School of Civil Engineering

Tropical Public Health Engineering Research Group

Low-cost Sanitation Improvements in Poor Communities:

Conditions for Physical Sustainability

A thesis submitted in fulfilment of the requirements for the award of the degree of

Doctor of Philosophy

by

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To my Family and Friends,

for all their love, support and encouragement

The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

During the last decades of the twentieth century, alternative solutions for provision of sanitation were put into practice in Brazil. These unconventional programmes, which embrace not only innovative technologies but also new social approaches, raised concerns about community/institution participation in both the implementation and the operation & maintenance (O&M) of low-cost sanitation systems.

The aim of the study reported herein was to identify and assess factors likely to influence the long-term sustainability of these low-cost sanitation programmes. For this, six sanitation programmes were studied regarding: the selection and design of the systems technologies; affordability and participation of the institutions on the management of the programme; acceptability/satisfaction of the users; and, possible social/health improvements brought to the communities. Data on these parameters were obtained by studying the documentation of the programmes, via interviews with stakeholders, observation of the systems' O&M schemes, technical inspection of the units and household questionnaire surveys.

The capacity of institutions in complying with the O&M requirements of the sanitation technologies was of major importance for the sustainability of the programmes. As to the strategies for O&M, the six case studies provided a rich scenario with different administrative levels (community or state companies) and maintenance schemes (centralised, decentralised or participatory). Regardless of the solution adopted, the lack of commitment of the institutions involved in the O&M scheme was among the main factors negatively influencing the sustainability of the programmes.

The four case studies based on condominial sewerage showed that enough experience had been accumulated for the reliable implementation of this technology. However, two important aspects of vulnerabilities were the lack of efficacy of the O&M schemes and deficiencies in users' awareness for the adequate utilisation of the systems.

Educational programmes are essential for the process of implementation of the sanitation systems, and these were included in all programmes studied. Nevertheless, the continuity in the delivery of educational messages was frequently neglected, in spite of its importance for both the maintenance of the implemented systems and the improvements in the social and health conditions of the poor communities.

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Abbreviations

ABES	Brazilian Association of Sanitation Engineering
BMS	Brazilian Minimum wage
BNH	National Housing Bank
CAERN	Water and Sanitation Company of Rio Grande do Norte
CAESB	Water and Sanitation Company of Brasilia
CAGECE	Water and Sanitation Company of Ceará
CEF	Brazilian Federal Savings Bank
COMPESA	Water and Sanitation Company of Pernambuco
DALY	Disability-adjusted Years of Life
DFID	Department for International Development
EMLURB	Municipal Company fir Urban Refuse Collection
FECOMO	Federation of the Olinda Residents Association
FIDEM	Foundation for Municipal Development
IBGE	Brazilian Institute of Geography and Statistics
KfW	Kreditanstalt für Wiederaufbau
MEP	Minimum Evaluation Procedure
O&M	Operation and Maintenance
ORS	Oral Rehydration Solution
PAHO	Pan American Health Organization
PHAST	Participatory Hygiene and Sanitation Transformation
PLANASA	National Plan of Sanitation
PREZEIS	Plan for the Regularization of the Special Zones of Social Interest
R$	Brazilian Reais
SANESUL	Water and Sanitation Company of Mato Grosso do Sul
SI	Sustainable Indicators
SISAR	Rural Sanitation Integrated System
STW	Sewerage Treatment Plant
SUDENE	Superintendence for the development of the Northeast
TIL	Tubs for Inspection and Cleansing
UN	United Nations
UNESCO	United Nations educational, Scientific and Cultural Organization
URB-Olinda	Urbanisation Company of Olinda
URL	Universal Resources Identifier
URB-Recife	Urbanisation Company of Recife
USAID	United States Agency for International Development
US$	United States Dollars
VDR	Reduced Flush Toilet Bowls
VIP	Ventilated Improved Pit
WCED	Water, Engineering and Development Centre
WHO	World Health Organisation
ZEIS	Special Zones of Social Interest

Chapter 1: Introduction

1.1. Introduction

1.1.1. Infrastructure Services in Developing Countries

Health problems in developing countries are frequently associated with the lack of basic infrastructure services such as water supply, sanitation, solid waste collection and housing.

One of the major causes of disparities between the health burden in developing and developed countries is the lack of adequate hygienic practices, which may result from both inadequate education and the absence of basic infrastructure. Therefore, the implementation of physical systems that are technically, socioculturally and economically adequate for the recipient users, as well as the promotion of better hygiene practices, are seen as absolutely relevant aspects for those who believe in the prevention of communicable diseases through environmental improvements and hygiene education.

Environmental modifications as a way of health promotion are not a new proposal. In the middle of the 19^{th} century, Chadwick reported to the United Kingdom parliament the precarious life conditions of the urban poor population at that time, and suggested the implementation of water supply and sewage collection systems to improve the health status of those communities (Chadwick, 1842). Additionally, WHO (1995) stated that "...the major factor in the improvement in health in the UK and other developed countries in the 19^{th} and 20^{th} centuries was not advances in medical care and technology, but certain social, environmental and economic changes: limitation in family size, increase in food supplies, a healthier physical environment, and specific preventive and therapeutic measures".

Although in the last decades of the 20^{th} century efforts have been made to promote and support water supply and sanitation programmes in the developing world at both international and local levels (as examples, the International Drinking Water Supply and Sanitation Decades; and Safe Water 2000), billions of people are still suffering from the absence of services. The amplitude of lack of services in this sector in the world can be illustrated by the following data (Kalbermatten & Middleton, 1998):

- One billion people lack safe water;
- Two billion people lack safe sanitation;
- Four billion people lack sewage treatment;

- All of them cannot realise their aspirations for a better life because they lack a healthy environment and, as a result, have only limited economic opportunities; and
- Three million children die from water-related, especially diarrhoeal, diseases each year.

Recent data confirmed the dimension of the above figures, by indicating that at the beginning of 2000 1.1 billion people worldwide were without access to improved water supplies and 2.4 billion without access to improved sanitation (WHO/UNICEF, 2000). This lack of service is, however, concentrated in the less developed regions of the world, as shown in Table 1.1.

Table 1.1. – Population lacking improved water supply and sanitation by regions of the world

Region	Lacking Improved Water Supply		Lacking Improved Sanitation	
	Rural	Urban	Rural	Urban
North America	0 %	0 %	0 %	0 %
Europe	13 %	0 %	26 %	1 %
Oceania	37 %	2 %	19 %	1 %
Latin America and The Caribbean	38 %	7 %	51 %	13 %
Asia	25 %	7 %	69 %	22 %
Africa	29 %	6 %	62 %	14 %

Source: WHO/UNICEF,2000

The above information clearly stresses that consistent actions are still needed to improve the quality of life of the poor in developing countries, which are, in general, currently undergoing a rapid increase in their urban population as discussed below.

1.1.2. The Urban Poor Population

The rapid urban growth evidenced mainly in the second half of the last century and the inability of developing country governments to provide opportunities for improved housing and basic services are intensifying the development of slums in urban centres.

Usually, these urban slums, known as *favelas* in Brazil, are formed suddenly when families invade unoccupied areas and build their homes using any available materials such as cardboard, sticks, mud and plastic sheets. These slums are, therefore, illegal settlements that do not follow any building recommendations, resulting in unsafe and densely occupied areas without any official infrastructure service.

This is certainly a picture of a huge social problem, which is not easy to solve without determination and political commitment. These people have no other place to live, they are illegal and they are poor (which would means *unimportant* for many politicians and officials).

The sanitation solutions (which are the main focus of this study) adopted by poor communities in squatter settlements are nearly always inadequate and promote a poor environment, which favours the transmission of diseases. Therefore, it is not surprising that health indicators, such as the infant mortality rate, are now at higher rates in the urban slums than in rural areas (Figure 1.1).

