks the beginning of the real sanitation programme in that it is the point at which people can start to realize the benefits of their investment. Continuing health education and technical assistance are required to ensure that new systems function properly. For example, longer-term assistance may be required to ensure that double pits are emptied and used in rotation.**

**Some householders may benefit from advice as to how to encourage all members of their family to use the facility in a clean and safe way. Laver (1986) described how local potters were taught to make ceramic tiles depicting good habits of latrine use, which could be fixed permanently on the latrine walls to act as a constant reminder of good practice.**

**Use of hard cleaning materials such as stones and corncobs leads to increased rate of sludge accumulation, and hence to a shortened life for the pit or tank before emptying or to blockages in water seals or pipes. Members of the community should be told about the effects of using such bulky cleansing materials, and encouraged to find alternatives. Where it is not the custom to use water for anal cleansing, leaves, grass or paper are preferable. Details of the maintenance required for different types of latrine can be found in Chapter 6.**

**The latrine superstructure, like all buildings, needs regular maintenance to ensure that it remains structurally sound and pleasing to use.**

**Responsibility for maintenance must never be left undecided until the need becomes apparent. By that time many people will have stopped using the facility and returned to their old places. The latrine itself may have become so unpleasant that it is more difficult to find somebody to care for it regularly. Maintenance becomes a particular problem where an agency has been constructing sanitation systems for people without their full involvement in planning and design. If householders are unsure of the ownership of the system they are less likely to accept responsibility for looking after it.**

## Agency responsibility

**The householder or user has primary responsibility for using and maintaining the latrine. The agency may have to assist in two areas: (1) ensuring the availability of special items such as vent-pipe screening; and (2) the provision of services requiring special equipment, such as pit emptying. Initial demand may not be sufficient for private traders to stock specialized vent screening or plastic water seals. While this demand builds up, the agency should ensure that such items may still be purchased from a public health department after completion of the construction phase. Where double pits are used, the householder should empty the pit at regular intervals, using the dry sludge on the land as a fertilizer. Where single pits require mechanical emptying, particularly in urban areas, an organization should be established or the local council should run vacuum tankers at an affordable cost to the householder.**

## Evaluation

**As a sanitation project nears the end of the implementation phase, it is helpful to carry out an evaluation or review of what has occurred. Evaluation, by personnel who have not been directly involved with the project, is only of relevance to the community if the agency is prepared to correct any mistakes identified, particularly those of a technical nature that may lead to difficulties with operation or maintenance in later years. Evaluation is important for the agency, as it gives staff a better understanding of what has been effective and why, and at the same time pinpoints any failures that could be avoided in future programmes.**

**In the sense that evaluation is an ongoing management tool to ensure effective use of resources, it is sometimes considered necessary to engage in constant evaluation of all stages of a programme. Regular monitoring should be carried out**

**as routine by the management of any agency involved. Constant evaluation is normally only justified in large programmes. Evaluation carried out during or at the end of the project should be done by people who are familiar with the project or other similar projects but who have not been closely associated with the planning and implementation. This is to avoid the natural tendency for people to make allowances for shortcomings and weaknesses in any scheme with which they have been involved.**

**Because of the pressures on project budgets and professional staff time, the evaluation has to give the required information at minimum cost. Occasionally it may be of interest to carry out a number of evaluations over a period of years subsequent to completion of the project. However, the results rarely justify the costs involved.**

**The World Health Organization has developed a minimum evaluation procedure (MEP) for water supply and sanitation projects (WHO, 1983). In this, evaluation is defined as "a systematic way of learning from experience and of using the lessons learned both to improve the planning of future projects and also to take corrective action to improve the functioning, utilization and impact of existing projects." Using the MEP, the first consideration is how effectively the facilities are working or functioning. This is followed by an investigation as to how well the sanitation system is being used and maintained by the people; and finally the impact on the health and welfare of the community is considered. A protocol for inspection of latrines, included in the MEP, is shown in Fig. 11.2.**

**Fig. 11.2. Protocol for the inspection of latrines**

Programme: _____ Province: _____

District: _____

Village: _____

Inspected by: _____

Date: _____

1. Household identification _____

2. Superstructure, type _____

| | Yes | No |
|---|---|---|
| Functioning | _____ | _____ |
| Gives privacy | _____ | _____ |
| Gives protection from rain | _____ | _____ |

3. Fixtures, type _____

| | Yes | No |
|---|---|---|
| Water in water seal | _____ | _____ |
| Lid | _____ | _____ |
| Suitable | _____ | _____ |

If not suitable specify problem

2. If not suitable specify problem _____

4. Pit lined Yes _____ No _____

Free depth _____ metres

| | Yes | No |
|---|---|---|
| 5. Cleaning material available | _____ | _____ |

6. Water for handwashing available at what distance? _____ metres

7. General condition

| | Good | Acceptable | Bad | Very bad |
|---|---|---|---|---|
| Smell | _____ | _____ | _____ | _____ |
| Flies | _____ | _____ | _____ | _____ |
| Mosquitos | _____ | _____ | _____ | _____ |
| Fouling | _____ | _____ | _____ | _____ |

8. Other comments

_____

_____

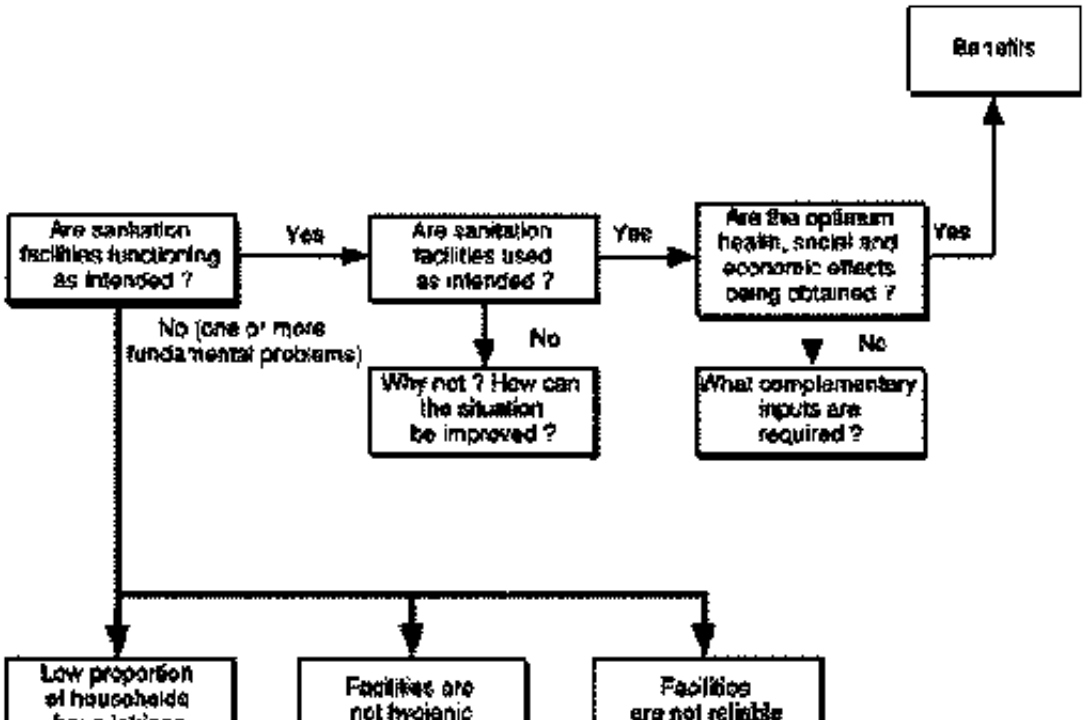
_____

***WHO 91501***

**Evaluation normally leads to recommendations for further action to improve the effectiveness of sanitary facilities. There should be a readiness within the programme institutions to make the recommended alterations if the time and expense of carrying out the evaluation are to be justified.**

## Functioning

**Evaluation of functioning, that is, determination of how well the different systems are working, can be considered in terms of the proportion of households in the target area who have constructed a sanitation system, and the reliability of the facilities (Fig. 11.3). Failure to reach at least 80% of the target population may be because the facilities are unaffordable or are not considered of immediate priority by the community in terms of expected benefits.**



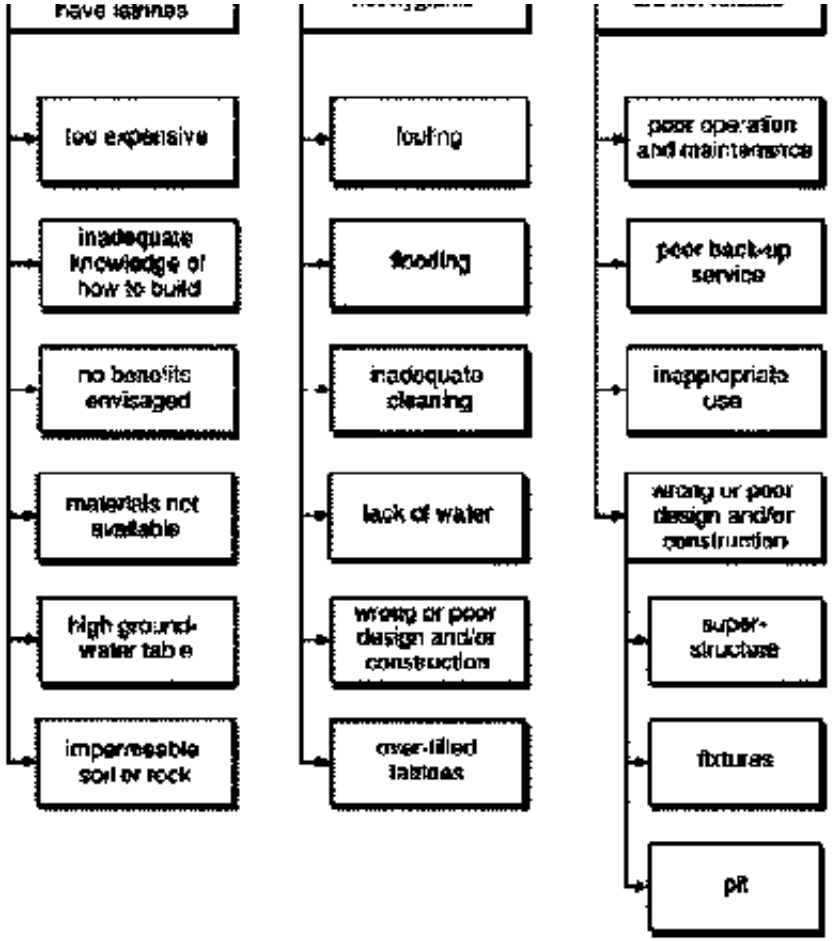



**Fig. 11.3. Evaluation of sanitation facilities**

***WHO 91373***

**Technical confusion over the design, use of inappropriate materials, a high groundwater table and hard rock all lead to a lower than anticipated response. Where the facilities are unhygienic (for example, because of constant fouling, flooding or fly nuisance), reasons for this failure should be investigated. Reliability should be considered in terms of operation and maintenance, rate of filling of pits,**

