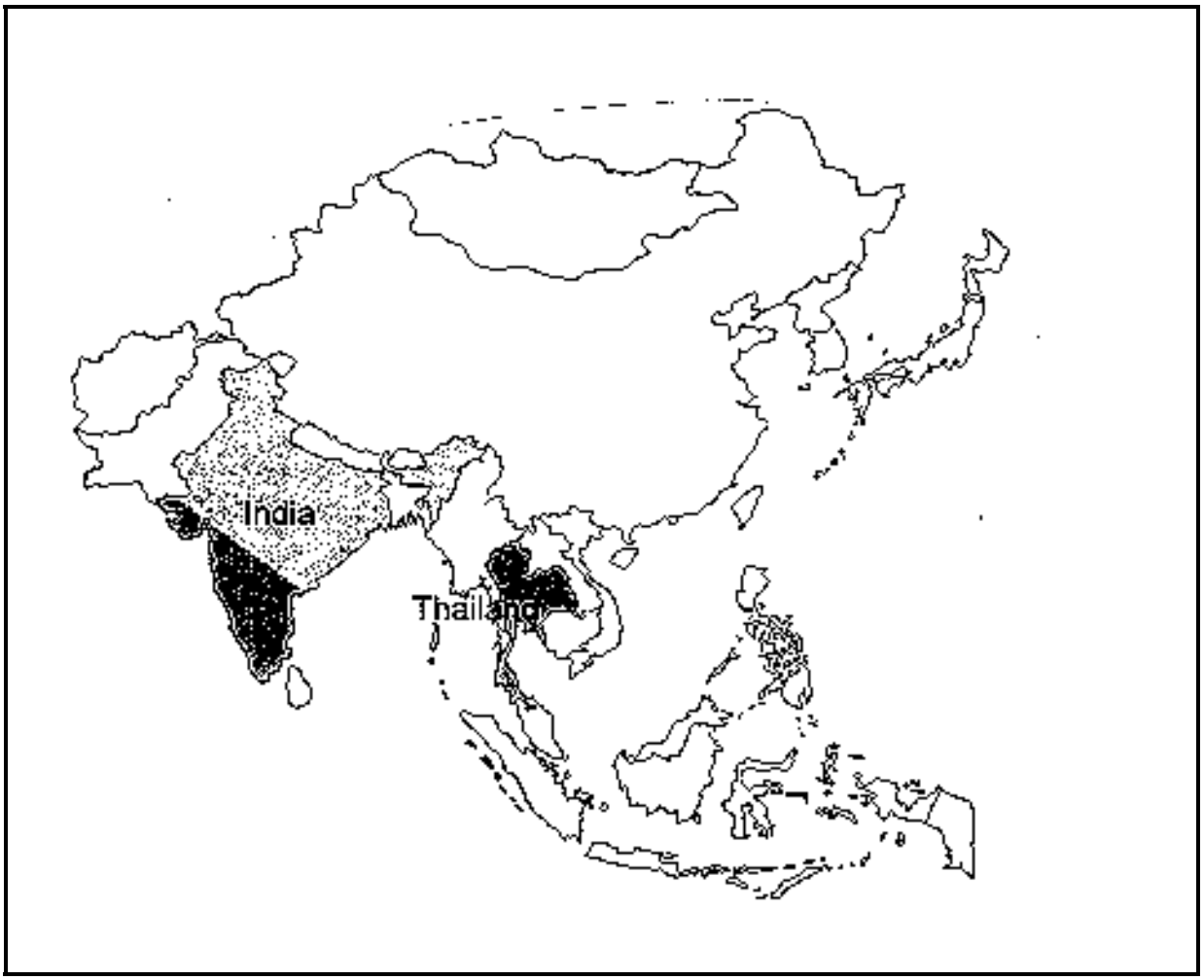
Operation and Maintenance of Sanitation Systems in Urban Low-Income Areas in India and Thailand

Report on a joint research programme, 1989-1993



IRC International Water and Sanitation Centre

IRC is an independent non-profit organization supported by and linked with the Netherlands Government, the United Nations Development Programme (UNDP), the United Nations Children's Fund (UNICEF), the World Health Organization (WHO), the World Bank and the Water Supply and Sanitation Collaborative Council.

Areas in which IRC's work in water and sanitation is concentrated at present include: community financing; community management; community participation; gender issues; health and hygiene; information and communication; monitoring and evaluation; operation and maintenance; rural water supply; sanitation; social mobilization; urban water supply; water resources management; and water treatment.

IRC has strong links with institutions in Africa, Asia and Latin America, and is establishing links with others in the newly independent states of Eastern Europe and Central Asia.

IRC
P.O. Box 2869
2601 CW Delft
The Netherlands

Telephone: **+31 - (0)15 2192939**
Telefax: **+31 - (0)15 2190955**
E-mail: **general@irc.nl**
URL: **www.irc.nl**

Operation and Maintenance of Sanitation Systems in Urban Low-Income Areas in India and Thailand

Report on a joint research programme, 1989-1993

Research carried out by:

HSMI, India

NHA, Thailand

CMU, Thailand

IHS, The Netherlands

IRC, The Netherlands

IRC International Water and Sanitation Centre

Delft, The Netherlands

1997

Since the final report on this research was issued in November 1993, it has been extensively used in training courses in India and the Netherlands. It has also been used by international firms and organizations active in the field of urban sanitation. Conditions encountered during the research have not substantially changed since 1993, and the subject of urban sanitation has become more of an issue in cities in the South. This has led to an increased demand for the report, and it has therefore been decided to republish it, with minor editiorial amendments, in the IRC Project and Programme Papers series.

The research for this publication was financed by the Netherlands Directorate for Development Cooperation (DGIS).

Table of Contents

List of Tables

List of Figures

Preface

Operations and maintenance of urban infrastructure has been neglected for many decades by both scientists and decision makers. Government and donors were predominantly concerned with the planning and provision of infrastructure. During the late 1980s, however, the consequences of ignored operation and maintenance aspects of urban development programmes have become very obvious. In many cases the requirements for operation and maintenance of the systems are not met, which often results in under- or even non-utilization by the target groups. Presently many governments are faced with the fact that in different sectors facilities have ceased to function properly, leading to major capital destruction. One of the investment areas in which lack of proper operation and maintenance directly affects the urban poor, is the sector of low cost sanitation.

Planners and engineers are often surprised by the occurrence of failing operation and maintenance, especially in those cases where sanitary systems have specifically been designed to minimize complicated and costly operation and maintenance requirements. Previous explorations on this phenomenon revealed that many factors, such as technology, socio-economic conditions, users' attitudes and institutional support, are of influence on the functioning of low-cost sanitation systems. However, these explorations did not lead to generally applicable insights into the requirements for operation and maintenance. The dramatic situations in the urban low cost sanitation sector and the complexity of the problems revealed, urged for systematic applied research in which the various aspects of the problems would be taken into account.

In 1989 it was agreed to launch a joint research programme focusing on the problems of operation maintenance of low cost sanitation in India and Thailand. Both countries were prepared to make institutional and financial arrangements to carry out the research. In India the Housing and Urban Development Corporation (HUDCO) and its training and research institute, the Human Settlements Management Institute (HSMI), based in Delhi, made available their professional capacity and institutional arrangements. In Thailand the same was done by the National Housing Authority (NHA) and the Faculty of Engineering of the University of Chiang Mai (CMU).

The design and methodology of the research were jointly developed during the preparatory discussions with the research teams of the two countries, based on the actual needs and perceptions of their own working environment. During the preparations and the actual research process the teams were supported by staff from IHS and IRC, for which IHS undertook the overall coordination.

As part of the research cooperation, joint activities were organized such as field visits and an inter-country seminar, which was held in Delhi, April 1992. During the seminar the outcome of the research was discussed in an international forum. In both the countries national seminars were held in order to enhance the dissemination of the research outcomes to the responsible agencies and professional institutions which were actively involved in this sector. The research outcomes for both Thailand and India are presented in country reports. The final report is written on the basis of these country reports, the available literature, and the discussions at the different seminars. Besides these reports, the research resulted in audiovisual materials which are being used for training purposes at HSMI, NHA, IHS and IRC.

Acknowledgements

Many people have contributed to the research programme. The research in India was carried out by Mr Sanjib Sarma, Ms. Asha Ganjoo and Mr Rajiv Sarma of HSMI, with support from Mr. Mulkh Raj, former Director Finance of HUDCO and HSMI. In Thailand the research team consisted of Ms Pornsawan Timasart, Ms Orawan Bejarapha, Mr Romran Srisumrit, Mr Soontorn Sroimara and Ms Chutima Charoensuk from NHA. At the CMU the research team was formed by Mr Thanintorn Sangkhasilapin, Mr Preecha Jengjalern, Ms Anchalee Jengjalern and Ms Suwanee Keawkingkeo. Mr Pree Buranasiri, Deputy Governor of NHA, also actively supported the research.

Mr Marc Jansen and Mr Gerd-Jan de Kruijff of IHS were actively engaged in the early identification and preparation of the project. Ms Marieke Boot and Mr Jo Smet of IRC and Mr Harry Mengers of IHS supported the country teams with technical advice. The country reports were prepared by the country teams. The final report was prepared by Ms Madeleen Wegelin of IRC.

The research project was financially supported by the Directorate for Development Cooperation (DGIS) of the Netherlands, HUDCO, NHA, and IHS.

Executive Summary

Developing countries are facing a rapid urban growth with an increasing demand for urban infrastructure services. The resources needed for these services are being stretched to their limit, which results in deterioration of the quality and adequacy of the infrastructure, particularly in low-income residential areas.

One of the basic services which suffers most from the budgetary constraints is the disposal of human excreta. This has led many governments to adopt low-cost technologies, which are cheaper to construct and require less water for functioning. To a large extent operation and maintenance of these systems can be carried out by the users, with the government responsible for the infrastructure to evacuate the waste beyond the household premises.

Over the last decade, problems have been experienced with these systems. Many have fallen into disuse for reason of early failure and/or misuse. This resulted in a lower service level to the target population and a consequent deterioration of the urban environment. Studies, which have been looking to these systems, have mainly focused on technical and financial aspects of the problem. The other aspects such as the actual use of the different technical options, the occurring problems and their possible causes, have not yet been investigated in a systematic way. In Thailand and India, this was the reason to initiate a study on aspects of operation and maintenance of sanitation systems in low-income urban areas, needed for the planning and design of future systems.

The study

The objectives of the study are to review the performance, use and operation and maintenance requirements of sanitation systems in low-income urban areas in India and Thailand. Specific attention is given to user attitudes and practices with regard to operation and maintenance of the systems and to the role of the authorities both in the provision of the systems and in their operation and maintenance. The outcome of the study includes an assessment of the requirements for operation and maintenance and recommendations for the planning, design, implementation and management of future sanitation schemes.

The research focuses particularly on the systems in which the participating institutions in the countries have an interest. For the Human Settlement Management Institute in India this is the double pit pour-flush latrine. For the National Housing Authority and the Chiang Mai University in Thailand, these are the cesspool system, the septic tank with anaerobic upflow filter and two types of treatment plants, the aerated lagoon system and the activated sludge system-aeration tank. Other systems found in the research areas are also included in the analysis, such as public latrines in India and septic tanks with soakaway in Thailand.

Major findings

In the research areas in **India**, the performance of the double pit pour-flush latrines is generally quite good. Technical problems are to a large extent related to indiscriminate use of a standardized design, without paying attention to soil conditions, groundwater table and the availability of water. Experiments with locally available construction materials to reduce construction cost are not attempted. The research showed that the capacity of the pits is very large as 70 percent of the first pit had not filled after five or more years. The quality of construction of the latrines is usually adequate, only the cover and alignment of the junction boxes require more attention. Daily operation and maintenance of the latrines does not pose

any problem for the users, but awareness on the functioning of the system and on the longer term operational requirements is lacking as a result of insufficient instruction.

A serious problem encountered is the non-use of the latrines. An important reason for this appears to be that the latrines are usually promoted through a system of grants and loans and not based on demand from the users. Where superstructures are provided with the latrine, the latrine is often used for other purposes and where they are not provided, people are reluctant to construct them. An approach where the community and the beneficiaries are involved in planning and implementation and awareness and motivation campaigns are carried out, is seldom used although it leads to much better results.

Local authorities are rarely involved in planning and implementation of the sanitation schemes, although they have the responsibility to motivate the beneficiaries, to provide services for operation and maintenance and to collect loan repayments. As a result, technical knowledge on the systems is insufficient and interest in providing services for operation and maintenance is lacking. There is no budget or strategy for services for operation and maintenance. Loan repayment is often not organized or pursued.

On the other hand, the authorities at national and state level who carry out planning and design and supervise implementation, are never responsible for operation and maintenance and are insufficient aware of the operation and maintenance requirements. This is for instance reflected in the selection of contractors and the determination of unit cost at state level and the lack of capacity building at local level.

In **Thailand** the research is carried out in slums and in housing projects of the National Housing Authority. All households have and use a toilet. Technical problems mainly relate to environmental pollution and health risks. People in slum areas which are flooded adapt their cesspools by making holes in the concrete rings. This results in raw sewage leaking in the standing water. The septic tank with anaerobic upflow filter as constructed by the NHA in two research areas does not function well and people find backwashing of the filter a dirty job to do. As a consequence, the anaerobic upflow filter is often bypassed causing black water to enter the sewerage system, for which the main treatment system is not designed. Location and type of sanitation system in the NHA projects does not meet users' preferences, resulting in private construction of new latrines. Awareness of health aspects and environmental pollution is largely lacking and people are generally happy with their toilets.

The on-site systems have to be desludged, which is sometimes a problem because adapted technologies for desludging in slums and low-income housing areas with small roads are not existing. Desludging services in the North of Thailand are privatized under control of the municipal authorities. This system is very efficient. In Bangkok the only legal desludging services are rendered by the BMA at very high cost. However, they only collect about a third of the waste produced, the rest is illegally collected by private agencies and disappearing in the environment.

The sewer systems taking sewage from the houses to the treatment plants are not functioning well. Due to soil inclination, many sewers are cracked and connections between branch and main sewers are broken, impeding the flow of sewerage. The sewers are full of sand and sewage leaks out. The sewers are difficult to clean not only because of the soil inclination, but also because the distance in manholes is too large and one of the systems requires equipment for cleaning which is not easily available. In one area, the treatment plant cannot function properly because only an estimated 60-80 percent of the total volume of sewerage reaches the

plant. The other plant functions reasonable well, but close monitoring is needed to establish the capacity of aerators needed for sufficient aeration.

In all NHA projects there are estate management offices located, amongst others responsible for operation and maintenance services. Due to insufficient training, technical assistance to the households is practical rather than environmentally sound. Feedback from the estate offices on experiences with operation and maintenance of the installed systems to the planning and design departments of NHA is insufficient.

In the NHA projects there is no separate budget for operation and maintenance of the sewerage and treatment plants, which results in the saving of expenses on operation and maintenance in favour of other tasks. The operation and maintenance of the main sewers and treatment plants was recently handed over by the NHA to the Bangkok Metropolitan Administration (BMA). This transfer was not without problems because the requirements and cost for operation and maintenance were not sufficiently clear, while the systems were already deteriorating. Moreover, BMA was not involved in the planning, design and construction of the sewers and plants and is therefore not able to adapt the systems to its technical and financial capacity.

Main lessons learned

Low-cost sanitation systems offer a viable solution for the safe disposal of human waste in low-income areas provided that requirements for operation and maintenance are taken into account from the start. Proper operation and maintenance depends on integrating its requirements in planning, design, implementation and management in which coordination between government, private agencies and residents is essential.

Laws and regulations, standardized procedures and technical designs are important for operation and maintenance. But actual decisions on the most suitable type of sanitation system and on the organization and management of operation and maintenance should always be based on local conditions, both with respect to technical and socio-economic feasibility and to users' preferences and capabilities.

Operation and maintenance require a sound organization and clear responsibilities. During planning and design, division of responsibilities and definition of tasks and accountability require ample consideration and agreement between parties concerned. Creating conditions in which responsibilities can be implemented as intended requires awareness raising, motivation, training and incentives both in the agencies and with the users.

A separate budget for operation and maintenance is required, not only to cover regular operation and maintenance, but also to allow for replacement and rehabilitation. A separate budget is necessary to avoid diversion of funds for operation and maintenance for other purposes in a situation where municipalities are perpetually short of funds.

Environmental pollution, as a consequence of private adaptations to sanitation systems and deterioration of existing systems due to neglect of maintenance, needs special attention. Although laws and regulations exist to protect the environment, they can only be effective if they are actively implemented.

These main conclusions confirm a number of known problems in operation and maintenance and show how difficult it is to apply available knowledge and experience in practice. They further emphasize the critical importance of a functional integration of requirements for

operation and maintenance in all phases of the provision of sanitation systems in low-income urban areas, right from the planning and design phase.

Chapter 1: Introduction

1.1 Statement of the Problem

In many developing countries governments are facing enormous urban growth, largely as a result of natural increase in population, but also due to migration from rural areas. As a consequence the demand for urban infrastructure services is also increasing. On the one hand there is socio-political pressure on the authorities to provide infrastructural services to the mushrooming urban settlements, while on the other hand, the resources needed for this infrastructure are being stretched to their limit. The result is an all-round deterioration in the quality and adequacy of the urban basic services supply and the people who are ultimately worst affected by this situation are those who live in urban low-income areas.

The disposal of human excreta is one of the urban basic services which is usually regarded as the responsibility of the government and which has been affected badly by budgetary limits. Conventional sewerage systems are not only extremely expensive, but they also require a level of water supply which is often not available, specifically in low-income areas. This has led many governments to adopt low-cost technologies, which are cheaper to construct and require less water to function. Moreover, the burden of operation and maintenance of these systems is considered to be minimal and can to a large extent be carried out by the users.

Selection of sanitation technologies is usually primarily based on the direct investment cost and far less on the longer term operation and maintenance requirements. Emphasis is placed on the construction of systems, while little attention is given to arrangements for operation and maintenance, to user and agency training and to the availability of the required equipment. The prime decision makers in the investment planning, programming and implementation of sanitation systems are usually national or state agencies, who generally do not have the responsibility for the operation and maintenance of the systems. This is left to the local authorities, who often have not been involved in their planning. Because of these circumstances, the actual requirements for adequate operation and maintenance of the different systems, both from the side of the responsible authorities and from the side of the users, have never been fully assessed.

Over the last decade, problems have been experienced with sanitation systems constructed in low-income urban areas. Many have fallen into disuse for reason of early failure and/or misuse. This generally resulted in a lower service level to the target population and consequent deterioration of environmental conditions. At the same time, it has caused scepticism amongst policy makers, executing agencies and target populations with regard to the feasibility of these systems. The extent or nature of the problems or the possible causes of these problems have not yet been investigated in a structured manner.

1.2 Background of the Research

The feasibility of a sanitation system (a physical structure for the disposal of human excreta) depends on the suitability of the technology with regard to environmental conditions such as water availability, soil conditions, groundwater level and population densities. But equally important to determine the feasibility are the socio-economic conditions in which the systems have to function. These are dependent on the one hand on the urban authorities responsible for the system and on the other hand on the users. So far, most studies carried out on low-cost sanitation systems have focused on technical and financial aspects, while issues concerning urban management, operation and maintenance and user attitudes have been given less attention. The studies which have been carried out suggest that generally requirements for operation and maintenance of different systems are not taken into account at either the planning or implementation phase. Moreover, a lot of schemes are developed with assumptions regarding technical functioning and user response, which in actual practice often have proved to be different. In India and Thailand, the need to reassess these initial assumptions has been realized as a result of practical experience with different sanitation systems.

In India, the central government has adopted a policy in which on-site sanitation technology is regarded as the only feasible sanitation system for small and medium sized towns. All towns below 100.000 inhabitants can apply for funds for on-site sanitation schemes in an attempt to increase sanitation coverage and at the same time remain affordable to local governments and beneficiaries alike. Recently, this ceiling has been removed and all towns and cities can apply for such schemes. A major motive behind the on-site sanitation schemes is also the aim of the government to put an end to the inhuman nature of the work carried out by scavengers, calling for the conversion of bucket latrines and the creation of meaningful alternative employment for the job losing scavengers.

As a result of this policy, a large number of schemes is being planned and implemented under a variety of circumstances and conditions. There are both positive and negative experiences which urgently need compilation and evaluation for subsequent feed back into the planning, design and implementation of new schemes. To date relatively little monitoring has been done of the schemes thus far implemented. Where monitoring is carried out, it is mainly restricted to the first two years of use of the systems, while problems with operation and maintenance often only surface after several years, for instance when pits have to be emptied or desludged. Moreover, little attention is paid to the ways planners and local authorities interact with the users to ensure that the systems are being used and maintained properly. Thus, there is a need for research to provide an insight in the requirements for operation and maintenance at different levels.

In Thailand, the National Housing Authority (NHA) is involved in slum upgrading projects and low-income housing schemes. It has been applying a variety of technology choices for sanitation, from conventional sewerage in the early schemes to on-site or partly on-site solutions in the later schemes. All of these have now been in place for more than five years. The NHA is reviewing and updating its planning and design criteria in the light of the experience gained over the years since they were last formulated. For this process feed back from the field is needed. It is the policy of NHA that housing and infrastructure schemes are taken over by the local government after 5 years. However, the transfer of the schemes has proven to be a problem. The local authorities refuse to accept the responsibility because the requirements for operation and maintenance are not sufficiently clear. Thus, it is imperative that the NHA gets more insight in these requirements.

Residents living in low-income urban areas in Thailand often construct on-site sanitation facilities by themselves. Very little is known about the technologies applied and their performance. The effect of these systems on the environmental conditions is not known nor is there any insight in the requirements for operation and maintenance. Therefore, the research also covers a number of these areas.

The research assesses the requirements for operation and maintenance of sanitation systems used in low income urban areas in India and Thailand. These systems are all based on techniques which require water for functioning, mostly pour-flush toilets connected to single or double leaching pits, to a septic tank or to a small scale sewerage system. Because these systems are widely used in Asia, the information will also be relevant for other countries in the region.

1.3 Collaborating Institutions

In India the research work was coordinated under the aegis of the **Housing and Urban Development Corporation (HUDCO).** HUDCO's training and research institute, the Human Settlement Management Institute (HSMI), has managed the research. HUDCO is a subsidiary organization of the Ministry of Urban Development of the Republic of India. It recently established a high level Low Cost Sanitation Committee with the purpose of critically reviewing and promoting low cost sanitation technology in all her low income shelter programmes. Over the past decade, HUDCO has been intensively exploring the lower cost limits of sanitation alternatives for low cost housing and slum upgrading areas within the context of lowering the overall cost of neighbourhood services. As such, new planning and design standards have been and are being tested to be included in an approach encompassing roads, water supply, drainage, solid waste, electric power and sanitation.

In Thailand, the research work was conducted under the aegis of the National Housing Authority (NHA) by their Centre for Housing and Human Settlements Studies, which has a direct supporting function within NHA in training and research for planning, design and implementation of the housing projects. The subject of operation and maintenance and related arrangements as well as technology choices feature prominently in several of their training activities. The Engineering Faculty of the Chiang Mai University (CMU) also collaborated in the research. Low-cost infrastructure aspects are included in their curriculum. In order to develop their teaching material on real field experience, research on low-cost infrastructure has received priority and has been included in their regular research programme. The University is also involved in so-called service to the community, in which help is offered to communities for better understanding and tackling of developmental problems.

The principal coordinator in the research was the **Institute for Housing and Urban Development Studies (IHS)** in The Netherlands. This institute offers training and related professional services in the fields of housing and urban development management, with a focus on low-income settlements in developing countries. Over the years IHS has developed a mixture of complementary activities including training, research, technical assistance and institutional development. The context of IHS' work is the rapidly urbanizing world, bringing innovative professional tools and management practices for a more efficient and equitable development of cities. It emphasizes the needs of low-income urban communities and the contributions they can make to the development process of cities. It also emphasizes the complementary roles of local government, NGOs, community organizations and the private sector.

The **IRC International Water and Sanitation Centre (IRC)**, in The Netherlands assisted in the research and in the drafting of the final research document. This centre aims to ensure the availability and use of appropriate knowledge and information in the water, sanitation and environment sector in developing countries. Activities include capacity building for information management, exchange of available knowledge and information, and generation and transfer of new knowledge on priority issues. Emphasis is given to community based approaches in rural and low-income urban water supply and sanitation, community management, participation and hygiene education, the role of women, maintenance systems, rehabilitation and environmental management.

1.4 Research Objectives

The specific research objectives were the following:

1) To review operation and maintenance aspects of on-site and off-site sanitation systems in low-cost housing and slum upgrading schemes, taking into account other infrastructure requirements that contribute to a sanitary environment.
2) To review the use and performance of these systems.
3) To review the user attitudes and practices with respect to operation and maintenance of sanitation systems.
4) To review the role of agencies that are involved in operation and maintenance of sanitation systems
5) To establish long-term institutional and investment requirements for the operation and maintenance of these sanitation systems.
6) To formulate operational recommendations for the planning, design, implementation and maintenance of future low-cost sanitation schemes.

1.5 Research Methodology

The research was divided in two phases. During the first phase (October 1989 - December 1990), the research teams were established, literature was identified and reviewed, the research design was developed and a pilot research was carried out. At the end of this phase, review meetings were held in Thailand, India and the Netherlands. During the second phase (January 1991 - May 1992) field research was carried out and country reports were written. Workshops were held in Thailand and India to discuss the findings with local agencies and an inter-country seminar was held to discuss findings and recommendations with a wider audience. On the basis of the country reports and the outcome of the national workshops and inter-country seminar this final document was prepared.

Establishment of research teams and institutional cadre

In view of the scope of the research, multidisciplinary teams were established, comprised of engineers, sociologists, economists, sanitary scientists and architects. Each of the three teams (HSMI, NHA and CMU) was headed by a coordinator. The research in India was executed under the existing bilateral programme of the Indian Human Settlements Programme in which IHS had a staff member as project leader. This framework offered a good arrangement for HSMI to carry out the research. In Thailand no cooperation programme existed that could serve as an institutional cadre. Therefore, separate agreements between IHS and NHA, as well as IHS and CMU had to be established.

Literature search and review

All collaborating research institutions participated in the search of relevant literature to ensure that experiences gained worldwide in the field of operation and maintenance were taken into

account. The bibliography in this document is the result of this search. Information gathered was exchanged and used as a basis for a review of the research objectives and the formulation of definitions for the key concepts used in the research. The following definitions were adopted:

Low-income areas:	an area where the population has an average household income below 6,000 Baht (Thailand). An area which is characterized by lack of basic infrastructure services and dominated by income groups living on or below the official poverty line (India).
Sanitation system:	a physical structure for the disposal of human excreta.
On-site sanitation:	a human excreta disposal system in which the sewage is stored and (sometimes) treated on the site.
Off-site sanitation:	a human excreta disposal system in which the sewage is transported away from the site for storage and/or treatment.
Operation:	the procedure and activities involved in the actual delivery of services to the public.
Maintenance:	a wide range of activities aimed at keeping the sanitation systems in a serviceable condition.

Research design

On the basis of the literature search and review of research objectives, the research design was developed on the following premises:

- focus on the study of sanitation systems that have a relevance for improving the living conditions in low-income urban areas. Thus included are on-site, off-site, individual and public sanitation systems;
- selection of research areas guided by the presence of sanitation systems in which the executing research institutes have an interest. For HSMI and HUDCO this is the two-pit pour-flush latrine, while for NHA these are neighbourhood on-site/off-site sewerage and treatment systems implemented in their housing projects. The sites selected for the research are predominantly low-income areas, but in view of the interest in particular sanitation systems, not all sites are exclusively low-income;
- selection of research areas where systems have been functioning for at least five years and of which secondary data are available. Different type of schemes are included with regard to funding/financing, administration and planning, integration with other development aspects and responsibility for operation and maintenance;
- aspects covered by the research include five broad areas: technical aspects, cost aspects, user aspects, organizational aspects and environmental aspects;
- inclusion in the research of ten small and medium sized towns spread over different states in India and eight research locations in Thailand. Of the areas in Thailand, four are located in the central region around Bangkok (by NHA team) and four in the Northern part of Thailand (by CMU team);
- use of different data collection methods based on field testing. Primary data are collected with the help of structured household questionnaires, observation checklists, interview checklists for local resource persons and questionnaires for agencies involved in planning, implementation and operation and maintenance. The household questionnaires are administered by hired interviewers. In Thailand these come from universities in Bangkok and Chiang Mai, in India qualified interviewers are selected in each town. All other interviews and checklists are administered by the research teams.

They also obtain secondary data from national and provincial/state agencies, statistical offices and municipal bodies.

- processing of the data from the questionnaires and observation checklists is done by HSMI and CMU. Both institutions have staff to develop an SPSS programme for entering and analysing the data.

Pilot research

Each of the three research teams carried out a pilot research in one area, taken from the selected areas. The objective of this pilot research was to test the approach and to add other methods of data collection if needed. The data processing was also tested and review meetings were held in India, in Thailand and in the Netherlands to discuss the results of the pilot phase. The data collection methods did not have to be changed drastically after the pilot research, so the pilot areas could also be included in the final research analysis.

1.6 Structure of this Document

Different institutions, government and private, are involved at various levels in planning, implementation and operation and maintenance of sanitation facilities. In chapter 2 and 5, an overview is given of the different institutions, their policies and responsibilities for India and Thailand respectively.

The basis of this document is the research carried out in India and Thailand. The results of this research are divided over a number of sections, covering a description of the research areas and their environmental conditions, the systems researched, the performance and cost of the systems, the user attitudes and practices, the support system for operation and maintenance. Chapter 3 describes the results in India, chapter 6 those in Thailand.

An analysis of the results, conclusions and recommendations are given in chapter 4 for India and chapter 7 for Thailand. The conclusions and recommendations are also based on the literature and on the discussions held during the national workshops and inter-country seminar.

The concluding chapter 8 discusses the lessons which can be learnt from the findings in the research to improve management of operation and maintenance of sanitation systems in urban low income areas.

Chapter 2: Institutions Involved in Sanitation Systems in India

In India the increase in coverage of sanitation facilities in low-income areas is considered a public affair. On-site sanitation technologies are being promoted as the only feasible technology for cities and towns with a population below 100,000 people, because conventional sewerage is not affordable for either the government or the individual households. Government agencies at national, state and municipal level, each have distinct roles in the planning and implementation of sanitation schemes. It needs to be realized that the programmes that cover low-cost sanitation schemes and the division of responsibilities among involved institutions at national and state level change regularly. The description below is mainly confined to the period when the studied schemes were implemented. Table 2.1 gives a short overview of the different agencies and their responsibilities. A detailed description of these agencies is given in sections 2.1 to 2.4, followed by an overview of the sanitation schemes carried out in the research towns in section 2.5.