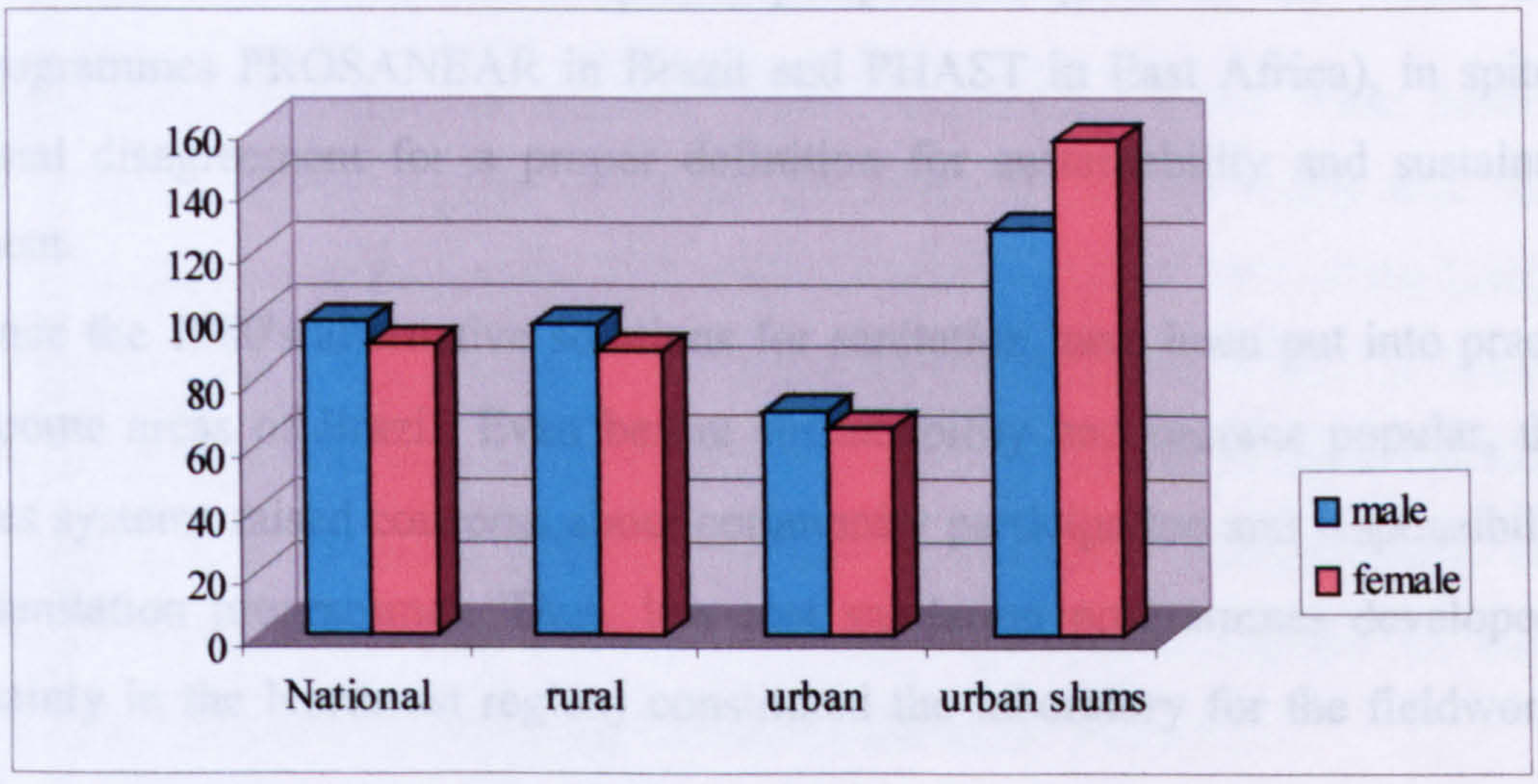


Figure 1.1. - Infant mortality rates in Bangladesh (1991). *Source: Mara (1996)*

Moreover, urban slums have a very high population growth rate. As stated in Choguill & Choguill (1996), "even in cities that are growing by as much as 10% a year, in many instances the percentage of slum dwellers and squatters is growing at twice that rate". The same authors also quoted data from UNCHS (1987) which report that the proportion of people living in informal settlements is making up as much as 32% of the population of São Paulo, 33% of Lima, 34% of Caracas and 59% of Bogota, and even worse, 85% of Addis Ababa, 70% of Luanda and 60% of Dar es Salaam.

1.1.3. Towards Sustainable Services

Sustainability may be interpreted in low-cost sanitation programmes as a pathway to drive systems towards their aims, changing the top-down managerial model of implementation, and designing systems with larger boundaries including social, economical and ecological aspects.

Thus, sustainable development concepts enable the technical (engineering) sanitation systems to be seen as just one part of a lager project, which should be also committed to health and social improvements.

Reed (1995) suggests that, towards sustainability, sanitation systems should be interpreted as *replicable* and *maintainable* systems. The term *replicability* is used to express a technically suitable, socially acceptable and economically affordable system, whilst the term *maintainability* refers to the proper operation of the systems during the totality of its design life.

Throughout the developing world, international agencies are funding programmes under sustainable development perspectives (such as the World Bank funded programmes PROSANEAR in Brazil and PHAST in East Africa), in spite of controversial disagreement for a proper definition for sustainability and sustainable development.

Since the 1980's alternative solutions for sanitation have been put into practice in low-income areas of Brazil. Even before sustainability had become popular, these alternatives systems raised concerns about community participation and responsibilities towards sanitation programmes. Thus, low-cost sanitation programmes developed in Brazil (mainly in the Northeast region) constituted the laboratory for the fieldwork of this study.

1.2. Brazil and Its Northeast Region

1.2.1. General Aspects

The Federative Republic of Brazil is a five hundred year old country which was discovered and colonised by Portugal and obtained its independence in 1822. Brazil has a territorial area of 8.5 million km^2 and is the fifth most populous country in the world with approx. 170 million people, based on the 2000 census (IBGE, URL-15, 2000).

The urban population in Brazil increased from one-third in 1940 to more than two-thirds in 1980 and to five-sixths in 2000 (IBGE, URL-22, 1996; URL-15, 2000). The average annual growth rate of the Brazilian population between 1980 and 1991 was 1.9%, representing a marked decline from the rates of 2.5% and 2.9% registered during the 1970's and 1960's, respectively (PAHO, URL-17, 1995). The increase of the country's population and of its urban population are illustrated in Figure 1.2.

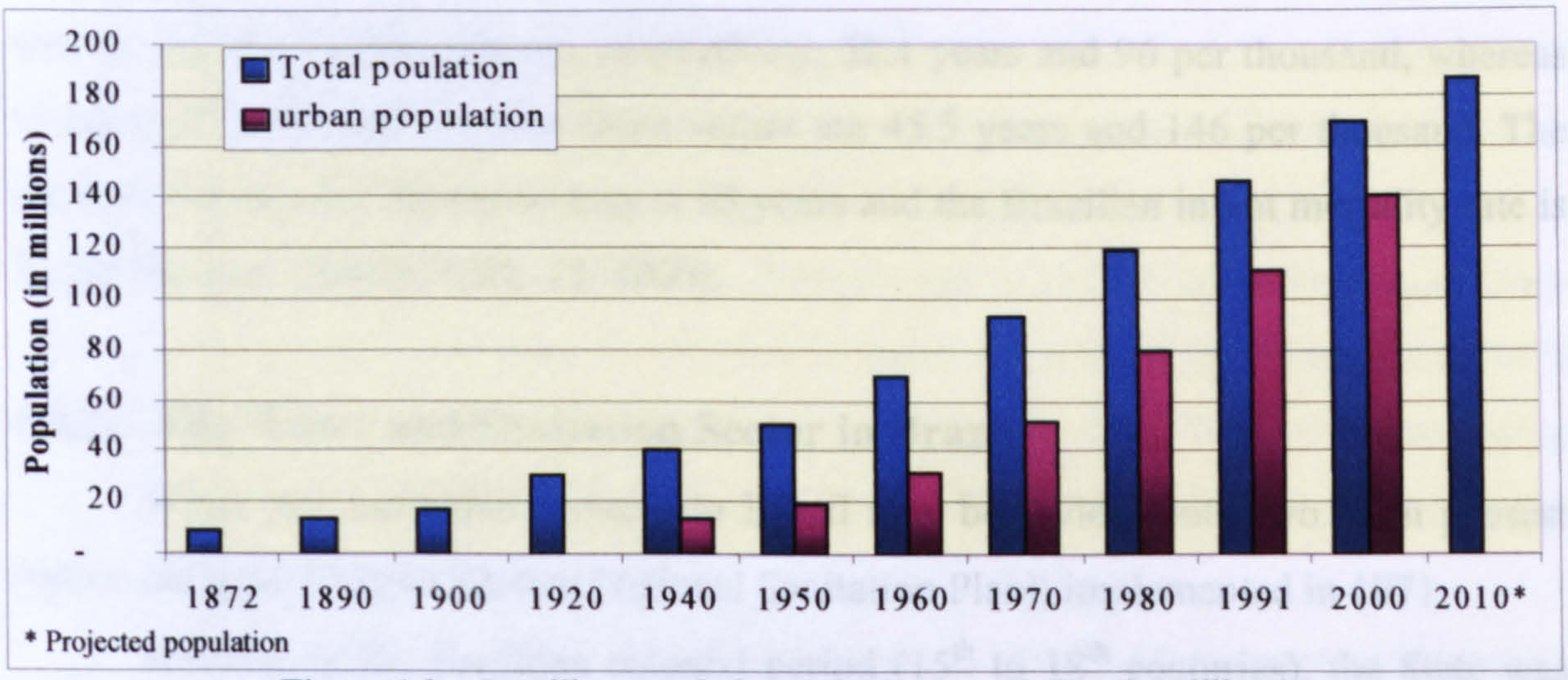


Figure 1.2. - Brazilian population and urban population (in millions).
Sources: IBGE, URL-15 (2000); IBGE, URL-16 (1996);IBGE,URL-22 (1996)

Brazil is divided into five regions: North, Northeast, Central West, Southeast and South. The Northeast region, in which the research for this thesis was mostly developed, is divided into nine states. This region contains approx. 28% of the Brazilian population and occupies 18.2 percent of the national territory (IBGE, URL-23, 2000).