**convenience of superstructures, and functioning of items such as water seals and vent pipes.**

## Utilization

**In recording the proportion of people using the systems, particular attention should be paid to the different categories in the community, such as women, men, children and old people. However, such information is often difficult to collect, as people may give replies they think the evaluator requires. Watching who uses a latrine may be considered an invasion of privacy. A careful combination of interviewing and observation is needed. Low rates of use may be due to technical inadequacies, sociological issues, lack of health education, or a general uncertainty regarding the system. It is important to distinguish between these different factors.**

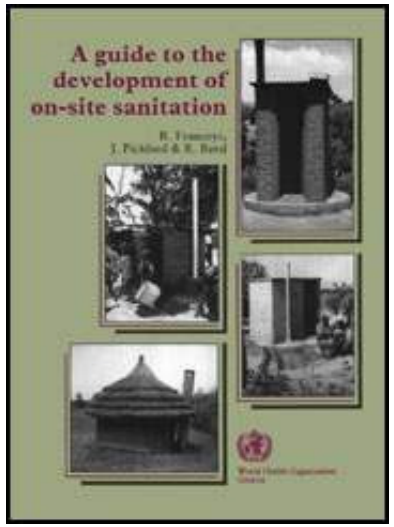
## Health impact

**Evaluation of health impact is only worth while when the factors hindering functioning and utilization have been overcome. The aim is to determine whether there has been any improvement in health and well-being as a result of the sanitation programme. Such studies tend to be expensive and normally require specially trained personnel such as medical officers and epidemiologists. Briscoe et al. (1986) gave detailed information on the complexities of measuring health impact. In particular, the authors looked at the conditions under which health impact evaluations should be carried out, the preferred indicators for measuring impact on health, appropriate methods for study, and means of interpreting the results. They concluded that such detailed evaluations are justified where further**

**large investments are contemplated and economic criteria are not sufficient to decide between alternative options, where systems are functioning and being utilized, and where sufficient resources (including scientific personnel) are available.**

**The ultimate evaluation is that of the householders themselves. A project can be considered successful where householders, by their own choice, have invested a significant amount of time and money in the implementation of their own sanitation systems, and demonstrate their satisfaction by their continued willingness to use, operate and maintain their latrines.**

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



## References

**ALUKO, T. M. (1977) Soil percolation tests in the Lagos area. *Journal of the Institution of Public Health Engineers*, 5 (6): 152-155.**

**ASSOCIAO BRASILEIRA DE NORMAS TCNICAS (1982) *Construcao e instalcao de fossas septicas e disposicao dos efluentes finais*. Rio de Janeiro (NBR 7229).**

**BALASEGARAM, M. & BURKITT, D.P. (1976) Stool characteristics and western diseases. *Lancet*, 1: 152.**

**BASKARAN, T.R. (1962) *A decade of research in environmental sanitation*. New Delhi, Indian Council on Medical Research (Special Report Series No. 40).**

**BERG, A. (1973) *The nutrition factor and its role in national development*. Washington, DC, Brookings Institution.**

**BLUM, D. & FEACHEM, R. G. (1983) Measuring the impact of water supply and sanitation investments on diarrhoeal diseases: problems of methodology. *International journal of epidemiology*, 12 (3): 357-365.**

**BOESCH, A. & SCHERTENLEIB, R. (1985) *Emptying on-site excreta disposal systems: field tests with mechanized equipment in Gaborone (Botswana).* Dbendorf, Switzerland, International Reference Centre for Waste Disposal (IRCWD Report No. 03/85).**

**BRADLEY, R. M. (1983) The choice between septic tanks and sewers in tropical developing countries. *The public health engineer*, 11 (1): 20-28.**

**BRANDBERG, B. (1985) Why should a latrine look like a house? *Waterlines*, 3: 24-26.**

**BRISCOE, J. (1984) Water supply and health in developing countries: selected primary health care revisited. *American journal of public health*, 74 (9): 1009-1013.**

**BRISCOE, J. ET AL. (1986) *Evaluating health impact: water supply, sanitation, and hygiene education*. Ottawa, International Development Research Centre.**

**BRITISH STANDARDS INSTITUTION (1972) *Code of practice: small sewage treatment works*. London (CP302).**

**VAN BURNE, A. ET AL. (1984) Composting latrines in Guatemala. *Ambio*, 13 (4): 274-277.**

**BURKITT, D. P. ET AL. (1974) Dietary fibre and diseases. *Journal of the American Medical Association*, 229: 1068-1074.**

**BUTLER, R. G. ET AL. (1954) Underground movement of bacterial and chemical**

**pollutants. *Journal of the American Water Works Association*, 46 (2): 97-111.**

**CAIRNCROSS, S. & FEACHEM, R. G. (1983) *Environmental health engineering in the tropics: an introductory text*. Chichester, Wiley.**

**CALDWELL, E. L. (1937) Pollution flow from pit latrines when impervious stratum closely underlines the flow. *Journal of infectious diseases*, 61: 270-288.**

**CAREFOOT, N. F. (1987) Human resources development. In: *Developing world water*, Vol. 2. London, Grosvenor Press International.**

**CARROLL, R. F. (1985) Mechanised emptying of pit latrines in Africa. In: Ince, M., ed., *Proceedings of the eleventh WEDC Conference: Water and sanitation in Africa*. Loughborough, Water, Engineering and Development Centre, pp. 29-32.**

**CHEESBROUGH, M. (1984) *Medical laboratory manual for tropical countries. Volume II: Microbiology*. Sevenoaks, Kent, Tropical Health Technology.**

**COTTERAL, J. A. & NORRIS, D. P. (1969) Septic tank systems. *Journal of the environmental engineering division, Proceedings of the American Society of Civil Engineers*, 95: 715-746.**

**CRANSTON, D. & BURKITT, D. P. (1975) Diet, bowel behaviour and disease. *Lancet,* 2: 37.**

**CROFTS, T. J. (1975) Bowel-transit times and diet. *Lancet,* 1: 801.**

**CURTIS, C. F. & HAWKINS, P. M. (1982) Entomological studies of on-site**

**sanitation systems in Botswana and Tanzania. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 78 (1): 99-108.**

**DENYER, S. (1978) *African traditional architecture*. London, Heinemann.**

**EGBUNWE, N. (1980) Alternative excreta disposal systems in Eastern Nigeria. In: Pickford, J. & Ball, S., ed. *Water and waste engineering in Africa. Proceedings of the sixth WEDC Conference*. Loughborough, Water, Engineering and Development Centre, pp. 137-140.**

**FEACHEM, R. G. ET AL. (1983) *Sanitation and disease: health aspects of excreta and wastewater management*. Chichester, Wiley.**

**FRANCEYS, R. (1987) Sanitation for low income housing, Juba, Sudan. In: *African Water Technology Conference, Nairobi.* London, World Water, pp. 141-149.**

**GEYER, J. C. ET AL. (1968) *Water and wastewater engineering*, Vol. 2. New York, Wiley.**

**GLENNIE, C. (1983) *Village water supply in the Decade: lessons from field experience*. Chichester, Wiley.**

**GROVER, B. (1983) *Water supply and sanitation project preparation handbook: Vol. 1: Guidelines.* Washington, DC, World Bank (World Bank Technical Paper No. 12).**

**HUTTON, L. G. ET AL. (1976) A report on nitrate contamination of ground-waters in some populated areas of Botswana. Lobatse, Botswana, Geological survey**

**(unpublished report BGSD/8/76).**

**INTERNATIONAL DEVELOPMENT RESEARCH CENTRE (1983)** ***The latrine project, Mozambique.*** **Ottawa (IDRC-MR58e).**

**JEEYASEELAN, S. ET AL. (1987)** ***Low-cost rural sanitation - problems and solutions*****. Bangkok, Environmental Sanitation Information Center.**

**KALBERMATTEN, J. M. ET AL. (1980)** ***Appropriate technology for water supply and sanitation: a planner's guide.*** **Washington, DC, World Bank.**

**KALBERMATTEN, J. M. ET AL. (1982)** ***Appropriate sanitation alternatives: a technical and economic appraisal*****. Baltimore, Johns Hopkins University Press.**

**KARLIN, B. & ISELEY, R. B. (1984)** ***Developing and using audio-visual materials in water supply and sanitation programs*****. Arlington, Water and Sanitation for Health Project (WASH Technical Paper No. 30).**