2.1 National Agencies

The **Ministry of Urban Development** has two distinct sets of responsibilities. One pertains to the construction and maintenance of government buildings and the management of central government land and property. The other responsibility is the broad policy formulation and monitoring of programmes in the area of housing, urban development, urban poverty alleviation and urban water supply. These are essentially state subjects, but the Government of India plays a coordinating and monitoring role and also supports these programmes through central sector schemes, institutional finance and expertise.

It is in this realm that the Ministry is involved in sanitation schemes. Targets for schemes are determined, funds are allocated to the different States and the division of loans and grants determined. These loans are to a large extent channelled through the Town and Country Planning Organization, which is also involved in planning, monitoring and evaluation of the schemes for which it provides funds. Recently, the Housing and Urban Development Corporation (HUDCO, see below), has taken over part of the responsibilities for sanitation from the Town and Country Planning Organization.

The **Ministry of Welfare** is entrusted with the responsibility to ensure the welfare of the general public with a special attention to the poorer and other deprived groups of society. The Ministry formulates the policy for improving the living conditions of the scheduled castes, the scheduled tribes and other backward classes. It also has the responsibility for implementation of the formulated programmes, while it promotes and supports programmes of other government and non-government agencies pertaining to their target group. The major sanitation scheme developed by this Ministry is the Scavenger Liberation Scheme. The Ministry determines the policy for conversion of bucket latrines, construction of new latrines and the rehabilitation of scavengers. The targets per State are determined as well as the number of towns where conversion will be carried out. The financing of the scheme at State level is planned and financial allocation and division of loans and grants are determined. The loans are channelled through HUDCO or State government agencies.

Table 2.1: Overview of agencies and their responsibilities for sanitation programmes

	Planning	*Implementation*	*Operation & Maintenance*
Ministry of Urban Development	- Determination of number of towns to be reached by sanitation programmes - Allocation of funds to different states for sanitation programmes - Determination of funds covered by grants and funds available for loans	- Loans channelled through the Town and Country Planning organization and/or HUDCO - Subsidy channelled through State Government agency	
Ministry of Welfare	- Determination of policy for: . conversion of dry latrines . construction of new latrines . liberation of scavengers . financing at State level - Determination of overall and townwise targets for sanitation programme - Preparation of guidelines for implementation	- Loans channelled through HUDCO and/or State Government agency - Implementation through State or selected NGO - Subsidy channelled through State Government agency	
HUDCO	- Preparation of guidelines for financing of . conversion of dry latrines . construction of new latrines . construction of public latrines - Assess loans application from authorized institutions - Formulate loan agreements	- Release of funds for implementation - Monitoring of progress and release of loan instalments if progress according to agreement	- Ensure repayment of loan by Directorate of Municipal Administration or Municipalities
Directorate of Municipal Administration	- Identification of towns for sanitation programmes - Determination of allocation of funds (loan & grants) - Directives for loan recovery - Planning for implementation at municipal level	- Supervision of implementation through municipal authority or private organization - Monitoring of proper utilization of funds	- Release of funds for maintenance - Ensure repayment of loan by municipality

	Planning	*Implementation*	*Operation & Maintenance*
e Water & Sewage Board	- Project planning - Preparation of engineering details - Preparation of budget	- Responsibility for project implementation - Selection and supervision of contractors - Technical guidance	- After implementation handing of responsibility for operation and maintenance to municipal authorities - Ensure repayment of loan by municipality
icipal Authority	- Planning of projects at local level - Training of staff - Selection of beneficiaries - Planning for motivation and education of beneficiaries - Preparation of loan agreement with beneficiaries	- Implementation of work - Selection of contractors - Supervision of contractors - Motivation and education of beneficiaries - Site selection of public latrines - Monitoring of implementation	- Provision of services for operation and maintenance of public latrines - Provision of services for private latrines if requested - Provision of pit emptying services - Recovery and repayment of loans
Governmental anizations	- Assist municipal authorities or State level organizations in project planning - Planning for motivation and education	- Construction of latrines - Technical guidance - Selection of contractors	- Provision of services for operation and maintenance (if guarantee period is included)

The **Housing and Urban Development Corporation (HUDCO)** is a subsidiary institution of the Ministry of Urban Development and is responsible for the financing of many of the sanitation schemes being carried out in the country. HUDCO considers loan applications from housing boards, slum clearance boards, improvement trusts, municipal authorities and any other agencies who are authorized by the State government to carry out sanitation programmes. Financial assistance is available for conversion of dry pit latrines to water seal pour-flush latrines, construction of new latrines in houses where no latrines existed and the construction of community latrines. HUDCO finances up to 50 percent of the total project cost. The first instalment is released after the loan agreement and other formalities have been completed. The subsequent instalments are released depending on the progress of work and satisfactory utilization of the amounts previously advanced. Thus HUDCO is involved in monitoring of the progress of the schemes and can intervene if repayments are not made in time or agreements are not carried out. They ensure repayment of loans after implementation through the Directorate of Municipal Administration or by the municipalities.

2.2 State Agencies

The **Directorates of Municipal Administration** are the key organizations at state level to coordinate and monitor the activities of the municipalities within a state. Identification of projects and resources is done through this body, which also has the responsibility for all State/Central grants and loans and project funds. The Directorate channels the resources and manpower to the different municipalities and has to ascertain the progress, implementation and proper utilization of funds at municipal level. The Directorates are involved in the planning of sanitation schemes at the municipal level and in the supervision of implementation, which is carried out either at municipal level or by a private organization (NGO or contractor) contracted by the Directorate. After implementation of the schemes, they have to ensure repayment of loans by the municipalities.

State Water and Sewerage Boards are created in some states to share the responsibility of the municipalities in the implementation of new projects and programmes in the field of water supply and sewerage/drainage. The boards are involved in project planning, the preparation of engineering details, planning for implementation and preparation of the budget. They have the responsibility for the implementation of the scheme and select and supervise the contractors. In some states, this responsibility has been extended to low-cost sanitation programmes. After implementation, the facilities are handed over to the municipalities for operation and maintenance.

2.3 Municipal Agencies

Municipal bodies are the key institutions in implementation and operation and maintenance of sanitation systems in low-income areas. They are formed and regulated by the State Municipal Acts, which specify their functions and their resource raising powers. The status of the body depends on the number of residents and the State Municipal Act.

Departments of importance for sanitation are the Public Health Department, the Public Works Department and the Revenue Department. The Public Health Department is headed by a Health Officer assisted by a Sanitary/Health Inspector. The sanitation branch, headed by a sanitary/health inspector is responsible for sanitation (cleanliness of roads, drains, public latrines, desludging and provision of food supplies). The staff of this branch consists of sanitary supervisors and sanitation labourers/sweepers. The health branch, headed by a health inspector is responsible for vaccination and prevention of epidemics. The staff consists of health workers.

The Public Works Department is headed by a Municipal Engineer, while each of the three branches (water, electricity and public works) is headed by an Assistant Engineer. It is their task to maintain the water supply, to construct and maintain roads and municipal properties, to approve building plans and to prevent encroachments. Sometimes, the responsibilities of the sanitation branch fall under the assistant engineer.

The Revenue Department is headed by a Revenue Officer/Inspector and is responsible for bill and tax collection. The organizational set-up may, however, vary and departments may be merged or have additional sections.

In the sanitation schemes, the municipal authorities are always responsible for the selection and motivation/education of beneficiaries and the preparation of loan agreements with the beneficiaries. In some schemes, they are also involved in planning and implementation. In that case, they receive the funds for implementation from the state and are responsible for selection of contractors, training of masons and supervision of the construction. Responsibility for repayment of loans to the state and cost recovery from the beneficiaries is always given to the municipalities. They also have the responsibility for operation and maintenance of public latrines and to provide services to the households for the operation and maintenance of their latrines.

2.4 Non-Governmental Organizations

In some states, the implementing agencies at state level, request a non-governmental organisation to implement the project at municipal level. NGOs like Sulabh International, Safai Vidhalaya and Rajastan Institute for Local Self Government have been involved in the implementation of sanitation schemes. Especially Sulabh International has carried out construction of public and private latrines in different states all over India. The task of the NGOs may be to assist the municipality in project planning and implementation, in motivation and education and to provide training for staff, masons and contractors. But they may also have the responsibility for implementation and execution of the scheme, procurement of materials and monitoring of progress. The organization of services for operation and maintenance is generally the task of the municipality, but sometimes the services required during the first five years of operation are provided by the NGO under a guarantee clause.

2.5 Sanitation Schemes Covered in the Research

The sanitation schemes carried out in India may be part of larger programmes aimed at ameliorating living conditions in urban areas or may be just sanitation related programmes. In the research two schemes form part of a larger programme, that is the Integrated Development of Small and Medium Towns (IDSMT) and the Urban Basic Services (UBS) programme. The other schemes covered are the Scavenger Liberated Scheme, the Basic Sanitation Scheme and the UNDP/World Bank Scheme. Table 2.2 gives an overview of the different schemes and the agencies responsible for respectively planning, implementation and operation and maintenance.

Integrated Development of Small and Medium Towns (IDSMT)

The Integrated Development of Small and Medium Towns is a centrally sponsored scheme initiated during the Sixth Five Year Plan (1980-1985) with the aim to promote integrated development of small and medium large towns with a population below 100.000 to reduce migration to larger cities. The programme covers 235 towns and is implemented with 50 percent central government funding and 50 percent funding from the state governments. Central funding on a 50-50 matching basis is available for land acquisition and development, traffic and transportation and market development. All other developments including sanitation have to be funded by the states, but form a part of the integrated development plans.

Single pit latrines, double pit latrines and community latrines are part of the programme. Implementation is usually carried out through a state agency such as the Water and Sanitation Development Board. There is no standard funding arrangement for subsidies, loans and beneficiary contribution. This differs per state (and even per town within the same state). After construction, the responsibility for operation and maintenance for the latrines is handed over to the municipal body for which no extra funds are made available.

Scavenger Liberation Scheme

The Scavenger Liberation Scheme is a scheme of the Ministry of Welfare, initiated in 1980 and is ongoing. It seeks to eliminate scavenging by conversion of bucket latrines into double pit pour-flush latrines in selected project towns. In addition, a major component of the scheme is the rehabilitation of the scavengers through training and financial assistance. A condition of the scheme is the whole town approach whereby all bucket latrines have to be converted and a law established to prevent the existence of bucket latrines.

Initially, beneficiaries were given a 50 percent grant and 50 percent loan for the conversion of their bucket latrines. But loan conditions differed in all states. The loan component was to become a revolving fund after recovery of the loans from the first beneficiaries in a 5-10 year period. The funds for the loan were provided by HUDCO. These funding arrangements were changed in 1989. The central grant of the Ministry of Welfare and the loan from HUDCO are now handed over directly to the state for conversion/construction up to plinth level. At least 15 percent of the loan is earmarked for construction of community latrines on pay and use basis, both for residential use and general public use.

Table 2.2 Overview of sanitation schemes and responsible agencies

	Planning	*Implementation*	*Operation and Maintenance*
IDSMT	Ministry of Urban Development	State or District Development agency	Responsibility of householders and local bodies
Scavenger Liberation Scheme	Ministry of Welfare	State	Responsibility of householders and local bodies
Basic Sanitation Scheme	State agency or Municipal body	State agency or Municipal body	Responsibility of householders and local bodies
UNDP/World Bank Scheme	State with UNDP/WB	State	Responsibility of householders and local bodies
Urban Basic Services	UNICEF with Municipal body	Municipal body	Responsibility of householders and local bodies

Basic Sanitation Scheme

In the Basic Sanitation Scheme HUDCO finances programmes and projects for sanitation improvements which are proposed by state agencies or municipal bodies. The financial assistance is available for conversion of dry latrines, for construction of new latrines in houses where no latrine existed and for construction of community and public latrines. HUDCO provides a loan for 50 percent of the cost of the latrines, the other 50 percent has to be borne by either central or state agencies or directly by the beneficiaries.

UNDP/World Bank Scheme

The UNDP/World Bank Scheme started in 1979 and is ongoing. The objectives are to convert existing bucket latrines, to provide latrines where no latrines were present and to provide community facilities where individual latrines are not feasible. The selection of towns to be included in the scheme is carried out by the state governments based on criteria set by the Government of India. These criteria include population (below 100,000), presence of a piped water supply, absence of a sewer system, representation of different socio-economic and physical conditions. The scheme promotes the double pit pour-flush latrine and is being carried out in 110 small and medium large towns in India.

The financing of the scheme varies in the different towns, depending on the arrangements per State and may or may not include a grant or a loan or both. Planning for the sanitation scheme is carried out at state level and implementation is also coordinated at state level. In this scheme, demonstration latrines are constructed in each town while construction of the latrines is checked by the funding agency. After construction, the responsibility for operation and maintenance service is handed over to the municipal body.

Urban Basic Services

The Urban Basic Services (UBS) programme was implemented during the period 1986-1990 on a pilot basis as a centrally sponsored scheme with UNICEF assistance. Since 1990, the programme has become the Urban Basic Services for the Poor (UBSP), in which the sanitation component has not been changed from the UBS programme. This programme is the only low-cost sanitation programme in which the local bodies are directly involved in planning and implementation.

The programme assists to upgrade basic services for the urban poor, especially women and children. Among the components of the programme is low-cost sanitation: the construction of low-cost pour-flush latrines; an intensive awareness creation and education programme to precede the provision of sanitation facilities; technical guidance, monitoring, supervision and training to be provided by UNICEF zonal offices. A grant of 40 percent of the cost of the substructure, but not exceeding Rs 500 per latrine, is provided as well as a 60 percent grant for latrines at schools. Full cost is provided for the training of masons and motivation and awareness programmes. The UBSP programme emphasizes community participation and people's involvement in the development efforts. The programme is implemented in 168 towns and financial responsibility is shared between central government, state governments, municipalities, the beneficiaries and UNICEF. Planning for the programmes is done at central and state level, implementation at local level with UNICEF assistance. Municipal bodies and beneficiaries are responsible for operation and maintenance of the latrines.

Chapter 3: Performance and Use of Sanitation Systems in India

In this chapter, the results are given of the research carried out in ten towns in India. The location and conditions in these towns are described in the first section and basic information on the research population is given. Different sanitation systems are found in the towns covered and these are described in section 3.2. The research focused on sanitation systems which are constructed as part of a sanitation scheme and the condition and performance of these latrines is described in section 3.3, followed by an assessment of operation and maintenance requirements of the latrines in section 3.4. Section 3.5 deals with the user attitudes and practices in maintaining the latrines. Public latrines are another common sanitation system in the towns studied. The condition and maintenance status and the attitudes of the users of these latrines are described in section 3.6. The organization of the sanitation schemes at local level is the responsibility of the municipal authorities, their management and their services for maintenance of the latrines are discussed in section 3.7.

3.1 Research Towns and Research Population

Of the ten towns covered in the research, seven have a population below 100,000. The towns are located in different parts in India (figure 3.1) with different climatic conditions and annual rainfall.

Basically three types of soil are found: sandy, sandy clay and clayey. Eight of the towns have a groundwater table below 3 meters and exceptionally high water tables are found in the central areas of Agartala (1-2m) and Silchar (0.7-1m). The densities vary from 1,775 to 9,915 persons per square kilometre. Most of the towns are rural in character except Hosur which has some industrial importance and Agartala and Silchar which are more urbanized regional centres. An overview of the general characteristics of the ten towns is given in table 3.1.

All towns have a piped water supply system which provides an intermittent supply ranging from 1-5 hours a day. In addition, handpumps and wells are found everywhere. The sanitation scenario in all towns contains a variety of systems including open air defecation, defecation into ponds/canals/rivers, single pit latrines, septic tanks, two-pit pour-flush latrines and public latrines. The stormwater drainage is generally through open surface drains with some exceptions for central areas where the drains are covered with stone or reinforced concrete (RCC) slabs.

A total number of 1,322 households was surveyed, selected on the basis of the sanitation system in use. Because of the preference of the sanitation programmes for double pit pour-flush latrines, most households covered in the research have this type of latrine (973 households). The other systems covered in the research are single pit latrines (115 households) and septic tanks (198 households). As non-use after construction appeared to be significant, a separate survey was carried out in six of the towns to assess whether there exists a relationship between non-use of the latrines and aspects of operation and maintenance. It was found that of the 302 households surveyed, 113 (37 percent) were not using the latrines. A detailed discussion on this issue is given in section 3.5. Information on aspects not directly related to operation and maintenance of the latrines at household level was gathered through interviews with the municipalities, the health officer, local leaders, contractors and sweepers and through observation.

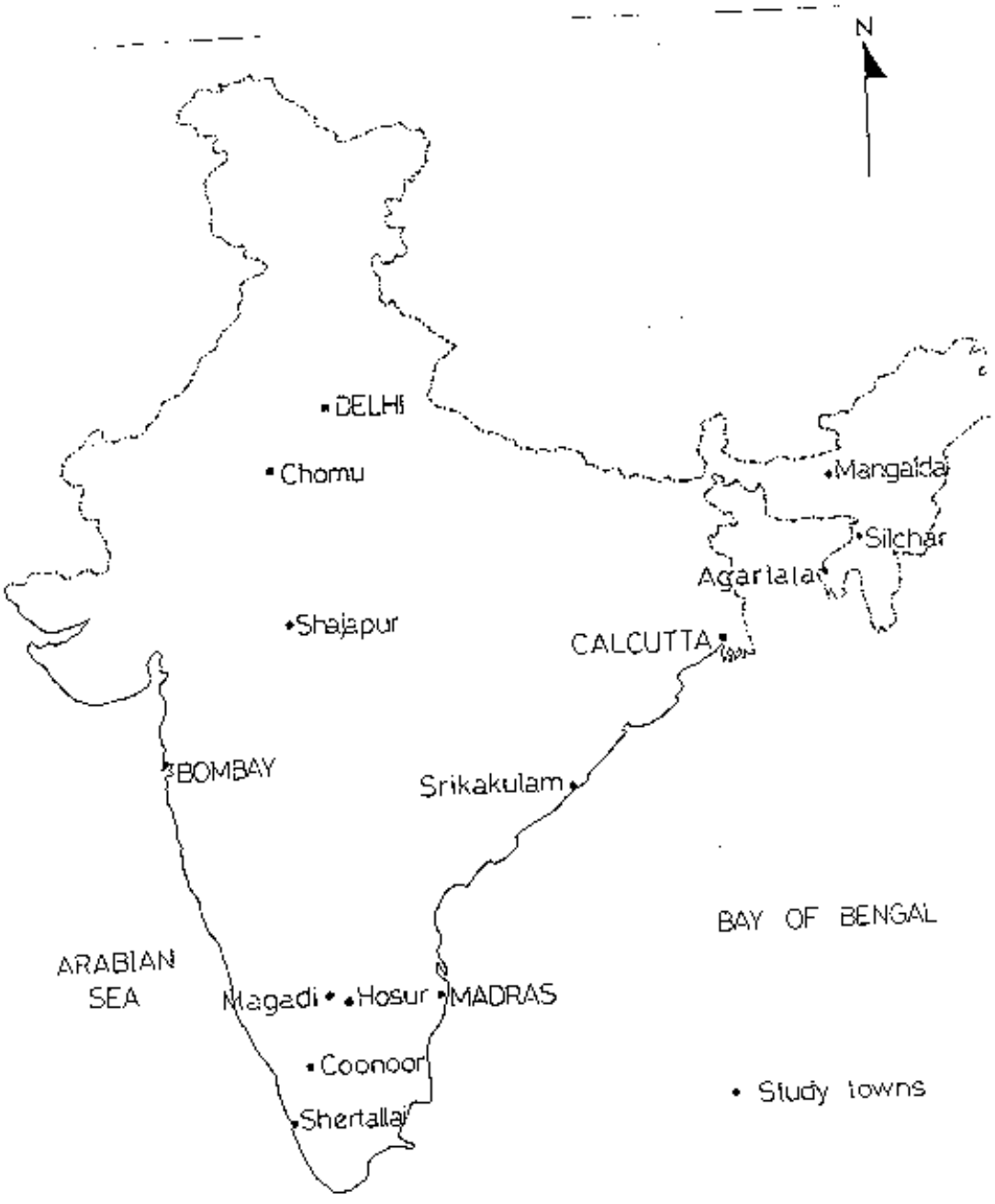


Figure 3.1 Location of research towns

Table 3.1: General characteristics of the towns

	CHOMU	SHAJAPUR	SILCHAR	MANGALDAI	AGARTALA	SHERTALLAI	COONOOR	KASERGODI	HOSUR	SRIKAKULAM
State	*Rajasthan*	*Madhya Pradesh*	*Assam*	*Assam*	*Tripura*	*Kerala*	*Tamil Nadu*	*Karnataka*	*Tamil Nadu*	*Andhra Pradesh*
Total population	40,000	50,000	138,000	40,000	158,700	44,000	53,000	24,000	100,000	88,864
Density population per square kms	1775	9291	6814	4444	9915	2719	3541	8888	7924	9293
Annual rainfall (mm)	589.3	1047.6	3225	1992	2023.4	3274.4	1549.2	1269.7	787.6	938
No. of House connections/1000 P	59	74	79	22	114	16	43	39	19	32
No. of public tapstands/1000 P	0.5	33	3	0.4	2	23	3	8	0.8	0.6
Water distribution in lpcd	65	85	110	34	101	38	47	11	40	80
Hours of supply per day	3-4	3-4	3-1	2	3-4	2-3	4-5	1-2	1-2	2-3
No. of primary schools/1000 P	0.2	0.7	0.34	0.22	0.33	0.18	0.20	0.37	0.12	0.25
No. of hospitals/1000 P	0.02	0.02	0.01	0.07	0.19	0.06	0.18	0.04	0.01	0.01

Source: Census of India 1981

The majority of the respondents own their houses (88 percent) and were resident before the latrine was constructed (91 percent). The average household size is 6 to 7 members. The household income varies from Rs. 745 (Shertallai) to Rs. 2,284 (Chomu), the average being Rs. 1,503. In the whole sample only 5 percent have no literate members in the household, while 46 percent have at least one member of the household with a college education. Most households are Hindu (83 percent), while 10 percent is Muslim and 6 percent Christian. For water supply, 40 percent have a private piped connection, 30 percent a private well or handpump and 30 percent fetches water from a communal supply (see table 3.2).

Table 3.2: General characteristics of research population

	CHOMU	SHAJAPUR	SIKONAR MANGALDAI	AGARTALA	SHERTALLAI	COONOOR	MADADI	KOSUR,SRIKAKULAM	
Number of respondents	122	199	109	132	144	200	162	121	127	150
Average Household Size	9	8	6	7	7	5	6	5	6	6
Religion										
Hindu (%)	93.5	67.7	90.8	68.2	97.6	88.5	47.5	46.7	67.4	96.4
Muslim (%)	6.3	32.3	9.2	26.6	2.4	2.5	3.3	1.7	6.7	2.9
Others/Christians (%)	–	--	–	3.1	--	9.0	49.2	1.6	3.9	0.7
Education										
Illiterate (%)	1.3	8.9	7.3	4.5	2.4	0	2.5	1.7	9.4	2.9
School (%)	45.6	47.5	35.8	50.0	46.9	50.5	73.6	26.4	62.7	38.2
College (%)	53.2	43.7	56.9	45.5	50.8	49.5	23.8	71.9	7.9	58.8
Average household income (Rs.)	2284	1280	2095	1634	2302	745	892	1517	1160	1126
No of Earners/family	1.5	2.1	1.7	1.5	1.6	1.6	1.5	1.2	1.5	1.3
House ownership (%)	94.3	97.5	88.1	87.9	95.2	99.0	73.0	75.2	81.9	80.3
Water supply										
House tap (%)	100	79.1	55.0	23.5	43.5	6.0	36.1	24.8	22.8	10.9
House Handpump (%)	0	0.0	5.5	53.0	17.7	0.5	0	0	0.8	2.2
House well (%)	0	3.8	1.8	5.3	0	31.5	1.5	1.7	2.1	10.9
Communal Tap/HP/Well (%)	0	16.4	33.0	13.6	24.1	48.5	58.1	5.8	67.6	34.3

Source: Primary Survey

3.2 Sanitation Systems in the Research Towns

Most of the sanitation systems in the research towns are on-site systems and include sanitary and non-sanitary types. Also bucket latrines and overhang latrines are found, which cannot be categorized as on-site system. A description of each of these systems is given below, including systems constructed and paid for by users themselves and systems which are constructed as part of a government programme.

Bucket latrines

Bucket latrines are also described as dry latrines because no water is used to flush the excreta. To avoid confusion with other types of dry latrines such as the VIP latrine, the term bucket latrine is used in this document. The bucket latrines have a bucket or any other receptacle such as an empty battery case for retention of faeces and sometimes urine and anal cleansing materials. The container is placed either on the floor in between footrests or in a small vault under the floor of the latrine cubicle. The receptacle is periodically emptied for disposal. Often, the emptying of the bucket can be done from outside through an opening in the wall, without having to enter the latrine. The removal is done by scavengers who collect the waste in larger containers and dump it either in a trenching ground or in an open area nearby. Collection is a health hazard and physically, socially and culturally unacceptable. Nearly 25 percent of the urban population is presently served by this system.

Overhang latrines

Overhang latrines are found in low-income communities located near water or marshy lands. They consist of a bamboo platform with a hole in the centre supported by stilts and sited directly over the water. The superstructure is made of split bamboo, tree branches and leaves. The user has to squat on the platform and the excreta falls directly in the water.

Single pit latrines

Single pit latrines of various types are found in all towns. Most are constructed by the users with locally available materials. The pit is usually unlined with a diameter of 1m and a depth of about 1.5m. If there is no pan, an improvised piece of sheet metal is put over a bamboo or wooden floor and formed into a shute leading to the pit. In the better versions, a standard ceramic pan with a waterseal is found, with a pipe connection to the pit. Bricks are used as footrests and both floor and footrests are plastered and finished with cement. If the pit is lined, this is done with honeycombed brickwork and a reinforced cement cover.

The superstructures are made from local materials like bamboo, straw, jute matting or wood and sometimes included a corrugated tin/asbestos sheet for roofing or polythene sheets for walls. When the pit is full, it is either emptied by hired scavengers or a new pit is dug. In the latter case, the superstructure is either moved to the new pit or a new superstructure is constructed. In the first case, when the contents of the pit are taken out, they are disposed of on nearby vacant areas.

Apart from this type of single pit latrine, two other indigenous types of latrines were found. The bottle type latrine is constructed in parts of Rajasthan and Gujarat and consists of a ceramic pan with waterseal connected with a pipe to a single bottle-shaped pit (narrow at the top, wide at the bottom) with a depth of about 10m. The bottle shape and the stability of the soil make digging of the pit at such depth possible. Local people claim that the system lasts almost indefinitely. Because of the very low groundwater tables, there is no risk of groundwater pollution.

In the north-eastern states, a tyre type latrine is popular with low-income households. It consists of a single offset pit with a depth of 1.5 to 2 meter, lined with several layers of truck tyres. The tyres prevent the pit walls from collapsing and the liquid leaches away through the bottom of the pit. Generally the pan is made of sheet metal with a shute towards the pit. When the pit is full, it is either excavated by scavengers or a new pit is dug. The superstructure is constructed of local materials, usually split bamboo or matting from dried tall grass.

In two schemes, the Urban Basic Services programme (UBS) and the Integrated Development of Small and Medium Towns programme (IDSMT), single pits were also constructed. In the technology used, the pan is located directly over the pit, which is unlined with a diameter slightly less than 1m and a depth of 1-1.25m. A reinforced concrete ring of 1m diameter and 45cm high is placed on top of the dug pit. This is capped with a prefabricated circular reinforced concrete slab with a built-in pan with waterseal. Footrests are also part of the slab. A ventpipe is erected through a small hole in the slab and extends to above the roof of the superstructure. When the pit is full, the concrete ring and slab are moved to a newly dug pit and the old one is covered with soil.

Septic tanks

The septic tank system is found popular with the more affluent families. Expertise for construction is commonly available, even in smaller towns and such systems are invariably private contractor built.

The septic tank consists of an underground concrete or brick tank separated by a suspended baffle wall. Excreta is digested anaerobically and settles to the bottom. Methane gas produced in the tank is removed through a ventpipe which releases the gas high enough to avoid nuisance from smell. The liquid effluent flows to an adjoining soakage pit.

Two pit pour-flush latrines

This system is propagated in most government sanitation programmes and therefore the research focuses largely on this system (figure 3.2).

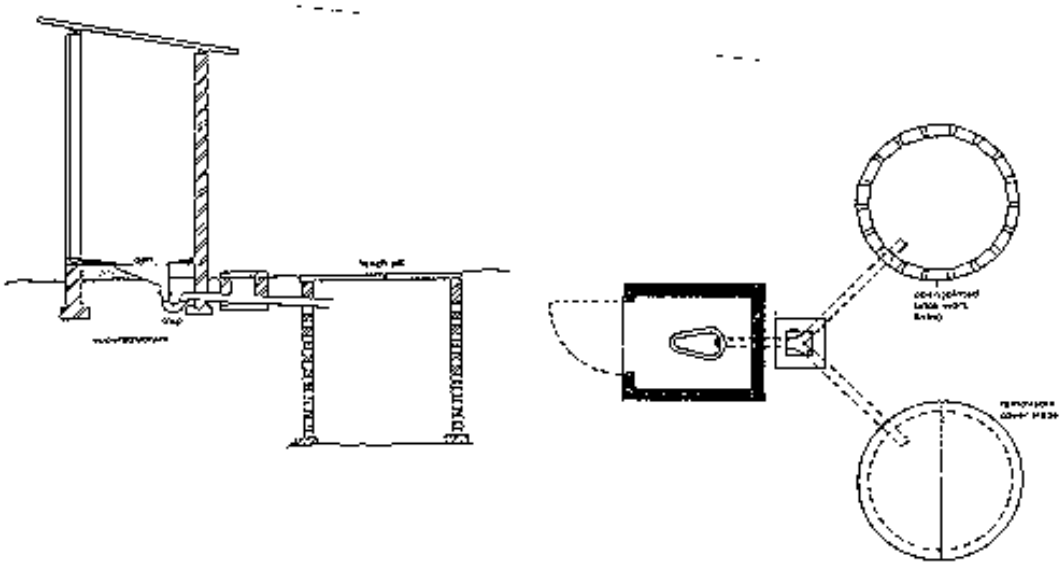


Figure 3.2: Two pit pour-flush latrine

The latrine consists of a waterseal squatting pan connected to a junction box outside the latrine, further leading to two underground leaching pits. The pan has a steep bottom slope of 30 degree, a narrow neck of 70mm and a 20mm waterseal trap set into the floor of the latrine. This construction enables complete flushing with only 2 litres of water.