Brazil's geographic regions are considered distinct from each other not only in climate, vegetation and cultural aspects, but also in economic characteristics, health burden and educational profiles. The Northern and Northeastern regions are the less developed, and have the lowest average income as shown in Table 1.2.

Table 1.2. - Total monthly average income in Brazil per working person (above 10 years old) in Reais

Region	Monthly Aver. Income (R$)
North	244.3
Northeast	144.9
Central West	291.3
Southeast	273.4
South	334.4

Source: IBGE, URL-18 (1999)

Health indicators in the North and Northeast are also worse than in the other regions. The risk of death due to intestinal infectious diseases is nearly 6.5 times greater in these regions than in the Southern and Central West regions (Moraes, 1996). Children born in the Northeast are 50 percent more likely to be classified as stunted than those born in the South region. Moraes (1996) also quoted that in urban areas of the Northeast region which are served with water supply and sanitation, the life expectancy at birth and the infant mortality rate are, respectively, 58.1 years and 96 per thousand, whereas in areas of inadequate services these values are 45.5 years and 146 per thousand. The national average for life expectancy is 68 years and the Brazilian infant mortality rate is 35 per thousand (IBGE, URL-23, 2000).

1.2.2. The Water and Sanitation Sector in Brazil

Water and sanitation services in Brazil may be divided into two main phases: *before* and *after* PLANASA (the National Sanitation Plan), implemented in 1971.

Initially, in the Brazilian colonial period (15th to 18th centuries), the State was nearly absent and sanitation solutions were mainly individual. From the middle of the 19th century to the beginning of the 20th, sanitation services became a responsibility of the State; however, there was insufficient institutional organisation for the provision of these services. This, together with a lack of technological knowledge, led to the regime of private concessions, which were given mainly to English capital companies such as the "Recife Drainage Company", the "Rio de Janeiro City Improvements Company Limited" and others (Costa, 1994).

These companies provided water abstraction and distribution services as well as the first wastewater sewerage system. However, the terms of the contracts were in most cases not accomplished, with long delays occurring in the delivery of the systems. Moreover, the areas covered by these companies were limited to urban centres, reaching just 10-15 percent of the population.

As reported by Costa e Silva (1990), the interests of the English companies in providing infrastructure services had only exploitation purposes and not the promotion of communities' well being. Thus, popular pressure, better institutional organisation of the State and the technological contribution of the engineer Saturnino de Brito contributed to the end of the concessions.

The development of state and municipal sanitation institutions marked the next period (from the end of the 19th century until the 1940's), during which there was nearly a 10-fold increase in water supply services (Costa, 1994).

In the Constitution of 1934, the municipalities were recognised as the primary administrators of local infrastructure services. Following this recognition, the institutional capability of the state agencies increased, resulting in a series of institutions responsible for water supply and sanitation services at both state and municipal levels.

At this time (the late 1950's), a variety of administrative models had already been tested by the sanitation sector and the autonomous service of the municipalities supported by the administration of the states was being consolidated (Costa, 1994).

The second phase started with the delivery of PLANASA by the military government. In financial terms, PLANASA changed the way in which resources were obtained and made municipalities dependent on the state water companies, so losing their participation in decision-making processes. Thus, these state companies were strengthened and they centralised all sanitation programmes.

The specific aims of the PLANASA were to supply 80 percent of the urban population with water systems and to provide sewerage systems for 50 percent of the urban population by 1980, attending all main municipal centres and Brazilian villages with more than 5000 inhabitants by 1985 (Costa, 1994). From 1970 to 1980, water supply services in the country increased from 54 to 76 percent (approx. 40 percent growth); however the increase in sanitation services reached just 36 percent of the population (approx. 60 percent growth - from 22.3 to 36 percent). These large gaps between the percentages of the population served by water supply and sanitation systems indicates how sanitation was being relegated to a second plan and contributed to the unhealthy environments found in the majority of Brazilian large cities.

The absence of municipalities in the decision making processes may have been an important factor in the selection of inappropriate technologies, which is a common criticism against PLANASA (Watson, 1995). Moreover, the services were deliberately concentrated in wealthier neighbourhoods, while the poor areas remained unserved. Therefore, in 1990, the percentage of urban residents served with piped water was 83 percent but only 37 percent of the Brazilian households were provided with sewerage systems (ABES, 1992). In the northeastern region of Brazil specifically, the percentage of households served with sewerage was only 11 percent, much lower than the national average (ABES, 1992).

As part of the attempt to overcome these differences, a World Bank funded programme called PROSANEAR is being experimentally implemented in Brazil with the objective of supplying water to and to collect/treat sewage from poor urban communities (Katakura & Bakalian, 1998). A first pilot programme was implemented connecting one million poor people to sewer systems and 90 percent of them to in-house water. These results were considered very impressive and motivated the implementation of a second pilot programme. The PROSANEAR programme is discussed further in Chapter 2.

In conclusion, since the beginning of the national economic crisis in 1983 and the abolition of the BNH (the main financial agency for PLANASA) in 1986, the sanitation sector in Brazil has been suffering from severe undercapitalisation, which limits new investments (Watson, 1995). From the middle of the 1980's the municipalities have been trying to re-assert their position as the primary managers of sanitation in their localities. However, the weak institutional organisation of the majority of the municipalities, associated with factors such as technical incapability and lack of financial resources, does not permit much effective change (Pontes *et al.*, 1996). On the other hand, new programmes are being developed to test more sustainable systems and this should bring a wider range of solutions to the sector.

1.3. Objectives of the Study

During the last two decades of the 20th century, alternative solutions for provision of sanitation systems were implemented in Brazil. These unconventional programmes, which embrace not only innovative technologies but also new social approaches, had as their main objective to reach poor communities, especially the urban poor.

Therefore, the aim of this study was to assess six low-cost sanitation programmes implemented in poor communities in the Northeastern and Central Western regions of Brazil. This assessment focused on the long-term sustainability of the programmes and was based on the study of the following aspects:

- Technical suitability, operation and maintenance of the sanitation systems;
- Institutional arrangements;
- Financial affordability;
- Sociocultural acceptability; and
- Health improvement.

It was expected, therefore, that this study would bring further insight into the conditions necessary for the sustainability of low-cost sanitation programmes.

1.4. Structure of the Thesis

As mentioned previously, the study of alternative sanitation systems and their steps towards a sustainable development are the main objective of this thesis, which has the following structure.

Chapter 1, this present chapter, introduces the study reported herein. It provides an overview of the precarious situation of poor communities that lack basic infrastructure services, more specifically sanitation services, emphasising the overcrowded urban squatter settlements and steps toward the implementation of sustainable services. The main profiles of the Northeast of Brazil, where the fieldwork was mainly developed, are also presented in this chapter.

Chapter 2 presents a review of the literature, providing the necessary support for the investigations developed in the fieldwork. Therefore, parallels are drawn between public health, the environment that poor people live in and the benefits provided by sanitation engineering improvements. The low-cost sanitation technologies applied in the case studies investigated are also reviewed. A discussion about sustainability concepts is then presented followed by examples of sustainable sanitation programmes, and ending with recommendations for evaluation procedures and the application of indicators of sustainability.

In Chapter 3, the methodology applied in the fieldwork is described. Chapter 4 presents the six case studies, describing the areas and the respective sanitation programme implemented, as well as the results obtained during the study.

Chapter 5 discusses the results under the perspective of seven aspects likely to influence the sustainability of the low-cost sanitation programmes. Finally, Chapter 6 presents the conclusions of the study and makes recommendations for further work.