**KHANNA, P. N. (1985)** ***Indian practical civil engineer's handbook.*** **New Delhi, Engineers' Publishers.**

**KIBBEY, H. J. ET AL. (1978) Use of faecal streptococci as indicators of pollution of soil.** ***Applied and environmental microbiology*****, 35 (4): 711-717.**

**LAAK, R. (1980) Multichamber septic tanks.** ***Journal of the environmental engineering division, Proceedings of the American Society of Civil Engineers*****, 106: 539-546.**

**LAAK, R. ET AL. (1974) Rational basis for septic tank system design. *Ground water*, 12: 348-352.**

**LAVER, S. (1986) Communications for low-cost sanitation in Zimbabwe. *Waterlines*, 4 (4): 26-27.**

**LETHEM, W. A. (1956) *The principles of milk legislation and control*. Rome, Food and Agriculture Organization of the United Nations (Agricultural Development Paper, No. 59).**

**LEWIS, W. J. ET AL. (1980) The pollution hazard to village water supplies in eastern Botswana. *Proceedings of the Institution of Civil Engineers*, 69: 281-293.**

**MCCARTY, P. (1964) Anaerobic waste treatment fundamentals, part 1. *Public works*, 95: 107-112.**

**MCCLELLAND, I. & WARD, J. S. (1976) Ergonomics in relation to sanitaryware design. *Ergonomics*, 19 (4): 465-478.**

**MACDONALD, O. J. S. (1952) *Small sewage disposal systems*. London, Harrison & Crosfield.**

**MCMICHAEL, J. K. (1976) *Health in the third world ... studies from Vietnam*. London, Spokesman Books.**

**MAJUMDER, N. ET AL. (1969) A critical study of septic tank performance in rural areas. *Journal of the Institute of Engineers (India)*, 40 (12): 743-761.**

**MARA, D. D. (1984) *The design of ventilated improved pit latrines*. Washington, DC, World Bank (TAG Technical Note No. 13).**

**MARA, D. D. (1985a) *Ventilated improved pit latrines: guidelines for the selection of design options*. Washington, DC, World Bank (TAG Discussion Paper No. 4).**

**MARA, D. D. (1985b) *The design of pour-flush latrines.* Washington, DC, World Bank (TAG Technical Note No. 15).**

**MARA, D. D. & CAIRNCROSS, S. (1989) *Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture*. Geneva, World Health Organization.**

**MARA, D. D. & SINNATAMBY, G. S. (1986) Rational design of septic tanks in warm climates. *The public health engineer*, 14 (4): 49-55.**

**MORGAN, P. R. (1977) The pit latrine - revived. *Central African journal of medicine*, 23: 1-4.**

**MORGAN, P. R. & MARA, D. D. (1982) *Ventilated improved pit latrines: recent developments in Zimbabwe*. Washington, DC, World Bank (World Bank Technical Paper No. 3).**

**NITRATE COORDINATION GROUP (1986) *Nitrates in water*. London, HMSO (Pollution Paper No. 26).**

**OLDCORN, R. (1982) *Management - a fresh approach*. London, Pan Books.**

**PACEY, A., ed. (1978) *Sanitation in developing countries*. Chichester, Wiley.**

**PACEY, A. (1980) *Rural sanitation: planning and appraisal*. London, IT Publications.**

**PARRY, J. (1985) *Fibre concrete roofing*. West Midlands, Intermediate Technology Workshops.**

**PHADKE, N. S. ET AL. (undated) *Study of a septic tank at Borivli, Bombay*. Bombay, CPHERI Bombay Zonal Laboratory.**

**PICKFORD, J. (1980) *The design of septic tanks and aqua-privies*. Garston, Building Research Establishment (Overseas Building Note No. 187).**

**PRADT, L. A. (1971) Some recent developments in night-soil treatment. *Water research*, 5: 507-521.**

**REYNOLDS, C. E. & STEEDMAN, J. C. (1974) *Reinforced concrete designers' handbook*. London, Viewpoint.**

**ROY, A. K. ET AL. (1984) *Manual on the design, construction and maintenance of low-cost pour-flush waterseal latrines in India*. Washington, DC, World Bank (TAG Technical Note No. 10).**

**RYAN, B. A. & MARA, D. D. (1983) *Ventilated improved pit latrines: vent pipe design guidelines*. Washington, DC, World Bank (TAG Technical Note No. 6).**

**RYBCZYNSKI, W. (1981) *Double vault composting toilets: a state of the art review*. Bangkok, Environmental Sanitation Information Center (ENSIC Review No. 6).**

**SANCHES, W. R. & WAGNER, E.G. (1954) Experience with excreta disposal programmes in rural areas of Brazil. *Bulletin of the World Health Organization,* 10: 229-249.**

**SCOTT, J.C. (1952) *Health and agriculture in China: a fundamental approach to some of the problems of world hunger*. London, Faber & Faber.**

**SHAW, V. A. (1962) A system for the treatment of nightsoil and conserving tank effluent in stabilization ponds. In: *Proceedings of the twentieth Annual Health Congress*. East London, South Africa, Institute of Public Health.**

**SIMPSON-HEBERT, M. (1984) Water and sanitation: cultural considerations. In: Bourne, P. G., ed., *Water and sanitation: economic and sociological perspectives.* Orlando, Academic Press.**

**SRIDHAR, M. K. C. ET AL. (1981) Health hazards and pollution from open drains in a Nigerian city. *Ambio*, 10: 29-33.**

**STUMM, W. & MORGAN, J. J. (1981) *Aquatic chemistry*. New York, John Wiley & Sons.**

**TACK, C. H. (1979) *Preservation of timber for tropical building*. Garston, Building Research Establishment (Overseas Building Note No. 183).**

**TANDON, R. K. & TANDON, B. N. (1975) Stool weight in northern Indians. *Lancet*, 2: 560-561.**

**TRUESDALE, G. A. & MANN, H. (1968) Synthetic detergents and septic tanks.**

***Surveyor and municipal engineer*, 131: 28-33.**

**UNCHS (undated) *Building with bamboo*. Nairobi, United Nations Centre for Human Settlements (UNCHS Technical Note No. 4).**

**UNITED NATIONS CHILDREN'S FUND (1986) *The state of the world's children 1986*. New York.**

**UNITED NATIONS DEVELOPMENT PROGRAMME (undated) *Decade dossier*. New York, UNDP Division of Information.**

**UNIDO (1978) *Guide to practical project appraisal*. New York, United Nations.**

**US DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE (1969) *Manual of septic tank practice*. Washington, DC (PHS No. 526).**

**US ENVIRONMENTAL PROTECTION AGENCY (1980) *Design manual: on site wastewater treatment and disposal systems*. Cincinnati, OH, Office of Research and Development, Municipal Environmental Research Laboratory.**

**WAGNER, E. G. & LANOIX, J. N. (1958) *Excreta disposal in rural areas and small communities*. Geneva, World Health Organization (WHO Monograph Series No. 39).**

**WAGNER, E. G. & LANOIX, J. N. (1959) *Water supply for rural areas and small communities*. Geneva, World Health Organization (WHO Monograph Series No. 42).**

**WALSH, J. A. & WARREN, K. S. (1979) Selective primary health care. *New England journal of medicine*, 301: 967-974.**

**WEIBEL, S. R. ET AL. (1949) *Studies on household sewage disposal systems; Part 1.* Cincinnati, OH, Environmental Health Center.**

**WILSON, J. G. (1987) The development of an appropriate vacuum tanker. In: *African Water Technology Conference, Nairobi*. London, World Water.**

**WINBLAD, U. & KALAMA, W. (1985) *Sanitation without water*. Basingstoke, Macmillan.**

**WHO (1950) *Expert Committee on Environmental Sanitation*: report on the first session. Geneva, World Health Organization (WHO Technical Report Series, No. 10).**

**WHO (1954) *Expert Committee on Environmental Sanitation*: third report. Geneva, World Health Organization (WHO Technical Report Series, No. 77).**

**WHO (1983) *Minimum evaluation procedure (MEP) for water supply and sanitation projects*. Unpublished document ETS/83.1.[a]**

**WHO (1984) *Guidelines for drinking water quality*, Vol. 1-3. Geneva, World Health Organization.**

**WHO (1985) *The control of schistosomiasis*: report of a WHO Expert Committee. Geneva, World Health Organization (WHO Technical Report Series, No. 728).**

**WHO (1986) *The International Drinking Water Supply and Sanitation Decade Directory: Review of National Progress (as at December 1983)* (WHO CWS Series of Cooperative Action for the Decade).[a]**

**WHO (1987a) *Technology for water supply and sanitation in developing countries:* report of a WHO Study Group. Geneva, World Health Organization (WHO Technical Report Series, No. 742).**

**WHO (1987b) *Prevention and control of intestinal parasitic infections*: report of a WHO Expert Committee. Geneva, World Health Organization (WHO Technical Report Series, No. 749).**

**WHO (1987c) *Review of mid-Decade progress (December 1985).* Unpublished document CWS/87.5.[a]**

**WHO (1989) *Health guidelines for the use of wastewater in agriculture and aquaculture*: report of a WHO Scientific Group (WHO Technical Report Series, No. 778).**

**WHO (1990) *The International Drinking Water Supply and Sanitation Decade. Review of decade progress (as at December 1988).* Unpublished document WHO/EHE/CWS/90.16.[a]**

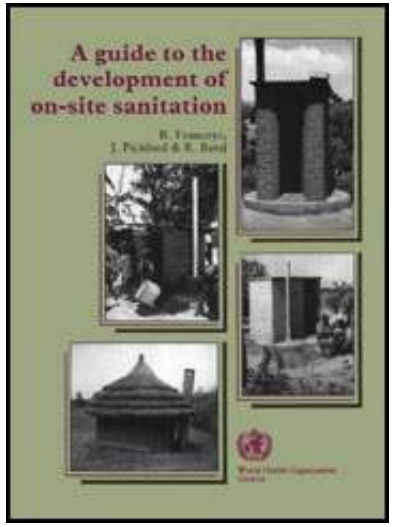
**[a] Available on request from Division of Environmental Health, World Health Organization, 1211 Geneva 27, Switzerland.**