The junction box has a Y-junction so that the flow can be directed to one pit at the time by blocking one branch of the Y-junction. It has a removable cover for easy inspection. The junction box is connected through a pipe or drain to two brick-lined leaching pits with the bricks laid in a honeycomb pattern. The bottom of the pit is left unlined. The pits are either square or circular and are fitted with reinforced concrete slabs.

The pans and traps are made of different kinds of materials such as glass fibre reinforced plastic (GRP), polyvinyl chloride (PVC), high density polyethylene (HDPE), ceramic, mosaic or cement concrete. The footrests are ceramic, concrete with mosaic finish, brick or stone. The connecting pipe or drain is made of non-pressure asbestos cement (AC) or a drain made of brick or stone. The drain bottom has to be semi-circular. The inlet pipe or drain has to enter at least 100mm into the pits. Within the pits the top 200-250mm are solid brickwork, below this the honeycomb brickwork starts down to the bottom.

There are three pit volumes, designed for 5, 10 or 15 users on the basis of an effective pit volume of respectively 0.68, 1.36, 2.04 cubic meter in dry condition or 1.0, 2.0 and 3.0 cubic meter in wet condition which is sufficient for three years of use.

When the pan is flushed, the excreta passes through the junction box into one of the pits. The liquid percolates out into the surrounding soil through the honeycomb openings and down through the open bottom of the pit. Only the solids accumulate in the pit. Each pit is designed to last for about three years. When one pit is full, the connection in the junction box is switched so the excreta passes into the second pit. The full pit is left for 18 months or longer after which all pathogens have died and the contents become a rich organic humus which is safe to handle and can be used as fertilizer. After this period, the pit can be opened and the contents removed, after which the pit can be used again.

The complete system can be located on the plot, the pit covers can be used as floor of a room in case there is not sufficient space outside.

Public latrines

Communal or public latrines are complexes containing a number of cubicles with toilets. The squatting pans are made of ceramic, fibre-glass, high density polyethylene (HDPE) or mosaic with footrests. The pans have a waterseal leading to twin leaching pits or septic tanks. In the larger cities, they may be connected to an underground sewer. In smaller cities also bucket latrines are found. The complexes are designed to have separate sections for men and women, a waterpoint where water for flushing and cleaning can be taken, electricity points in each cubicle for visits at night, a room where cleaning/maintenance equipment and tools may be kept safely and an attendant to ensure proper operation and maintenance of the facility.

3.3 Condition and Performance of Private Latrines

Table 3.3 gives an overview of the technical status of the sanitation systems covered in the research. In this section a systematic overview is given of the status and performance of the various latrine parts.

Table 3.3: Technical status of sanitation systems

	CHONU	SHAJAPUR	SILCHAR	MANGALDAI	AGARTALA	SIDDYALLAS	GOONOOR	MADADI	HOSUR	SRIKAKULAM
Type of soil	Sand	Black Cotton	Clay Sand	Clay Sand	Clay Sand	Sand	Clay Sand	Red Clay	Clay	Clay Sand
Depth of ground water (m)	18-22	7-13	0.7-1	2-3	1-2	3-10	15-20	15-20	5-15	3-5
Location of latrine inside the house (%)	41.3	44.6	7.3	4.5	0.8	19.0	10.7	0	2.4	2.2
Adjacent (%)	4.3	-	50.5	12.9	5.5	1.5	5.7	23.1	22.8	31.4
In courtyard (%)	33.7	29.3	41.3	76.5	92.7	78.5	80.3	69.4	37.0	58.4
Outside the house	20.7	26.1	0.9	6.1	-	1.0	3.3	7.4	37.8	8.0
Completed superstructure										
Single Pit (%)	89.5	-	28.6	30	75	40	-	41.9	31.6	10.0
Double Pit (%)	82.4	63.3	75.3	76.4	88.5	32.8	81.1	87.8	34.8	72.3
Septic Tank (%)	100	90.9	89.9	100	100	92.7	100	-	41.1	100
Superstructure material permanent										
Septic Pit (%)	94.7	-	7.1	-	12.5	-	-	74.2	64.7	0.0
Double Pit (%)	90.2	62.0	48.1	85.5	76.9	21.0	100	100	69.6	100
Septic Tank (%)	100	90.9	94.4	91.7	91.7	100	100	-	94.7	100
In the house (%)	98.6	79.1	55.0	23.5	43.5	19.5	39.0	24.8	24.4	10.9
Pit cover in good condition (%)	95.7	47.6	51.6	68.3	61.7	82.4	81.1	82.2	46.7	46.2
Septic tank cover in good condition (%)	100	100	100	83.3	100	100	90.6	-	60.0	100
Spillage/Rain water entering pit/tank (%)	1.1	8.9	28.0	16.7	8.1	54.8	25.6	31.7	45.2	18.2
For double pit only										
Pour-flush pans (%)	94.1	57.1	100	91.6	0	86.6	93.9	35.6	79.8	80.2
Tap inside toilet (%)	16.7	5.4	14.9	2.7	0	25	5.6	7.5	52.4	54.2
Distribution Box well connected (%)	35.4	21.1	35.1	65.5	76.0	91.6	58.9	92.2	51.7	75.0
Vent pipe installed (%)	66.7	8.9	3.9	15.5	10.6	-	-	55.6	3.4	-

Location

Most households have their latrines on the plot, but often located as far away from the house as possible, irrespective of the size of the plot or type of system. Where houses are surrounded by a wall, the latrine is usually located against the wall. 11 percent of the respondents has constructed the latrines outside the plot. It was observed by the researchers that where no walls surround the plot or if the facility is constructed outside the plot boundary, the latrine is often not used, because people do not want to make the investment needed for a complete separate superstructure. The decision on the location of the latrine was usually taken by the household and the contractor together.

Pits

The designs of double pits are standardized at state level and all contractors are given the details of the design to be followed. The adherence to the standardized design, is not always positive as soil conditions sometimes require an adaptation. Although designs do exist for different soil conditions, these are generally not applied by the contractors, most probably because they are not aware of the existence of these specific designs.

> *In Shajapur, the clayey black cotton soil does not have much leaching capacity. This was known to the contractors and households and they modified the design by themselves without any technical guidance of the implementing agency. The result is a fully plastered double pit with the dividing wall slightly suspended to act as a septic tank with an overflow into the open drain. Technically, the modification does not lead to an improvement, while also environmental conditions are threatened by the overflow of contaminated waste water into the open drain.*

In Silchar, Mangaldai and Agartala, the high water tables are not accounted for in the design, with the result that the leaching capacity of the pits is insufficient and during rains the pits (and sometimes pans) become submerged. In Mangaldai the texture of the soil and the pressure surrounding the pit also proves to be a problem as the soil enters the pits through the honeycombs. In addition, the area is prone to earthquakes and many of the pits have collapsed as a consequence of the earthquakes.

It is remarkable that almost 70 percent of the first pits had not yet been filled, although more than half the double pit latrines were more than 5 years in use and the volume is based on calculations of a pit filling up in two years. The pits which had been full and were already switched generally took between 2 and 5 years to fill.

Most single pits, 151 in number, are constructed on the initiative of the householders themselves and have different sizes and forms. Half of the households does not have any problems with the pits. Where problems are experienced, this usually is a result of overflowing of pits or pans when the pits are full or the ground is flooded. Almost all single pits are emptied when they are full, usually by scavengers.

Only in Shertallai single pits are constructed under the IDSMT programme. Although the performance of these single pits is good, a number of them has been converted into double pits at a later stage, because people preferred the double pit system.
There is no control over the construction of septic tanks, as this is all done on the initiative of the households themselves. The septic tanks covered in the research, have in 60 percent of the cases no soakage pit and the overflow is directly led into the drains. From the perspective of the households, the performance of the septic tanks is very good. The absence of a soakage pit does not affect the functioning of the septic tank and it reduces the cost of construction. From

the point of view of environmental sanitation, the picture is different as the effluent constitutes a health hazard if led to an open drain or left to soak in the ground. In none of the towns, the municipal authorities take any action against this problem. The health officers are mainly concerned with curative aspects of health and not with environmental degradation through sanitation.

Pit covers

In six of the towns, the covers of the double pits were generally in good condition. In Shahjapur, Silchar, Hosur and Srikakulam about half of the pit covers were cracked or broken, probably because not sufficient cement was used in the concrete. The covers have handles made of reinforced rods of 10mm diameter, which invariably get rusted and break easily. The covers of the septic tanks were in good condition everywhere.

Junction box

The junction box is the component of the latrine which needs the most technical expertise as proper functioning of the latrine depends to a large extent on the performance of the junction box. If not well connected, the junction box gets blocked and if pipes are used instead of drains, the pipes have to be broken to remove the blockage. Often these broken pipes are not replaced.

In more than a fourth of the latrines, the junction box was not visible because it had been cemented over. Therefore the condition could not be ascertained, but the fact that it was impossible to open the box already indicates that there will be a problem when one of the pits gets filled and switching needs to be done.

Where the junction box was visible, it was generally found to be well constructed and connected, except in Chomu, Shajapur, Silchar and to some extent in Hosur. One of the deficiencies was the difficulty to remove the block of the Y-junction for switching, necessitating damage to the pipe connection.

Another element causing problems was the cover which was often found badly constructed, consisting of two bricks cemented into place or a stone slab which was not large enough. In such cases, dust and waste can easily enter the box and the chance that the connection into the pit gets blocked is high. Only in some towns, the box covers fit exactly into grooves and can be easily lifted.

Pans and footrests

Different types of pans were found in all towns and most (80 percent) were in good condition and to a lesser extent clean on inspection (66 percent). In all schemes, the pans are supplied as part of the latrine programme and usually the same type is supplied for all latrines within a town. If people do not like the pans supplied, they are allowed to buy their own pans. The mosaic pans, which are cheapest at less than Rs 100 are not much liked by the users because of their dark colour and lack of smoothness, which makes cleaning difficult. The fibreglass pour-flush pans at a cost of about Rs 100, are not available everywhere. Although they are easy to clean, they are not much liked because they discolour over time and are prone to damage from burning cigarette/bidi butts. Although much more expensive at Rs 350, the ceramic pans are preferred because they are easy to clean and not prone to damage. Full-flush ceramic pans are frequently found, installed by the households themselves, but these pans require more water for flushing; the pour-flush ceramic types are only obtainable in Coonoor and Hosur.

The alignment of the U-trap to the pan and the functioning of the U-trap do not pose much problem except in those towns which have a water shortage. The footrests are separate from the pans and made of ceramic, brick or stone. They were found well placed and in good condition in most cases (87 percent).

Ventpipes

In 200 houses with single and double pit latrines ventpipes were found. In Chomu and Magadi, the percentage of double pit latrines with ventpipes were 67 percent and 56 percent respectively. The pour-flush latrines do not require a ventpipe because the smell is blocked by the waterseal and the gasses evaporate through the leaching pit, but at the request of the households, ventpipes are installed in many places. Apparently, people are aware of the need to include a ventpipe in other types of latrines and do not want to run the risk of having a defective latrine because of the absence of a ventpipe. It had been noticed that if ventpipes are not included in the latrine, the users are likely to add a ventpipe by themselves, thereby damaging the latrine slab or pit cover. Thus to avoid this happening, ventpipes are included if people insist on it.

Superstructures

In three of the towns covered in the research, Srikakulam, Coonoor and Magadi, the latrine programme included the superstructure. These superstructures are all made of permanent material and in good condition. However, many of the latrines in these towns are not used as a latrine, but for other purposes such as storeroom or bathroom. To have a separate lockable room is apparently a higher priority than to have a latrine.

In all other towns, the latrine programmes provided the latrine up to plinth level and the people themselves had to construct a superstructure. In some towns, many of the people did not construct a superstructure and consequently did not use the latrine. The pans of these latrines were soon filled with dust, sand and leaves and beyond the possibility of being used. The extent of non-use of the latrines is discussed in section 3.5.

In the households covered in the survey, many have a superstructure made of permanent materials (70 percent). Divided over the different types of latrines, the best superstructures are found with the septic tanks (98 percent permanent), followed by double pit (70 percent) and single pit (35 percent). The superstructures are generally also complete, that is with walls, a lockable door and a roof. Where the superstructure was not listed complete, this was mostly because either the door was missing (7 percent) or the door was not lockable (9 percent). The single pits have the least permanent type of superstructures, except in Chomu, where the very deep bottle type pits are found which last 'forever' and therefore the superstructures are also made to last long. The other exception is Agartala where 75 percent of the single pits have a permanent superstructure. Here, the concept of an individual household latrine commonly includes a superstructure, irrespective of technology used. Moreover, the high annual rainfall probably has an influence on the need for a permanent superstructure.

If superstructures are not made of permanent material, this does not imply that they are not being used. In fact in the town of Shertallai, where latrine usage and user awareness are exceptionally high as a consequence of the awareness creation programmes conducted under the UBS scheme by UNICEF, only 21 percent of the superstructures are made of permanent material. The UBS scheme has promoted the use of local materials to ensure that all people could afford to construct a superstructure. At a later stage these could be improved.

Cost of the latrines

It is very difficult to ascertain the cost of the latrines because the respondents were often not aware of the cost of the material and labour which were provided by the programme. On the other hand, the cost of the latrines as given by the municipalities does not include the cost of the superstructures if they are not included in the programme. Moreover, for the double pit latrines, the cost for the latrines for different number of users also differs and was not indicated separately in all cases. The research findings have therefore only to be seen as indicative. The cost of the latrines as provided by the programmes is given in table 3.4.

The cost of the single pit latrines with superstructure varies from Rs 2,847 in Chomu for the very deep bottle shaped pits with permanent superstructure to Rs 236 in Srikakulam for the pits with a cement ring and a superstructure made of bamboo and wood. The average cost of the single pit latrine is Rs 950. Except in Shertallai where the single pits were part of a latrine programme, all cost are borne by the users.

The cost of the septic tanks varies from Rs 2,861 to Rs 11,667 with an average of Rs 5,812, including superstructure. The variation in cost can be explained by the presence or absence of the soakage pit and the quality of the superstructure. It was observed that some of the superstructures of the latrines having a septic tank included a bathing area as well. The cost of the septic tanks is always borne by the users.

The cost of the double pit latrines also varies considerably from Rs 870 in Shertallai to Rs 3,079 in Mangaldai, without superstructure. An average of Rs 2,188 for latrines up to plinth level is found. The cost for the latrines in the earlier schemes is lower than that of later schemes because the price of the material increased considerably over time, this explains the low cost in Shertallai. The high cost in Mangaldai can be explained because all construction materials have to be brought in from outside the State.

Table 3.4: Sanitation schemes in research towns

	CHOMU	SHAJAPUR	SILCHAR	MANGALDAI	AGARTALA	SHERTALLAI	COONOOR	MAGADI	HOSUR	SRIKAKULAM
Programme	UNDP/WP	Liberation of Scavengers	UNDP/WB	UNDP/WB	Liberation of Scavengers	IDSMT & UBS	UNDP/ WB	IDSMT	IDSMT	LCS/UBS
Year of completion	1985	1989	1989	1988	.. 1995	1996 IDSMT 1990 UBS	1991	Not yet	1988	1986 LCS 1987 UBS
Cost of latrine	2500-2800	1300-1525	2000-2800	2300-3100	2070-3425	350-450 1 Pit 830-930 2 Pit	3700-4700	2400-3600	Unknown	500-1750 2 pit 350 1 pit
Financing	Grant 300-500	Grant 50% Loan 50%	Loan 100%	Loan 100%	Grant 50% Loan 50%	Grant 200-450 IDSMT 500-650 UBS	Grant/Loan depending on Income	Grant 50% Loan 50%	Grant 50% Loan 50%	Grant 50% LCS 900 UBS
Interest	-	10%	10.5%	8.6%	-	-	8.5%	9.7%	7.8%	-
Repayment period	-	5 yrs	10 yrs	25 yrs	10 installments	-	10 yrs	25 yrs	25 yrs	-
% Recovery upto 1990	-	21.6%	9.1%	2.5%	15.6%	-	1.8%	Not yet started	Not yet started	-
Superstructure included	No	No	No	No	No	No	Yes	Yes	No	Yes (LCS)
Implementing agency	Private contractor (municipal body)	Sulabh	Private contractor and Sulabh (municipal body)	Private contractor (municipal body)	Sulabh	Private contractor (municipal body)	TNWS&DB	KUWS&DB	District Development Agency	Private contractor (municipal body)
Instructions received by beneficiaries	67%	18%	30%	49%	59%	100%	50%	57%	83%	74%
First pit full %	18%	40%	57%	13%	23%	64%	1%	17%	32%	10%

3.4 Operation and Maintenance of Private Latrines

Water use

Availability of water is a problem in a number of towns, especially in low-income areas where sanitation programmes are carried out. In Coonoor, Magadi, Hosur and Srikakulam it was observed that many latrines are not being used as a consequence of water scarcity. Also in the survey, 80 percent of the respondents who are using the latrines in these towns experienced water shortage for latrine use.

> *In Coonoor people often have to walk a distance of more than a kilometre over hilly terrain to get water. The water obtained with such difficulty is not used to flush and clean the latrines.*

Despite this, 56 percent of the respondents said they use more than two litres of water per flush and 22 percent even more than four litres, regardless of whether they have a piped water supply or obtain water from a communal tap. This high use of water for flushing is probably a consequence of the fact that 40 percent of all respondents have a full-flush pan which requires more water for flushing. Most families also use about one or more buckets of water for cleaning their latrines.

Cleaning of pans

Almost 85 percent of the households said they clean their pans at least once a week. Three out of four households use detergents or acid as cleaning agents. Regarding the cleaning of pans of septic tanks, only households in Coonoor and Shertallai make restricted use of chemicals in order not to disturb the bio-chemical process in the tanks.

Pit switching

Of the double pit latrines, in more than 70 percent of the cases, the first pit has not yet filled and switching has not yet taken place. Where the pit has been switched, half of the users have called scavengers to do this for them while the other half did the job themselves. Switching was often difficult because the junction box was covered with bricks cemented into place or completely covered with soil. Also, the plug of the pit not in use was often made of cement which was difficult to remove.

In Agartala where the latrine programme is implemented by Sulabh International, a guarantee for five years is given to the users that Sulabh will carry out the switching and first time emptying. In two other towns where Sulabh also implemented the scheme, this service is not given.

Pit emptying

Of the single pits covered in the survey, 60 percent had been full. These pits had almost all (95 percent) been emptied. This was mainly done by private scavengers (62 percent), but also by the household themselves or by the municipality. The equipment used for emptying is usually bucket and rope or bucket and spade, although pit contents are unsafe for handling. The price for emptying varies from no charges at all (28 percent) to Rs 350 in one case. The price paid most often is Rs 100 (31 percent), followed by Rs 150 in 20 percent of the cases.

Septic tanks had been emptied in 34 percent of the cases by either private scavengers (87 percent) or the municipality (12 percent). This too is almost always done with bucket and rope. Charges for emptying are higher than those for single pits, in half the cases Rs 200-Rs 250, but varying from Rs 50 to Rs 800.

From the double pit latrines only 137 (14 percent) had actually emptied one pit. This could have been done by the households themselves, but only in 17 cases this happened. Apparently people prefer to pay private scavengers (53 percent) or the municipality (16 percent) to carry out this task. Usually the equipment used is bucket and spade, bucket and rope or spade and shovel. The prices paid for this service vary from no charges to Rs 800, with Rs 100 paid most often, followed by Rs 150 and Rs 200.

Interviews with private scavengers in the towns revealed that generally the liquid from the pits is dumped in the open drains while the solids are either brought to a compost yard, the trenching ground or buried on the plot. Apparently no distinction is made between pathogenic waste from single pits and septic tanks and pathogen free waste from the double pits. No control over the dumping sites is carried out by the municipalities. In none of the towns does a demand exist for the dry pit contents for use as fertilizer, although in Magadi farmers sometimes empty the pits for free in exchange for the use of the contents as manure.

In Chomu, people experience problems in arranging scavengers to empty their double pits because the local sweepers ask very high prices of up to Rs 400 for emptying. People therefore have to find scavengers from other places to carry out the emptying. A similar kind of problem was noted in Shajapur.

> *In this town the "jamindari" system is prevalent under which only one particular group is entitled to carry out cleaning operations in a locality and neither the municipality or any other agency can perform these services without their help in that area. The jamindars ask Rs 300-Rs 450 for double pit latrines and Rs 850 to Rs 1,000 for septic tanks. The reason for these high prices is the fact that the low-cost sanitation programme has jeopardized the regular monthly income from servicing of dry latrines, while the jamindar system ensures that nobody else can carry out the job at lower rates. The result of this situation is that many of the latrines are abandoned when the pits are filled.*

3.5 User Attitudes and Practices Related to Private Latrines

Motivation campaigns for latrine programmes

Although municipalities are expected to carry out awareness campaigns to motivate people for sanitation programmes, no funds are provided for this nor is staff trained for this purpose. In three towns local leaders were approached to help identify beneficiaries, but they were not involved in motivation except in Shertallai. Here an extensive user awareness campaign was conducted as part of the UBS programme before the sanitation scheme was implemented. Interviews with local leaders in all other towns revealed that they had not been given an explanation of the technology and the programme and therefore felt reluctant to become involved in motivation. In some towns they felt that there were other problems such as water supply and drainage which required more attention than latrines.

A local leader interviewed in Magadi was very much against the sanitation programme. He found the construction substandard and often incomplete and government money being wasted. He felt that people had to be educated and motivated before construction was started, but that anyway people's basic needs were not being addressed in the programme.

Involvement of women through women organizations has not been carried out at all although women are generally more motivated to have a latrine than men, because it is more difficult for them to go for outside defecation. Also NGOs have not been involved in promotion and user awareness programmes before or after construction of the latrines in any of the towns.

Reasons for having a latrine

The reasons for having a latrine differ considerably per town, but on average, health reasons are cited most often (28 percent). This percentage is relatively high because of the fact that in Shertallai all people cited health as a reason for having a latrine.

It should be noted that Shertallai is markedly different from all other towns in aspects of user attitudes and awareness. Not only are health considerations the reason for having a toilet in almost all cases, but also the use of the latrine by all family members is higher than average as well as the awareness of the operation of the system. In this town awareness creation programmes were conducted by voluntary agencies under the UBS programme. Also local leaders were fully involved in the implementation of the scheme and UBS volunteers were identified at neighbourhood level to motivate the community.

Other reasons cited for participating in the latrine programme are dissatisfaction with existing dry latrines and public latrines (26 percent) or not having access to a latrine at all (21 percent). Motivation from the municipalities is cited by only 7 percent of the households while another 4 percent said they had been forced by the authorities to accept a latrine.

Latrine use

Because of the focus of the research on operation and maintenance, the household interviews were only carried out in houses where there was a long term experience with use and maintenance of the latrines. Hence almost all households in the survey use their latrines (98 percent). However, in 30 percent of the cases, rather evenly divided over the different towns, not all members of the household make use of the latrine, this included children over five years of age (figure 3.3).

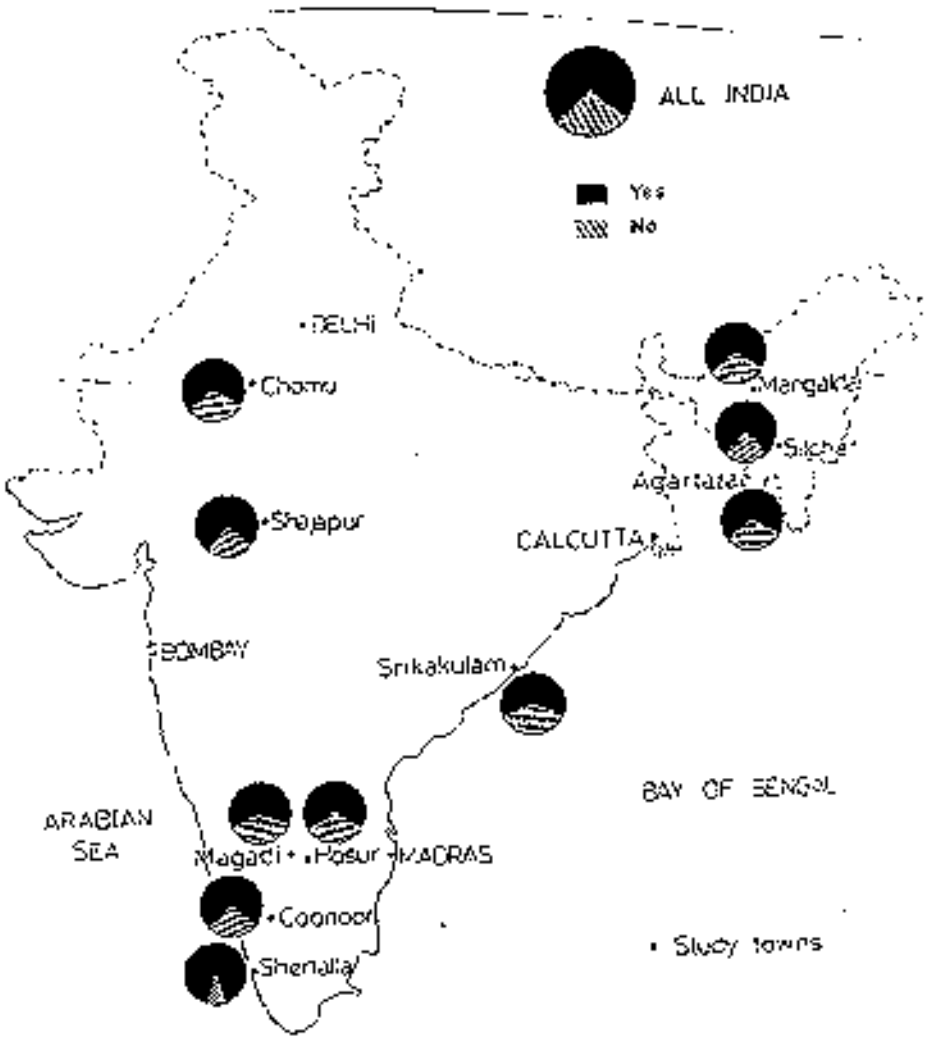


Figure 3.3: Extent of latrine use by all family members

The younger ones rarely use the latrine at all and in 70 percent of the cases their faeces is disposed of in an unhygienic way although adults often are aware (68 percent) that also children faeces is harmful. Of the children over five years of age almost half have difficulties in using the latrines for reasons such as the pan being too large, not being able to squat properly, not being used to a latrine or disliking the interior.

Non-use of the latrines

Information regarding the extent of non-use of latrines provided under the various sanitation programmes was gathered through an additional survey carried out in six of the towns. Table 3.5 gives an overview of the extent of non-use of latrines in the different towns. For the households not using the latrine, a division is made between those who never used the latrine and those who abandoned the latrine after some time.

Table 3.5: Extent of non-use of latrines per town

	Number of households surveyed	Number of households using facilities	Number of households who never used facilities	Number of household who abandoned facilities	Percentage of non-use
Shajapur	51	22	17	12	57%
Mangaldai	50	42	2	6	16%
Silchar	50	41	3	6	18%
Magadi	50	34	9	7	32%
Hosur	50	23	18	9	54%
Srikakulam	51	27	14	10	47%
Total	302	189	63	50	

Of a total of 302 households, 113 households (37 percent) do not use the latrine. Of these, 63 (55 percent) never used the latrine at all. The reason given for non-use in this group is most frequently (40 percent) connected to absence of a superstructure. This absence is due to lack of funds or because of preference for open air defecation. Other reasons mentioned are unfinished construction of the substructure, undesirable location of the latrine or the fact that the households thought that emptying of the latrine would be too difficult.

A second category of 50 households (45 percent) have abandoned the latrines after some time. In almost half of the cases this occurred within one year after construction, a quarter within four years and the rest at a later time. The main reasons given for abandonment are collapse (32 percent) and frequent blockages (24 percent). Other reasons mentioned include damage to the latrine structure and the difficulty of emptying the pit.

Awareness of operation of the system

Less than half of the users of septic tanks knew that without a connection to a sewer network, septic tanks should be provided with a soakaway pit for the effluent (84 respondents out of a total of 198). Also less than half considered the effluent or even the contents at the time of desludging to be harmful. Only a third of the users was aware of the fact that the use of chemical detergents negatively affects the bio-chemical degradation of the pit contents.

For the double pit latrines (973 in total), less than half of the respondents was aware that the pit contents are only safe to handle after a period of 1-2 years and that the technology of double pits is especially designed for this reason. Only 8 percent of the people kept a record of pit changing dates. The lack of understanding of the technology also becomes evident in the fact that a fourth of the respondents thought that the pits could be used simultaneously and in the fact that in many towns both pits are emptied at the same time after the second pit is filled.

Because the users are responsible for the operation and maintenance of their latrines, it is crucial that proper instructions are given to prepare them for this task. Only half of the respondents received such instructions and consequently less than half of the respondents was able to switch the pits themselves and the emptying of the pits was mostly done by private scavengers. Indication that a pit is full, is either by overflowing pans or overflowing pits, because there is no system for finding out if a pit is full before it starts to overflow. Half of the households indicated that they would need periodic municipal checking to monitor the filling of the pits and to check whether the system works properly. But also municipal agencies do not have any system for checking.

User contribution and loan repayment

For all septic tanks and most single pits, all cost were borne by the users themselves and no loans were given. For single pit latrines in the sanitation programme in Shertallai and Srikakulam no loans were given either, but the materials for the construction of the latrine were provided and a small subsidy of about Rs 200-250 for the construction of a superstructure. The users spent on average Rs 100 in Shertallai and Rs 42 in Srikakulam for their single pit latrines.

The direct user contribution for the double pits varied per scheme, but in most schemes a direct user contribution was only required for the construction of the superstructure. Where the superstructures were included in the scheme, in Coonoor, Magadi and part of the latrines in Srikakulam, the own contribution was generally low, from Rs 15 in Coonoor to Rs 466 in Magadi.

In Chomu, the direct user contribution was highest with an average of Rs 1,774, which is caused by the fact that the UNDP/WB scheme in this town only gave a Rs 300-500 grant for the latrine and all other cost had to be borne by the users. In all other towns, the direct user contribution was on average between Rs 1,000 to Rs 1,500.

Of the 752 respondents who had taken a loan for the construction of their latrine, 483 (64 percent) did not repay any amount of money (see table 3.4). Of the remainder, 108 (14 percent) said they paid their instalments and 161 (22 percent) said they sometimes did.