Chapter 2: Literature Review

2.1. Introduction

The primary aim of what is discussed in this thesis is the improvement of the quality of life in low-income communities. However, quality of life is a vague concept and things that may be vitually important for one group of people may have no effect on other groups.

An example of this may be given by comparing the worries related to the health problems of two distinct populations: (1) poor people living in low-income areas of developing countries, and (2) people living in areas where infrastructure services are not a problem (a common situation in developed countries). Whilst the latter group nowadays worries about non-communicable diseases (such as cardiovascular diseases, cancer and stress), which have indeed increased in importance, the former group is still dying from diseases such as diarrhoea and helminthic infections that may be avoided through better environmental conditions and healthier hygiene habits.

Thus, quality of life may be a function of the condition which people are living under as well as of their expectations for improving these conditions. Therefore, this relative concept would be more accurately defined by the communities themselves rather them by any provider of developmental interventions. Nevertheless, infrastructure services resulting in environmental improvements, more specifically (for this study) sanitation services, are believed to be of great impact on the quality of life of low-income communities in developing countries.

Thus, in this chapter, aspects related to the health of the poor are reviewed, focussing on the sustainability of sanitation programmes designed for low-income communities.

2.2. Relation between Sanitation, Public Health and the Environment

2.2.1. The Environment and Diseases

Anthropogenic changes in the environment have influenced the development of a wide range of diseases. As creatures that are constantly interacting with their surrounding area, humans may be the biggest beneficiaries and sufferers from their own imposed environmental modifications.

The effects of the environment on public health may be closely related to the economical status, nature of work, place of living, habits and traditions of people, who usually modify their immediate environment to seek a more comfortable life, although this does not necessarily or always mean a healthier life.

In Murray *et al.* (1993), three large groups of causes-of-death and diseases were defined: communicable, maternal and perinatal (group I); non-communicable (group II) and injuries (group III). In all of these three groups, the causes-of-death and diseases can also be associated with the characteristics of the environment in which people are living. For example, changes in the environment for the provision of proper housing or sanitation facilities may avoid the spread of communicable diseases. On the other hand, environmental pollution due to industries or traffic may contribute to the onset of non-communicable diseases, and also injuries may result from unintentional accidents in the housing, working or leisure environments.

Figure 2.1. shows the fraction of diseases attributed to environment related aspects. Therefore, diseases such as diarrhoea and malaria have 90% of their burden attributed to environmental causes.

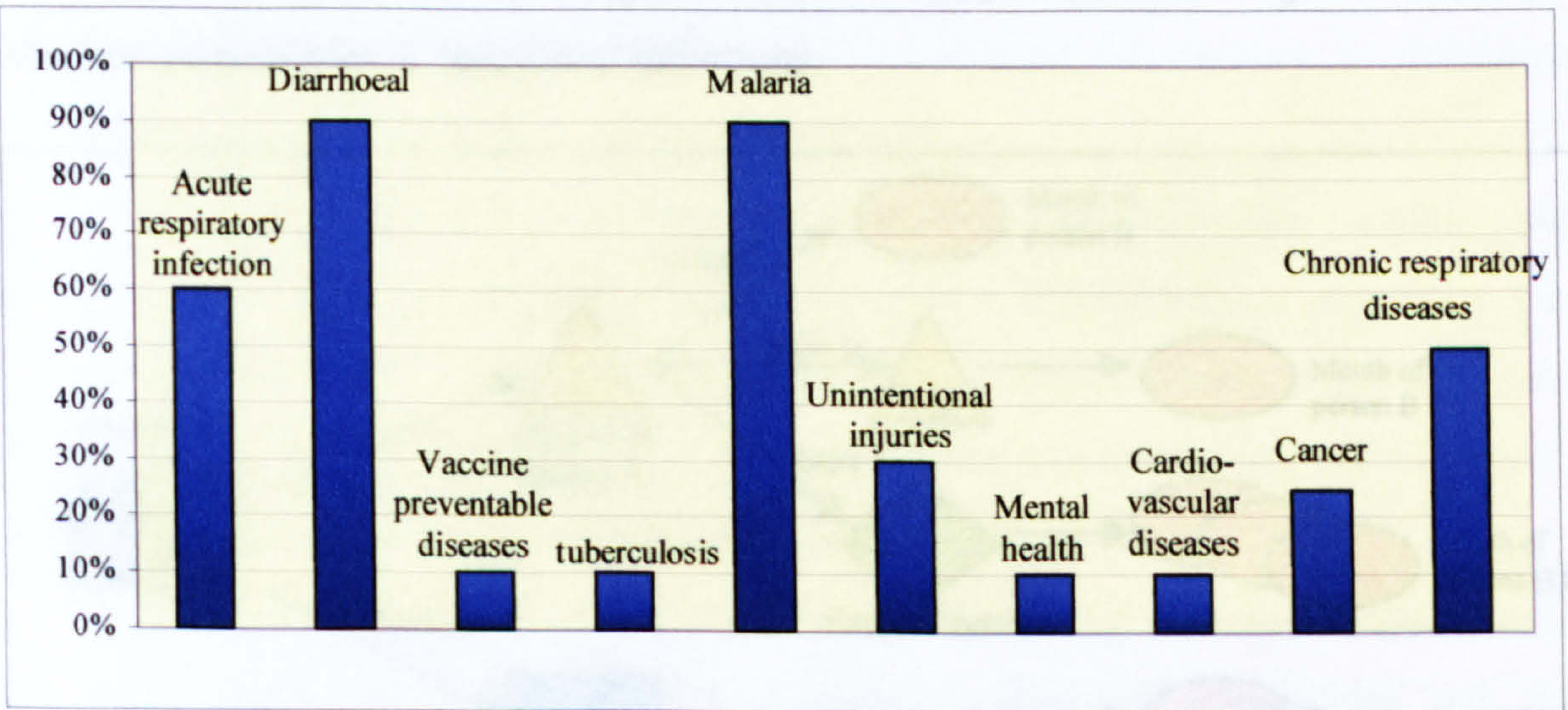


Figure 2.1. – The environment and the burden of diseases *(adapted from DFID, 2000)*

In the specific case of water- and excreta-related diseases, the most accepted classification is related to the environment that promotes the transmission of these diseases (Feachem, 1977; Mara and Feachem, 1999). Moreover, another proposed version of the environmental classification of diseases suggests two transmission routes: the domestic and public domains (Cairncross *et al.*, 1996), dividing the transmission of diseases into the family (private) and the public environments.

Thus, the above examples emphasise the relationship between the environment and diseases. The main importance of this is that once the environment is accepted as a source of diseases, the implementation of disease barriers may be focused on modifications of the environment (preventive) instead of just being concentrated on patients (curative). Cairncross (URL-26, 1999) emphasises, in an example of children treated with drugs against intestinal worms, that treatment is not a sustainable option as the children are quickly reinfected, and the author indicates an environmental intervention (sanitation, in this case) as the sustainable option.

2.2.2. Disease Classification

As suggested previously, diseases may be classified according to the environmental promotion of their transmission rather than by their causative agents or by their effects on patients. Therefore, environmental classifications of diseases are based on the possible transmission routes for the transportation of the causative agents from the environment to people.

Although there are a number of potential routes for the transmission of diseases, the faeco-oral routes are of the highest importance in public health. Figure 2.2 illustrates the four possibilities of faeco-oral infections.