**YEAGER, J. G. & O'BRIEN, R. I. (1979) Enterovirus inactivation in soil. *Applied and***

***environmental microbiology*, 38: 694-701.**

**DE ZOYSA, I. ET AL. (1984) Perceptions of childhood diarrhoea and its treatment in rural Zimbabwe. *Social science and medicine*, 19: 727-734.**

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



# Back Cover

## Selected further reading

**ASHWORTH, J. (1982) Urban sullage in developing countries. *Waterlines*, 1 (2): 14-16.**

**BOURNE, P. G., ed. (1984) *Water and sanitation: economic and sociological perspectives*. Orlando, Academic Press.**

**CROSS, P. (1985) Existing practices and beliefs in the use of human excreta. *IRCWD news*, 23: 2-4.**

**DECK, F. L. O. (1986) Community water supply and sanitation in developing countries, 1970-1990: an evaluation of the levels and trends of services. *World health statistics quarterly,* 39 (1): 2-39.**

**EDWARDS, P. (1985) *Aquaculture: a component of low cost sanitation technology.* Washington, DC, World Bank (World Bank Technical Paper No. 36).**

**ELMENDORF, M. & BUCKLES, P. (1980) *Socio-cultural aspects of water supply and excreta disposal.* Washington, DC, World Bank.**

**GOLLADAY, F. L. (1983) *Appropriate technology for water supply and sanitation: meeting the needs of the poor for water supply and sanitation.* Washington, DC, World Bank.**

**GOTAAS, H. B. (1956) *Composting: sanitary disposal and reclamation of organic***

***wastes.*** **Geneva, World Health Organization (WHO Monograph Series No. 31).**

**GUNNERSON, C. G. & STUCKEY, D. C. (1986)** ***Anaerobic digestion: principles and practice of biogas systems*****. Washington, DC, World Bank (World Bank Technical Paper No. 49).**

**HEALEY, K. A. & LAAK, R. (1974) Site evaluation and design of seepage fields.** ***Journal of the environmental engineering division, Proceedings of the American Society of Civil Engineers*****, 100: 1133-1146.**

**HINDHAUGH, G. M. A. (1973) Night soil treatment.** ***Consulting engineer,*** **37 (9): 47, 49.**

**INTERNATIONAL DEVELOPMENT RESEARCH CENTRE (1981)** ***Sanitation in developing countries. Proceedings of a workshop on training held in Lobatse, Botswana, 14-20 August 1980.*** **Ottawa (IDRC-168e).**

**INDIAN STANDARDS INSTITUTION (1969)** ***Code of practice for design and construction of septic tanks*****. New Delhi (IS 2470, part 1 and part 2).**

**LECLERE, M. & SHERER, K. (1984)** ***A workshop design for latrine construction: a training guide.*** **Arlington, Water and Sanitation for Health Project (WASH Technical Report No. 25).**

**LEWIS, W. J. ET AL. (1982)** ***The risk of groundwater pollution by on-site sanitation in developing countries: a literature review*****. Dbendorf, Switzerland, International Reference Centre for Waste Disposal (IRCWD Report No. 01/82).**

**MCGAUHEY, P. H. & KRONE, R. B. (1967) *Soil mantle as a wastewater treatment system*. Sanitary Engineering Research Laboratory, University of California.**

**NICOLL, E. H. (1974) Aspects of small water pollution control works. *Journal of the Institute of Public Health Engineers*, 12: 185-211.**

**VAN NOSTRAND, J. & WILSON, J. G. (1983a) *The ventilated improved double-pit latrine: a construction manual for Botswana*. Washington, DC, World Bank (TAG Technical Note No. 3).**

**VAN NOSTRAND, J. & WILSON, J. G. (1983b) *Rural ventilated improved pit latrines: a field manual for Botswana*. Washington, DC, World Bank (TAG Technical Note No. 8).**

**PARLATO, R. (1984) *A monitoring and evaluation manual for low-cost sanitation programs in India*. Washington, DC, World Bank (TAG Technical Note No. 12).**

**PATHAK, B. (1981) *Sulabh Shauchalaya (hand flush water seal latrine): a simple idea that worked*. Patna, India, Amolla Prakashan.**

**PEEL, C. (1977) The public health and economic aspects of composting night soil with municipal refuse in tropical Africa. In: Pickford, J., ed., *Planning for water and waste in hot countries. Proceedings of the third WEDC Conference.* Loughborough, Water, Engineering and Development Centre, pp. 25-36.**

**RAMAN, V. ET AL. (1969) Secondary treatment and disposal of effluent from septic tanks. 4. Preliminary studies of treatment by upward (reverse flow) rock filters. *Journal of the Institute of Engineers (India),* 49 (6): 90-93.**

**SAGAR, G. & JAIN, A. K. (1982) Ferrocement septic tanks. *Journal of ferrocement*, 12 (1): 63-69.**

**SANDERS, A. & CARVER, R. (1985) *The struggle for health*. Basingstoke, Macmillan.**

**SHUVAL, H. I. ET AL. (1981) *Night-soil composting*. Washington, DC, World Bank (Appropriate technology for water supply and sanitation, Vol. 10).**

**US PUBLIC HEALTH SERVICE (1933) The sanitary privy. Washington, DC (revised type No. IV of *Public health report* (Wash), Suppl. 108).**

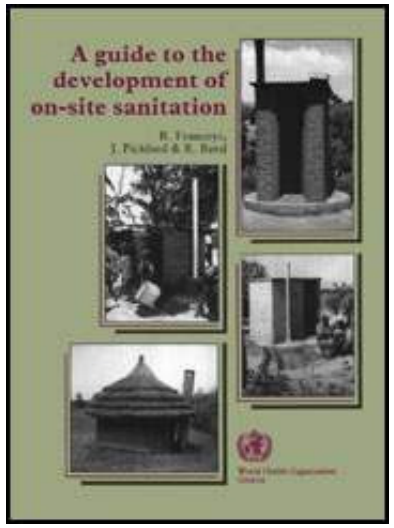
**VINCENT, L. J. ET AL. (1961) A system of sanitation for low cost high density housing. In: *Proceedings of a symposium on hygiene and sanitation in relation to housing, Niamey,* pp. 135-172 (Publication No. 84, CETA/WHO, Niger).**

**WHO (1980) *Epidemiology and control of schistosomiasis*: report of a WHO Expert Committee. Geneva, World Health Organization (WHO Technical Report Series, No. 643).**

**WHO REGIONAL OFFICE FOR SOUTH-EAST ASIA (1985) *Achieving success in community water supply and sanitation projects.* New Delhi (Regional Health Paper No. 9).**

**VAN WIJK-SIJBESMAN, C. (1985) *Participation of women in water supply and sanitation: roles and realities*. The Hague, International Reference Centre for Community Water Supply and Sanitation (IRC Technical Paper No. 22).**

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw






## Glossary of terms used in this book

**adobe** • Bricks dried slowly in the sun, but not in direct sunlight, made of clay that

**has been thoroughly mixed with water, often with straw, grass or other natural fibres added.**

**adsorption • The adhesion, in a thin layer, of liquids to the surface of solids with which they are in contact.**

**aerobic • Living or taking place in the presence of air or free oxygen.**

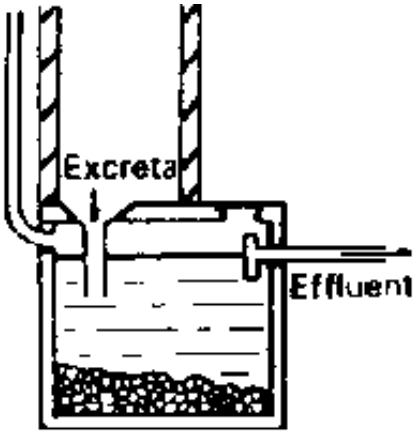
**agency • Government department, or bilateral, international, nongovernmental or similar organization taking primary responsibility for a project.**

**aggregate • Gravel, broken rock or sand that is mixed with cement to make concrete; coarse aggregate particles are normally 6-18 mm in size; sand is known as fine aggregate.**

**anaerobic • Living or taking place in the absence of air or free oxygen.**

**aqua-privy • Latrine in which excreta fall directly through a submerged pipe into a watertight settling chamber below the floor, and from which effluent overflows to a soakaway or drain.**

**biochemical oxygen demand • *See* BOD.**




**Figure**

**biodegradable • Able to be broken down by biological processes through the action of bacteria and other microorganisms.**

**biogas • Mixture of gases, mostly methane and carbon dioxide, produced in anaerobic decomposition of waste materials.**

**BOD • Biochemical oxygen demand: the mass of oxygen consumed by organic matter during aerobic decomposition under standard conditions, usually measured in milligrams per litre during five days; a measure of the concentration of sewage.**

**cement mortar • Mixture of four or fewer parts of sand to one part of cement, with a suitable amount of water.**

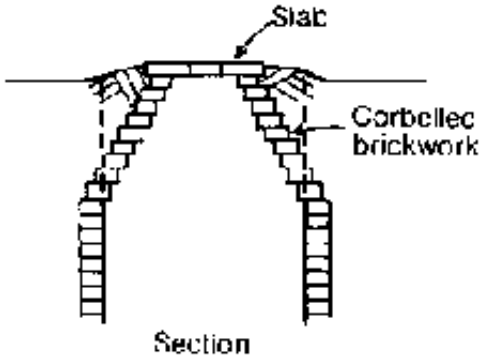
**cesspit • A subsurface container for the retention of sewage until it is removed by vacuum tanker or other means.**