3.6 Condition, Use and Maintenance of Public Latrines

Public latrines are common in the towns studied, except in Magadi where no public latrine is present. The numbers vary from one only in Silchar and Mangaldai to 29 in Coonoor. However, many of these latrines are officially closed down because they have deteriorated beyond use and are therefore not included in the survey. The pay-and-use complexes of Sulabh International are also not included because in the towns surveyed they are located in public places such as markets and bus-stands and are not specifically meant for use by local residents. A total of thirteen public latrine complexes, which serve for use by local residents in five towns are covered in the survey.

Technical system

The technical systems used for the public latrines are bucket latrines (3), double pits (1) or septic tanks (9). A special design was found in Coonoor where a latrine complex is connected to four leaching pits of which two are in operation at a time. Owing to the hilly terrain the pits are located at different levels with a separation of up to 5 meters from the latrine. Where septic tanks are used, six of the septic tanks do not have a soakage pit which results in raw sewage in the drains or ponding of sewage effluent. Even where soakage pits are present, half

have an insufficient capacity. The discharge pipes to the septic tanks and pits are in many cases badly constructed or broken. Discharge of sullage is either to open drains, soakage pits, septic tanks or into the open street.

All public latrines with the double pit and septic tank systems have full flush pans, except one complex in Coonoor which has pour-flush pans. This means that at least 3 litres of water are needed for flushing. However, seven of the complexes have no water source at all, three have a piped supply with a tank at ground level and the remainder has handpumps without a collection tank. Thus water is hand carried by the users in tins or small buckets, the amount of water being insufficient for both ablution and flushing. The result is blocked waterseals, choked pipes and drainage channels, in many cases leading to such conditions that the complexes are abandoned. Often, the bucket latrines are in better condition because at least the problem of blocked waterseals and choked pipes does not exist. On the other hand, these latrines have a problem with bad smell and fly nuisance in addition to high health risks for the municipal scavengers who have to serve the complexes.

Superstructures

Only in six cases out of thirteen separate sections for men and women exist and only one has handwashing facilities. None of the complexes has a facility for bathing or washing. Doors are missing altogether in five complexes, while in another four the doors are broken. Walls and roofs are often in poor condition.

> *In Srikakulam, the municipality spent an amount of about Rs 1,000,000 for the renovation of twelve public latrines in 1986. But the latrines were getting choked due to improper use even before the work was completed. Because of theft of doors, taps and septic tank covers, the latrines were soon again beyond repair.*

Ventilation is no problem mainly due to the absence of doors. For the same reason light is not a problem, at least during the day. Electric light is only functioning in one complex, while some complexes have light fixtures but no electric connection or bulbs.

Environmental hygiene

The overall cleanliness of the complexes and their surroundings is poor in all cases. Stagnant water is found in and around half the complexes and surrounding areas are prone to flooding during rain. Waste water drains both inside and outside are choked and dirty. Animals like dogs, cows and pigs are roaming everywhere. Flies are also a marked problem in all complexes.

Operation and maintenance of public latrines

None of the latrines investigated has permanent attendants. Sweepers to clean the complex are present in five of the complexes during the whole day, for the remainder the sweepers only come during specific hours, twice daily. Their presence does not always lead to better hygienic conditions, as the respondents all complained about improper cleaning and upkeep. There is no supervision from the part of the local authorities. In only two complexes the cleaning is done with the use of detergents. Cleaning and repair tools are not available in any of the complexes, nor is there a storage place to keep equipment. No records for cleaning, repair or pit emptying are kept at any place.
The users do not have to pay for the latrines and also do not receive any instruction on the correct operational procedures for the latrines.

User attitudes towards public latrines

A total of 153 people were interviewed who make use of the public latrines. Half of the respondents use the facility more than once a day. About 70 percent of them live within 100m of the facility. Of those who use the latrine only once a day, half lives within 100m, the rest further away, but generally within 200m distance. Most people use the latrine because they do not have a private latrine and they generally belong to the lowest income groups. However, 30 percent of the people do not always actually use the facility itself, but the area directly surrounding it, because they consider the latrines to be too dirty. If people have small children, they do not take them to use the public latrine but let them defecate in their courtyards, the drain or in the street. A majority of the respondents feels that the latrines are not safe for women, even if there is a separate section for women. The reason most probably being that the doors cannot be locked. The users have not been consulted in the planning for the latrine in most cases (80 percent) although they almost all were living in the neighbourhood before the latrine complex was constructed. Common problems experienced with the latrines include non availability of water, no lights, no cleaning and flooding during the rain. Half of the users said that the public latrines are the responsibility of the municipality and they were unwilling to make any contribution towards the maintenance cost of the latrines.

Within the neighbourhoods, often latrine complexes are not liked because of the pollution and health risks they cause. In Shertallai, people forced the municipality to close a public latrine because sewage effluent was polluting a nearby water canal which was regularly used as an auxiliary water source. In Silchar a latrine complex was dismantled by the people because it was polluting the surroundings and was a source of insect breeding and stench. The households in the area which did not have any latrine, thereafter constructed their own latrines. In Hosur, a latrine complex was found where a family had padlocked one cubicle for private use.

3.7 Institutional Management for Operation and Maintenance

Documents reviewed in the municipalities of the research towns show, that no special funds are earmarked for operation and maintenance of low cost sanitation schemes. In most towns, sanitation resorts under the department of public health and it was impossible to separate the budget for sanitation from the other budgets in this department. Moreover, owing to frequent transfers of municipal staff and non-existence of official records which show expenditures for operation and maintenance of sanitation systems, it was not possible to get an insight on these expenditures. From interviews it becomes clear that budgets from the department of public health for sanitation only cover the salaries of municipal sweepers (80 percent-95 percent of the budget) and (at best) recurrent cost for maintenance of the equipment used and expenditures on chemicals (for public latrines).

Since there is no budget for operation and maintenance, there is no specific organization for it either. Most municipal authorities are not even aware of the requirements for operation and maintenance. This is probably to a large extent due to the fact that they are usually not involved in planning and/or implementation of the low-cost sanitation programmes and not conversant with the technology of the double pit latrine. In most programmes, the state level agencies are responsible for implementation and supervision. They select the contractors to carry out the work, and sometimes these contractors do not come from the town itself and leave after the work is done. The selection of contractors is often arbitrary and does not include experience in the two-pit technology as a criterion. Moreover, the contractors selected often contract out to sub-contractors. No specific training is given to the contractors to ensure that they are able to carry out the construction according to standard. This not only affects the

construction of the pits, but in some cases led to adaptations in the design which are technically unsound. Only in the case of Sulabh International, a guarantee period is sometimes included for the functioning of the latrines.

Where the municipal authorities are responsible for implementation and supervision, the municipal engineers do not always receive a special training in low-cost sanitation. Yet, they often lack knowledge about the technology and are sceptical about such a low-cost technology. Only in Srikakulam and Shertallai, did the municipal engineer train the contractors, while in Agartala the municipal authorities hired Sulabh to implement the programme. In none of the programme documents any mention is made of the activities expected from the municipalities for operation and maintenance of the latrines installed. The health officer who usually heads the sanitation department is responsible for the management of septic tank cleaning and checking of public health hazards. The sweepers are responsible for cleaning drains, tank desludging, pit emptying operations and the cleaning of public latrines. They are supervised by the sanitary supervisors. Due to lack of regular personnel, temporary labourers are specifically hired for drain cleaning and desludging operations by the municipalities. Neither the regular personnel nor the labourers receive any specific training for their tasks.

Basic equipment for operation and maintenance such as wheel barrows, spades, buckets and baskets are available in all towns, be it not in sufficient quantities. The more elaborate equipment needed for safely desludging septic tanks and single pits, such as vacuum tankers, tractor trailers and vacuum tankers are only found in Silchar, Agartala and Shertallai. The municipalities do not provide safety measures for the labourers who have to directly handle excreta while emptying pits and tanks with spades and buckets. This results in lack of motivation of the labourers to perform their tasks well, while at the same time supervision is also not carried out sufficiently.

Apart from the responsibility for operation and maintenance, the municipal authorities also have the responsibility for the collection of loan repayments. Table 3.4 gives an overview of the cost recovery in the different towns. The table indicates that the collection of loan repayments is very weak indeed. In none of the towns a schedule for collection exists and many authorities feel that it is too much trouble to collect the dues, which they cannot keep themselves but have to channel to the state authorities. The table also indicates that there is no relationship between either repayment period or rate of interest and repayment from the beneficiaries. The beneficiaries often are not even aware that they have to pay back the loan. Collection methods, motivation of the municipal authorities and motivation and awareness of the beneficiaries probably have more influence on loan repayments than the rate of interest or repayment period.

Chapter 4: Interpretation of Findings and Operational Recommendations for India

The conclusions and recommendations in this chapter are based on the findings of the research, including references found in the literature collected by the collaborating research institutions. The discussions held during the national workshop and the inter-country seminar in India in April 1992, are also taken into account.

4.1 Technical Aspects

Standardization of design to be adapted to local environmental conditions

Although technical adaptations of the standard double pit design exist for different soil conditions, all double pit systems constructed under the different programmes follow the same standard design. While this has certain advantages such as facilitating planning, cost calculation and supervision of technical construction, it also has a number of distinct disadvantages.

First of all, local soil conditions are not sufficiently taken into account. In Shajapur, the clayey black cotton soil does not have a sufficient leaching capacity, with the result that the pits fill up quickly. Both local contractors and beneficiaries were aware of the conditions of the soil, but did not have the technical knowledge to improve the design in such a way that hygienic standards are ensured. Experiments with the design should have been carried out on location by technical experts and local contractors before starting the programme on a large scale.

In Silchar, Mangaldai and Agartala, high groundwater tables lead to submersion of the pits during the monsoon time. Although high groundwater tables do not necessarily negatively affect the process of decomposition in the pits, the overflowing of pit contents when the pits get submerged is definitely not desirable. Moreover, construction of latrines becomes more difficult and where groundwater is used for water supply, this supply will become polluted. The contents of the pit also do not dry and cannot be shovelled out. This proved to be a problem also faced in Sri Lanka (personal communication from Chief Medical Officer of Health, Colombo) and other parts of India (Sarma and Jansen, 1989). The raising of the pits should be indicated in towns where groundwater levels are high and concrete rings could be used for pit lining to facilitate construction.

Standardization usually not only applies to design, but also to construction materials used for the pits. Even in areas where natural stone cut from rock is cheap and abundant, bricks are used for the pit lining. These are always more expensive than stone and where they are not readily available, extra cost for transportation is added. Apart from stones as a material for pit lining, other local materials may well be suitable, such as impregnated bamboo or logs.

Standardization does not promote experimenting with design and materials used. This not only applies to adaptations to local soil conditions and materials used, but also to the dimensions and the shape of the pits. The fact that in 70 percent of the double pits in the sample, the first pit had not even been filled after 5 years, indicates that the capacity of the pits may be too large. Similar results were found in other studies in India (HUDCO and HSMI, 1991). However, it was pointed out in the seminar that the pits are likely to fill up faster after the first emptying because of a gradual reduction of the leaching capacity of the soil surrounding the pit. Also, the number of actual users may be less than the pits are designed for, explaining the low pit filling rate. A minimum acceptable design interval

between successive manual desludging could be one year. But to provide flexibility in removing the pit contents, it is advisable to keep this interval at two years (Roy, 1989).

Cost reductions could be attained by reducing the size of the pits, specifically where the soil has a high permeability, as was done in the Baldia Soakpit Pilot Project in Karachi, Pakistan. Here, adaptations in design and materials used for construction led to a reduction in costs from Rs 2,000 per latrine to Rs 800 per latrine (Bakhteari and Wegelin-Schuringa, 1992). From a financial point of view, the optimal size of a leach pit should be decided when the decision on type of lining and material for the pit cover has been made. These two items are the most expensive in the substructure of the latrine (Roy, 1989).

The negative factors of standardization , however, should not lead to an abandoning of standards as this would make supervision of construction difficult and lead to a low technical quality of latrines. Thus, per town, field demonstration/pilot units should be constructed, taking into account local conditions, both of soil types and of construction materials. Where different types of soil exist within one town, it may be necessary to have more than one type of latrine. The demonstration models not only ensure adaptation to local conditions, but also serve as an example for contractors, supervisors and beneficiaries. The design which is chosen after the pilot latrines have been constructed, should be adhered to per town.

Handles of pit covers need improvement

Problems were experienced with the handles of the pit covers. These are generally made of 10mm steel bars which become rusty with time and easily break when the covers are lifted. A possible solution to this problem would be to have 15-20mm steel bars which are painted or oiled yearly to prevent rusting. Other solutions could be experimented with, even with local specific materials.

Cover and alignment of junction boxes require more attention

The biggest problem experienced with the junction boxes is that they are often cemented over or permanently sealed and therefore difficult to open. Thus people are not able to check regularly if everything functions properly and in case of blockage they have to call somebody to assist in opening of the junction box. After opening, often the cover is not always sealed back in position leaving the junction box half open, which increases the risk of blockage. In some towns the box covers fit exactly into grooves facilitating inspection and placement. Local construction standards should include the junction box cover, avoiding total embedding in the soil and the use of separate bricks, and promoting either stone slabs or reinforced concrete covers.

If the Y-junction is constructed with an open drain channel and the alignment is not smoothly finished, faeces is likely to pile up in the junction box. If the blockage of the pit not in use is not properly sealed, the result may be that both pits get filled at the same time. More attention should therefore be given to the training of contractors and masons in these specific aspects.

Selection and availability of pour-flush pans requires action

Pour-flush pans requiring less water than full flush pans are recommended for double pit latrines and supplied with all programmes. These pans are made of glass fibre, mosaic cement or ceramic. The ceramic pans are liked best, but the pour- flush type is only fabricated in two places in India and therefore not available everywhere. The users are allowed to buy their own preferred type of pans and usually buy the expensive ceramic full-flush pans which require more water for flushing, thereby risking the hydraulic overloading of the pits. The

production of pour-flush ceramic pans should be made more widespread to fulfil demand in all towns where low-cost sanitation schemes are being carried out.

Sufficient water availability to be ensured

The majority of the respondents use more than two litres of water per flush and most use one or more buckets of water to clean their latrines. In four towns more than half of the respondents professed to have shortage of water for flushing of their latrines. Although most towns officially have an average production of water of more than 40 lpcd, this amount is obviously not available in all parts of the towns, and specifically not in the low-income areas where the sanitation programmes are carried out. In a number of towns this shortage of water leads to non-use of the latrines. The use of grey water (without detergents and chemicals) for flushing could be promoted in these towns, as was done in Karachi, Pakistan (Bakhteari and Wegelin-Schuringa, 1992). Where availability is too low even for that, it may be necessary to discontinue promotion of pour-flush latrines and promote a dry technology such as VIP-latrines instead.

Superstructures to be provided or not?

The division of superstructures to type of system in the research shows that latrines with septic tanks almost all have a complete superstructure, generally made of permanent materials, while for single pits this is far less likely. For the double pit latrines, the picture is more diverse. In three towns, Coonoor and Magadi and part of Srikakulam, the superstructures were provided as part of the programme and all superstructures are made of permanent material. But many latrines are used for other purposes than intended. In Shertallai, the percentage of permanent superstructures is lowest, but latrine use is the highest in the whole research.

There is a discussion going on whether or not superstructures should be included in all low-cost sanitation schemes. The extent of non-use of latrines found in the follow-up survey, supports the importance of this discussion. Those in favour maintain that if superstructures are included, the latrines are more likely to be used and less likely to get choked by dust, leaves or other debris, eventually leading to non-use. So far, the superstructures which are constructed as part of the programmes are all made of permanent materials, which has the advantage that they last long, but also has certain disadvantages.

First of all, permanent superstructures are expensive, thus increasing the overall cost to the government or the beneficiary (if loans are paid back). Secondly, if the superstructures are much better than the houses of the beneficiaries, they may well not be used as latrines but for other purposes such as storeroom or bathroom. This situation was observed in Magadi and Coonoor and is also mentioned in the literature (Roy, 1989). To reduce costs and avoid the latrines being used for other purposes, it may be possible to include superstructures of less permanent materials, which the beneficiaries can upgrade themselves at a later stage.

Those against including superstructures argue that the latrines are already subsidized to such an extent that the least the beneficiaries can be expected to do, is to construct a superstructure. This would not only reduce the costs to the government, but could also be used as a yardstick to ensure that those receiving a latrine are indeed motivated to have one. If awareness campaigns have not been carried out and motivation is low, the superstructure may not be constructed at all because beneficiaries are not willing to invest in a latrine. This was indeed the case for 40 percent of the households, covered in the follow-up survey on the extent of non-use, who did not use their latrine.

In a evaluation study on low-cost sanitation in West Bengal, households indicated that selection of beneficiaries should be made on the basis of capability to invest in a superstructure. In this town, many people who applied for a latrine could not be included in the scheme, while at the same time many who received a latrine did not construct a superstructure (HUDCO and HSMI, 1991).

However, the type of material used for the superstructure does not need to be expensive and permanent, as long as the superstructure gives sufficient privacy and protection against rainwater and debris entering the pans, as has been done in the sanitation programme in Shertallai. If demonstration latrines are being built in the town to ensure a technical design adapted to local conditions, superstructures of local specific materials should also be included as an example. The beneficiaries could be requested to have materials for the superstructure in their possession before work on the substructure is started, in order to assure that the superstructure is indeed built.

4.2 User Related Aspects

Motivation campaigns and user involvement increase success

The main issue with respect to the beneficiaries of latrine programmes, is the lack of awareness creation campaigns and involvement of the communities in the implementation of the schemes. Only in Shertallai, a systematic effort was taken to involve the community. This resulted in a successful sanitation programme. The community leaders interviewed in the other towns generally feel that they have been insufficiently informed, which in turn is reflected in the lack of interest in the sanitation schemes in the community at large. Yet, in programmes in other places in India or elsewhere where the community has been involved from the start, either through the local leaders, through existing organizations or through a newly established sanitation committee, motivation for latrines is much higher. Promotion through these channels has proven more effective because people have confidence in their own community leaders. But it is necessary to first convince these leaders of the advantages of the schemes. This requires time and concerted effort from the municipal authorities who are usually responsible for this aspect of the sanitation schemes.

It was mentioned in the seminar that motivation should be done on the basis of aspects of convenience, privacy and status rather than on health aspects. Although sanitation does improve environmental conditions, large scale health benefits can only come about in combination with a number of other interventions such as improved water supply, drainage and solid waste. In addition, health is usually not the most important factor why people in low income areas are motivated to have a latrine.

The results of the survey indicate that about half the respondents had never been attending any health or hygiene related awareness creation programmes and that no activities relating to sanitation awareness are being carried out in schools. The potential of schools in promoting hygiene awareness and latrine use was stressed during the national seminar. Schools can be suitable places for demonstration latrines, while teachers and children can be an entrance point for the promotion of low cost sanitation within a community.

Effective demand for latrines to be created

Both at the national Indian workshop and the inter-country seminar in April 1992, discussions were held on the need for effective demand for latrines before a sanitation scheme can succeed. It was stressed that a distinction has to be made between the approach for conversion of bucket latrines and completely new construction of latrines. Where latrines are converted, people are already motivated to use a latrine and often the superstructures already exist. Thus emphasis should be put on operation and maintenance aspects of the new technology. Where the scheme involves first introduction and new construction, efforts should first be directed towards awareness and motivation to create an effective demand.

Knowledge on technical operation of the systems to be increased

The daily or weekly requirements for operation and maintenance of the latrines such as using water for flushing and regularly cleaning of the pan and latrine slab are professed to be carried out by almost all latrine users and generally do not pose problems if there is sufficient water available. Most people who are using the latrines are very satisfied with the technology. But this does not imply that they understand how the latrine system functions. This is understandable because almost half of the respondents has not received any instructions on operation and maintenance of their latrines. Even if instruction was given, quite often people had forgotten these instructions by the time they had to do the first switching. Most people are not aware that the contents of the pit are safe to handle after a year and that there is no need to empty two pits at the same time.

Since the persons responsible for operation and maintenance of the latrines are usually women, it is imperative that education on requirements for operation and maintenance and on technical aspects of the systems is specifically directed towards women. This may imply that special measures to reach these women have to be taken.

Organized support needed for emptying and service

The double pit system is promoted as a system which can be maintained by the householder themselves, but the research outcome indicates that people may not be willing to do this because it is culturally unacceptable. Contact with excreta, even if dry, is traditionally confined to distinct groups in society. This in itself is no problem, because at least the scavengers do not run a health risk when emptying the pits. But it stresses the need for organized service support. This could be carried out by municipal sweepers or by private scavengers. They should however be trained to understand the technology, not only for switching and emptying, but also to help when there are other problems such as blockages. Similar findings and suggestions were done in an evaluation of a low cost sanitation programme in Bangladesh (UNDP/World Bank, 1989)

Alternatively, a guarantee system, such as Sulabh International is giving in Agartala for the first five years after construction, could be required from all implementing agencies. It is obvious that in Agartala where this guarantee exists, it has an impact on the motivation of people to have a latrine.

Clear communication channels increase efficiency

With the organization of a service system, attention has to be given to communication. Not only this research, but also others (Sinha and Gosh, 1989 and Sarma and Jansen, 1989), indicate that users often do not know where to go if they face problems with their latrines. Sinha and Gosh (1989) found that users with guarantee cards from Sulabh International would go to the municipality for service. The municipality did not convey the message to Sulabh

International and also gave no service. Sinha and Gosh suggested that a community representative would be selected to act as a mediator between users, municipality and Sulabh International.

Mechanical equipment necessary for the desludging of septic tanks

Awareness of the owners of septic tanks on the functioning of this system is not very high either. Less than half of the respondents were aware of the need for a soakage pit or the fact that the pit contents are harmful. Because septic tanks are all constructed on private initiative, it will be more difficult to reach the users with information. All septic tanks are emptied by scavengers or the municipal services, but only in Srikakulam mechanical pit emptying equipment is available. In all other towns tank emptying is done manually.
In the seminar it was discussed that for this reason the construction of septic tanks should be prohibited in those towns where mechanical equipment for desludging is not available.

4.3 Institutional Aspects

Local bodies to be more involved in planning and implementation

In almost all towns, the local bodies do not have an adequate organization for operation and maintenance activities. This issue was discussed at length in the workshop and the seminar and is reflected in the literature (Sarma, Suresh and Jansen, 1989; HUDCO and HSMI, 1991). It is felt that this situation is largely due to the fact that local bodies are not enough involved in planning and implementation of the low cost sanitation schemes. Usually, the state level organizations are responsible for implementation and supervision. Because engineers at local level are not involved in implementation or trained in the technology, they are often not aware of the technical and other requirements needed to sustain the schemes. This not only concerns the technology, but also possible approaches to carry out motivation and awareness creation programmes. It also results in lack of motivation with the local bodies to carry out the responsibilities for operation and maintenance at a later stage. Generally local bodies are treated as weak, incompetent and ill-equipped and the tendency exists to strengthen the nodal agencies at state level to make up for the deficiencies at local level. It was stressed that this trend needs to be reversed and local bodies should become involved in all stages of planning, implementation and post installation phases of low cost sanitation schemes.

Responsibilities for operation and maintenance need to be clearly defined

Another reason for inadequate support for operation and maintenance by the local bodies is the fact that responsibilities are usually not clearly defined. Within the local bodies different departments may be involved in sanitation, such as health, public works and water supply. They each have their own role, but coordination between the departments is lacking, resulting in an inefficient organization where activities are overlapping or not being carried out at all. This issue was also mentioned in the literature (UNCHS, 1989) and it was stressed that operation and maintenance problems always have to be seen in a broader urban context, taking into account the linkages between the different departments. Interventions in the past usually focused too much on the individual infrastructure sectors and consequently did not lead to an improvement.

Need for capacity building at local level

Within local bodies training activities will have to be conducted to enable the staff to carry out their tasks in planning and implementation of low-cost sanitation and post construction operation and maintenance. Municipal engineers need to get a better understanding of low cost sanitation technologies in order for them to instruct contractors, masons and sanitation staff at local level and to be able to supervise construction. Other staff needs to be equipped

with skills for the administration of loan applications and management of large sanitation schemes. In addition staff, male and female, has to be trained on how to promote low cost sanitation and how to conduct awareness creation programmes. If such staff is not available and/or outside support is needed, local non-governmental organizations should be encouraged to become involved. At community level, local leaders and/or community based organizations, should be approached to assist in motivation and promotion. Funds for training and promotion need to be part of the funds earmarked for low cost sanitation at state level.

Procedures for selection of contractors need reassessment

The selection of contractors is a problem not only identified in this research, but in many other researches as well (Sarma, Suresh and Jansen, 1989; Sinha and Gosh 1989; HUDCO and HSMI, 1991). At present, contractors get paid after completion of construction of the latrines and it often takes a long time before payment takes place. Small contractors or individual masons do not have the capacity to pre-finance such contracts. Thus, only large contractors are interested in sanitation schemes and very often experience with low cost sanitation is not considered in the selection. These large contractors cannot be found in all towns and therefore they often come from outside. This has the disadvantage that experience with the technology is not available in the town itself when problems arise with the latrines at a later stage. Even if a guarantee clause is included in the contract, it is difficult to get hold of the contractors if they come from outside. The contractors are aware that it is difficult to call them if there are technical defaults in the construction and this can have an influence on the quality of construction. In the research this was experienced in Shajapur and Coonoor. To avoid this problem, masons from the neighbourhood should be hired for the construction and be given a training, as was successfully done in Quetta, Pakistan.

Sub-contracting may lead to low technical standards

Another issue with contractor selection is that large contractors give sub-contracts to small local contractors. These are often not familiar with the technology and are not trained by the main contractor, nor are they properly supervised. This may result in latrines of a low quality or in adaptations of the design which are technically unsound. Large contractors and small contractors alike are often only provided with the standard design specifications and not aware of existing variations in design to suit local conditions, such as raised pits for high groundwater tables.

Demand driven approach required for loans and grants

The funds available for a sanitation scheme and the number of latrines to be constructed are determined at state level. They also decide the division between grant and loan, the interest rate for the loan component and the repayment period. These decisions are not based on demand for sanitation programmes from the municipalities nor on income level of the intended beneficiaries. Little effort is directed to raise the interest of the local bodies or the beneficiaries who they represent. Yet, the administration of the loans and repayment schedules is the responsibility of the local body. Many of the local bodies were found not to be aware of the procedures involved in the low-cost sanitation schemes and this led to a number of problems. For instance, if the loan is channelled through HUDCO, the application for the loan has to be processed through the municipal body. Because they are not sufficiently informed on the schemes, it often takes a very long time before all formalities are fulfilled, leading to a delay in the scheme. When the funds are finally transferred, they may be insufficient due to interim price rises.

Unit cost need to reflect cost at local level

The unit cost of the latrines is determined by the state and does not take variations in material cost and labour cost into account. Very often, the amount is not sufficient to cover the cost per latrine, for instance if construction materials have to be brought in from elsewhere. This makes it difficult to find contractors who are interested in the scheme, but also implies that only large scale contracting is attractive. In addition, there is no price rise clause in the contracts, while it takes at least a year and often longer to construct all latrines for the scheme. By that time the price of materials may have risen. The result is that fewer latrines are constructed than planned. Where the scheme is planned as a whole town approach to eradicate scavenging, the obvious result is that not all dry latrines are converted and the town does not become scavenger free.

Uniformity needed with regard to subsidies and loans provision

There is a lack of uniformity in the low-cost sanitation schemes, not only between states, but within the state and even within the towns if more than one scheme is being carried out. This makes monitoring of the schemes extremely difficult. At town level, it may lead to refusal of beneficiaries to pay back loans if they are aware that other sanitation schemes are provided with a full grant.

Loan recovery in all cases is very poor. Part of the problem may be that the payments collected cannot be kept by the municipal authorities, but have to be channelled to the state. This reduces incentive for the municipalities to collect the repayments. Both in the national workshop and at the inter country seminar it was suggested that a percentage of the loans recovered should be given to the municipal authorities on the condition that a proper loan recovery system is set up. In some towns, loans are collected as part of a sanitation tax, in other towns they are collected together with other taxes or separately. In any case, loan recovery should begin immediately after construction is completed and not long afterwards as is now the case. Moreover, beneficiaries have to be made aware of the obligation of loan repayment, while sanctions should be determined and adhered to in case of default.

4.4 Public Latrines

Privatization a possible alternative for effective operation and maintenance

The outcome of the research shows that public latrines for which the municipality has the responsibility for operation and maintenance do not function under the current system. At the same time, experience in many parts of India, where public latrines for use by local residents have the pay-and-use system and are operated and maintained by an NGO, shows that public latrines can be feasible. During the inter-country seminar it was mentioned that even with the existing low-cost sanitation schemes for private household latrines, there is a need for community latrines for about 60 percent of the low-income urban residents.

Because of this need, private initiatives are taking place to avoid the use of badly maintained public latrines. In Silchar, the research team came across some latrines which were shared between a number of families on their own initiative. In Hosur, one cubicle of a public latrine was padlocked by a single family for private use. More examples may be available of specific solutions for community level latrines. There is a need for research into this issue.

Deficient technology, construction and management leading to problems

Most of the problems experienced with the public latrine complexes in the research can be attributed to bad construction and bad management. The technology selected is inappropriate in many cases, such as septic tanks without a soakage pit and/or location in flood prone areas

leading to ponding of the effluent. In towns where no mechanical desludging equipment is available, the use of septic tanks for public latrine complexes should be prohibited, because they cannot be emptied in a hygienically safe manner. Similarly, the use of bucket latrines should also be prohibited and towns considered for low-cost sanitation schemes should be required to convert the bucket public latrines, if they are still needed after the household scheme is implemented.

The construction of the superstructures of the complexes is also deficient because many of the complexes have no separate section for women. During the seminar the necessity of separate sections was discussed as well as the size of each section. These should be the same for the male and female sections and construction standards have to include lockable doors, ventilation, sufficient space for bathing and washing and a guarded space for storing tools and cleaning equipment. Moreover, water availability should be guaranteed, either through the presence of a handpump or through the presence of a storage tank. A public latrine cannot function without this because absence of water invariably leads to blockage of the pans.

Incentives needed to keep latrines clean and functioning

Municipal attendants and sweepers get paid regardless of their performance. Therefore no incentive exists for proper operation and maintenance from their part. Moreover, funds needed for operation and maintenance are often not available within the municipalities with the result that blockages are not removed, broken or stolen parts not replaced, and septic tanks not desludged. One of the reasons why the pay-and-use latrines function so well, is that there is an immediate benefit for keeping the complexes clean because more people will use them and more income will be earned. This income is usually more than sufficient to cover all cost for operation and maintenance. It may be possible to propagate a system for the municipal attendants in all public latrines with an incentive for proper maintenance or to privatize operation and maintenance of the complexes. In addition, planning for operation and maintenance of the existing complexes should be done together with the community, and especially with those residents who do not have their own latrine to ensure a sense of responsibility from their part as well.