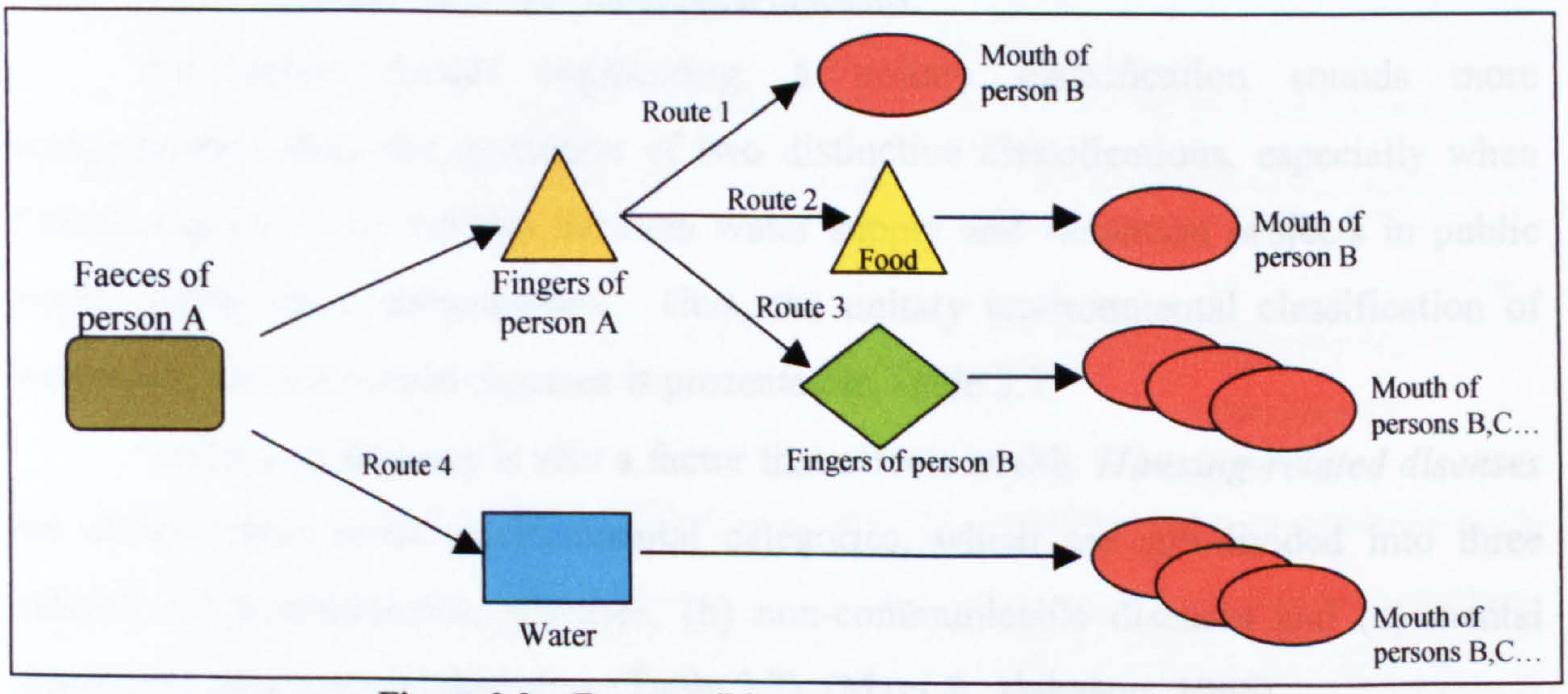


Figure 2.2. - Four possible routes of faeco-oral infections

The routes used by the causative agents of most helminthic infections are also worth noticed. In these routes, faeces are deposited in soil or water and the infective form of the causative agents reaches human hosts by ingestion or skin penetration.

For public health, the *water-*, *excreta-* and *housing-related diseases* have major importance. The ***water-related diseases*** were environmentally classified by Bradley

(White *et al.*, 1972) into four categories. Category I is the water-borne diseases, related with the quality of the drinking water; category II is the water-washed diseases that are mainly caused by the unavailability of a sufficient quantity of water; category III is the water-based diseases, caused by pathogens that spend part of their life cycle in one or more intermediate aquatic host (the main example is schistosomiasis); and, category IV is the water-related insect vector diseases that are caused by pathogens transmitted via insect vectors that breed in (or near) water.

The environmental classification of ***excreta-related diseases***, developed by Feachem *et al.* (1983) and as modified by Mara and Alabaster (1995), is divided into seven categories. Categories I and II include diseases associated with the faeco-oral routes of transmission (non-bacterial and bacterial, respectively), while category III diseases are transmitted through contaminated soils that may reach human body via the mouth, but also via skin penetration. Categories IV and V diseases rely on intermediate host(s) to become infective. Finally, categories VI and VII depend on insect and rodent vectors, respectively, to promote their transmission.

Considering both the identification of several new water- and excreta-related pathogens, and, the fact that many water-related diseases are also classified as excreta-related diseases, Mara and Feachem (1999) suggest an unitary environmental classification for water- and excreta-related diseases.

For public health engineering, a unitary classification sounds more comprehensive than the utilisation of two distinctive classifications, especially when considering the close relation between water supply and sanitation projects in public health improvement programmes. Thus, the unitary environmental classification of water- and excreta-related diseases is presented in Table 2.1.

Inadequate housing is also a factor that affects health. ***Housing-related diseases*** are divided into seven environmental categories, which are sub-divided into three classes: (a) communicable diseases, (b) non-communicable diseases and (c) mental illness and psychosocial disorders (Table 2.2), (Mara & Alabaster, 1995).

Table 2.1. - Unitary environmental classification of water and excreta-related diseases

Environmental transmission	Examples	Control
CATEGORY A: Faeco-oral waterborne and water-washed diseases		
▪ Non-latent (except *Ascaris*) ▪ No intermediate host ▪ Infectivity: medium to low (bacteria), high (others) ▪ Persistence: medium to high (bacteria), low to medium (others, except *Ascaris*: very high) ▪ Able (bacteria) and unable (others) to multiply outside host	▪ *Viral*: Hepatitis A, E and F, Poliomyelitis, Rotavirus diarrhoea ▪ *Bacterial:* Campylobacteriosis, Cholera, *Helicobacter pylori* infection, Pathogenic *Escherichia coli* infection, Salmonellosis, Typhoid and paratyphoid, Yersiniosis ▪ *Protozoan*: Amoebiasis Crystosporidiasis, *Cyclospora cayetanensis* diarrhoea, *Enterocytozoon bienusi* diarrhoea, Giardiasis, *Isospora belli* diarrhoea ▪ *Helminthic*: Ascariasis, Enterobiasis, Hymenolepiasis	▪ Improved water quantity, availability and reliability (water-washed disease control). ▪ Improve water quality (waterborne disease control ▪ Hygiene education
CATEGORY B: Non-faeco-oral water-washed diseases		
▪ Non-latent ▪ No intermediate host ▪ High infectivity ▪ Medium high persistence ▪ Unable to multiply	▪ Skin infections (scabies, leprosy, yaws) ▪ Eye infections (trachoma, conjunctivitis, including that caused by *Encephalitozoon hellen* ▪ Louse-borne fever	
CATEGORY C: Geohelminthiases		
▪ Latent ▪ Very persistent ▪ Unable to multiply ▪ No intermediate host ▪ Very high infectivity	▪ Ascariasis ▪ Trichuriasis ▪ Hookworm infection	▪ Sanitation. Effective treatment of excreta or wastewater prior to reuse. Hygiene education
CATEGORY D: Taeniases		
▪ Latent ▪ Persistent ▪ Able to multiply ▪ Very high infectivity ▪ Cow or pig intermediate host	▪ Beef and pork tapeworm infections	▪ As C above, plus cooking of meat and improved meat inspection

Continue

Environmental transmission	Examples	Control
CATEGORY E: Water-based diseases		
▪ Latent ▪ Persistent ▪ Able to multiply ▪ High infectivity ▪ Intermediate aquatic host (s)	▪ *Bacterial:* Leptospirosis; Tularemia; Legionellosis ▪ *Healminthic*: Schistosomiasis; Clonorchiasis; Fasciolopsiasis; Guinea worm infection ▪ *Fungal*: Pulmonary hemorrhage due to *Stachybotrys altra* infection	▪ Decrease contact with contaminated water. Improve domestic plumbing. Public education. ▪ Decrease contact with contaminated waters. Sanitation. Treatment of excreta or wastewater prior to reuse. Public education. ▪ Drying of flood-damaged homes. Public education.

Examples	Control
CATEGORY F: Insect- vector diseases	
▪ *Water-related:* Malaria, Dengue, Rift Valley fever, Japanese encephalitis, Yellow fever, African sleeping sickness, Onchocerciasis, Bancroftian filariasis ▪ *Excreta-related:* Fly-borne and cockroach-borne excreted infections[a], Bancroftian filariasis	▪ Decrease passage through breeding sites. Destroy breeding sites. Larvacide application. Biological control. ▪ Use mosquito netting and impregnated bed nets. ▪ Improved stormwater drainage ▪ Public education
CATEGORY G: Faeco-oral waterborne and water-washed diseases	
▪ Rodent-borne excreted infections[a] ▪ Leptospirosis ▪ Tularemia	▪ Rodent control: Hygiene education ▪ Decrease contact with contaminated water: public education

[a] The excreted infections comprise all those diseases in Categories A, C and D and the helminthic diseases in Category E.