**compost • Humus produced by composting of organic matter; valued as a fertilizer or soil conditioner.**

**composting • Controlled decomposition of organic solid waste in moist conditions so as to produce humus.**

**concrete • Mixture of cement, sand, aggregate and water which hardens to a stone-like solid.**

**corbelling • Construction in which bricks, blocks or stones are built so that an upper course projects inwards beyond the course below to support a load, such as a manhole cover or squatting slab.**




**Figure**

***WHO 91471***

**curing • Process of keeping concrete or mortar damp for at least the first week after it is cast so that the cement always has enough water to harden.**

**decomposition • Breakdown of organic matter into more stable forms by the action of aerobic or anaerobic microorganisms.**

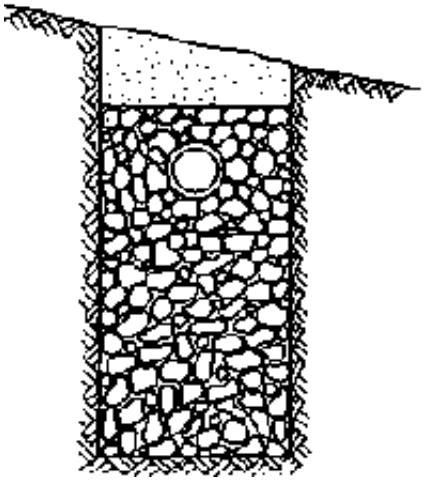
**desludging • Removing settled solids from pits, vaults, tanks and septic tanks.**

**digestion • Decomposition of organic matter in wet conditions.**

**drain • Pipe or channel for carrying wastewater, effluent, rainwater or surface water.**

**drainage field • Area of land used for infiltration of wastewater into soil.**

**drainage trench • Trench in which a drain is surrounded by stone or other inert material used as a soakaway for liquid dispersion.**



**Figure**

**effluent • Liquid flowing out of a tank or sewage works.**

**excreta • Faeces and urine.**

**facultative anaerobe • Organism that can live in either the presence or absence of air or free oxygen.**

**fall • Slope along a pipe or channel or across a floor, measured as the amount by which one point is lower than a higher point.**

**ferrocement • Cement mortar reinforced by layers of steel mesh.**

**flotation • Process by which solids less dense than water rise to form a scum.**

**former (mould) • Frame, usually wooden, to hold and maintain the shape of concrete while it is setting.**

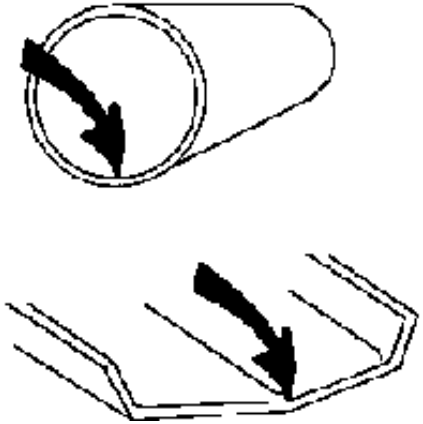
**greywater • *See* sullage.**

**groundwater • Water beneath the ground surface.**

**helminth • A worm, which may be parasitic or free-living.**

**host • A man or animal in which a parasite lives and from which it obtains food.**

**humus • Decomposed vegetable matter - the end-product of the composting process.**



**Figure**

***WHO 91369***

**invert • Bottom of the inside of a pipe or channel.**

**larva • Worm-like stage of development of insects and helminths, which can move and seek food.**

**latrine • Place or building, not normally within a house or other building, for deposition, retention and sometimes decomposition of excreta.**

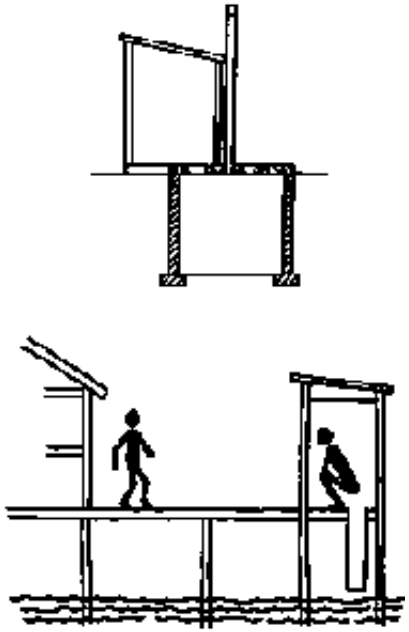
**mortar • Mixture of mud, or of lime and/or cement with sand and water, used for joining or for providing a smooth waterproof surface.**

**mould • *See* former.**

**nightsoil • Human excreta, with or without anal cleaning material, which are deposited in a bucket or other receptacle for manual removal (often taking place at night).**

**offset pit • Pit that is partially or wholly displaced from its superstructure.**

**overhung latrine • Latrine sited such that excreta falls directly into the sea or other body of water.**



**Figure**

**pan • Basin to receive excreta which are then flushed into an outlet pipe by water poured in or by water delivered around the rim of the pan from a cistern.**

**parasite • Organism that lives in or on another living organism, called the host, from which it obtains its food.**

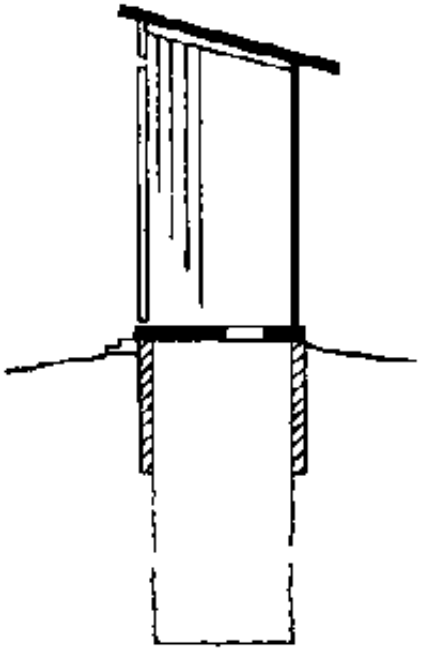
**pathogen • Organism that causes disease.**

**percolation • Movement of liquids through soil.**

**pit latrine • Latrine with a pit for accumulation and decomposition of excreta and from which liquid infiltrates into the surrounding soil.**

**pollution • The addition of harmful liquid, solid or gaseous substances to water, soil or air.**

**pour-flush latrine • Latrine where a small quantity of water is poured in to flush excreta through a water seal into a pit.**



**Figure**

**programme • Continuous undertaking for planned objectives with commitment by an institution for long-term support of operation and maintenance; may include a series of projects.**

**project • Planned budgeted event with realizable goals within a specified time period.**

**retention time • Time taken for a volume of liquid to pass through a tank or treatment process, or the time during which a solid or liquid is held in a container.**

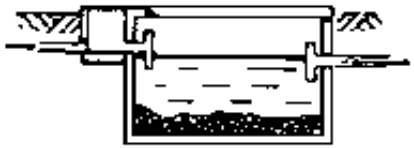
**sanitation • The means of collecting and disposing of excreta and community liquid waste in a hygienic way so as not to endanger the health of individuals or the community as a whole.**

**screed • Layer of mortar (usually cement mortar) laid to finish a floor surface.**

**scum • Layer of suspended solids less dense than water and floating on top of liquid waste from which they have separated by flotation.**

**sedimentation • Process by which suspended solids denser than water settle as sludge.**

**septic tank • Watertight chamber for the retention, partial treatment, and discharge for further treatment, of sewage.**



**Figure**

**sewage • Wastewater that usually includes excreta and that is, will be, or has been carried in a sewer.**

**sewer • Pipe or conduit through which sewage is carried.**

**sewerage system • System of interconnected sewers.**

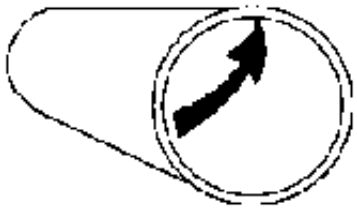
**sludge • Solids that have been separated from liquid waste by sedimentation.**

**soakaway • Soakpit or drainage trench for subsoil dispersion of liquid waste.**

**soakpit • Hole dug in the ground serving as a soakaway.**

**soffit • Top of the inner surface of a pipe (also known as "crown") or lower surface of a slab.**

**squat hole • Hole in the floor of a latrine through which excreta fall directly to a pit below.**



**Figure**

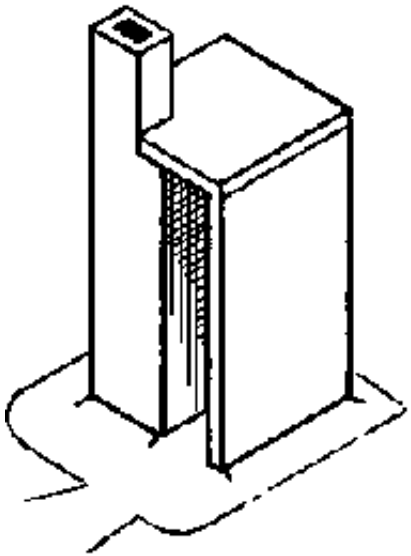
***WHO 91370***

**sullage • Wastewater from bathing, laundry, preparation of food, cooking and other personal and domestic activities that does not contain excreta.**

**superstructure • Screen or building of a latrine above the floor that provides**

**privacy and protection for users.**

**surface water • Water from rain, storms or other precipitation, or street washing lying on or flowing across the surface of the ground.**



**Figure**

**toilet • Place for defecation and urination, which may be the superstructure of a latrine.**

**toilet, chemical • Receptacle used for defecation and urination that contains a strong chemical disinfectant which retards decomposition and reduces smell.**