Where public latrines do not exist, but there is a need for latrine provision above household level, possibilities should be explored together with the community to assess options of shared latrines, private cubicles within complexes or other alternatives such as community managed complexes.

Chapter 5. Institutions Involved in Sanitation in Thailand

In Thailand institutional involvement in sanitation pertains to laws and regulations to protect the environment and promote public health. The Ministry of Interior, the Ministry of Science, Technology and Energy and the Ministry of Public Health each have distinct roles covering public sanitation. An organizational chart showing communication from central level to local level is given in figure 5.1. The construction, operation and maintenance of sanitation systems in individual houses is considered the responsibility of the occupant of the house.

5.1 National Agencies

The **Ministry of Interior** is responsible for the overall administration of the country in accordance with government policy and law. Apart from the responsibility for the administration of the country, two agencies which are of importance with regard to housing (including sanitation) fall under the responsibility of this ministry, these are the Land Subdivision Committee, under the Land Department and the NHA.

The **Land Subdivision Committee** has to approve all plans for the division of private land for private housing estates. They ensure that ownership of the land is legal and transfer of landtitles is in accordance to the law. They also ensure that in the planning for the housing estate adequate space is reserved for infrastructure facilities such as roads, drains, sewerage and treatment plants.

The **National Housing Authority** (NHA) is responsible for the provision of government housing for low and middle income people in the urban areas of the country. Some of the housing projects are targeted at higher income groups to cross-subsidize efforts for the lower income groups. In all its housing projects, NHA is responsible for planning and implementation, including sanitation systems. Overall planning is done by the Policy and Planning Department and implementation is carried out through the Construction Department. The sanitation systems may be on-site, off-site or a combination of these two, depending on type of housing, soil conditions, location and income level of the target group. Some of the housing projects include a central waste water treatment plant. NHA is responsible for operation and maintenance of all infrastructure for as long as it takes to own the houses in hire-purchase arrangements, thereafter the responsibility is carried over to the municipality in which the project is located. For rental housing projects this situation is different and transfer of responsibility is often sooner. However, in 1990 it was agreed between NHA and the Bangkok Metropolitan Administration (BMA) that BMA would gradually take over the responsibility for the operation and maintenance of all central treatment plants and main sewers in the NHA housing projects.

In each housing project, an Estate Management Office (EMO) is located. The number of staff employed at this office depends on the number of houses in the project. The responsibilities of the EMO include administration, collection of monthly rents or hire-purchase instalments, the provision of services for the operation and maintenance of infrastructure and community development aspects.

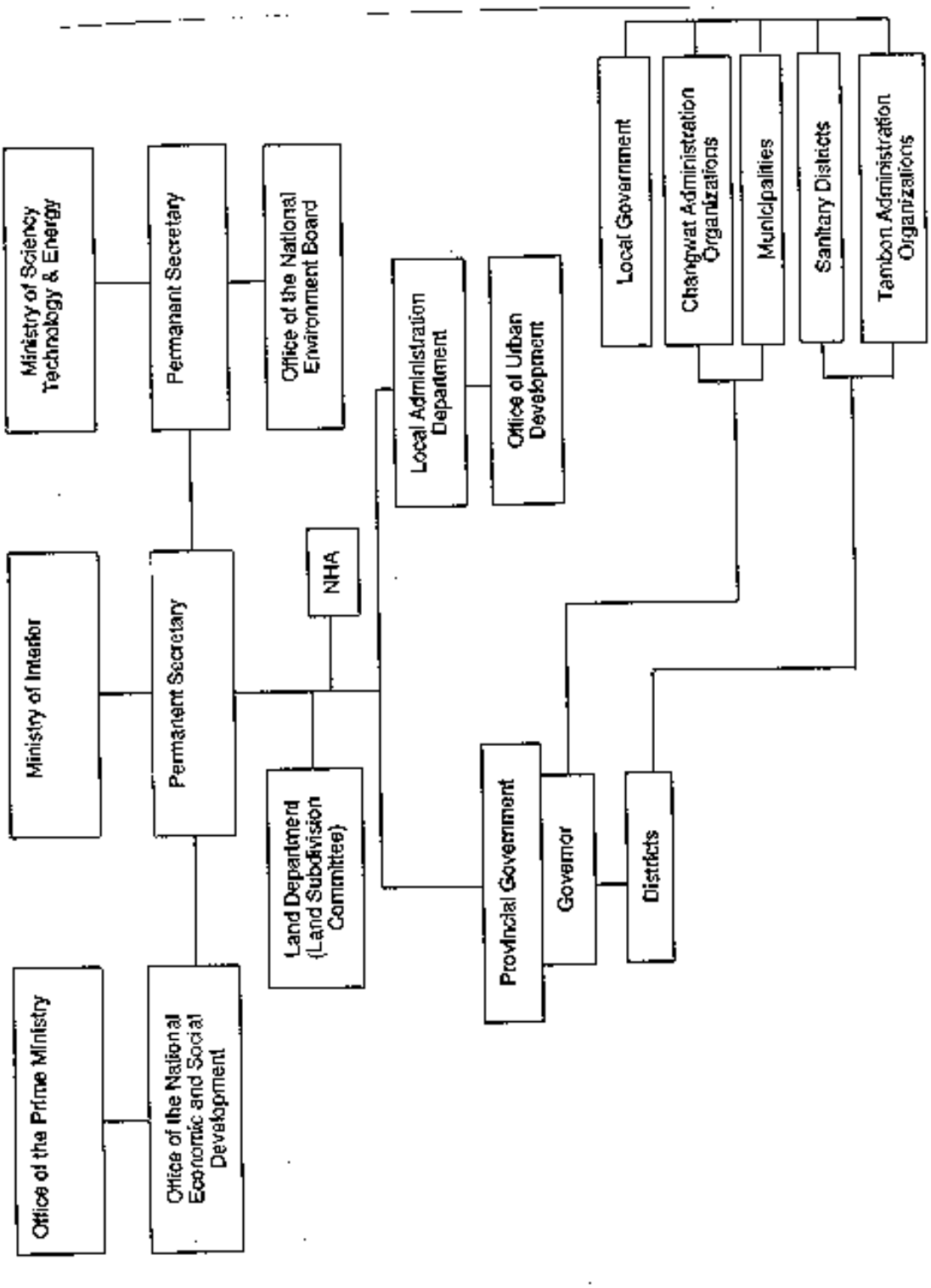


Figure 5.1: Communication from central level to local level. Adapted from: Asian Institute of Technology and Coopers & Lybrand Associates (1988)

If a central treatment plant is located in the project, special staff is employed for the operation and maintenance of the treatment plant. Within the NHA, the Office of the Secretary for Estate Management of the Community Development Department supervises the EMO offices and is responsible for operation and maintenance of the infrastructure.

Apart from the provision of new housing projects, the NHA is involved in slum improvement. Usually, the activities are confined to the provision of water supply, the construction of concrete footpaths, the organization of solid waste collection and where possible, the construction of drains. Improvement of sanitation systems or motivation for improvement by the households themselves is not done by the NHA.

The office of the **National Environmental Board (NEB)** which is part of the Ministry of Science and Technology and Energy is responsible for national policy guidelines to protect the environment. In 1985, the NEB announced the Domestic Effluent Guidelines to set the standard of domestic effluent for all municipalities in the country. In 1989 these guidelines were announced by the Ministry and local governments were advised to follow these guidelines. The guidelines distinguish between types of buildings, such as offices, condominiums, hotels and housing estates of all sizes. The minimum requirements depend on the type of building, area and number of people covered. The guidelines do not cover individual houses, unless they are located in an estate.

The **Ministry of Public Health** is responsible for environmental health and sanitation in the country. One of the main laws pertaining to sanitation is the Public Health Act, which was enacted in 1941. The act gives the authority to local government to issue regulations to organize solid waste collection and environmental sanitation. Local governments are authorized to give recommendations to land owners to install, enhance or change sewerage systems.

It is also the task of the ministry to ensure that all people, both in urban and rural areas have a toilet in their house. Already in the 1950s, the ministry started a public awareness campaign for sanitation coverage in urban areas. This campaign has been very successful because sanitation coverage in urban areas is almost complete and since many years people do not have to be motivated to have a toilet, even in the poorest urban areas. The ministry is presently concentrating on the rural areas. Motivation and health education campaigns are being carried out in all rural areas to motivate the population for sanitation. The goal is to have complete coverage by the year 1997.

5.2 Provincial Agencies

Apart from ensuring that the national laws and regulations are followed within their province, departments at provincial level do not have any specific tasks concerning sanitation in the urban areas. The head of the provincial government is the Governor, who is appointed by the Ministry of Interior. The Governor coordinates between central government and the local governments within the province boundary. At provincial level, the subcommittee of the Land Subdivision Committee has to approve the plans for all housing estates, even those located within the municipalities. In the provinces, a distinction is made between municipalities, sanitary districts and provincial administration organization which covers the rural areas. A sanitary district is similar to a small municipality and includes those towns which are not a municipality. Its functions are similar to that of a municipality and a sanitary committee is elected to govern the authority area. The provincial administration organization does not have an elected head, but is headed by the Governor of the province.

5.3 Municipal Agencies

The municipal authorities are headed by an elected mayor and have control over all infrastructure and housing within their boundaries. They follow the domestic effluent guidelines of the National Environmental Board for control of domestic effluent of the type of buildings covered in the guidelines. At municipal level a Municipal Building Code is established and enforced which covers plans for houses to be constructed and extension of existing houses. In these plans, on-site sanitation systems can be cesspools or septic tanks with soakaway, but if a connection to the stormwater drainage is planned, an anaerobic upflow filter may be required (at least in Chiang Mai). There are no regulations for sanitation which cover existing individual houses and slum areas. Although connection of on-site sanitation systems to the open drain is prohibited, there is no department which controls this.

Within the municipal authorities, the Department of Drainage and Sewerage is responsible for the planning, design, construction, operation and maintenance of stormwater drainage, sewerage and waste water treatment plants. The Sanitation Department (Chiang Mai) and the Department of Public Cleansing Service (Bangkok) is responsible for garbage collection, street cleaning and pit emptying services, including control of nightsoil transportation and disposal.

In Chiang Mai, the Department has given a concession to two private companies for desludging services. In Bangkok, the BMA provides the only legal pit emptying service.

The Department of Public Health in the municipality is responsible for public education in environmental sanitation. Although public education is carried out, this does not seem to cover information on the risks and adverse effects of an unsanitary sanitation system on environmental health.

5.4 Private Sector

Most housing estates and private houses are developed by the private sector. The estates are controlled by the NEB guidelines for domestic effluent and by the regulations of the Land Subdivision Committee and Local Building Code. In the larger housing estates, a waste water treatment plant is often prescribed. This usually is an aerated lagoon system. For the smaller schemes, septic tanks with soakaway used to be recommended, but now this often has changed into septic tank with anaerobic upflow filter.

In Chiang Mai and Chiang Rai, private agencies are involved in the desludging services. They have a concession for a three year period to carry out all emptying services in the municipalities. These companies pay respectively, Baht 300,000 and Baht 100,300 per year to the Chiang Mai and Chiang Rai municipalities. The fees they can levy for their services are determined by the municipality and the dumping sites are also approved by the municipality.

In Bangkok many private companies are illegally involved in emptying services. The main problem in this respect is the fact that these companies are not allowed to use the sludge treatment plant of the Bangkok Metropolitan Administration (BMA) and are therefore likely to dump the wastes illegally in some other place, thereby causing a serious environmental health risk.

Chapter 6. Performance and Use of Sanitation Systems in Thailand

In this chapter, the results are described of the research carried out in eight sites in northern and central Thailand. In the first section an overview is given of the different research locations and the research population. This is followed by a description of sanitation systems commonly found in urban areas in Thailand in section 6.2. In sections 6.3 and 6.4 the sanitation systems found in the slum areas and their performance are discussed as well as the experiences with operation and maintenance. The same is done for the sanitation systems in the NHA housing projects in section 6.5 and 6.6. Section 6.7 deals with the user attitudes and practices in operation and maintenance of latrines, both in slum areas and in NHA housing projects. In the last section, an assessment is made of issues in institutional management for operation and maintenance.

During the pilot phase, surveys were carried out in Rakaeng and Tung Song Hong. Some of the information asked in the second phase, was not obtained in these sites; where applicable, this is indicated in the text and tables.

6.1 Research Areas and Research Population

Location of the research areas

Of the eight sites covered in the research, four are located in cities in the northern part of Thailand and four in cities in the central region. Figure 6.1 shows the location of the cities.

In the North, three sites are within the municipality of Chiang Mai. Of these Rakaeng and Erawan are slum areas and Nong Hoy a National Housing Authority (NHA) project. The fourth site is located in the municipality of Chiang Rai, a slum area called Doi Thong. In the central region, three sites are located in the Bangkok Metropolitan Area. Of these Huay Kwang and Tung Song Hong are NHA housing projects and Bordin is a slum area. The fourth site is also a NHA housing project, Chonburi I, located just outside the municipal boundaries of Chonburi, a city east of Bangkok. The administration of Chonburi I falls under the administration of the Sanitary District Ang Sila.

Distinction between NHA housing projects and slum areas

In the description and analysis of the research data, a distinction is made between the NHA housing schemes and the slum areas. The main reason for this is the fact that in all NHA housing projects, the residents are living in houses or apartments constructed by the NHA and these always include a toilet. Therefore they have never been involved in planning or construction of their toilet facilities, unless they have changed the original system. Also the provision of related infrastructural services, such as water supply, drainage and solid waste collection is organized through the NHA. In the slum areas, sanitation systems are always constructed by the households themselves, without any control by local authorities or involvement of NGOs. The same applies for other infrastructure systems, unless the slums have been improved by NHA or other agencies. Of the total number of 901 households surveyed, 409 live in slum areas and 492 live in NHA housing projects.

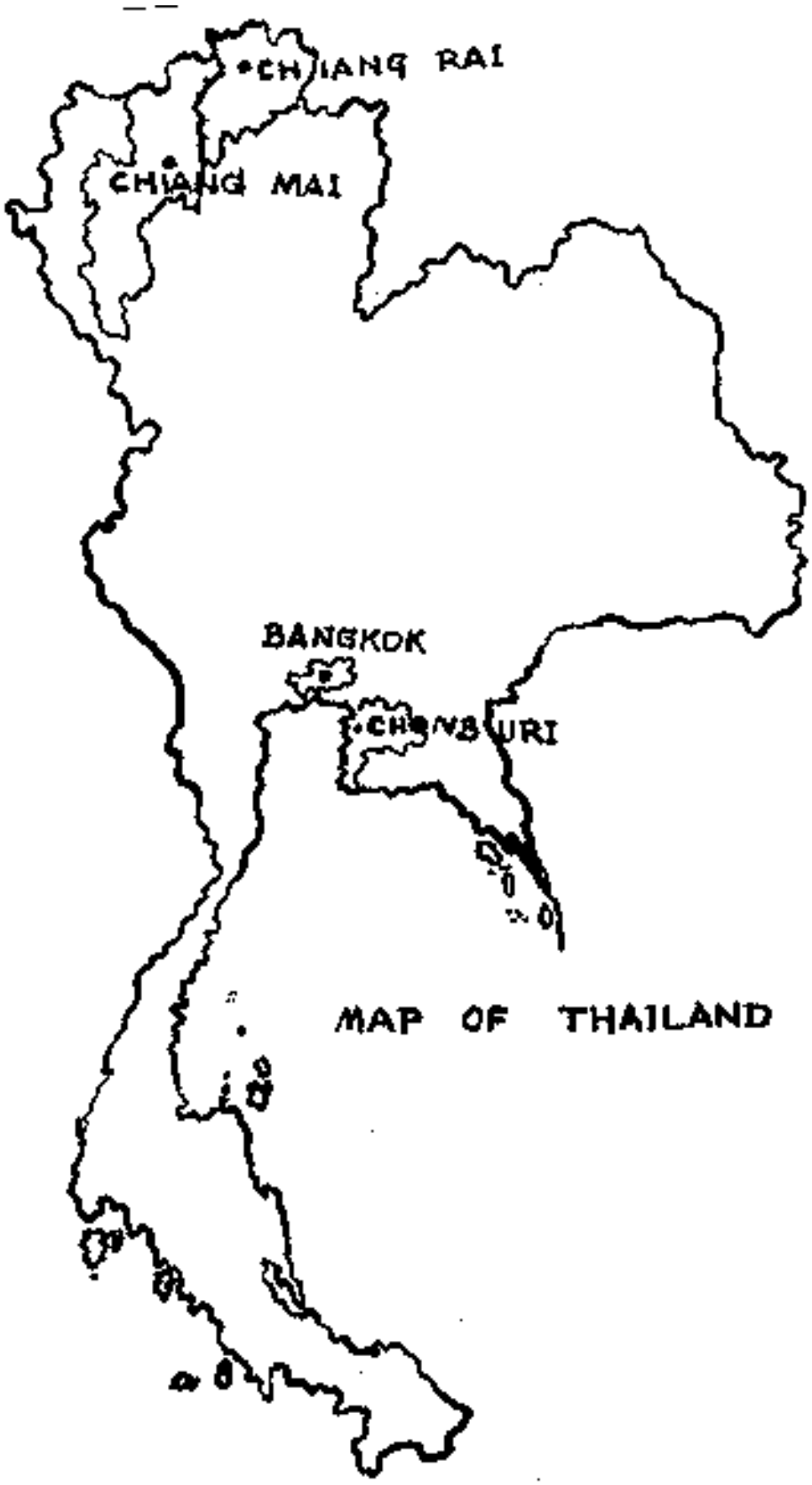


Figure 6.1: Location of research cities

Table 6.1: General characteristics and environmental conditions of the research sites

	SLUM AREAS				NHA HOUSING PROJECTS			
	Erawan	Rakaeng	Dol Yong	Bonkai	Nong Pol	Chonburi	Huay Kwang	Tung Song Hong
Number of household studied	46	100	143	120	133	120	120	119
Housing condition:								
Permanent	50%	82%	72%	87%	98%	95%	98%	*
Not Permanent	50%	18%	28%	13%	2%	4%	2%	*
Latrine	cesspool	cesspool	cesspool	cesspool	Septic tank with soakaway or with an anaerobic upflow-filter	Cesspool and Septic tank with soakaway	Off-site activated sludge	Septic tank with anaerobic upflow filter or soakaway connected to off-side aerated lagoons
Soil condition:								
dry	50%	48%	99%	2%	87%	99%	98%	*
wet	15%	30%	1%	38%	13%	1%	2%	*
permanently flooded	35%	22%	0	60%	0	0	0	*
Water supply	No	Yes	Part	Yes	Yes	Yes	Yes	Yes
Drainage system	No	Yes	No	No	Yes	Yes	Yes	Yes
Solid waste collection	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School	No	No	No	No	2 kindergarten	No	1 Primary school	2 Primary schools 3 kindergarten
Health facility	No	No	No	No	No	No	One health centre	One health centre

* Question not asked in pilot phase

Environmental conditions

An overview of the environmental conditions in the research sites is given in table 6.1 and it clearly shows the differences between the NHA sites and the slum areas. Of the slum areas, only Doi Thong does not have a problem with stagnant water. This site is located on a hill, while the other slum sites are located in low lying, water-logged areas. Part of these areas are permanently under water and the houses are constructed on stilts. Erawan is located over a natural waterway. If drains exist, they are constructed at the side of the walk-way which is higher than the land over which the houses are constructed. Drainage of rainwater, grey water and effluent from septic tanks to the street drains is therefore not possible.

The NHA projects are located on dry land because landfill is always done before construction starts. However, due to groundwater extraction and the soft soil of Bangkok, land inclination is a widespread problem.

Of the four slum areas, two (Bordin and Rakaeng) have been upgraded by the municipal authorities and most basic infrastructure services, i.e. concrete walkways, piped water supply and electricity have been provided. In the two other slum areas (Erawan and Doi Tong), the situation is different. In Erawan, no legal water connections are permitted and only a few households have a water connection tapped from a legal connection nearby. Other households buy water for drinking or fetch it at the fire station nearby. Many houses have a shallow well from which water for bathing and washing is taken. In Doi Tong, a third of the households has a legal water connection, the others fetch drinking water from an open well located in the middle of the slum. Another well which used to provide water for drinking is now contaminated by a cesspool located less than 2 metres from the well. In addition, many houses have a private shallow well which provides water for washing and bathing.

In none of the slum areas, solid waste is collected from the houses. Usually refuse containers are placed at central locations such as small market places. In Bordin people throw most of their garbage in the stagnant water under their houses and this situation was also observed in Erawan, be it to a lesser extent.

All NHA projects have piped water supply with house connections, regular solid waste collection, concrete footpaths, surfaced roads, stormwater drains and in case of off-site treatment (Huay Kwang and Tung Song Hong) a sewerage system and central sewage treatment plants.

Almost all households interviewed have a private pour-flush or cistern-flush toilet. The toilet systems in the slums are mostly a one-pit cesspool and sometimes septic tank with soakaway. In the NHA projects different on-site sanitation systems are found: one-pit cesspool, septic tank with soakaway pit and septic tank with anaerobic upflow filter. In Huay Kwang sewage from each apartment building is treated in septic tanks before flowing into the sewers and led to an activated sludge plant located within the project area. In Tung Song Hong on-site pre-treatment is designed to take place in a septic tank with anaerobic upflow filter. The overflow comes in the sewers which lead to an aerated lagoon for further treatment.

Tenure

Table 6.2 gives an overview of the tenure situation in the slums and the NHA schemes. In Rakaeng and Doi Tong security of tenure is quite high because the land is either owned or rented from the municipality. In Bordin, security of tenure is not so high although most people rent the land from the landowners. The problem here is, that they do not know how

long the owners will allow them to stay. Even though the slum has been improved by the NHA, the owners still can claim their land.

As Erawan is an illegal slum area, it is questionable if the 20 percent of the respondents who claim to own the land indeed do so because of the illegality of the settlement. Also those who claim to rent the land may well pay rent to people who do not own the land. Because of the age of the slum (more than 20 years), it is very difficult for the municipality to evict the people, although the slum is located above and aside a natural stream. Although security of tenure is low, half of the houses are made of permanent material and are being improved. However, the environmental conditions are bad and basic infrastructure is lacking.

The NHA projects differ from each other in types of houses provided and in resident status. Nong Hoi, Chonburi I and Tung Song Hong have a hire-purchase type of tenure. The houses are fully owned after twenty years. Huay Kwang consists of rental apartments in flats. In Nong Hoy and Tung Song Hong a core with sanitary block was provided by the project and the people had to complete the house by themselves. In Chonburi I, one and two storey single family houses are constructed by the NHA. All projects have a defined target group and transfer of ownership is not allowed during the first five years. However, illegal transfer takes place, often resulting in occupancy by people with a higher income than the original target group.

Table 6.2 shows that the mobility of residents in NHA projects is higher than that in slum areas and the trend of selling out is confirmed by the research data. It is remarkable that of the NHA projects, the renters in Huay Kwang are the longest occupants. The length of stay in the slum areas explains the fact that more than 70 percent of the houses is made of permanent material. The houses have been improved over a long period of time.

Table 6.2 Tenure and length of stay

	SLUM AREAS				NHA HOUSING PROJECT			
	Erawan	Rakaeng	Doi Tong	Bordin	Nong Hoi	Chonburi I	Huay Kwang	Yung Song Hong
Tenure								
- Own land and house	20	23	12	1	66	60	0	*
- Own house, rent land	22	51	78	82	5	1	0	*
- rent land and house	0	21	2	17	27	34	98	*
- not own, not rent	56	4	6	0	1	0	2	*
- other	2	1	2	0	1	5	0	*
	100	100	100	100	100	100	100	
Length of stay								
- less than one year	11	8	7	1	14	13	8	*
- one to four years	9	16	12	13	42	27	17	*
- five to ten years	20	15	19	18	43	33	26	*
- more than ten years	60	61	62	68	1	27	49	*
	100	100	100	100	100	100	100	

* Question not asked in pilot phase

56

Characteristics of the research population

The households in all sites are almost exclusively Buddhist, except in Bordin where 68 percent is moslem. The level of education is comparatively lower in the slum areas where 21 percent has no formal education and 50 percent only primary education. For the NHA projects, 28 percent have primary school and the rest secondary school or more. Information on income should be seen as indicative, but shows that the average household income is lower in the slum areas than in the NHA projects. Most people in the slums earn less than Baht 4000 per month with averages of Baht 2,800 in Erawan, Baht 2,900 in Doi Tong and Baht 4,700 in Bordin. Bordin has a higher average with 50 percent earning between Baht 2,000 and 6,000 and 43 percent more than that. This can be explained by the fact that generally income in Bangkok is higher than in other parts of the country, but life is also more expensive. In the NHA projects, average income was Baht 5,800 in Nong Hoy, Baht 6,000 in Huay Kwang and Baht 5,000 in Chonburi I. Information on income was not obtained in the pilot phase.

6.2 Sanitation Systems in Urban Areas

All toilets in the urban areas in Thailand have a water-seal system. These usually consist of a squatting pan with pour-flush water seal, but in the middle and higher-income housing projects cistern-flush or pour-flush toilet seats are found.

Human excreta is either treated on-site or off-site. Three different types of on-site sanitation systems are common in urban areas: the cesspool, the septic tank with soakaway system and the septic tank with anaerobic upflow filter. The four main off-site treatment systems are oxidation pond, aerated lagoon, activated sludge system and oxidation ditch.
All these systems are briefly described below.

Cesspool system

The cesspool system is developed from the pit latrine and is commonly used in slum areas. It consists of several (usually three or four) reinforced concrete rings, 80cm in diameter and 40cm in height, which are placed on top of each other to form a tank (figure 6.2)

The bottom is preferably open and the walls are perforated with several holes (about 25-50mm diameter) to allow the liquids to seep into the soil. Sometimes the tank is surrounded by a coarse gravel pack to improve percolation in less permeable soils. The retaining solid excreta digests anaerobically and becomes sludge. When the cesspool is full, it is usually emptied by a vacuum truck through a removable cap in the cover. The intervals between emptying may range from less than a year to more than ten years depending on absorption capacity of soil, percolation capacity of tank, tank size, number of users, and amount of water used for flushing.

This system is found in all slum sites in the research and was originally also installed in the NHA housing project Chonburi I.

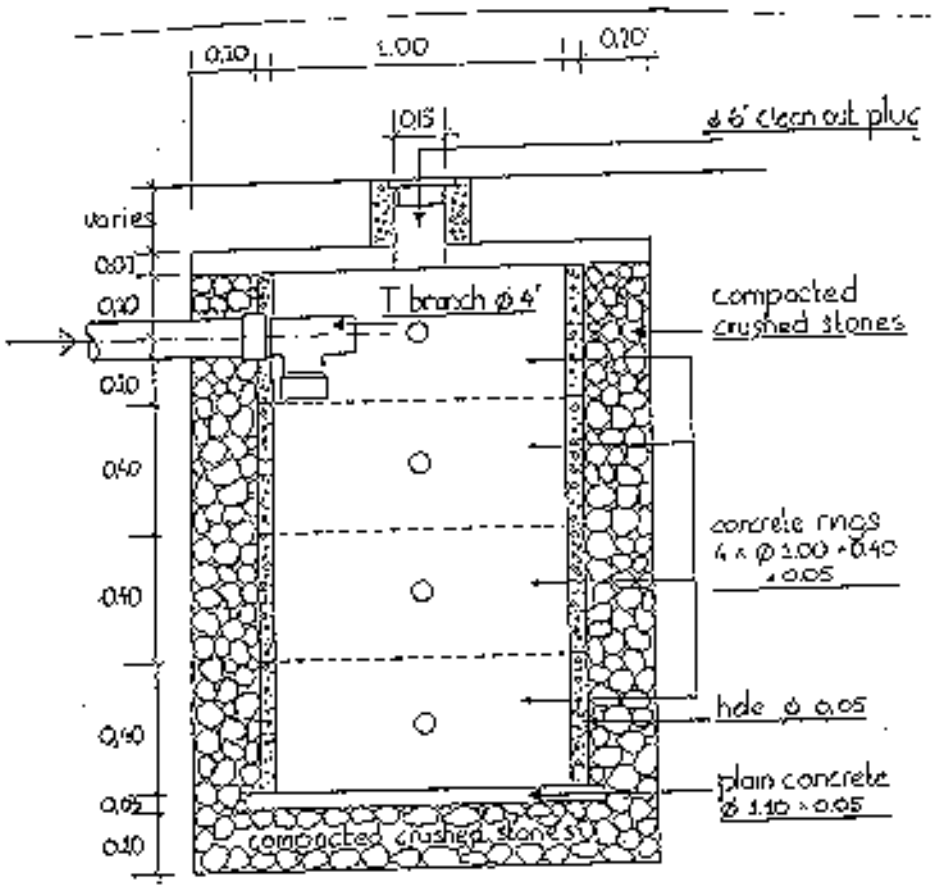


Figure 6.2 Cesspool (Chonburi design)

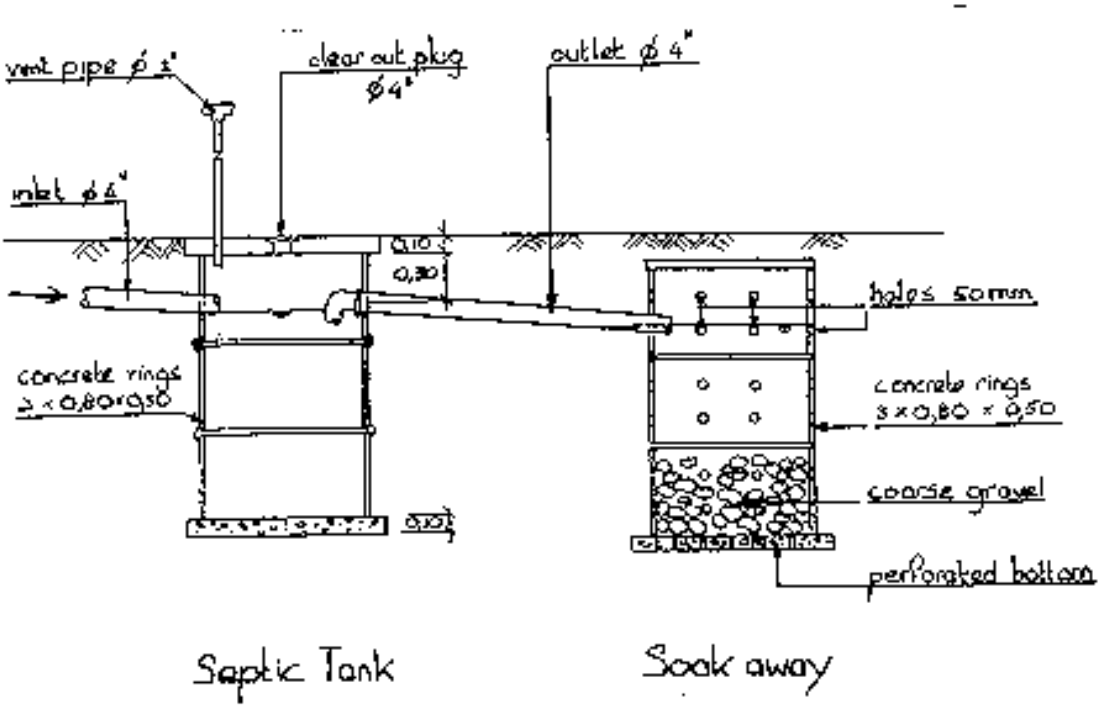


Figure 6.3 Septic tank with soakaway pit

Septic tank with soak-away pit system

The septic tank with soak-away system is developed from the cesspool system. It consists of two tanks made of reinforced concrete rings (diameter 0.8 m, height 0.4 m). The first tank, the septic tank, is water-tight and has a concrete bottom. The human excreta is separated in settleable component which decomposes into sludge and the effluent that is led into the soakaway pit. This second tank has many seepage holes around and a permeable bottom to allow the effluent to seep out in the ground (figure 6.3).