Source: Mara & Feachem (1999)

Table 2.2 - Environmental classification of housing-related diseases

(a) Communicable Diseases	(b) Non-communicable Diseases	(c) Mental Illness & psychosocial disorders
CATEGORY I: Diseases related to defects in building and peridomestic environment		
1. Building-related insect-vector diseases 2. Building-related rodent-vector diseases 3. Peridomestic insect-vector diseases 4. Geohelminthiasis 5. Diseases due to animal faeces 6. Diseases due to animal bites 7. Overcrowding-related diseases	1. Dust-, smoke- and damp-related diseases 2. Building-related carcinoma 3. Building-related insect vector diseases 4. Accidents 5. Traffic fumes diseases	1. Neuroses 2. Violence 3. Delinquency and vandalism 4. Drug and alcohol abuse
CATEGORY II: Diseases related to defective water supply		
1. Faeco-oral (waterborne and water-washed) diseases 2. Non-faeco-oral water-washed diseases 3. Water-based diseases 4. Water-related insect vector diseases	1. Water-quality related disease 2. Water-related carcinomas	1. Acute psychoses
CATEGORY III: Diseases related to defective sanitation		
1. Non-bacterial faeco-oral diseases 2. Bacterial faeco-oral diseases 3. Geohelminthiasis 4. Taeniasis 5. Water-based helminthiasis 6. Excreta-related insect-vector diseases 7. Excreta-related rodent-vector diseases	None known	1. Acute psychoses
CATEGORY IV: Diseases related to defective refuse storage and collection		
1. Refuse-related insect vector diseases 2. Refuse-related rodent-vector diseases	None known	None known
CATEGORY V: Diseases related to defective food storage and preparation		
1. Food-borne excreta-related diseases 2. Food-borne zoonoses 3. Food-borne microbial toxins diseases	None known	None known
CATEGORY VI: Industry-related diseases		
1. Air-borne excreta-related diseases 2. Air-borne water-based diseases	1. Diseases due to industrial toxicants 2. Accidents	1. Psychiatric organic disorders due to industrial toxicants 2. Neuroses

Source: Mara & Alabaster (1995)

The main advantage of environmental classifications of diseases may be the possibility of applying adequate engineering interventions in order to break the disease transmission routes. Therefore, the division proposed by Cairncross *et al.* (1996), dividing diseases into public and domestic domains, may be very helpful in the planning of disease control.

In such a classification, domestic domain is understood as the private area of the households including yards and other surrounding areas where the general public have no free access. The common areas such as schools, parks, work places, streets and so forth, are under the public domain classification. Through this division, diseases may be identified as having their main focus of transmission confined among household members and, consequently, requiring "in-house" interventions for their control, or, diseases may have their main focus on public places requiring more extensive interventions involving all community members, or all citizens or maybe whole nations.

However, considering the chaotic situation of urban poor settlements, such as the Brazilian favelas, the division between domestic and public domains may be highly confusing. The high-density occupation of these areas, their precarious condition and the absence of peri-domestic physical limits may compromise health interventions based only on the public or only on the domestic domains.

2.2.3. Diseases and Poverty

In general, diseases that are related to lack of sanitation, inappropriate housing or poor hygiene habits are associated with poverty. These diseases are easily spread in the absence of adequate engineering interventions and under low levels of personal and domestic hygiene, both frequently found in poorer communities.

Accordingly, "extreme poverty" is the world's biggest killer and the greatest cause of ill-health. Extreme poverty is, also, formally recognised as a disease and is classified in the International Classification of Diseases under the code Z59.5 (WHO, 1995, URL-1). UNCHS (URL-2, 2001) estimates that between one-quarter and one-third of all urban households in the world live in absolute poverty.

On a global basis, the "diseases of the poor" are well illustrated by the data presented in the Global Burden of Disease and Injury study (Murray & Lopez, 1996a; 1996b). As shown in Figures 2.3 and 2.4, the communicable group of diseases is responsible for about 50 percent of the total disease burden in developing countries (measured as disability-adjusted years of life (DALYs) lost), while the same group of diseases represents only 9 percent of the DALYs lost in developed countries.

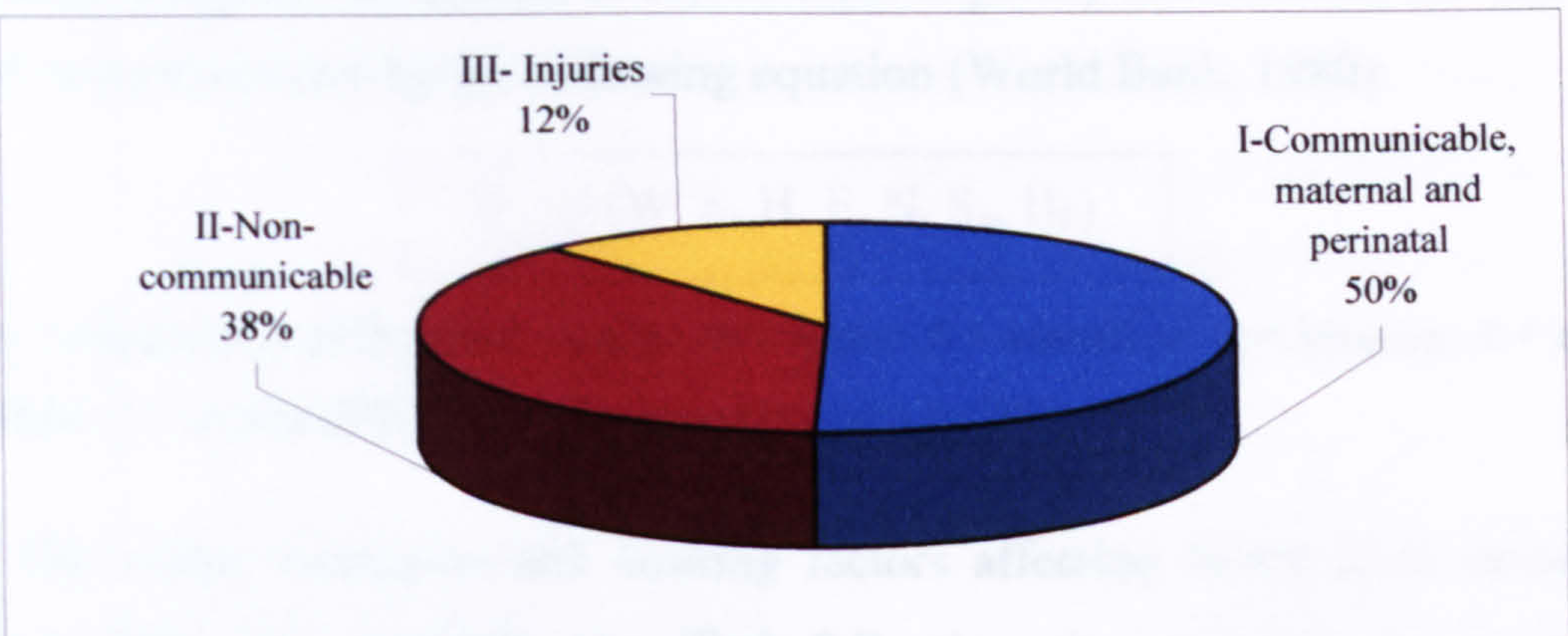


Figure 2.3. - DALY's lost in Developing Countries (1990). *(Source: Murray et al., 1994)*