**transpiration • Loss of moisture by a plant through its leaves.**

**trap • *See* water seal.**

**vacuum tanker • Lorry-mounted tank into which the contents of septic tanks, aqua-privies, cesspits, vaults or pits are drawn by vacuum pump for transport to a treatment or disposal site.**

**Figure**

**vault • Watertight tank for storage of excreta.**

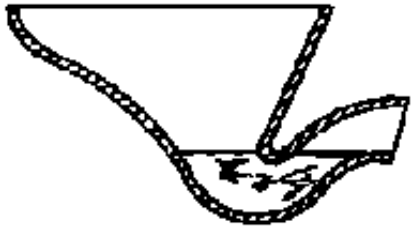
**vector • Insect or other animal that can transmit infection directly or indirectly from one person to another, or from an infected animal to a person.**

**vent pipe • Pipe provided to facilitate the escape of gases from a latrine or septic tank.**

**VIP latrine • Ventilated improved pit latrine; pit latrine with a screened vent pipe and a partially dark interior to the superstructure.**

**wastewater • Sewage or sullage.**

**water closet (WC) • Pan from which excreta is flushed by water into a drain.**

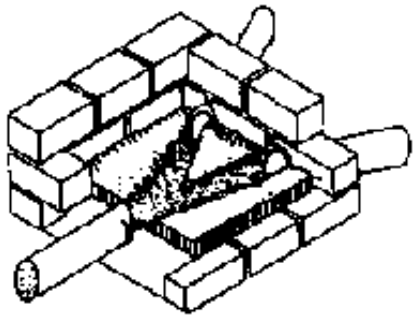


**Figure**

**water seal • Water held in a U-shaped pipe or hemispherical bowl connecting a pan to a pipe, channel or pit to prevent the escape of gases and insects from the sewer or pit.**

**water table • Surface level of groundwater.**

**Y-junction • Chamber in which liquid may be directed along either of two pipes or channels.**

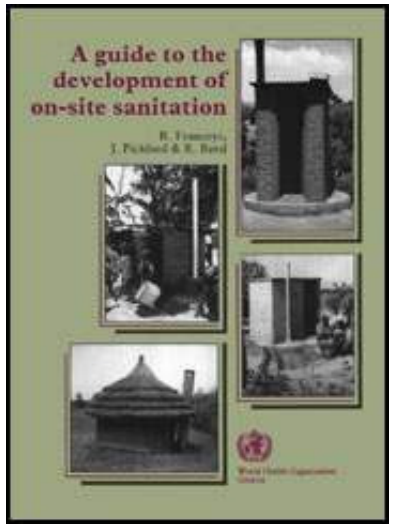


**Figure**

***WHO 91371***

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

A Guide to the Development of On-site Sanitation (WHO, 1992, 246 p.)
*(introduction...)*
Preface






## Annex 1. Reuse of excreta

**Human excreta should be regarded as a natural resource to be conserved and reused under careful control rather than being discarded. Excreta for reuse are derived from:**

**- nightsoil, including that collected by municipal systems or private contractors, and the nightsoil of individual households or groups of households and used on their own gardens or farms;**

**- solids from full pit latrines;**

**- sludge, scum and liquor from septic tanks, aqua-privies, vaults and cesspits; and**

**- raw and treated sewage and sludge from sewage treatment works (which are outside the scope of this book).**

**Solids from pit latrines are innocuous if the latrines have not been used for two years or so, as in alternating double pits. Raw excreta from all other sources are likely to include recently excreted faeces and may therefore contain active pathogens.**

**There are three basic methods of using this resource: agriculture, aquaculture, and biogas production.**

## Use in agriculture

**Human excreta are a rich source of nitrogen and other nutrients necessary for plant growth. The most common method of reuse is direct application to the soil as a fertilizer. Nightsoil contains about 0.6% nitrogen, 0.2% phosphorus and 0.3% potassium, all of which are valuable plant nutrients. The humus formed by decomposed faeces also contains trace elements which reduce the susceptibility of plants to parasites and diseases. Humus improves the soil structure, enhancing its water-retaining qualities and encouraging better root structure of plants. Soil containing humus is less subject to erosion by wind and water and is easier to cultivate.**

## Health risks

**For centuries, untreated nightsoil has been widely used as a fertilizer in east and south Asia, although there is an increasing awareness of the public health dangers involved. Pathogens of all kinds can remain viable in the soil and on crops (see Table 2.4). Death of pathogens on crops is usually caused by desiccation and direct sunlight, so pathogens are generally more persistent in humid cloudy climates than in arid areas.**

**It has been suggested that the use of raw excreta and the effluent from septic tanks is acceptable only if confined to industrial crops and foodstuffs that are cooked before being eaten. However, even with these crops, there is considerable risk of pathogen transmission to agricultural workers, to people involved in transporting crops, and to those processing industrial crops or preparing food for cooking. Therefore such use must be carefully planned with strict surveillance by the health authorities.**

**The risks arising from pathogen transmission from the use of untreated excreta or sludge on food crops may be greater for populations with high levels of hygiene and health (for example people in towns) than for agricultural workers living in areas where excreta-derived diseases are endemic (Feachem et al., 1983).**

### *Excreta on paddy fields*

**Fields with crops standing in water during part or all of the vegetation period are potential transmission sites for schistosomiasis if fresh excreta are used as fertilizer (Cross & Strauss, 1985).**

### *Fertilization of trees*

**Treated or untreated sewage is sometimes used to irrigate trees. This practice is most common in arid climates, where trees are watered to control desertification, to provide shade and windbreaks, or to cultivate coconuts and some other food crops. The main health risk is to workers and members of the public who have access to the plantation.**

***Excreta on pasture***

**When excreta are applied to land on which cattle graze there is a danger of the spread of beef tapeworm, whose eggs may survive on soil or pasture for more than six months.**

**Composting**

**Excreta may be treated in various ways to eliminate the possibilities of disease transmission. Apart from storage in double-pit latrines, the most appropriate treatment for on-site sanitation is composting.**

**Composting consists of the biological breakdown of solid organic matter to produce a humic substance (compost) which is valuable as a fertilizer and soil conditioner. It has been practised by farmers and gardeners throughout the world for many centuries. In China, the practice of composting human wastes with crop residues has enabled the soil to support high population densities without loss of fertility for more than 4000 years (McGarry & Stainforth, 1978).**

**Nightsoil or sludge may be composted with straw and other vegetable waste, or with mixed refuse from domestic, commercial or institutional premises. The process may be aerobic or anaerobic.**

**Aerobic bacteria combine some of the carbon in organic matter with oxygen in the air to produce carbon dioxide, releasing energy. Some energy is used by the bacteria to reproduce. The rest is converted to heat, often raising the temperature to more than 70°C. At high temperatures there is rapid destruction of pathogenic bacteria and protozoa, worm eggs and weed seeds. All faecal microorganisms, including enteric viruses and roundworm eggs, will die if the temperature exceeds 46°C for one week. Fly eggs, larvae and pupae are also killed at these temperature. No objectionable odour is given off if the material remains aerobic.**

**In the absence of oxygen, nitrogen in organic matter is converted to acids and then to ammonia; carbon is reduced to methane and sulfur to hydrogen sulfide. There is severe odour nuisance. Complete elimination of pathogens is slow, taking up to twelve months for roundworm eggs, for example.**

***Practical composting***

**The traditional method of composting is to pile vegetable waste with animal manure and nightsoil or sludge on open ground. Aerobic conditions may be maintained by regular turning of the material, which also has the advantage of making the moisture content more uniform throughout the tip. Under aerobic conditions, rapid decomposition of organic matter takes place in the first 2-4 weeks. The process is considerably shorter than under anaerobic conditions. Controlled composting in mechanized composting equipment shortens the process even more.**

**According to Flintoff (1984) there are five preconditions for successful composting:**

**- suitability of the wastes;**

**- marketability of the product;**

**- support of authorities, particularly those in agriculture;**

**- a price for the product that is acceptable to farmers; and**

**- a net cost (i.e., process costs less income from sale) that can be sustained by the operating authority.**

***Pretreatment***

**In developing countries most domestic refuse is vegetable matter, and there may be little paper, glass or metal. Where these materials are more common, paper can be composted and some glass is acceptable in compost if it is ground up at some stage of the composting process. Metals need to be removed. Textiles, plastics, leather and the like may be removed or they may be shredded and included in the compost. Dust and ash may also be included but, if they form too large a proportion of the refuse, the value of the compost is reduced.**

**Working over refuse heaps with forks to break down large lumps helps the composting process. Broken-down refuse has a greater surface area for air to enter and for bacteria to attack. It allows less penetration of rain and fly control is easier.**

***Control of composting***

**Too much moisture in a heap of composting material fills the spaces between particles, preventing air from getting in. On the other hand, bacteria do not flourish if the material is too dry. The optimum moisture content is 40-60%. Moisture content can be increased by spraying a compost heap with water, and can be decreased by adding dry straw or sawdust. Frequent turning allows a heap to dry naturally by evaporation.**

**For optimum value to plants, the ratio of available carbon to nitrogen in compost should be about 20. In the composting process carbon is used by the bacteria, so the best raw material for composting has a higher carbon: nitrogen ratio, say about 30. The carbon: nitrogen ratio of nightsoil is about 6, of fresh vegetable waste around 20, and of dry straw over 100. The ratio of mixed household refuse is often in the range 30-50, but it may be higher if there is a high paper content. The desirable ratio of 30 can sometimes be obtained by judicious mixing of incoming waste, for example by adjusting the proportions of nightsoil or sludge and vegetable waste. It is rarely practical to determine the carbon: nitrogen ratio by chemical analysis; a good operator learns to judge what mix of materials will produce the best compost.**