In terms of sewage treatment this two-stage process is more effective than the cesspool system. BOD (Biochemical Oxygen Demand) and suspended solids content is reduced by about 30-60 percent. The performance efficiency depends largely on the design of the tank, the volume of waste and water versus volume of the tanks and the regular emptying. This system is used in some low-income housing projects and also in a number of slums. In the research, it was found in Chonburi I, Nong Hoy and Tung Song Hong and in some houses in the slums.

Septic tank with anaerobic upflow filter

The septic tank with anaerobic upflow filter (AUF) is a further development from the septic tank and soak-away pit system. It is also a two-tank system, the first tank is the septic tank and the second the upflow filter tank (figure 6.4)

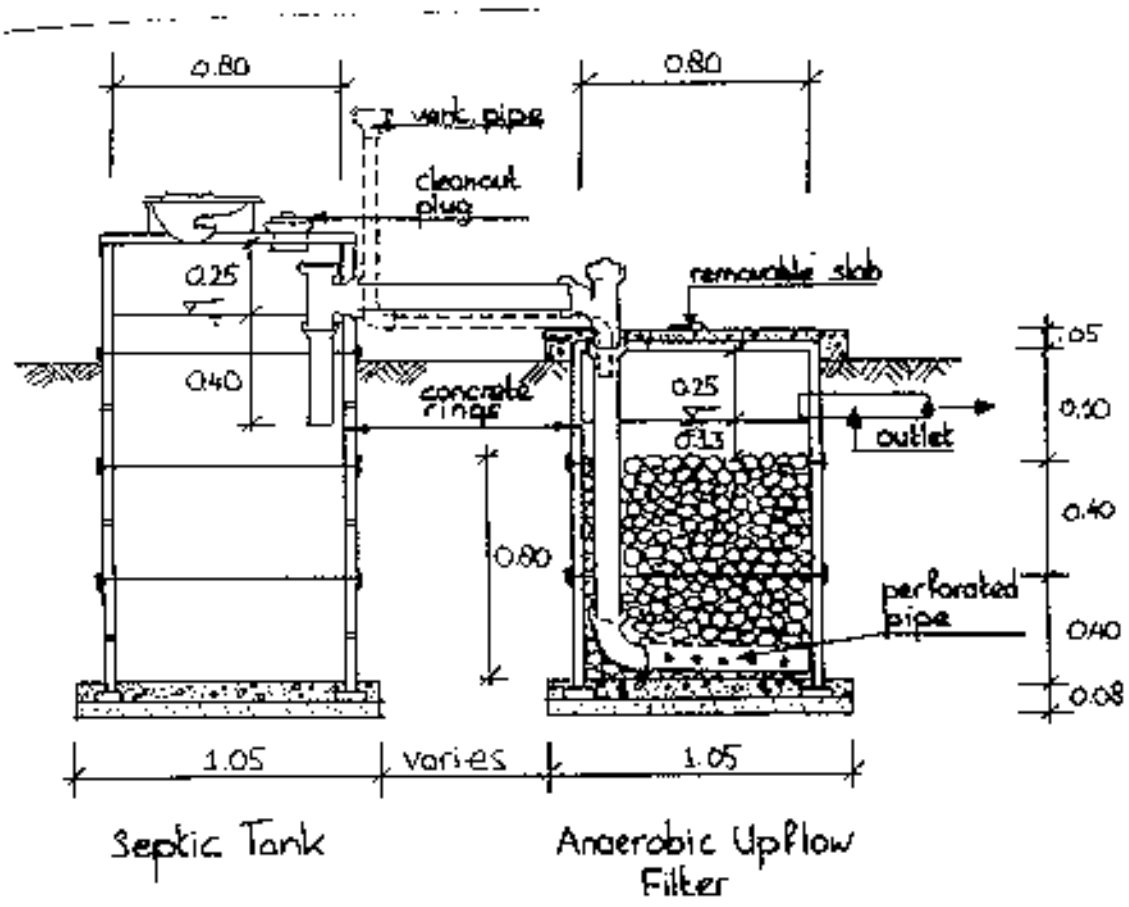


Figure 6.4: Septic tank with anaerobic upflow filter

The septic tank operates as described in the previous system. The AUF receives the effluent from the septic tank. The principle of the AUF is that the septic tank effluent flows in an upward direction through a pack of coarse filter material. The filter material allows for the sedimentation of suspended solids and the attachment of biological film containing anaerobic bacteria and other anaerobic micro-flora. These filtration mechanisms of the AUF in combination with the septic tank lead to very high reductions of BOD and suspended solids (about 60-80 percent), while faecal coliform densities may be reduced to 90 percent. The effluent from the AUF usually flows into a sewerage system or into a storm drainage system.

The AUF system, using crushed stones as a filter medium, was installed in the NHA housing projects in Nong Hoy and Tung Song Hong.

Oxidation ponds

Oxidation ponds are a natural method of decomposing sewage waste containing human excreta. The sewage passes through two ponds in series, the facultative and the maturation pond. In the facultative pond the biological and bio-chemical processes can be either aerobic or anaerobic depending on BOD load per pond area, the depth of the pond and the ambient temperature. The oxygen is obtained from the surface of the ponds. Typical detention periods for tropical temperatures are 12 and 4 days respectively for facultative and maturation pond. Typical depths are 2 and 1.2 m for facultative and maturation pond. The performance efficiency for BOD ranges between 90 and 98 percent and for faecal coliform content it is in the order of four log units (99.99 percent). The sludge accumulates in the first pond, and has to be removed. The effluent of the maturation pond is discharged into the surface waters. This system is not found in the research areas.

Aerated lagoon system

The aerated lagoon system consists usually of two ponds or basins in series (figure 6.5). The first pond receives the raw sewage, where it remains for about four days. Oxygen intake is accelerated by floating aerators. The aerated lagoon is followed by a settling or polishing pond with a short detention time of about 2 days. This pond is primarily meant for sludge settling. After this second pond the treated water is discharged in surface water. A reduction of 70-95 percent of BOD can be obtained. This system is used in Tung Song Hong.

Conventional activated sludge system - aeration tank

The activated sludge system with aeration tank is a combination of primary sedimentation, activated sludge process and final sedimentation (figure 6.6). In the primary sedimentation tank a substantial part of the BOD and suspended solids is removed. In the activated sludge process the waste water and activated sludge is mixed and aerated by surface aerators and remains for several hours in the tank. This stimulates aerobic bacteria and protozoa to multiply and to form settleable flocs with the floating organic waste products. Most of the settled sludge in the final sedimentation is returned for inoculation to the incoming waste water prior to the activated sludge process. BOD removal can reach 85-95 percent. The liquid effluent may be treated with chlorine and disposed in surface water.

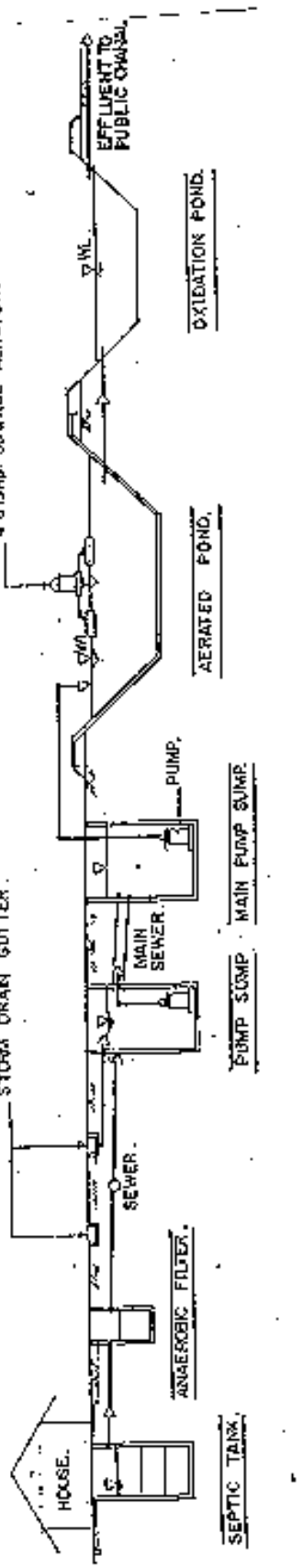


Figure 6.5: Schematic diagram of the aerated lagoon and polishing pond in Tung Song Hong

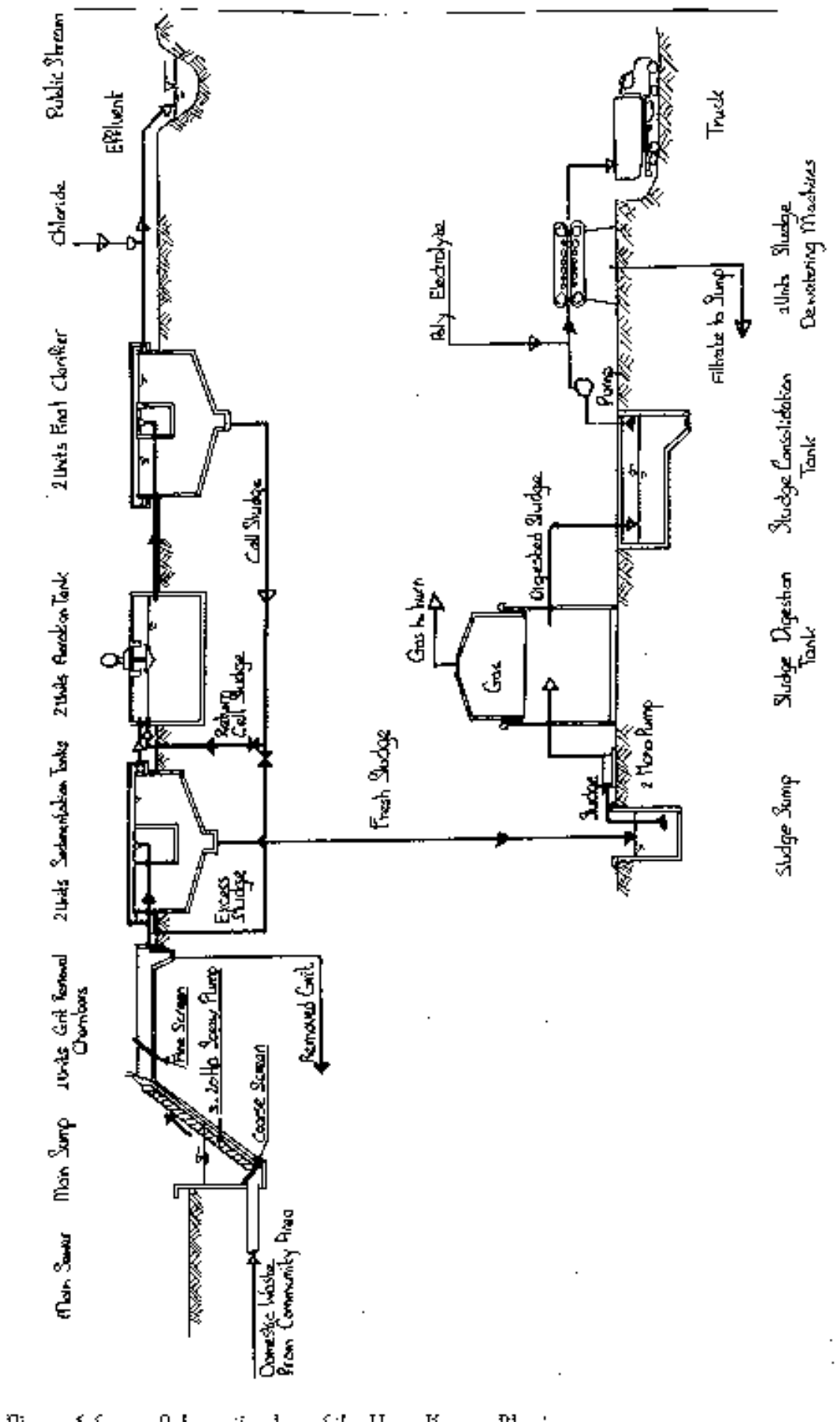


Figure 6.6: Schematic plan of the Huay Kwang Plant

The sludge is thickened by anaerobic digestion. This is a complex biochemical process resulting in a relative hygienically safe sludge that can be dried on fields, then mixed with chemical fertilizers and used for agricultural and horticultural activities. The wet sludge can also be mixed with solid waste and dumped. This system is found in the Huay Kwang housing project.

Activated sludge system - oxidation ditch

The activated sludge system with oxidation ditch is different from the conventional system with aeration tank in that there is usually no primary sedimentation. Furthermore, the activated sludge process takes place in a long, shallow (1-1.5 m) channel, oval in shape. Aeration is usually done by mechanical rotors or brushes. This method therefore requires a larger area of land than the conventional activated sludge system, but it is cheaper to construct. Final sedimentation and anaerobic sludge digestion is the same as for the conventional activated sludge process. This system is not found in the research areas.

6.3 Condition and Performance of Latrines in Slum Areas

Location of the latrines and pits

All latrines in the research areas are located inside or attached to the house. The cesspool system as described in 6.2 is used by almost all respondents (86 percent), but the waterseal pan is usually placed directly over the pit. The other households have a septic tank with soak-away pit. Most cesspools have three or four concrete rings, hence a pit depth between 1.20m to 1.60m. Where houses are built on stilts, the cesspools may have up to six rings, depending on the distance between the floor and the ground below the house. In Rakaeng, Bordin and Erawan, many of the houses have permanently stagnant water below them. To facilitate percolation of the liquid into the water, residents have made extra holes in the concrete rings below and above the water level. This results in direct contamination of the stagnant water with the contents of the cesspool systems. The contaminated water causes health risks for children who play in the water and offers a perfect breeding ground for mosquitoes, particularly the culex species which causes filariasis.

Most cesspools have a ventilation pipe to allow gases to escape. These pipes are made of PVC with a diameter of half an inch or one inch.

In Doi Thong and in the parts of the other sites which are not permanently flooded, the cesspools are dug into the ground and the liquid effluent leaches through the soil. Only where wells are located less than 10m away from the cesspools do they cause health risks, contaminating the well water. In such cases, residents do not use the water for drinking because it smells, has a bad taste and is not clear.

Waterseal pans

All waterseal pans are made of cement with a smooth finishing to facilitate cleaning and most are placed directly over the pit. This facilitates construction and reduces the cost as no connection pipes are needed. However, it also makes emptying difficult. Therefore, sometimes a separate hole is made in the floor for emptying. The pans require 3-4 litres of water for flushing, which is no problem for the users.

Superstructures

The walls and doors of the superstructures are made of used materials such as wood and zinc sheets, with a few exceptions in Doi Thong where bricks are used for the walls. The roofs are either made from zinc sheets or dried leaves and a few have tiles. The floors are all made of wood in Erawan and Bordin. In Rakaeng 60 percent is made of wood and the rest of cement. In Doi Thong all floors are made of cement because the houses are located on the ground and not on stilts. The ventilation is sufficient only in 56 percent of the superstructures, but this does generally not lead to bad smell because the waterseals prevent this. The toilets were found to be smelling in only 16 percent of the houses. Most people are satisfied with their toilets (77 percent).

Cost of the latrines

The average cost of a cesspool latrine, which includes both substructure and superstructure is Baht 1,943 in Doi Thong and Baht 1,818 in Bordin. In Erawan, the cost is much higher at Baht 5,400, for which no reason could be found. Information for Rakaeng is not available. Most people constructed the toilets themselves or with the help of a neighbour. The cost of materials for construction of the substructure is about Baht 1,100 (concrete rings at Baht 500, a pan of Baht 300, Baht 300 for cement and sand for the floor and the sealing). The cost of materials for construction of a septic tank is about Baht 2,000, because of the extra rings for the second tank and the connection pipes.

6.4 Operation and Maintenance of Latrines in Slum Areas

Water use

About a third of the people reported to use 3 litres of water for flushing the toilets, while almost half of the people said to use more than that (47 percent). There is no relationship found between the amount of water used for flushing and the availability of water in the house. No mention is made of blockages of the water seal which may be due to the fact that the waterseal is located directly over the cesspool. Flushing is only a problem if the water level under the houses becomes unusually high during the rainy season.

Cleaning and emptying

Most people clean their toilets at least once a week and most (83 percent) use chemical detergent to do this. All toilets were observed to be clean.

Theoretically speaking, the cesspools have to be emptied every 2-5 years, depending on the number of users. The research shows that in Bordin and Doi Thong, the number of people who never had their cesspools emptied is quite high, respectively 95 percent and 80 percent, although in both slums more than 80 percent of the people are resident for more than 5 years. In Bordin the low filling rate can be explained by the many holes in the cesspools, through which also the sludge seeps out. In Doi Tong, absorption capacity of the soil is very good and the cesspools large enough to last a long time.

In the other two communities, about a fourth of the cesspools are emptied at intervals of less than a year, 18 percent has their cesspools emptied with an interval of 1-3 years. About half of the respondents never had their pits emptied, obviously for the same reason as in Bordin. The cesspools are emptied by municipal services or private companies, rarely by the people themselves. For emptying in Chiang Mai and Chiang Rai, 200 Baht has to be paid per pit, which is the standard price set by the municipality. In Bangkok, Baht 50 is charged per m^3, with a minimum of Baht 150 by the municipal emptying service. Emptying is always done with mechanical emptying equipment. Because the vacuum trucks have long hoses, they can

reach most houses in the slums. Only in Bordin, this could have been a big problem, but here cesspools are almost never emptied.

6.5 Condition and Performance of Sanitation Systems in NHA Projects

Superstructures

The toilets in all housing projects are similar to each other in all aspects concerning the superstructure. The toilets are usually located within or attached to the house. The location of the toilets proved to be a problem in the projects where a core with sanitary block was provided. This block was located in the middle of the plot and the toilet would consequently be located in the middle of the house. This is culturally not acceptable, people want their toilets in the back of the house. Thus, almost all people in Nong Hoy had and an estimated 70 percent of the people in Tung Song Hong moved their toilets to the back. Also in Chonburi the location of the toilet and lay-out within the house was frequently changed, because the door of the toilet was opening facing to the front of the house, which is not considered appropriate.

The floors are made of cement, the walls of cement blocks and the doors of wood. The roofs are made of tiles except in Huay Kwang which has apartment blocks. The ventilation is good in most of the places (70 percent), bad smell was found in about 14 percent of the toilets. In the apartment building in Huay Kwang almost half of the people have installed a toilet seat, for Nong Hoy this is 5 percent and in Chonburi 20 percent. Most people are satisfied with their toilets (76 percent) at present and only 15 percent wants to carry out further improvements.

Cesspool system

In Chonburi I, the NHA constructed a cesspool system in all houses (see section 6.2 for a description). The system is specific because the tank is surrounded by crushed stones forming a 20cm ring to act as a filter. The cover of the tank is made of concrete with a screwable brass plug with a 6 inch diameter. All houses were provided with this cesspool, but it was found that 37 percent of the people has changed it into a septic tank with soak-away. It is not clear if they used the original cesspool and added a soak-away or if they constructed a completely new system. The reason for the change is most probably because people do not seem to like a one pit system and also because of expansion of the original house with a consequent move of the toilet to the back of the house. No problems are experienced with the cesspool or septic tank systems.

Septic tank with anaerobic upflow filter

The septic tank with anaerobic upflow filter is constructed in Nong Hoy and Tung Song Hong (see section 6.2 for a description). In Nong Hoy, the effluent from the anaerobic upflow filter is designed to drain into the open stormwater drainage system. However, most people have constructed a new septic tank and soak-away system because of the undesirable location of the original system. Consequently, no insight has been gained on the performance of the anaerobic system in this project. The septic tanks are constructed by the private sector and perform well.

In Tung Song Hong, the septic tank with anaerobic upflow filter was not moved as in Nong Hoy. The excreta is first treated in the septic tank and anaerobic upflow filter. The filter medium in the AUF consists of crushed stones. The effluent of the AUF is discharged in the combined (sewage and stormwater) sewerage system, and led to a central sewage treatment plant using the aerated lagoon system (figure 6.4).

The research found that the AUF is not functioning well. The problem is caused by the fact that the perforations of the distribution pipe at the bottom of the AUF get clogged easily. Moreover, the suspended solids and biological film which become attached to the crushed stones on the bottom of the AUF tank prevent the upward flow after some time. This results in clogging of the interconnecting pipe between the AUF and the septic tank and consequent fast filling up of the septic tank. The AUF is in many cases located underneath the kitchen and cleaning of the filter by backwashing is a dirty and cumbersome job. Thus, when people went to the Estate Management Office (EMO) for help, they were advised to bypass the AUF, i.e directly connect the septic tank to the sewerage or to convert the AUF into a soakaway pit by removing the crushed stones. An estimated 70 percent of the households has now changed the system into either one of these options. Direct connection from the septic tank to the sewerage leads to increased loads of BOD, SS and pathogen content in the effluent. Samples of the effluent from the anaerobic filter at four pump sumps indeed showed that the BOD and faecal coliform content (above 200,000 MPN/100ml) is much higher than could be expected for an AUF effluent.

Another problem reported, is the immersion of the ventpipe of the septic tank below the water level. Therefore gases cannot escape, which can affect the flushing of the toilet. Moreover, not all ventpipes are screened to prevent flies from entering.

The sewerage and aerated lagoon system in Tung Song Hong

The on-site treated sewage is discharged to the branch sewer (diameter 20cm) in the walkways, then to the main sewer pipe (diameter 30-50 cm) and by gravity and pumps (in sumps) to the central treatment plant of Tung Song Hong (figure 6.5).

The sewerage system also receives sullage and 60 percent of the surface drain water (the rest drains directly into the ground). People reported problems with flushing during the rainy season because the contents of the full sewers are flowing back into the septic tanks as the sewers receive also stormwater run-off. Only the start of the stormpump can cause an increased flow in the sewers, which stops the backflow. There are eleven sumps with submersible pumps and one main sump with pump near the central treatment plant from where the waste water is pumped into the aerated lagoon. Some of these pumps have been removed and are being used for other purposes because the operators believe that they could not be used efficiently, especially where sewers show an inverted slope near the sump. The inverted slope is reported to be the result of inclination of the soil.

In some sumps the iron screen cover to keep garbage out is removed, resulting in a lot of garbage in the secondary and main sump. In the main sump no screens are installed that can prevent garbage from being pumped to the aerated lagoon. Garbage can cause damage to pumps and should be retained from the lagoon and pond. Also many stormwater drains and several sewers are blocked by garbage. Cleaning of the sewers is difficult because the interval distance between manholes is sometimes more than 40m.

The aerated lagoon (see section 6.2 for description) has four surface aerators, but actually only one is operated at a time because operators assess this to be sufficient to achieve a good effluent quality of water. Observation indicated insufficient aeration all over the lagoon area, resulting in a dead corner in the lagoon and probably short circuiting from inlet to outlet. The treatment plant is found to be effective in BOD reduction ($BOD_{effluent}$:9.7mg/l) and in reduction of faecal coliform density ($FC_{effluent}$:1,700 MPN/100). The area of the plant is about 9,700 square meters and has a capacity of 3,000 m^3/day and can serve about 15,000 people.

Sewerage and activated sludge plant in Huay Kwang

The NHA housing in Huay Kwang consists of apartment buildings and therefore a central sewage treatment is constructed. Each building has its own septic tank where by design excreta and sullage are primarily treated. These septic tanks do not function any more, but are bypassed. In some places overflowing sewage was observed near the septic tanks, most probably caused by the fact that many branch sewers are broken or blocked, impeding the flow of sewage. The original sewer pipes within the buildings and in the branch lines were made of cast iron. These pipes become blocked by corrosion and are gradually being replaced.

The treatment plant receives 800-1,000 m^3 sewage per day. The dry weather flow (DWF) reduced from about 1,650 m^3/day in 1982 to 900 m^3/day in 1993. Theoretically, the estimated population of 16,800 produces 3,360 m^3/day. This implies that about 60-80 percent of the sewage is not reaching the plant but drains in the underground, the environment or directly into canals. In all cases this causes serious pollution to the environment. The reasons for loss of sewage are assessed to be poor condition of the lateral and branch sewers (to be rehabilitated in 1994), broken connections between branch and main sewer lines and blocked sewers. Moreover, some sewers are reported to be sloping in the wrong direction, as a result of soil inclination and/or improper construction, and are said to be directly draining into the canal. Although the sewerage system is designed to receive also rainwater (combined sewerage system), many stormwater drains also directly drain into the canal.

The treatment plant uses the activated sludge with aeration system (see section 6.2 for description and schematic flow diagram). The plant, built in 1972, has a design capacity of 2,500-3,000 m^3/day for a community of about 17,000 people. The plant is greatly under-utilized because it only receives 800-1,000 m^3/day. Of the two primary sedimentation tanks and two aeration tanks only one of each is in operation. The other tanks are out of operation because of poor maintenance that resulted in breakdown of crucial parts (e.g. aerator broken, desludging pipe blocked).

Despite the poor condition of the plant, the performance is said to be good. Table 6.3 gives influent and effluent values and efficiency percentages for some key parameters.

Table 6.3: Huay Kwang Sewage Treatment Plant: estimate of typical influent, effluent values and performance efficiencies for key parameters

parameter	unit	influent	effluent	efficiency	typical value
BOD	mg/l	200	20-25	90%	
COD	mg/l	250-400	20-40	92%	
Suspended Solids (SS)	mg/l	150	15-20	90%	
Sludge Volume Index					200-250

Investment cost of sanitation systems in NHA housing projects

In the housing projects, which provided complete houses, the cost of the superstructures of the toilet are included in the total cost of the houses and therefore difficult to assess. The only cost which are borne directly by the residents are improvements such as tiles, finishing of the walls, painting of doors and lighting fixtures. In case of relocation of the toilet, as is done in Chonburi I, the new structure is of course paid for by the residents.

In the core housing schemes, the cost of the superstructures is borne by the residents, but also here these are included in the total cost of the house and difficult to assess.

The investment cost of the substructures depend on the system. For the on-site systems, the cost are estimated to be between Baht 2,000 and 2,500 for the cesspools in Chonburi, between Baht 3,000 and 3,500 for a septic tank with soak-away and between Baht 5,000 and Baht 6,000 for the septic tank with anaerobic upflow-filter in Nong Hoy and Tung Song Hong. With average incomes varying from Baht 2,800 to Baht 4,700 in slums and average incomes varying from Baht 5,000 to Baht 6,000 in NHA projects, it shows that people are prepared to spend a relatively large amount on the construction of a latrine.

In Tung Song Hong, the investment cost for the aerated lagoon and polishing pond was Baht 10.9 million in 1984. In Huay Kwang, the investment cost for the activated sludge system was Baht 24 million in 1972.

6.6 Operation and Maintenance of Sanitation Systems in NHA Projects

Operation and maintenance of sanitation systems at household level

The operation and maintenance of the toilets in the houses and of the septic tanks and upflow filters is the responsibility of the households. Most people use between 2-4 litres of water for flushing which is not considered any problem because all people have a house connection to the water supply. Cleaning is done 1 to 3 times a week and more than 70 percent of the people use chemical cleaning agents.
Whenever people have problems with the operation and maintenance of the substructure parts of the toilet, they usually go to the EMO for assistance. Technical problems are either solved by the technical staff of EMO or by a private service agent.

The problems with the clogging of the AUF in Tung Song Hong, as mentioned in section 6.5, could not be solved by desludging, because the septic tank would fill up quite quickly again. The technical staff of EMO did not backwash the filters, either because these filters were difficult to reach and backwashing is a dirty job or because they did not know how to do this. They were never trained in operation and maintenance of the AUF system. Thus they constructed a bypass to the filter or changed the filter into a soakaway pit. Most people (85 percent) never had their septic tanks emptied, which can be explained by the bypass of the AUF directly into the sewer. Where clogging did not occur or where the system has been changed, people are very satisfied with the system because operation and maintenance does not require much effort.

For desludging, the EMO in Tung Song Hong refers people to the BMA, which they can contact themselves. The BMA has vacuum trucks of several types that can reach most houses directly or through a long suction hose of about 35 metres. Yet some houses cannot be reached by the long hoses in which cases another solution has to be found. The BMA charges Baht 50 per m^3, with a minimum of Baht 150.

In Nong Hoy, most people have installed septic tanks with soakaway instead of the original system. Some soakaways are connected to the open stormwater drain. All systems are functioning without problems and do not require any efforts except when they are full. Emptying is done by the desludging services and most houses can be reached easily for desludging. The cost for desludging is Baht 200 per pit, usually the soak-away is emptied at the same time, bringing the cost to Baht 400.
In Chonburi I, both cesspools and septic tank with soakaway systems function well and emptying services are provided through the municipality of Chonburi at Baht 300.

In Huay Kwang, households are found to throw waste into their toilets, resulting in the sewer pipes getting clogged in the building. Whenever, this happens, the EMO is contacted and the technicians remove the waste. All people connected to that sewer are charged for the work, in the hope that they will be more careful in the future.

Operation and maintenance of the sewerage and treatment plants

In Tung Song Hong, the responsibility for the operation and maintenance of the main sewer line and the treatment plant was carried over to the BMA in 1992. The EMO still has the responsibility for the branch lines. Major operational problems include blockage by household and street refuse, organic material and silting. Moreover, due to inclination sewers are said to be cracked allowing soil to enter the sewers and causing blockage of flow. Cleaning and desludging of stormwater drains and sewers is insufficiently done by EMO. The budget for operation and maintenance is not enough to keep the sewers operating well, but the EMO does have rehabilitation of sewer-sections in his year plan.