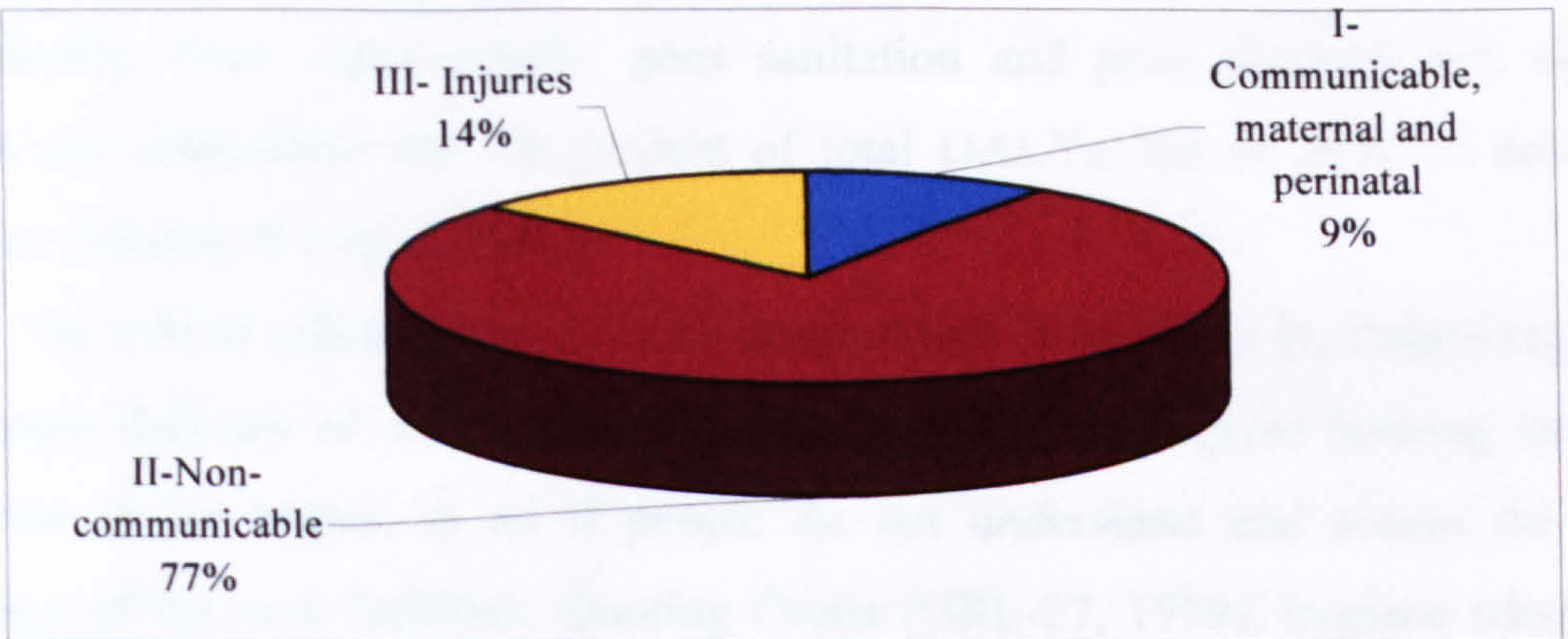


Figure 2.4. - DALY's lost in Developed Countries (1990). *(Source: Murray et. al., 1994)*

Among the communicable, maternal and perinatal group of diseases, those more directly related to the lack of adequate environmental sanitation (infectious and parasitic diseases) are also presented in a higher proportion than the other diseases in the developing countries (Figure 2.5).

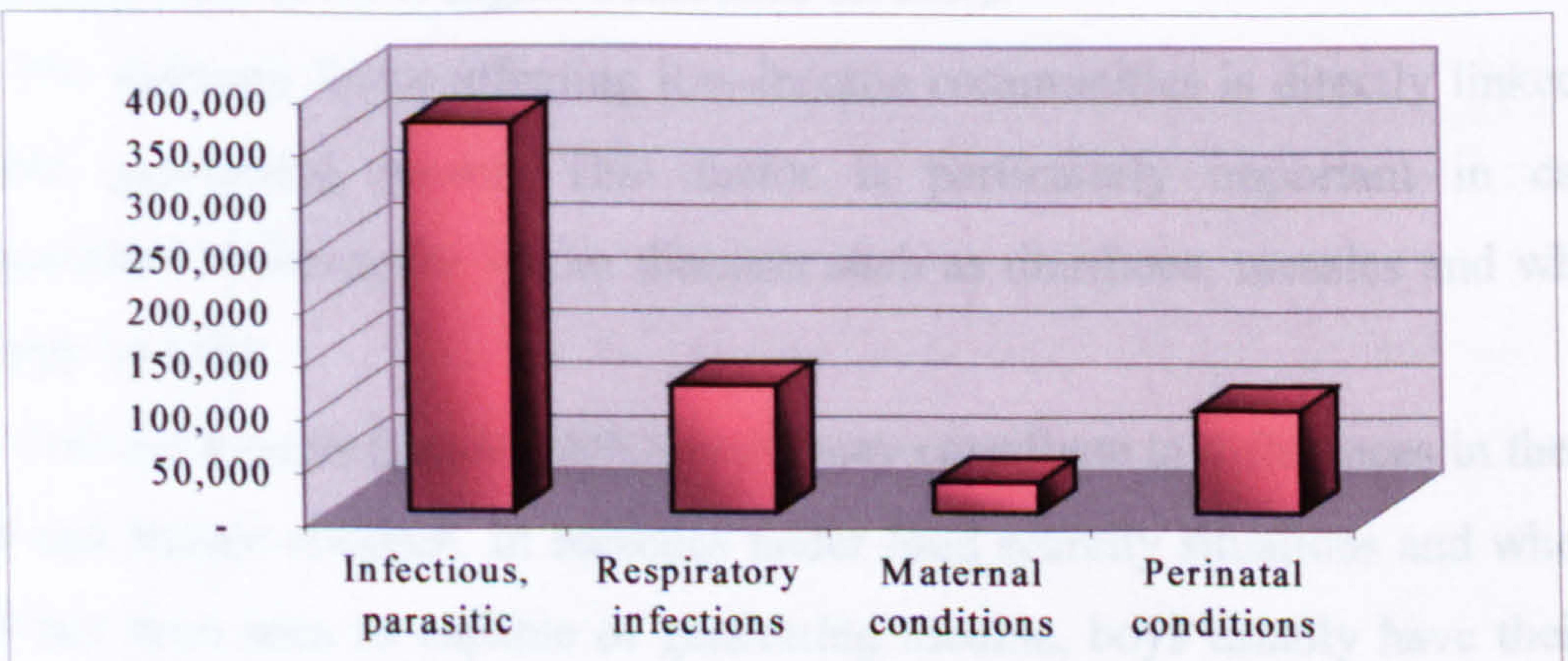


Figure 2.5. - DALYs lost for communicable, maternal and perinatal diseases in Developing Countries (1990) in thousands *(source: Murray et. al., 1994)*.

The influence of economic conditions on people's health has driven authors to indicate a better income distribution as the main point to be reach in health improvement programmes (Zaidi, 1988). In order to justify this relation, the "diseases of poverty" were expressed by the following equation (World Bank, 1980):

$$\boxed{D = f\,(W, S, H, E, N, S_x, H_f)}$$

where D = disease of an individual or family; W = water; S = sanitation; H = housing; E = education; N = nutrition; S_x = gender differences; H_f = access to health facilities.

The *water, sanitation* and *housing* factors affecting health have already been discussed. They are formally classified following the concept of environmental classification of diseases and poorer communities are undoubtedly the most affected by these factors. Poor water supply, poor sanitation and poor personal and domestic hygiene are responsible for 7.6 percent of total DALYs lost in 1990 in developing countries (Murray & Lopez, 1997).

The role of *education* in hygiene programmes is essential for improving health. The simple delivery of water and sanitation facilities or adequate housing may have very little or no impact at all if people do not understand and accept the correct utilisation of the new facilities. Quoting Curtis (URL-27, 1999), hygiene education is potentially one of the most effective weapons to reduce the toll of diarrhoeal diseases. Usually, educational programmes focusing on health improvements are targeted at women who, especially in lower-income groups, are primarily responsible for bringing up children, cleansing and food preparation. Better education, however, does not just improve hygiene habits, but also increases the opportunities for better jobs and consequently contributes to higher household incomes.

The *nutrition* factor affecting low-income communities is directly linked to the household purchasing power. This factor is particularly important in cases of undernourished children, for whom diseases such as diarrhoea, measles and whooping cough may be fatal.

Cultural aspects (*gender differences*) may contribute to differences in the raising of male and female children. In societies under food scarcity situations and where girls are still not been seen as capable of generating income, boys usually have their needs given a higher priority. Chen *et. al.* (1981) found that in Bangladesh over 14 percent of female children were classified as severely malnourished compared to only 5 percent of males. Finally, the unavailability of *health facilities* and the unaffordability of medicines are other factors affecting the health of poor householders.

The above factors affecting health, especially the health of poorer households, are interconnected. Once initiated the improvement of one of those factors, householders would be motivated to apply efforts (economical and social) to improve one or more of the other factors. As an example, after the implementation of a condominial sewerage system through the PROSANEAR programme in Brazil, householders started to improve the quality of their houses, and also their social organisation was strengthened, so allowing them to request better health facilities and other needs (Katakura and Bakalian, 1998).

2.3. Public Health Benefits from Engineering Improvements

2.3.1. Sanitation: a Matter of Public Health

Access to water supply and sanitation facilities is frequently indicated as a priority for the control of a wide range of infectious and parasitic diseases. The association between lack of sanitation and diseases transmission is substantial. When the transmission routes of excreta-related disease are understood (see Figure 2.1), people's infection risks can be straightforwardly identified in non-sanitised environments.

In the Global Burden of Diseases and Injury Study, risk factors associated with poor water supply, sanitation, and personal and domestic hygiene were considered the second major contributor for DALYs lost world-wide. Table 2.3 shows the percentage of DALYs for the ten major disease risk factors in 1990 in developing countries (after Murray & Lopez, 1997).