**During composting the volume is reduced by 40-80% and the weight by 20-50%.**

***Windrows and pits***

**Unless expensive mechanical plant is used, aerobic composting of municipal refuse is usually carried out in long heaps called windrows. The best height for windrows is about 1.5 m. In heaps more than 1.8 m high, the material at the bottom becomes too compressed; in heaps less than 1 m high, too much of the heat**

**generated by the bacteria is lost.**

**The width and length of windrows should be planned for the most efficient handling of materials and the best utilization of the area available. The initial width is often 2.5-3.5 m at the bottom. In dry weather the cross-section should be trapezoidal, as shown in Fig. A1.1, but during the rainy season a more rounded shape prevents the material getting too wet.**

**For composting small quantities (for example, from a single village), refuse should be stored until there is enough to make a pile about 3 m in diameter and 1.5 m deep.**

**For composting nightsoil, a common method is to place alternate layers of nightsoil (about 50 mm thick) and vegetable waste (about 200 mm thick) in pits or windrows. Fig. A1.2(a) shows how a windrow can be formed to ensure destruction of faecal pathogens by high temperature. Vegetable matter below and at the edges provides some insulation. Fig. A1.2(b) shows an alternative method: after a windrow has been in use for two or three days and the temperature has risen, a trench or pocket is formed in the centre and nightsoil is poured in.**

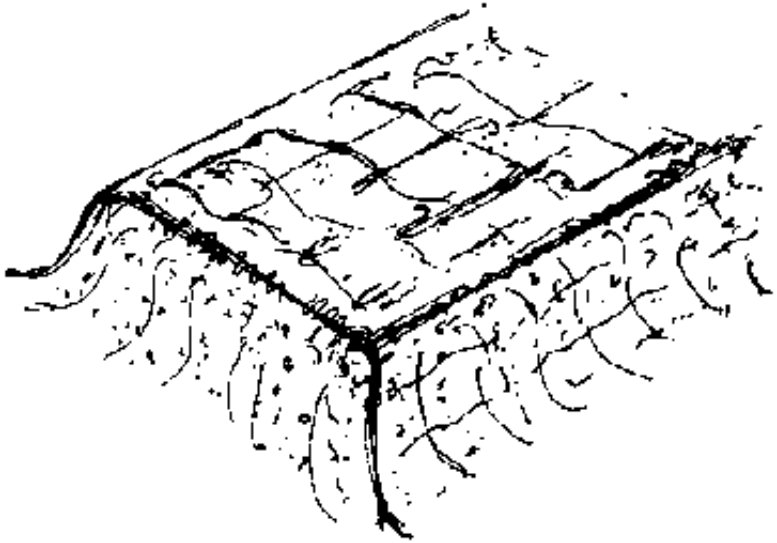


**Fig. A1.1. A compost windrow**

***WHO 91502***

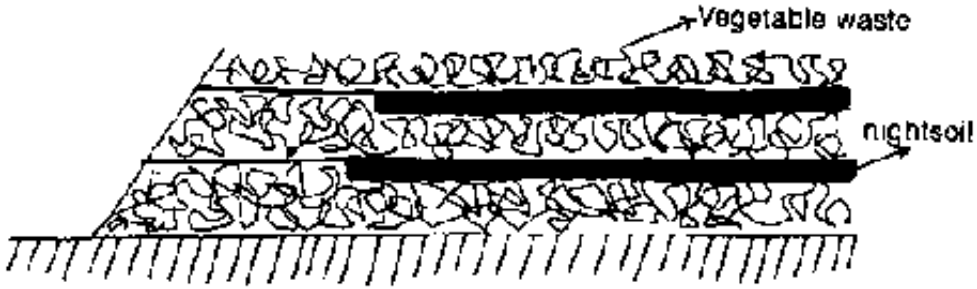



**Fig. A1.2. Placing nightsoil in a compost windrow (a)**

***WHO 91503***


**Fig. A1.2. Placing nightsoil in a compost windrow (b)**

***WHO 91503***

***Temperature, aeration and turning***

**Providing that the material being composted remains aerobic the temperature may rise to 45-50°C during the first 24 hours. A few days later it will reach 60-70°C, well above the lethal temperature for all pathogenic organisms. Fig. A1.3 shows the variation in temperature during aerobic composting of mixed municipal refuse; the points marked T indicate when the material was turned for aeration.**

**Various methods of aeration have been tried. For a small refuse heap (as in a village), refuse can be tipped over bamboo or timber poles which are removed when the heap is complete, leaving holes through which air reaches the refuse (see Fig. A 1.4). Other approaches, including forced aeration (using compressed air blowers or suction) and use of porous floors, have not been very successful in keeping large masses of material aerated.**

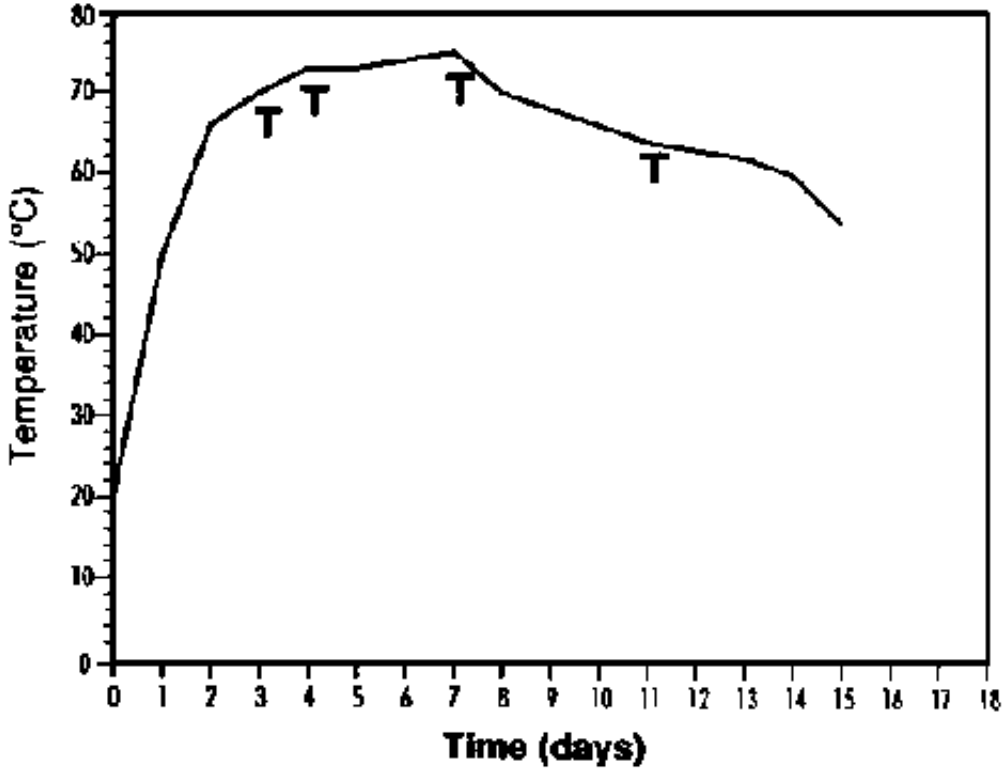



**Fig. A1.3. Temperature variation during aerobic decomposition of mixed refuse (T = point at which material was turned for aeration)**

***WHO 91372***

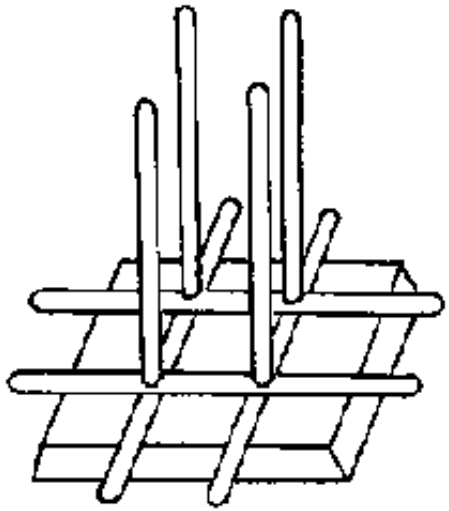


**Fig. A1.4. Aeration of compost by placing around poles (A)**

***WHO 91504***

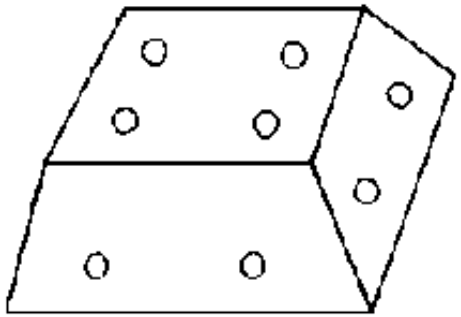


**Fig. A1.4. Aeration of compost by placing around poles (B)**

***WHO 91504***

**Material in windrows can be turned by labourers using forks or by adapted earth-moving equipment. Turning should keep the heap aerobic. In addition, material at the outside should be moved to the centre, because the outer layers may:**

**- be too wet because of rain;**
**- be too dry owing to evaporation (especially on the side facing the wind),**
**- be unaffected by the temperature rise in the centre of the windrow;**
**- contain large numbers of flies, fly eggs and larvae.**

**Some operators turn their windrows every two or three days. However, aerobic conditions can be maintained with less frequent turning after the first week or so. One suggested pattern is to turn the windrow after one day and then on the 3rd, 7th, 14th and 21st days. On the 28th day the material is put into a storage area to await removal.**

**Generally compost is only required at certain times of the year. If there is only one harvesting and sowing season a year, an area sufficient to store most of the year's production of compost may be required. During storage, compost continues to "mature", but high temperatures cannot be maintained. The time taken for stabilization depends on the initial carbon: nitrogen ratio, the moisture content, maintenance of aerobic conditions and the particle size. Unless precautions are taken, fly breeding may be a problem when compost is stored.**