In the main sewer are the sumps with pumps, which were partly removed by the NHA operators, as mentioned in section 6.5. Maintenance of these sumps is insufficient, as for instance is shown by the removal of the iron grits to keep the garbage out and the fact that water is standing in the sumps. The main sewer is believed to have the same problems as the branch sewers and is also insufficiently cleaned and maintained.

The plant is operated by one full-time and two part-time workers. The performance was described in section 4.5. The major operational problems are localized aeration resulting in dead corners of the lagoon and solid waste entering the plant because no screen was installed. The mechanical part of the treatment plant is routinely checked. The operators are satisfied with the system because it is easy to operate, economic and reliable. The operators use their experience to determine how many of the four aerators have to run for proper performance. If the water turns blackish and starts to smell, they start an additional aerator. However, one surface aerator has been out of order for a long time. The department in NHA responsible for supervision of the different EMOs is still checking the performance of the plant every three months and is coordinating with the BMA whenever problems arise.

Also in Huay Kwang, the responsibility of the main sewerage system and the sewage treatment plant were carried over to the BMA. And also here, the branch lines remained the responsibility of the NHA.. The performance of the sewerage system is described in section 6.5.. The EMO stated that cleaning of the sewers poses a problem. The sewers are designed to flow by gravity and are therefore laid at a rather steep angle. It is said this needs special equipment to clean and this equipment is not easily available in Thailand. Only a few companies seem to be able to carry out this cleaning, which is expensive. Cleaning is also made difficult by the broken connections between branch and main sewer lines, and by obstruction through corrosion and wrongly sloping sewers due to soil inclination. NHA is

planning to rehabilitate the branch sewer lines in 1994. According to the BMA, who carried out a survey of the main sewer line, no serious problems are found in this sewer.

Operation of the plant was observed to be poor. The grit removal chambers were both completely filled up, the scum remover in the primary sedimentation tank did not function properly and sedimentation was not taken out. Also maintenance is poor. Several metal parts are nearly falling apart from rusting. Mechanical and electrical equipment does not function optimally and several concrete structures are also in poor condition. This while a total labour force of more than 25 people is in charge of operation and maintenance of the main sewer (about 10km) and the plant.

Poor maintenance is the result of a low maintenance budget but perhaps also because the supply of sewage is far below the design capacity of the plant making parallel running of sedimentation and aeration tanks unnecessary.

6.7 User Attitudes and Practices

In all households surveyed all members of the households (except very small children) use the toilet. No problems are experienced with this use by either small children, old people or pregnant women. The few households without a toilet, use the toilet of neighbours or nearby family. Having a toilet and keeping it clean is absolutely normal and no point for motivation or discussion. Most people are satisfied with their present toilets and if any improvement is considered, this is confined to the superstructure or replacement of the pan.

In the slum areas, people generally have not received any instruction on the maintenance of their latrines, as most toilets are built by the users themselves. But in the NHA housing projects this is different. In Tung Song Hong and Huay Kwang, the first people who moved in received instruction booklets from the EMO. However, people who moved in later were never given the booklets, because they were no more available. Knowledge on proper use and maintenance is therefore deficient, particularly on issues like using chemical agents for cleaning the toilets (which is harmful for the bacteria in the septic tank and anaerobic upflow filter) and the effects of throwing waste in the toilets. Also knowledge on the functioning of the systems is low and the consequences of bypassing the filter or soakaway pit for the environment are not realized. People are satisfied as long as the system keeps functioning. None of the EMOs carries out any activities to make people more conscious of their responsibility towards the environment.

Awareness of the environmental health hazards in the slums as a consequence of the seepage of pit contents into the standing water is absent. The environmental conditions in the slums seem to be accepted as inevitable, because the residents themselves cannot do much about it. They do not have the technical knowledge nor the funds to install a sanitation system which does not contaminate the water. However, in communities with wells, people are aware that some of the wells are contaminated and that the water cannot be used for drinking.

Awareness of excreta-related diseases is quite high in all sites surveyed and the causes of diarrhoea, dysentery, cholera and parasites are known as well as the fact that insects often are the vectors of these diseases. However, this knowledge does not seem to influence the habit in the slums of throwing garbage under the houses. The occurrence of a number of excreta-related diseases was checked during the research, by asking the people about the illnesses they had in their households during the last twelve months. It was found that in the communities located on low-lying (flooded) land without basic infrastructure and with high

densities, the occurrence of excreta-related diseases is higher than in the dry land communities and the NHA housing projects.

Formal health training programmes have only been given in Bordin, at the time when this area was upgraded. All other communities receive their health and hygiene information mainly through the media, such as radio, TV and newspapers.

6.8 Institutional Management for Operation and Maintenance

Institutions involved in the operation and maintenance management for sanitation services in this research are the NHA, BMA, Chiang Mai and Chiang Rai municipalities and the Ang Sila Sanitary District. Except for the NHA through their Estate Management Offices (EMO), these institutions are not concerned with functioning of sanitation systems at household level. An overview of responsibilities for operation and maintenance is given in table 6.4.

Table 6.4 Overview of responsibilities in operation and maintenance of sanitation systems

O&M task	ACTORS				
	House hold	private company	NHA	Municipality	District
cleaning toilet	x				
repairs toilet	x	x			
cleaning AUF	x	x			
repairs on-site system	x	x			
desludging tanks	x	x		x	x
cleaning stormwater drains			x	x	x
cleaning sewerage			x	x	x
maintenance sewerage			x	x	x
O&M sewage plants				x	x
monitoring effluent			x	x	x
monitoring sewage plants			x	x	x

Sanitation responsibilities of the EMO

In all NHA housing projects, the Estate Management Offices are responsible for general management issues and coordination of sanitation services. The main task of the EMO is the administration and collection of rents or down-payments for the hire-purchase of the houses. But they are also responsible for the environment and therefore have to keep the drains clean and the sewers functioning. Thus, removing of blockages in the sewers is done by the technical or cleaning staff, as far as possible. Major blockages and problems which cannot be solved by the EMO staff, are reported to the NHA office for action. The technical staff advises people who have problems with their sanitation systems and even carry out repairs for payment. The technical staff also has to approve the building plans in the core-housing areas, including a change in the sanitation system. They approved cesspools and septic tanks with soakaway pits, even where septic tanks with AUFs had originally been installed. The advise

given by the EMO technicians in Tung Song Hong on the bypass of the AUF, shows that they are not sufficiently aware of the technical requirements of the system or on the reason for the installation of the filter.

Desludging services and disposal

In Bangkok, the Department of Public Cleansing Service of BMA, division of Night Soil Collection and Disposal is the only legal agency to provide desludging services. Sludge is disposed in two plants with a total capacity of 1,200 m^3/day and one drying yard. However, many private companies are illegally involved in desludging. Because they are illegal, they do not have access to treatment plants or authorized dumping sites, resulting in illegal dumping of the sludge. This is cheaper because no payment for treatment has to be done, but also because it saves them the trip across the city to the plants which are located at the fringe. In view of the traffic congestions in Bangkok, it would cost them too much to bring it there. A BMA official estimated that 3,000 tonnes of faeces are produced in Bangkok daily, while the BMA only collects 1,000 tonnes at the most. This means that two thirds is disappearing. This is partly the result of defective household sanitation systems, but also indicates the extent of activity of private desludging companies. These companies charge much more than the BMA, according to the BMA by intimidation. The fact that people ask for the private services is caused by the fact that the general public is insufficiently aware of the services of the BMA. So far, no legal action seems to be undertaken against these private desludging companies.

In Chonburi I, the desludging services are carried out by the Chonburi Municipality because the Ang Sila Sanitary District does not have a vacuum truck. Because of the limited distance between the municipality and Chonburi I and the capacity of the municipal services, this arrangement works well.

In Chiang Mai and Chiang Rai, the municipalities have given out concessions to two private companies to provide the desludging services. Respondents are in general satisfied with this service, as it is reliable and not too expensive. The municipalities approve the prices for desludging and have designated areas suitable for dumping of the sludge. The delivery of the services is the sole responsibility of the companies. The municipalities do not monitor or check the desludging and disposal of sludge.

Treatment plants

In 1990 it was agreed between the NHA and the BMA, that the BMA would gradually take over the operation and maintenance responsibilities for the treatment plants and main sewers located in the NHA housing projects in the Bangkok metropolitan area. For the rental housing projects, the NHA will pay half of the cost for operation and maintenance during the first five years, based on the cost of the years 1985 and 1986, with a 5 percent increase per year. For the hire-purchase projects, the NHA pays for operation and maintenance (electricity and repairs) as long as the period for hire-purchase lasts, which is up to 20 years. During these periods, the NHA will supervise and monitor the BMA personnel working in the plants and also monitor the functioning of the plant. BMA carries out its own monitoring and coordinates with the Central Service Division of the Community Housing Department, which does the monitoring for NHA. The responsibility for the other sanitation infrastructure remains under the NHA, and therefore under the EMO.

Huay Kwang was the first NHA project to be transferred to BMA. The transfer was not easy because the BMA felt that they did not have sufficient insight in the cost for operation and maintenance and moreover felt that the plants were not maintained sufficiently by the NHA, forcing them into large expenditures and much effort. The BMA had the staff working at the plants specifically trained in operation and maintenance of these plants. They also received some on-the-job training from the NHA operators.

The BMA also feels that if in future they are to take over the responsibility for all treatment plants in NHA projects, they should be involved in the planning and designing of the plants, to assure that operation and maintenance requirements will be within the capacity of the BMA.

Service costs and expenditures

In general, it was found that both the organization and the budget for sanitation services is insufficient in the institutions responsible for operation and maintenance. The NHA does not have a separate budget for the operation and maintenance of the sewerage systems and the treatment plants, it is combined with the budget for the EMO. The EMO has a total budget to cover its cost, but most of this budget is taken by salaries of the personnel. This situation, for instance, leads to saving on electricity expenses for the plants by not using all aerators and taking out pumps. It also leads to saving on yearly cleaning of the sewers.

The NHA is charging the residents a service charge, included in the rent and hire-purchase instalments, but this is not enough to cover the cost for the EMO office or operation and maintenance. Other income comes from the sale of houses and permits for markets and stalls.

The Sanitation Feasibility Study (Sanitation feasibility study for Bangkok North-Central Zone (no.7), 1992 (in Thai)) estimated the cost for operation and maintenance of a sewerage system at Baht 50/m per year and the cost of central sewage treatment plants at Baht 30 per household per month. The operation and maintenance costs of the sewage treatment plant at Huay Kwang were originally estimated by NHA at US$ 35,000 per year. Over the period 1985-1989 (five years) the average expenditures for operation and maintenance were US$ 45,000 for a sewage volume of about 1,250 m^3/day, with expenses for labour being 38 percent of the cost, electricity requiring 42 percent and for repairs, spares and materials on average 9 percent with two years of nearly 0 percent. The operation and maintenance expenditures for the Tung Song Hong aerated lagoon plant was US$ 45,750/year or Baht 31 per house per month for a sewage volume of 2,500 m^3/day.

The BMA has to subsidize its sanitation services from taxes. In Bangkok the fee for pit emptying is Baht 50/m^3, with a minimum of Baht 150 per visit. BMA states that the cost for desludging is Baht 500 per m3 and for treating Baht 800/m^3. This means a subsidy of Baht 1150 per m3. The yearly expenditures for sewerage, treatment plants, drainage, solid waste and night soil collection and disposal were combined in 1992 1,316.4 million baht or about 14 percent of the total budget. The night soil section (sludge collection and disposal) spent Baht 95.4 million in 1992.

Chonburi spent Baht 239,000 for the running of two vacuum trucks, income from desludging services was not available.

In Chiang Mai and Chiang Rai, the private companies have to pay Baht 300,000 (Chiang Mai) and Baht 100,300 (Chiang Rai) per year for the concession. The municipalities determined the desludging fee at Baht 200 per pit and allocated a site for dumping. With a cost of about Baht 153.000 per month for running the services, the companies appear to be earning enough to make the services profitable.

Chapter 7: Interpretation of Findings and Operational Recommendations for Thailand

This chapter is based on the research findings as discussed in Chapters 5 and 6 as well as on the literature review and the outcomes of the national workshop and the inter-country seminar in April 1992.

7.1 Technical Aspects

Cesspools contaminate environment in flooded areas

A conventional cesspool system only functions properly in areas where soil conditions permit the fluid to leach out. In the slum areas many of the houses are built above permanently standing water. This water prevents the fluid from leaching out and during the rainy season, the raised level of the surrounding water can make flushing difficult. To facilitate leaching, people make more holes in the concrete rings with the result that the surrounding water becomes contaminated with raw sewage.

Because the cesspools in slums are constructed on private initiative and because people do not have a viable alternative, a change of this situation is not in sight. In theory, a septic tank with anaerobic upflow filter would minimize contamination of the surrounding water, but experience with the type of filter used in the research areas, is not very promising. Therefore, research is needed to see if solutions can be found, appropriate for the conditions in permanently flooded areas. Landfill could be a first step, but the communities themselves cannot do this. Even if the government would contemplate landfill, the land may well become attractive to either private developers or people with higher incomes, resulting in replacement of the original residents. Another option would be to facilitate desludging services in the slums through the use of small pumping units which can easily reach the houses inside the slums, or the use of booster pumps.

Cesspools to be located away from wells

In communities located on dry land, the cesspool is an appropriate solution for people with a low income. However, these cesspools should be located at a distance of at least 25 metres from a well and always at the downward side of the groundwater flow. Where this distance cannot be kept, the cesspools should be converted to a septic tank with soak-away. A cheaper solution in densely populated slums could be the addition of an envelope of either sand or crushed stones around the cesspool, which acts as an extra filter, as was done in Chonburi I.

Location of cesspools to allow for emptying

The need for easy emptying should be considered before deciding on the location of the cesspools. Where space allows, the pits should be located off-site from the toilet pan to facilitate emptying. Alternatively, a separate opening could be made in the slab above the pit, for emptying purposes. This opening would have to be tightly covered to prevent smell and attraction of insects.

In areas where the pits need regular desludging, as in the slums and many NHA projects, the pits should be located in such a way that they can directly be reached from the outside. A problem experienced in a number of the research sites, is that the hose for desludging has to enter through the living room in the house, thereby contaminating the home environment.

Location of toilet to incorporate cultural preferences

Cultural preferences of future residents have to be taken into account when planning the location of toilets in housing schemes. In Nong Hoy, almost all residents constructed a new toilet at the time they started building their houses. The location of the toilet in the middle of the plot was unacceptable to most because the preferred location is in the back of the house. In part of the houses in Tung Song Hong, a similar problem occurred. The planning and design departments in NHA, should be particularly aware of these kind of problems, to avoid the same mistake being made elsewhere.

Septic tanks preferred in NHA projects

The research showed that in the NHA project Chonburi I, where a cesspool was provided with the houses, many residents converted this system into a septic tank with soakaway pit. The main reason for this seems to be that people consider a one pit system to be too basic. A cesspool may be an acceptable system for people living in slums, but the residents living in NHA projects who do not belong to the lowest income groups prefer a more advanced type of system.

The anaerobic upflow filter needs improvement

More experimentation is needed to improve the functioning of the AUF. The filter in the AUF is made of crushed stones and the perforated pipe at the end of the inlet pipe is buried in the stones. The perforations in the pipe and the bottom layers of the stones easily get clogged. This problem can be avoided by regular backwashing. However, the AUF is often difficult to reach because they are located underneath the house or the street. Also people find cleaning of the excreta contaminated filters an unacceptable task. An improved AUF with crushed stones is now being installed by NHA in other projects, but it is doubtful whether the stones act well as a filter medium. Moreover, a hygienically safe cleaning system needs to be developed, to be carried out by EMO technicians or BMA desludging crews.

Over the last 10 years much research and field experimenting has been carried out on the development of the AUF. The rationale is that urban areas are rarely centrally sewered and that effluent from toilets is polluting surface water, such as klongs and canals. This has led to anoxious conditions of these waters and public health risks. The AUF is meant to further reduce the BOD, suspended solids and bacterial density of the waste water and so reduce the pollution of the urban surface waters and environment.

> *Because the filters with crushed stones are not functioning well, research is specifically done in different kind of filter media. Some of the filter media are made of plastic of various shapes. These media shapes take into account the best ratio of surface area and volume to create optimal conditions for sedimentation and micro-flora development and activities. These media seem to be highly efficient and do not clog up easily and can be used in the common reinforced concrete tanks. However, because these media are not being produced on a large scale, they are as yet rather expensive for low income housing projects. More try-outs are needed with a number of different AUF systems in NHA projects.*

Inclination of soil causes malfunctioning of sewers

Many of the sewers in Huay Kwang and Tung Song Hong are cracked because the soil was not compacted sufficiently at the time of construction. As a result of the soil inclination sewers are found to slope in the wrong direction and many connections of the branch sewers to the main sewers are broken, impeding the flow of sewerage. Silting of the sewers is widespread because sand comes in through the cracks. Much of the sewage leaks out into the ground and in Huay Kwang, some sewers are said to drain into the canal because the inverted slope makes flowing into the main sewer impossible.

An estimated 60-80 percent of the total volume of sewage in Huay Kwang does not reach the treatment plant, but directly contaminates the environment. This also has an adverse effect on the functioning of the treatment plant because the inflow of sewage is insufficient for the operating capacity of the plant and the sewage contains too much sand and solid waste which causes operational problems in the plants. Rehabilitation of the sewers in both projects is necessary and seems to be planned for the coming years.

Operation and maintenance requirements of sewers to be taken into account in the planning phase

In Huay Kwang, the sewers are designed to function by gravity, and are laid at a rather steep angle. This necessitates a specific machine for cleaning which is not easily available in Thailand. Insufficient consideration of operation and maintenance requirements at the planning stage is also evident in Tung Song Hong. The distances between the manholes are too long, which makes cleaning of the sewers difficult. Moreover, the sewers which also receive stormwater run-off, do not have sufficient capacity to discharge the excess rainwater during the rainy season, causing backflow into the septic tanks and difficulties in flushing.

Control on the upkeep of sewers required

Apart from the problems, caused by inclination of the soil, mentioned above, general maintenance of the sewer system needs improvement. Some of the sump pumps which are designed to accelerate the flow are removed and used for other purposes. The flow is also impeded by solid waste which can enter the sewers in places where the iron screen covers in the sumps are taken out.

Procedures for operation and maintenance of the treatment plants need to be improved

Close monitoring of the Tung Song Hong treatment plant is needed to establish what capacity of aerators is sufficient without consuming too much electricity. The operators figured that only one or two of the four aerators would do, but observation indicated insufficient aeration resulting in a dead-end corner in the lagoon. More experimenting is needed to find the right balance and the results should be used by the planning and design departments of NHA for future plants.

It is difficult to assess the extent of deficiency in operation and maintenance procedures and practice with respect to the quality of the effluent in Huay Kwang because the inflow of sewage is only a fraction of the inflow for which the plant is designed. But one sedimentation tank and one aeration tank are not in operation and mechanical parts are broken down as a result of poor maintenance. Also parts of the plant which do function, are not maintained and degradation of the equipment is visible everywhere. When the branch sewers are rehabilitated, also the functioning of the main sewer and the treatment plant need reassessment and rehabilitation. If the plant still has an over-capacity, after the rehabilitation process has been completed, it may be possible to connect neighbouring areas to the plant.

7.2 User Related Aspects

Environmental awareness to be raised

It cannot be expected that without public awareness of the health consequences of an unhygienic environment, people will be motivated to improve their sanitation systems. The awareness raising campaigns carried out in the 1950s by the Ministry of Public Health through public health officers in each neighbourhood, were successful to the extent that at present all households in urban areas have a toilet. At this stage, awareness raising should be focused on public health risks resulting from deficient functioning of toilets and disregard for environmental sanitation. It is therefore recommended that the government introduces activities aimed at increasing an interest in improving environmental conditions, for instance through public campaigns, through school curricula and possibly through primary health care channels and religious institutions. Care should be taken that both men and women are reached in these campaigns.

EMO tasks to include user education

Households in the NHA projects need to be better informed about the functioning of their sanitation system and the requirements for operation and maintenance. Although it is unlikely that people themselves would clean their AUFs, they should at least be aware of the need to have them regularly cleaned and how to get it done. Similarly, they need to know about the adverse effects of chemical cleaning agents on the chemical processes in septic tanks and the effects of throwing garbage in the toilet or in the sumps and drains. The staff in the EMO could for this purpose carry out regular briefing sessions for people who have newly moved in. Instruction leaflets should be available on the type of sanitation system in the houses and on the requirements for operation and maintenance. In addition, the EMO could try to enhance awareness through the community committees which are functioning in most NHA projects, for instance by yearly competitions on cleanest streets and/or apartment buildings.

7.3 Institutional Aspects

Attention for sanitation required in slum improvement projects

At present, slum improvement activities of the NHA do not include sanitation. Generally, slum improvement entails the provision of a piped water supply system and the construction of concrete footpaths and where possible drainage. As a result, the environmental sanitation remains an uncontrolled problem, especially in slums located in permanently flooded areas. There are various ways in which the NHA could include the improvement of environmental sanitation in its activities without the need for much extra funds. Examples are awareness raising about health risks resulting from an unhygienic environment and assessing together with the residents what can be done to improve existing sanitation systems to reduce environmental pollution.

Role of EMO in sanitation to be enhanced

The EMO can play a crucial role in maintaining environmental sanitation in the NHA project areas, but to make this happen, their technicians need additional training. The residents usually approach the EMO when problems arise concerning the sanitation systems. The technicians assist in solving the problems, but not always adequate. In the case of Tung Song Hong, the EMO technicians advised the residents to either bypass the Anaerobic Upflow Filter or to convert the filter into a simple soak-away. Whereas, this advice was practical, it was not good from an environmental hygiene point of view. Thus, technicians need to receive a training on the benefits and functioning of the AFU and on other sanitation systems

constructed in the project areas, including requirements for operation and maintenance of these systems, and what to do in case of problems.

Similarly, the EMOs role could be improved in approving the building plans for the individual houses constructed by the residents. In Nong Hoy, almost all residents planned to construct a septic tank with soakaway instead of the septic tank with AUF which was provided by the project. This was always approved by the EMO, regardless the implications for the environment or the fact that the NHA must have had a reason to originally install a different system.

Separate budget required for operation and maintenance of sewers and treatment plants

At present, there is no separate budget for operation and maintenance of the sewers and the treatment plants. Part of the funds have to come from the general budget of the EMO and part comes from a budget in NHA. The result of this situation is, that the EMO tries to save on expenditures for operation and maintenance, in favour of other tasks. Examples are the saving on electricity by functioning of only two aerators in Tung Song Hong and interrupted functioning of the plant in Huay Kwang. Additional savings are acquired by irregular cleaning of the sewers (not once a year, but less) and insufficient maintenance of the mechanical equipment at the plants. Expenditure sheets for the years 1985-1989 for Huay Kwang show that expenses for maintenance of the plant was on average only 9 percent of total operation and maintenance expenditures of the plant with two years of nearly 0 percent.

To remedy this undesirable situation, a budget should be established for operation and maintenance of sewerage systems and treatment plants, separate from the budget of the EMO for other activities. This budget should be sufficient for yearly inspection and cleaning of the sewers and replacement and/or rehabilitation of malfunctioning sections. The size of this budget should be based on a realistic cost estimate, rather than on the too low expenditure rate of the past.

Feedback system to be enhanced

Whereas regular monitoring is being done by the Central Services Division of the Community Housing Department and valuable information is available at EMO, this information is generally insufficiently used for corrective measures and project improvement. For example, regular monitoring of effluent is done at the plants, but the monitoring information is not used to improve performance. The staff at the plants is employed by the BMA, which makes direct supervision and suggestions for improvement by NHA staff more difficult. But the operators should be informed on the performance of the plant. They also should know how to correct the operation to attain a better performance.

Similarly, results of performance of sanitation systems at household level do not seem to be fed back into the planning and design departments of the NHA. Such as for instance, the fact that the Nong Hoy residents did not make use of the sanitation system provided because of the undesirable location. Also, the problems in Tung Song Hong with the AUF are known to the extent that an improved AUF is being installed elsewhere. However, only part of the problems is being addressed and no attention is paid to alternative filter media and cleaning procedures. It therefore seems doubtful if the improved AUF can provide a solution. Only clear monitoring procedures for the performance of sanitation systems and a clear feed back system into the planning and construction departments makes learning from the experience profitable.

NHA and BMA responsibilities need better tuning

Reflection is needed on the best division of responsibilities between NHA and BMA to optimize operation and maintenance of sewers and treatment plants. At present, the NHA is responsible for planning, design, construction and the first five years of operation and maintenance, after which the BMA takes over. However, the transfer from NHA to BMA is not without problems, with the BMA reluctant to take over the responsibility for operation and maintenance. One reason is that the BMA did not have any say in planning, design and construction of the systems. Another important reason is that the systems are already deteriorating before take over, thus putting BMA to great expense. In the first years after the take over, the NHA is paying half of the expenses on operation and maintenance, the amount of these expenses is based on a calculation of expenses paid in past years. Considering the fact that in some of these past years, expenditures on operation and maintenance were almost zero, the BMA is sceptical about this arrangement.

It may be a good idea for BMA to be actively involved in the planning of new sanitation systems to facilitate take-over. Also, take-over may be better immediately after completion of construction to avoid problems arising from (alleged) insufficient maintenance and to facilitate the establishment of a well functioning organization for operation and maintenance from the start. As an alternative, BMA could carry overall responsibility from the very beginning, with the obligation to use NHA services for the actual planning, design, calculation of cost and supervision of implementation. However, this may make it more difficult for NHA to include the cost for the main sewer and the plant in the price of the houses, especially in view of cross-subsidies in housing for different target groups. An optimal solution will require more discussion between NHA and BMA, which should take place as soon as possible and should result in a clear and agreed division of responsibilities.

Privatization of desludging services enhances efficiency

Privatization of the desludging services as is done in Chiang Mai and Chiang Rai can provide a good option for increased efficiency of the services and a reduction of cost. Not only will the municipal authorities earn on the concessions, but they are also relieved of the burden of the organization and management of desludging services. Private companies tend to be more customer oriented and give a good service to the households within a couple of hours after they are called. However, designation of a dumping ground and the control on hygienic desludging and dumping should remain the task of the municipal authorities to ensure that environmental pollution is kept to a minimum.

Desludging services in Bangkok require creative solutions

Because of the good experience with private companies in Chiang Mai and Chiang Rai, the possibilities were discussed for such a solution for Bangkok. The BMA is at the moment the only legal desludging service and they have to subsidize their services to the amount of Baht 1,150 per m^3. These high costs are mainly due to the facts that land prices are high and dumping sites and treatment plants are located at the edge of the city. This means that the desludging trucks have to transport the sludge a long way with many traffic jams, thus allowing for only a few trips per day.

Many private agencies are operating in Bangkok and their work is only profitable because they charge more than BMA and more importantly, because they do not transport the sludge to a legal dumping ground or treatment plant. They dump it at convenience as near as possible to their area of operation. It is unlikely that their activities will remain profitable if they also have to transport the sludge to legal sites. These problems call for a series of creative solutions.

To make desludging services less costly and less liable to illegal practices, it may for instance be possible to divide Bangkok in a large number of zones which are served by legal private desludgers who deliver the sludge to small treatment plants constructed by BMA. These treatment plants should be operated by BMA on a cost basis with the private companies paying per m3 dumped at the plant. This solution implies that part of the desludging services could be privatized, even in Bangkok, provided proper zoning is applied. However, measures should be taken to prevent unwanted monopolies of services and fees should be regulated by BMA. It may be that zonal treatment plants (and thus the desludging services) will require a permanent subsidy, to prevent that the cost for desludging will be expensive to the extent that more people will illegally connect their septic tanks to drains and open channels. But at least the present cost could be reduced, efficiency enhanced and environmental pollution minimized.
In addition, continued legal action will need to be taken against desludging companies for illegal operating and dumping.

Adapted desludging techniques required for slum areas

One of the problems encountered with desludging in slum areas - and probably an additional reason why people make holes in their cesspools - is that the desludging tankers of the BMA cannot always reach the houses. Although these tankers usually have hoses up to 35 meter and pumps strong enough to pump over such a distance, many houses in the slums (and sometimes even in NHA housing projects) cannot be reached. It is therefore recommended that BMA (and possibly private enterprises) look into the possibilities to use small pumping units to desludge or use booster pumps to bridge a longer distance than the present 35 meters.

Chapter 8: Issues in Operation and Maintenance: Lessons Learned

General lessons learned

Low-cost sanitation systems do offer a viable and satisfactory long term alternative for the safe disposal of human excreta in urban low-income areas provided that requirements for operation and maintenance are taken into account from the start. Operation and maintenance of low-cost sanitation systems is not an issue that only comes up when there are problems with the functioning or use of the installed systems, or when pits or tanks have to be emptied. Neither is it only a private concern of the individual households. Rather, proper operation and maintenance depends on integrating its requirements in planning, design, implementation, organization and management in partnership between government, private agencies and residents. This is the main conclusion from the research on operation and maintenance of sanitation systems in urban low-income areas in India and Thailand.

A second important conclusion is that the best solutions to meet requirements for operation and maintenance are always local specific. A legal framework and general guidelines are important pre-conditions as are municipal laws and regulations, standardized procedures and technical designs. However, actual decisions on the most suitable type(s) of sanitation systems and organization and management of operation and maintenance should always be based on the local conditions, both with respect to technical and socio-economic feasibility and to users preferences and capabilities.

A third major conclusion is that successful operation and maintenance is dependent on the one hand on sound organization and a clear division of responsibilities, and on the other hand on the knowledge, skills and motivation of both agency staff and residents. Operation and maintenance require a number of routine activities and a number of control actions to guarantee the safe disposal of human excreta. How responsibilities are best divided between government agencies, non-government organizations, private enterprises and residents is an issue requiring due consideration and agreement. Creating conditions in which the responsibilities can be implemented as intended requires awareness raising, training and incentives.

The need for a separate budget for operation and maintenance is the last major conclusion. This budget not only has to cover regular operation and maintenance, but should also allow for replacement and rehabilitation. Because this will only become necessary after a certain period, the budget needs to increase over time. A budget separate from other budgets is necessary to avoid diversion of funds for operation and maintenance for other purposes in a situation where municipalities are perpetually short of funds.

These conclusions may not be very striking as such. Others have pointed at one or more of these conclusions before, and they do not only apply to sanitation, but also to other infrastructural services such as water supply and solid waste collection and disposal. Rather, the striking thing is that the research shows how difficult it is to apply available knowledge, especially on a large scale and it indicates that major efforts should be directed to put into practice what is known, to make it actually happen.

Planning

Successful long term operation and maintenance starts with proper planning. Proper planning starts with a realistic assessment of the desired sanitation situation in an urban low-income area and the resulting operation and maintenance tasks and resources required. Thus it will be asking for problems, not to involve the parties responsible for operation and maintenance in this important phase.

The residents are always one important party to be involved. They are in the best position to indicate what are the preferred types and sites of latrines, what costs they are able and willing to bear and what tasks they can fulfil. Likewise it will be necessary to involve the agency or agencies carrying operation and maintenance responsibilities. Available manpower, skills, and equipment for operation and maintenance have to be taken into account, as have the funds required to cover the recurrent costs. If one or more resources are not sufficiently available, appropriate measures have to be taken to address identified constraints in time, or technical solutions have to be selected on the basis of resources available.

From the point of view of successful operation and maintenance the findings seem to indicate that the agencies and people responsible for operation and maintenance should be the same as the agencies and people responsible for planning and implementation. This to avoid decisions based on investment costs only, and to increase commitment and accountability. However, this may not always be realistic in view of the wider tasks and responsibilities of government agencies. In any case, those responsible for operation and maintenance have to be involved in the process of planning and implementation to ensure adaptation to local conditions and a sense of responsibility towards the system.

Technical design and costs

Standardization of technical designs has many advantages. It saves costs, it facilitates planning and training in latrine construction, it promotes quality standards of construction and it makes inspections and public health control easier.

But advantages of standardized designs will turn in disasters when they are not checked against and accordingly adapted to the local environment, the socio-economic conditions and the preferences of the residents. The adverse effects of using an unchecked standardized design are clearly shown by the findings of the research in India, where in some towns the sanitation systems cannot function because of impermeability of the soil or high groundwater tables. The problems are also clear from Thailand where the residents' acceptance of the septic tank with anaerobic upflow filter is low because the filter needs regular cleaning. Thus, involvement of local level authorities or institutions in planning and design is necessary, for which training and awareness raising is needed at that level.

To increase cost-effectiveness, it is not only important to check and, if necessary, adapt standardized designs both at neighbourhood and at household level, but also to look into possibilities to use locally available materials for the substructure and superstructure as this tends to lower the total costs.

More applied research is needed to experiment with technical designs. In Thailand, where nearly all households have a latrine, the main issue is how to prevent environmental pollution. This holds true especially for the slum areas with permanently standing water, but also concerns for example the septic tank with the poor functioning anaerobic upflow filter. In India, where large parts of the urban low-income population do not have access to a latrine,

finding lower cost options is an important area of investigation. The research finding that in many areas it takes many years before one of the pits of the double pit system is full, indicates that experiments are needed with smaller pits to save costs. Also, more attention should be given to short term and intermediate solutions such as public latrines and shared latrines. However, none of these applied researches should be carried out without applying the main lesson learned that operation and maintenance requirements should be an integrated part from the very beginning and that all relevant parties - government, private and residents - should be actively involved.

Implementation

Quality of construction is a pre-condition for proper operation and maintenance, and for the safe disposal of human excreta. The research indicated that the quality of construction as such is not a major problem, but that there are two issues that require due attention.

The first issue is that construction has to meet design standards. If this is not the case, problems will arise in operation and maintenance, for instance with junction boxes which are badly aligned or buried and waterseal pans requiring too much water or partly constructed septic tank systems. Some of these problems may be just practical or a cost factor, but others can be a direct threat to public health.

The second issue is the deliberate adaptations to make a sanitation system more convenient and/or cheaper with respect to operation and maintenance. These adaptations may be made at the time of construction, or afterwards, to alleviate problems with operation and maintenance. The research showed many such examples, like the holes made in the concrete rings to increase the leaching capacity of the pits in high water table areas in Thailand, the bypassing of the anaerobic upflow filter, the opening up at the same time of the two pits of the double pit system. The net result is that these systems do not provide for the safe disposal of human excreta, and thus do not meet their purpose in the first place. Rather, these wrongly adapted systems contribute to public health risks and environmental pollution.

Division of operation and maintenance responsibilities

Already in the planning phase, it is necessary to consider and take decisions about the division of operation and maintenance tasks and responsibilities between the local government, the residents and possible non-government organizations and private enterprises. The best strategy for the division of responsibility is local specific, but there are a few generalizations to make. Occasionally, the strategy will need evaluation to assess its cost-effectiveness and to decide on changes and improvements as appropriate.

The responsibility for operation and maintenance at household level of private latrines always rests with the household. The municipal authorities always have at least a control and a support role to play. Within this general framework there are many options for cost-effective operation and maintenance. In India, effective use was made of Non-Government Organizations but their involvement so far has been more directed to community based planning and implementation than to long term operation and maintenance. Both in India and Thailand the role of the local government in operation and maintenance seems to be defective at best, non-existent at worst. This is not to imply that the local government could not play an effective role, but that a number of measures have to be taken, both with respect to training and motivation and to organization and management (see below). The research also indicates that there is ample scope to involve the private sector.

Involvement of the private sector has great potential for better construction and operation and maintenance services provided the municipal authorities take their control and support role seriously to ensure that standards are kept and public health is served.
For example, involvement of local masons in India would have various advantages. It ensures that the technology is locally known and thus facilitates both additional latrine construction beyond official sanitation schemes and easily obtainable maintenance and repair services. Moreover, a local mason is known in the community which reduces the change of sub-standard construction. In some of the research sites in Thailand, the private desludging companies offer a good example of the advantage of private sector involvement. Not only do they provide timely services, but the local authorities even earn on the concessions, while they still have control over fees and dumping sites. The experience with private desludging services in both India and Thailand show the importance of dumping control.

Awareness raising, training and motivation

To carry out operation and maintenance responsibilities well and in time much more attention needs to be given to awareness raising, training and motivation. Government staff, private sector workers and the general public all require to have a basic awareness of the importance of safe excreta disposal. And, dependent on their further responsibilities, they need to have a sufficient understanding of the technical and health aspects of the various sanitation systems. For example, households need to understand how their double-pit latrine functions and why it should function in a certain way. The research findings indicate, that this understanding is often lacking and that this can result in deficient operation and maintenance. Also, examples in India and Thailand show that technical staff may give ill advice to solve sanitation problems due to a lack of knowledge. In addition, both technical skills and motivation are required to do a good job and training and incentives should provide for this. Both the local government and non-government organizations have a role to play in awareness raising, training and motivation to arrive at satisfactory operation and maintenance performance.

Operation and management

Proper operation and maintenance requires a clear organization and financial management. The research shows that this is an area for improvement, especially for the responsible municipal agency, and should be based on earlier decisions with respect to the best division of responsibilities (see above under the headings planning and division of operation and maintenance responsibilities). The various types, timing and frequencies of routine operation, maintenance and control activities have to be determined, job descriptions have to be made and tasks assigned, and implementation schedules have to be prepared and strictly followed. Monitoring and supervision is also required for good performance and timely adaptations.

Neglecting clear organization and management easily lead to dramatic results. Obvious examples are the closing down of public latrines and the abandonment of private latrines in India because no provisions are made for maintenance, desludging and repairs. In Thailand, due to deterioration of the sewers, only a fraction of the total volume of sewerage is reaching the treatment plant, which in turn cannot function properly with such a low inflow.

Proper management of operation and maintenance is only possible when there is a budget to carry out the necessary tasks. However, the research findings indicate that this is a major weak point. The municipal budget, which is usually already limited, often does not earmark funds specifically for operation and maintenance of sanitation systems, and thus funds may be easily spent on other activities which are politically more visible and financially more attractive. The need for regular maintenance and upkeep is not always recognized if the effects of lack of maintenance are not immediately visible. Apart from the need for a separate budget for routine operation and maintenance of sanitation systems, it is necessary that the budget allows for major replacements, upgrading and extensions. This budget should to a large extent be generated from the users of municipal infrastructure services.

Coordination between agencies

Successful operation and maintenance often requires coordination between different agencies. In the two countries, the sanitation systems require water, hence the operation and maintenance of the systems is usually very dependent on the functioning of the water supply. Yet, lack of water is a problem in a number of towns in India, affecting the performance of the sanitation systems. Similarly in both countries, the health departments are responsible for awareness raising to create a demand for improved sanitation and to help reduce environmental health risks. However, their actual involvement is largely lacking, although their importance is recognized. In one of the towns in India. where awareness raising and sanitation improvements were integrated, remarkable results were achieved.

Laws and regulations

Sanitation laws and regulations are necessary to provide an umbrella for proper operation and maintenance. In both countries such laws exist, but even if they apply to sanitation systems at household level, they are very difficult to enforce without a proper organizational set-up.

Increasing coverage and use

Although not exactly the focus of this research, the low coverage level and use of sanitation systems in urban low-income areas in India, as in many other parts of the world, justify to make some observations.

The research indicates that promoting a demand for sanitary latrines is a major precondition to reach a sustainable higher sanitation coverage. Awareness raising and joint decision making by government agencies and residents on locally best solutions are instrumental to this. Loans and grants may help to accelerate coverage, but only when embedded in a total approach based on motivation and participation in which also a properly organized cost recovery structure and a down payment to establish commitment and accountability should be included. If not, the money may easily go to people who can afford to construct a latrine by themselves, or result in latrines that are not used. It may also lead to non-repayment of loans due to lack of interest by municipal authorities and residents alike. The experience in India makes this clear. The experience in India also shows, what positive results can be achieved when hands are joined and motivation is high.

List of Abbreviations

AC	Asbestos cement
AUF	Anaerobic upflow filter
Baht	Thai currency (1992: 1$ = 26 baht)
BMA	Bangkok Metropolitan Administration
BOD	Biochemical oxygen demand
CMU	Chiang Mai University
DWF	Dry weather flow
EMO	Estate management office
FC	Faecal coliform
GRP	Glass fibre reinforced plastic
HDPE	High density polyethylene
HSMI	Human Settlements Management Institute
HUDCO	Housing and Urban Development Corporation
IDSMT	Integrated Development of Small and Medium Towns
IHS	Institute for Housing and Urban Development Studies
IRC	International Water and Sanitation Centre
KUWS&DB	Karnataka Water, Sewerage and Drainage Board
LCS	Low cost sanitation
Lpcd	Litre per capita per day
MPN	Most probable number
NEB	National Environmental Board
NGO	Non-governmental organization
NHA	National Housing Authority
PVC	Polyvinyl chloride
Rs	Rupees, Indian currency (1992: 1$ = Rs 28)
SS	Suspended solids
TNWS&DB	Tamil Nadu Water, Sewerage and Drainage Board
UBS	Urban Basic Services
UBSP	Urban Basic Services for the Poor
UNCHS	United Nations Centre for Human Settlements
UNDP	United Nations Development Programme
RCC	Reinforced concrete
UNICEF	United Nations Children's Fund

Bibliography

All India Institute of Hygiene and Public Health (1988). Pour flush water seal latrines : design, construction and maintenance. Session in a workshop on "Low cost on-site sanitation in urban areas", Calcutta, 22-24 August 1988. Calcutta, India, All India Institute of Hygiene and Public Health

All India Institute of Hygiene and Public Health (1988). Operation and maintenance problems with particular reference to community latrines. Session in a workshop on "Low cost on-site sanitation in urban areas", Calcutta, 22-24 August 1988. Calcutta, India, All India Institute of Hygiene and Public Health

All India Institute of Hygiene and Public Health (1988). Socio-economic and cultural aspects of sanitation, hygiene education, people's participation and the role of women. Session in a workshop on "Low cost on-site sanitation in urban areas", Calcutta, 22-24 August 1988. Calcutta, India, All India Institute of Hygiene and Public Health

Asian Institute of Technology and Coopers & Lybrand Associates (1988). Economic, institutional and technical implications of alternative urban sanitation and recycling options : a case study of Chonburi, Thailand. (AIT research report ; no. 230). Bangkok, Thailand, Asian Institute of Technology

Bakhteari, Quratul Ain and Wegelin-Schuringa, Madeleen (1992). *From sanitation to development : the case of the Baldia soakpit pilot project*. (Technical paper series / IRC ; no. 31). The Hague, The Netherlands, IRC International Water and Sanitation Centre

Baldisimo, Julito M.; Lohani, B.N. and Evans, Warren (1988). Scavenging of municipal solid waste in Bangkok, Jakarta and Manila. (Environmental Sanitation Reviews ; no. 26). Bangkok, Thailand, Environmental Sanitation Center

Bamberger, Michael and Hewitt, Eleanor (1986). Monitoring and evaluating urban development programs : a handbook for program managers and researchers. (World Bank technical paper ; no. 53). Washington, DC, USA, World Bank

Bijlani, H.U. and Chakrabarty, B.K. (1983). Low cost sanitation and affordable shelter. In: *AIHDA journal*, no. 1, p. 57-86

Boesch, Andrew and Schertenleib, Roland (1985). Emptying on-site excreta disposal systems : field tests with mechanized equipment in Gaborone (Botswana). (IRCWD-report; no. 03/85). Duebendorf, Switzerland, International Reference Centre For Waste Disposal

Bomba, Winson G. (1980). The role of health education in sanitation programme. In: Sanitation in developing countries : proceedings of a workshop on training held in Lobatse, Botswana, 14-20 August 1980. (IDRC report ; no. 168e). Ottawa, Ont., Canada, International Development Research Centre. p. 101-104

Brooke, Simon and Lindfield, Michael (1988). *Managing urban infrastructure upgrading : a Thailand case*. Sydney, Australia, Sinclair and Knight

Cairncross, Sandy (1988). Small scale sanitation. [3rd ed.] (Ross Institute of Tropical Hygiene bulletin ; no. 8). London, UK, Ross Institute of Tropical Hygiene, London School of Hygiene and Tropical Medicine

Cairncross, Sandy and Feachem, Richard G. (1983). *Environmental health engineering in the tropics : an introductory text*. Chichester, UK, John Wiley

Central Building Research Institute, India (1987). Low cost sanitation for rural and urban houses. Rev. ed. (Building research note). Roorkee, India, Central Building Research Institute, India

Central Public Health and Environmental Engineering Organisation (1978). Conversion of bucket privies into sanitary water-seal latrines : report on a National Seminar, Patna, May 25, 26 and 27, 1978. New Delhi, India, Central Public Health and Environmental Engineering Organisation, Ministry of Works and Housing

Chandler, Charles G. (1985). Achieving success in community water supply and sanitation projects. (SEARO regional health papers ; no. 9). New Delhi, India, World Health Organization, Regional Office for South-East Asia

Clifton, R.H. (1974). *Principles of maintenance*. London, UK, Edward Arnold

Cross, Piers (1982). A review of sociological aspects of urban sanitation : March 18 - April 9 1982. Maseru, Lesotho, Housing Division, Ministry of Interior

Directorate of Panchayati Raj (1989). Spot survey sanitation activities in the rural areas of Uttar Pradesh. Lucknow, India, Directorate of Panchayati Raj

Donnelly-Roark, Paula (1980). New participatory frameworks for the design and management of sustainable water supply and sanitation projects. (WASH Technical report ; no. 52). Arlington, VA, USA, Water and Sanitation for Health Project

Elmendorf, Mary and Buckles, Patricia K. (1980). Socio-cultural aspects of water supply and excreta disposal. (Appropriate technology for water supply and sanitation ; vol. 5). Washington, DC, USA, World Bank

Gibbs, Ken (1984). Privacy and the pit privy - technology or technique? In: *Waterlines*, vol. 3, no. 1, p. 19-21

Government of Botswana; UNICEF; World Bank and UNDP (1988). Self help environmental sanitation project : end of project evaluation report. New York, NY, USA, United Nations Children's Fund

Hardoy, Jorge E. and Satterthwaite, David (1987). Housing and health : do architects and planners have a role? (Offprint series ; no. HS11). London, UK, International Institute for Environment and Development

Hasan, S.M. (1984). Evaluation of low cost twin pit pour flush latrines in ten sub-divisional towns of Bangladesh. New York, NY, USA, United Nations Development Programme

HUDCO and HSMI (1991). Evaluation study of low cost sanitation programme : Madya Pradesh. New Delhi, India, Urban Infrastructure Wing, Housing and Urban Development Corporation

HUDCO and HSMI (1991). Evaluation study of low cost sanitation programme : Andra Pradesh. New Delhi, India, Urban Infrastructure Wing, Housing and Urban Development Corporation

HUDCO and HSMI (1991). Evaluation study of low cost sanitation programme : Maharashtra. New Delhi, India, Urban Infrastructure Wing, Housing and Urban Development Corporation

HUDCO and HSMI (1991). Evaluation study of low cost sanitation programme : West-Bengal. New Delhi, India, Urban Infrastructure Wing, Housing and Urban Development Corporation

Jampa, Sudjai (1987). Suitable and practical waste treatment systems for communities : a proposal report to the National Housing Authority. Bangkok, Thailand, Chulalongkorn University

Khare, R.S. (1962). Ritual purity and pollution in relation to domestic sanitation. In*: Eastern anthropologist*, vol. 15, no. 2, p. 125-139

Kywe, Aung (1986). Acceleration of sanitation programmes through community participation in Burma. Rangoon, Myanmar, World Health Organization

Leksakundiloke, A. (1981). Preparation of training course programme on implementation of low cost sanitation in Thailand. (IHS report ; no. 859). Rotterdam, The Netherlands, Institute for Housing and Urban Development Studies

Lewis, W. John; Foster, Stephen S.D. and Drasar, Bohumil S. (1982). The risk of groundwater pollution by on-site sanitation in developing countries : a literature review. (IRCWD-report ; no. 01/82). Duebendorf, Switzerland, International Reference Centre for Waste Disposal

Makhatha, S.N. (1987). Single and double pits in Lesotho. In: Rural water and engineering development in Africa : the edited proceedings of the 13th WEDC conference, Malawi, 6-10 April 1987. Loughborough, UK, Water Engineering and Development Centre, Loughborough University of Technology. P. 32-35

Mangal, R.C. (1985). Water supply and sanitation : research activity in Roorkee, India. In: Olsson, Eskil. Seminar on apropriate technology for water supply sanitation in developing counties. (Document ; no. D19:1985). Stockholm, Sweden, Swedish Council for Building Research. p. 51-55

Mara, D. Duncan (1982). Appropriate sanitation alternatives for low income communities : a brief introduction. In: Appropriate technology for water supply and sanitation. Washington, DC, USA, World Bank

Mara, D. Duncan (1984). The design of ventilated improved pit latrines. (TAG technical note ; no. 13). Washington, DC, USA, World Bank

Mara, D. Duncan (1985). The design of pour-flush latrines. (TAG technical note ; no. 15). Washington, DC, USA, World Bank

Mara, D. Duncan (1985). Technical and public health aspects of low cost sanitation programme planning. In: Olsson, Eskil. Seminar on appropriate technology for water supply sanitation in developing countries. (Document ; D19:1985). Stockholm, Sweden, Swedish Council for Building Research. p. 6-28

Mara, D. Duncan (1985). Ventilated improved pit latrines : guidelines for the selection of design options. (TAG discussion paper ; no. 4). Washington, DC, USA, World Bank

Matiting, P.M. (1980). Problems of acceptability of low-cost sanitation programs. In: Sanitation in developing countries : proceedings of a workshop on training held in Lobatse, Botswana, 14-20 August 1980. (IDRC report ; no. 168e). Ottawa, Ont., Canada, International Development Research Centre. p. 111-112

Mbere, N. (1980). Some sociological aspects of sanitation provision (with particular reference to Botswana). In: Sanitation in developing countries : proceedings of a workshop on training held in Lobatse, Botswana, 14-20 August 1980. (IDRC report ; no. 168e). Ottawa, Ont., Canada, International Development Research Centre. p. 105-110

Menaruchi, Anant et al. (1985). Research report on methodology for community based sanitation development program including financial management. Khon Kaen, Thailand, Banphai District Hospital

Ministry of Home Affairs (1988). Study on the operations and maintenance of city infrastructure : final report. Jakarta, Indonesia, Directorate-General of PUOD, Ministry of Home Affairs

Ministry of Local Governement and Rural Development (1988). Orangi Pilot project : paper for the national workshop on rural water supply and sanitation, 5-7 April 1988. Karachi, Pakistan, Ministry of Local Governement and Rural Development

Ministry of Panchayat and Local Development and UNICEF (1982). A policy for sanitation : report of the conference held in Pokhara 6-11 October 1982 : part II: sanitation. Kathmandu, Nepal, Ministry of Panchayat and Local Development

Muller, Mike (1988). Increasing the effectiveness of a latrines programme. In: *World health forum*, vol. 9, no. 3, p. 345-351

Munch-Petersen, Nils Finn (1989). Low cost sanitation in Bangladesh as related to the Low cost sanitation project covering 84 pourashavas : consultants report. Copenhagen, Denmark, Hoff and Overgaard

Naju, F.Z. (1985). Low cost sanitation : a state of the art review. In: Olsson, Eskil. Seminar on Appropriate technology for water supply sanitation in developing countries. (Document ; no. D19:1985). Stockholm, Sweden, Swedish Council for Building Research. P. 56-63

Ngamkitpiboon, Ch. (1981). Low cost sanitation with special reference to on-site sewage systems. (IHS-report ; no. 886). Rotterdam, The Netherlands, Institute for Housing Studies

Orth, Hermann (1988). A comparison of alternative sanitation options applied to a medium sized town. In: Asian Institute of Technology. Seminar on Anaerobic waste treatment and sanitation technologies, Bangkok, Pattaya, 1-3 September 1988. Bangkok, Thailand, Environmental Engineering Division, Asian Institute of Technology. 19 p.

Otis, Richard J. and Mara, D. Duncan (1985). The design of small bore sewer systems. (TAG technical note ; no. 14). Washington, DC, USA, World Bank

Pacey, Arnold (1978). *Sanitation in developing countries.* Chichester, UK, Wiley

Parlato, Ronald (1984). A monitoring and evaluation manual for low cost sanitation programs in India. (TAG technical note ; no. 12). Washington DC, USA, World Bank

Parlato, Ronald (1989). Marketing low cost sanitation : issues paper. Washington, DC, USA, World Bank

Patel, M. (1980). Environmental determinants of health and their influence on infant mortality : the case of Sri Lanka. In: *Marga Journal*, vol. 6, no. 1, p. 67-80

Pathak, Bindeshwar (1981 [?]). Sulabh Shauchalaya : hand flush water seal latrine : a simple idea that worked. Patna, India, Amola Prakashan

Pathak, Bindeshwar (1989). Task force on the problems of scavengers. New Delhi, India, Sulabh International

Pathak, Bindeshwar and Mazumdar, N.B. (1987). Sanitation for low cost housing colonies. In: Workshop on "Low cost infrastructure and urban environment". New Delhi, India, Institute of Town Planners and Sulabh International

Perrett, Heli (1983). Social feasibility analysis in low-cost sanitation projects. (TAG technical note ; no. 5). Washington, DC, USA, World Bank

Perrett, Heli E. (1984). Monitoring and evaluation of communication support activities in low-cost sanitation projects. (TAG Technical note ; no. 11). Washington, DC, USA, World Bank

Perrett, Heli E. (1985). Involving women in sanitation projects. (TAG discussion paper ; no. 3). Washington, DC, USA, World Bank

Prakash, Ved (1986). Role and structure of user charges in financing urban services in developing countries. In: *Regional development dialogue*, vol. 7, no. 2, p. 1-24

Priel, V.Z. (1974). Systematic maintenance organisation. London, UK, MacDonald and Evans

Professional Social Workers Forum (1988). Health for all through household toilets. (Training series ; no. 2). Madras, India, Professional Social Workers Forum

Raj, Mulkh (1991). Financing of urban infrastructure in India. New Delhi, India, Housing and Urban Development Corporation

Rao, B.B. (1983). Low cost sanitation solutions. In: *AIHDA journal*, no. 1, p. 38-56

Rashid and Skytta (1989). Bangladesh : United Nations Development Programme/World Bank Low Cost Sanitation Project (BGD/85/004) : evaluation report. New York, NY, USA, United Nations Development Programme

Rijnsburger, Jaap (1990). Emptying pit latrines : WASTE fills a vacuum in Dar es Salaam, Tanzania. In: *AT source*, vol. 18, no. 2, p. 29-33

Roy, A.K. (1985). Low cost water-seal latrine programme in urban communities of India. Washington, DC, USA, World Bank

Roy, A.K. (1989). Review of low cost sanitation technologies in India : revised assignment report (Oct. 15, 1989 to Dec. 29, 1989 limited to 16 working days). [S.L., S.N.]

Roy, A.K. et al. (1984). Manual on the design, construction and maintenance of low-cost pour-flush waterseal latrines in India. (TAG technical note ; no. 10). Washington, DC, USA, World Bank

Runyoro, S.K. (1981). Pit latrine emptying. Loughborough, UK, Department of Civil Engineering, Loughborough University of Technology

Ryan, Beverly A. and Mara, D. Duncan (1983). Pit latrine ventilation : field investigation methodology. (TAG technical note ; no. 4). Washington, DC, USA, World Bank

Rybczynski, Witold; Chongrak Polprasert and McGarry, Michael (1978). *Low-cost technology options for sanitation : a state-of-the-art review and annotated bibliography.* Ottawa, Ont., Canada, International Development Research Centre

Sarma, Sanjib and Malhotra, Rajiv (1988). HUDCO basic sanitation scheme, Raipur, Madhya Pradesh. New Delhi, India, Human Settlement Management Institute

Sarma, Sanjib and Jansen, Marc (1989). Use and maintenance of low cost sanitation

facilities : study of Srinagar city, Jammu and Kashmir. New Delhi, India, Human Settlement Management Institute

Sarma, Sanjib; Dave, Suresh and Jansen, Marc (1989). Use and maintenance of sanitation facilities in low income shelter areas : study of Malkapur town, Maharashtra. New Delhi, India, Human Settlement Management Institute

Scalf, Marion R. and Dunlap, William J. (1977). Environmental effects of septic tank systems. Springfield, VA, USA, National Technical Information Service

Simbeye, E.K. (1980). On-site excreta disposed technologies. In: Sanitation in developing countries : proceedings of a workshop on training held in Lobatse, Botswana, 14-20 August 1980. (IDRC report ; no. 168e). Ottawa, Ont., Canada, International Development Research Centre. P. 27-33

Simpson-Hebert, Mayling (1983). Methods for gathering socio-economic data for water supply and sanitation projects. (TAG technical note ; no. 1). Washington, DC, USA, World Bank

Sinha, Bakshi D. and Ghosh, Arun K. (1990). *Evaluation of low-cost sanitation : liberation, training and rehabilitation of scavengers.* New Delhi, India, Arnold Publishers

Sulabh International (1986). Project report on low cost pour- flush latrines in urban areas : Chandralok, Durgapuri and Jaggiwan Nagar. Patna, India, Sulabh International

Sulabh International (1986). Project report on low cost pour-flush latrines in Najafgarh Town. Patna, India, Sulabh International

Sundararaman, Veena (1986). The social feasibility study in the role of women in rural sanitation (report of the study in four villages of Maharashtra State). Bombay, India, Research Centre on Women's Studies, SNDT Women's University

Tim Koordinasi Pembangunan Perkotaan (1988). Policies for city infrastructure operation and maintenance in Indonesia. Draft. Jakarta, Indonesia, Tim Koordinasi Perkotaan, Ministry of Home Affairs and Finance

Trinidad, A. and Robles-Austriaco, L. (1987). *Ferrocement pour flush latrine*. Bangkok, Thailand, International Ferrocement Information Center

UNCHS (1984). A review of technologies for the provision of basic infrastructure in low-income settlements. Nairobi, Kenya, United Nations Centre for Human Settlements

UNCHS (1986). The design of shallow sewer systems. Nairobi, Kenya, United Nations Centre for Human Settlements

UNCHS (1989). Urban management programme : issues of operation and maintenance : problem inventory, strategic options, planning, programming and budgeting, management of monitoring and operation. Draft. Nairobi, Kenya, United Nations Centre for Human Settlements

UNEP (1988). Environmental guidelines for domestic wastewater management. (UNEP environmental management guidelines ; no. 14). Nairobi, Kenya, United Nations Environment Programme

Vines, Marcus; Reed, Bob and Pickford, John (1989). Reduced cost sewerage for developing countries. Loughborough, UK, Water, Engineering and Development Centre, Loughborough University of Technology

Viraraghawan, T. and Biswars, N. (1986). On-site waste water management : North-American experience and possible lessons for India and other developing countries. In: *International journal for development technologies*, vol. 4, p. 99-109

Ward, Catherine F. and Foster, Stephen S.D. (1981). On-site sanitation and groundwater quality : a methodology for monitoring. Duebendorf, Switzerland, International Reference Centre for Waste Disposal

Ward, Catherine F. (1989). Groundwater quality monitoring in relation to on-site sanitation in developing countries. In: *Journal of the Institution of Water and Environmental Management*, vol. 3, no. 3, p. 295-302

Watt, S.B. (1976). Village sanitation improvement scheme, India. In*: Appropriate Technology*, vol. 2, no. 4, p. 15-16

Watt, S.B. (1984). *Septic tanks and aqua-privies from ferrocement*. London, UK, Intermediate Technology Publications

Wegelin-Schuringa, M. (1991). *On-site sanitation : building on local practice*. (Occasional paper series / IRC ; no. 16). The Hague, The Netherlands, IRC International Water and Sanitation Centre

WHO (1983). *Minimum evaluation procedure (MEP) for water supply and sanitation projects*. Geneva, Switzerland, World Health Organization

WHO, Regional Office for South-East Asia (1984). Low cost water supply and sanitation technology : pollution and health problems. (SEARO regional health papers ; no. 4). New Delhi, India, World Health Organization Regional Office for South-East Asia

WHO, Regional Office for South-East Asia and UNDP (1985). Case study on community attitudes towards public and private toilets, Maldives. New Delhi, India, World Health Organization Regional Office for South-East Asia

Wijk-Sijbesma, Christine van (1987). Drinking water and sanitation: women can do much. In: *World Health Forum*, vol. 8, no. 1, p. 28-32

Wilson, J.G. (1985). Low cost sanitation in Botswana. In: Olsson, Eskil. Seminar on appropriate technology for water supply sanitation in developing countries. (Document ; no. D19:1985). Stockholm, Sweden, Swedish Council for Building Research. P. 64-72

World Bank (1984). Master plan and feasibility report on low cost water seal latrine programme in 15 towns of Madhya Pradesh. Vol. I and II. Washington, DC, USA, World Bank

World Bank (1985). Evaluation on community latrines in Tamil Nadu. Washington, DC, USA, World Bank

Zajac, Vincent (1984). Urban sanitation planning manual based on the Jakarta case study. (World Bank technical paper ; no. 18) (Appropriate Technology for Water Supply and Sanitation ; no. 14). Washington, DC, USA, World Bank