***Condition and quality of compost***

**Tests of compost during and after stabilization show whether the process is going well and whether the finished product is suitable for agricultural use. Except in a large mechanical composting plant, the condition of the compost is gauged by simple methods. It is reasonable to assume that pathogenic organisms will be killed if the temperature rises above 65°C. This can be confirmed by poking an iron bar or wooden stick into the heap and pulling it out after about ten minutes. It**

**should then be too hot to hold. The temperature falls when stabilization is complete. Absence of an unpleasant smell and absence of flies also indicate satisfactory aerobic composting (Flintoff, 1984). An experienced operator can check that all is well from the appearance of the composting material. It should look moist, but not so wet that liquid seeps out. While aerobic stabilization is progressing the appearance will change from day to day. Anaerobic conditions are shown by a pale green, slightly luminous appearance of material inside the heap.**

**Farmers and market gardeners may want to know the chemical composition of compost derived from nightsoil or sludge. The major plant nutrients (nitrogen, phosphorus pentoxide and potassium oxide) are likely to be about 3% by weight, three times the concentration in compost from municipal refuse.**

**Use in aquaculture**

**The practice of depositing excreta into fish ponds or tanks is common in many Asian countries. In some places, latrines are placed immediately over or alongside ponds; elsewhere nightsoil is tipped from carts, tankers or buckets. Nutrients in excreta result in a rich algal growth, which encourages aerobic conditions and provides food for certain fish.**

**Carp and tilapia are especially suitable for such ponds, but a variety of fish species may coexist, some feeding on large algae, some on small algae, some on zooplankton; some prefer the bottom layer, some the top. Fish are usually netted for human consumption, but in some places they are dried and ground up for feed for poultry or animals. Ducks may also be kept on the ponds.**

**There are three health risks associated with fish farming in ponds that receive excreta.**

**(1) Pathogens may be transmitted on the body surfaces or in the intestines of the fish without causing overt disease in the fish; the pathogens may then be passed to people handling the fish.**

**(2) Helminths, particularly flukes, may be transmitted to people who eat infected fish that has not been properly cooked.**

**(3) Helminths with intermediate hosts (such as *Schistosoma* with water snails) may continue their life cycle in ponds.**

**The WHO publication. *Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture* (Mara & Cairncross, 1989), gives further useful information.**

**Biogas production**

**The search for alternative sources of energy has led to widespread use of organic waste to produce a combustible fuel which can be used for domestic cooking. Basically, a biogas plant consists of a chamber in which excreta are fermented, producing gas which contains about 60% methane. The biogas is collected at the top of the chamber, from which a pipe leads to domestic appliances or to flexible storage containers.**

**A few biogas plants operate entirely on human excreta. For example, in Patna, India a 24-seat pour-flush latrine serves several thousand people and generates**

**sufficient energy to light a 4-km length of road. However, most plants, of which there are more than 7 million in China (Li, 1984), are dependent on animal excreta with which human excreta are processed. A medium-sized buffalo or cow provides about twenty times as much gas as a person. The minimum feed is that from one cow and a family of people, although it is more usual to add excreta from at least four cows. In China it is customary to produce biogas from the excreta of pigs.**

## Construction

**Although there are many variations, the most common types of domestic plant have a floating or fixed dome under which the gas collects. The floating dome type, shown in Fig. A1.5, is widely used in India. In China, masonry or concrete fixed domes are usual, as shown in Fig. A1.6. They are generally cheaper than those with a floating roof. The daily gas output is approximately equal to one-third the volume of the digester.**

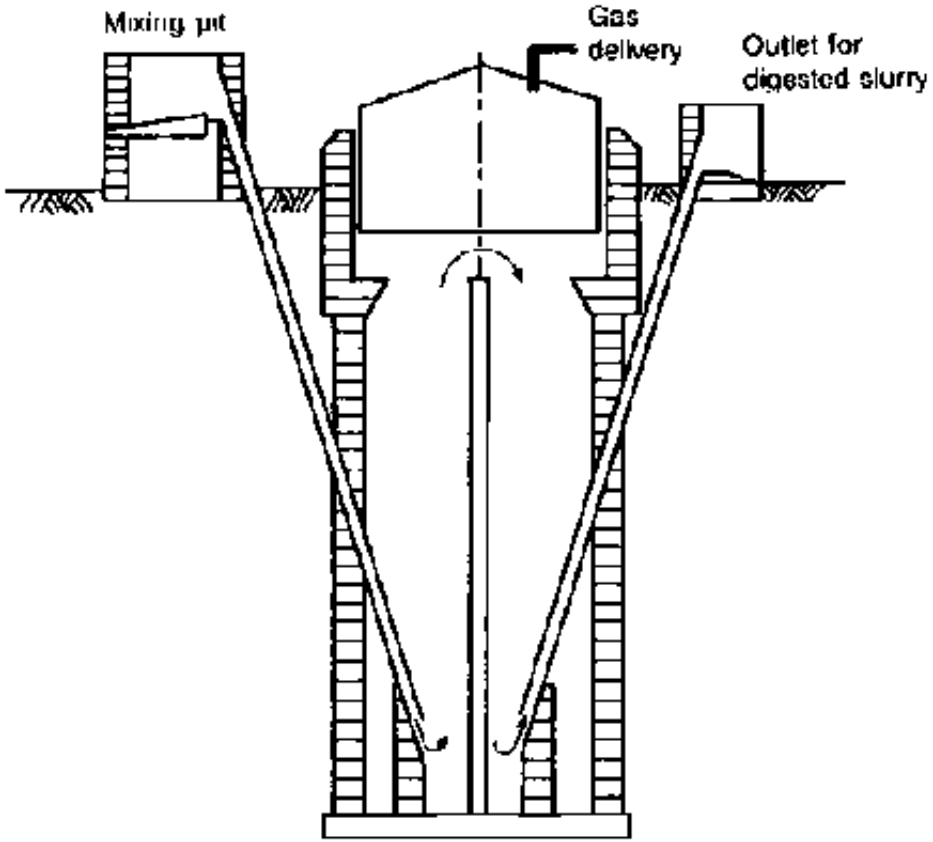



**Fig. A1.5. Biogas plant with floating dome**

***WHO 91505***

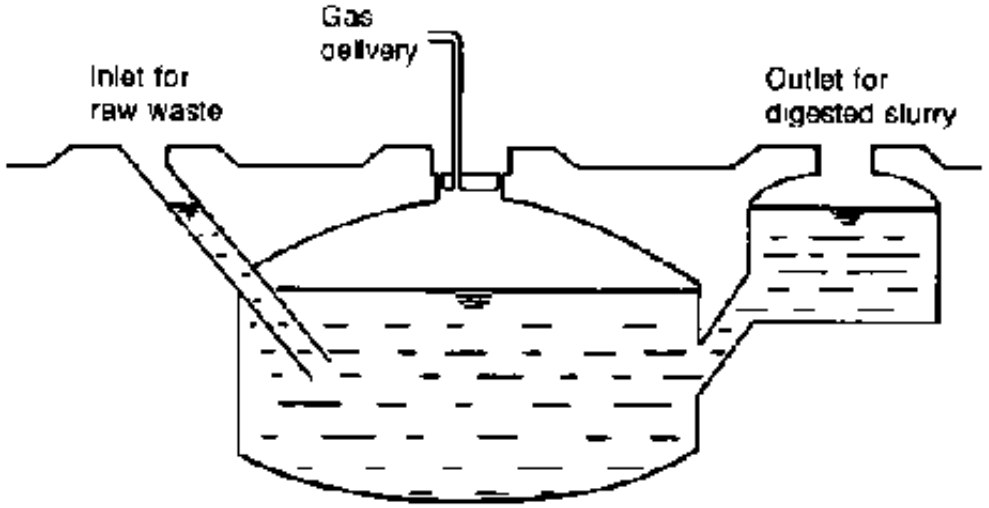



**Fig. A1.6. Biogas plant with fixed dome**

***WHO 91506***

## Operation

**Excreta are often mixed with straw or other vegetable waste, such as that used for animal bedding, and equal quantities of water added to make a slurry. This is fed to the inlet side of the chamber. Effluent slurry is removed after a retention time of 30-50 days. Biogas production is greater at higher temperatures. At 30°C the rate of generation of gas is about twice that at 25°C, and little gas is produced if the temperature is below 15°C.**

**The effluent slurry is usually dried in the open and used as a fertilizer. On a dry solids basis, the nitrogen content is greater than in untreated excreta because of the loss of carbon in the gas. The nutrients in effluent slurry, whether dried or applied directly to land, are more readily taken up by plants.**

## Health risks

**Retention of excreta in biogas tanks results in the death of many pathogens, including *Schistosoma* eggs. A few hookworm eggs survive, and there is high survival of roundworm eggs.**

## References

**CROSS, P. & STRAUSS, M. (1985) *Health aspects of nightsoil and sludge use in agriculture and aquaculture*. Dbendorf, International Reference Centre for Waste Disposal (IRCWD Report No. 04/85).**

**FEACHEM, R. G. ET AL. (1983) *Sanitation and disease: health aspects of excreta and wastewater management*. Chichester, Wiley.**

**FLINTOFF, F. (1984) *Management of solid wastes in developing countries*, 2nd ed. New Delhi, WHO Regional Office for South-East Asia (South-East Asia Series No. 1).**

**MCGARRY, M. G. & STAINFORTH, J. (1978) *Compost, fertilizer, and biogas production from human and animal wastes in the People's Republic of China*. Ottawa, International Development Research Centre.**

**MARA, D. & CAIRNCROSS, S. (1989) *Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture*. Geneva, World Health Organization.**