Table 2.3. - Percentage of DALYs attributable to each of ten risk factors in DC's- 1990

Risk Factor	% of Total DALYs
Malnutrition	18.0
Poor water supply, sanitation, and, personal and domestic Hygiene.	7.6
Unsafe sex	3.7
Tobacco	1.4
Alcohol	2.7
Occupation	2.5
Hypertension	0.9
Physical inactivity	0.6
Illicit drugs	0.4
Air pollution	0.4

In Foster (1998), the provision of basic sanitation was indicated by Water for Sanitation and Health (WASH, renamed Environmental Health Project) as the most effective intervention for health improvement.

Also, based on data from WHO, The Economist (1998) published a table showing the reduction of diarrhoea, roundworm, schistosomiasis and guinea worm infection that was attributable to water and sanitation improvements. Among the values given, even the lowest percentage of disease reduction (22 percent for diarrhoeal disease) is an impressive value: it represents 180 million people not affected by the disease (based on 900 million diarrhoea episodes per year). However, the differences among the percentages reported (ranging from 22 to 76 percent) is a reminder that facilities provision is not enough by itself and reinforce the role that hygiene education has to play in the prevention of diseases such as diarrhoea and the geo-helminthiases.

The different impacts in health gained through improvements in programmes focused on the quality of the supplied water, on its availability and on sanitation were assessed by Esrey *et al.* (1985). In this study, the authors concluded that water quality has a smaller impact in health improvements than water availability or sanitation, but well-designed projects combining water supply, sanitation and hygiene education may achieve reductions in diarrhoeal disease morbidity of 35-50 percent.

Moreover, a USAID-supported project found that *"health and nutrition benefits from improved sanitation, especially improved excreta disposal, may be even greater than those associated with better access to safe water alone"* (UNICEF, URL-24, 1998). Accordingly, Annan (URL-25, 2000) states that *"no single measure would do more to reduce disease and save lives in the developing world than bringing safe water and adequate sanitation to all"*.

Another study concluded that of more than 52 million deaths in 1996, over 17 million (i.e. nearly 33 percent) were due to infectious or parasitic diseases (WHO, 1997, URL-3). In Brazil, 21 million people live without access to safe water and 44 million are not served with sewerage networks or septic tanks (Katakura & Bakalian, 1998). The majority of these people survive with hugely inadequate amounts of water, which they usually obtain from "pirate-sellers" or unsafe sources, and they have sewage flowing openly around their houses. This situation may be directly translated into the high infant and under-five mortality and morbidity rates (see Section 1.2.1.) compared with those in developed countries.

2.3.2. Diarrhoeal Diseases

Diarrhoeal diseases are classified by WHO as the second major cause of death in the world (Table 2.4.). They are responsible for 3.1 million deaths per year, which mainly occur in the undeveloped countries. The group of people most affected by diarrhoea are children under-five years of age who carry a disease burden of approx. 86% of the cases in the world and 78 percent in the Latin America and Caribbean region (Murray and Lopez, 1994).

Table 2.4. - The ten biggest killers according to WHO.

Disease	Morbidity (deaths per year)	%
Acute respiratory infections	4,400,000	26.2
Diarrhoeal diseases	3,100,000	18.4
Tuberculosis	3,100,000	18.4
Malaria	2,100,000	12.5
Hepatitis B	1,100,000	6.6
HIV/AIDS	1,000,000	5.9
Measles	1,000,000	5.9
Neonatal tetanus	500,000	3.0
Whooping cough	355,000	2.1
Roundworm and hookworm	165,000	1.0

Source: Mara (1997).

Different definitions of diarrhoea have been applied in different studies. A number of them are based on the frequency of episodes per day, such as "more than two watery or loose motions in 24 hours" (Rahaman *et. al.*, 1979) and "under 1 year of age: 5 or more liquid stools per 24 hours; over 1 year: 3 or more liquid or semi-liquid stools proceeded by 2 weeks of normal stools" (Scrimshaw *et. al.*, 1967). Recent studies however, which have applied a more community-based approach, consider the mother's definition more suitable for the assessment of cases of diarrhoeal diseases (Schorling, 1990; Moraes, 1996).

Examples of diarrhoeal diseases include cholera, typhoid fever, paratyphoid fever, salmonella, rotavirus, campylobacter, shigella, giardiasis, dengue fever, cryptosporidiosis, among others, which are caused by a variety of pathogens such as bacteria, parasites and viruses.

Cholera is an example of a devastating diarrhoeal disease with recurrent pandemics around the world since 1817. The ongoing pandemic, the seventh, started in 1961 in Indonesia, then, spread through Asia, Africa and reached Latin America in 1991 (Tauxe *et al.*, 1995). In Brazil, cases of cholera reached a peak of more than 60,000 confirmed cases and 670 deaths in 1993 (Momem, 1998). It declined to 3,044 officially reported cases in 1997 (Ministério da Saúde, URL-28, 1998). The cases reported in 1997 were concentrated in the Northeast region of the country (98 percent of the cases).

Tauxe *et al.* (1995) reported that no effective vaccination is yet available against cholera, but the interruption on the transmission of the causative organism (*Vibrio cholerae*) had successfully prevented and controlled many epidemics. The authors also stress that the provision of safe water and sewage treatment for nearly all people in industrialised nations has made the transmission of cholera extremely unlikely in those countries.

Another highly infectious enteric pathogen is *Cryptosporidium parvum.* This protozoan parasite was for long well known by veterinarians, but was recognised as a human pathogen only in 1976 (Guerrant, 1997). Cryptosporidium is able to infect with as few as 30 oocysts and can cause diarrhoea illnesses lasting longer than 1 to 2 weeks in a previously healthy person and indefinitely in immunocompromised patients. The parasite is transmitted by ingestion of oocysts excreted in faeces of infected humans or animals. The transmission can occur through person-to-person or animal-to-person contact, ingestion of faecally contaminated water or food, or contact with faecally contaminated environmental surfaces (CDC, URL-29, 1995). There is also concern with the waterborne transmission of cryptosporidium. Oocysts were present in 65-97 percent of surface water (i.e. rivers, lakes and streams) in tests throughout the United States (CDC, URL-29, 1995); additionally, this parasite is resistant to chlorine, is small and is difficult to filter, therefore becoming a threat to water supply treatment systems.

A study in an urban slum in NE of Brazil detected cryptosporidium oocysts in human stools in 6.3 percent of samples collected in the dry season and in 14.3 percent of the samples from the rainy season. In animals stools, 10.2 percent of the samples had oocysts, and 22.2 percent of freshwater samples collected from a variety of sources were also positive (this include a sample from the city water company) (Newman *et al.*, 1993).

Dengue fever is a water-related insect-vector disease (Category F of the unitary environmental classification, Table 2.1), which is transmitted by the *Aedes aegypti* mosquito. This mosquito breeds in calm freshwater sites such as household water tanks, vessels and containers accumulating rainwater. Diarrhoea can be one of the symptoms of the disease that may be fatal especially in its stronger version, dengue hemorrhagic fever. Dengue re-emerged in Brazil in the 1970s and large outbreaks followed in the next decades (Momen, 1998). In 1997, a total of 254,987 cases of dengue fever were officially reported in Brazil, with approx. 77 percent of the cases occurring in the Northeast of the country (Ministério da Saúde, URL-28, 1998).

A series of programmes carried out around the world with the objective of reducing diarrhoea mortality has been based on the Oral Rehydration Therapy - ORT, which relies on the administration of an Oral Rehydration Solution - ORS. Among the main advantages of this form of therapy are: the ease with which it can be learned, the rehydration solution can easily be prepared by mothers and that it can usually be afforded by poorer households. Such factors have increased the popularity of ORT and have made it an important lifesaver.

However it must be remembered that ORT is a remedy and does not prevent the occurrence of diarrhoea (Okun, 1988). Therefore, water supply and sanitation improvements, as well as the promotion of hygiene education, are fundamental in reducing the incidence of diarrhoeal diseases (Stanton & Clemens, 1987; Hoque, 2000).

Esrey *et al.* (1985) reviewed 67 studies on the impact of water supply and sanitation on diarrhoea-related issues. The same authors updated this review in 1991 based on an assessment of 17 additional studies (Esrey *et al.*, 1991). Based on these reviews it may be concluded that, although diarrhoeal morbidity and mortality are also strongly related with the level of the mother's literacy, hygiene practices and child nutritional status, water and sanitation play an important role in improving rates of child survival. In the studies considered by the authors as having a more rigorous methodological design, improvements in water supply and sanitation were considered to be responsible for 65 percent reduction in diarrhoea-related diseases and over 55 percent in child mortality.

Moreover, VanDerslice & Briscoe (1995), reported that providing private excreta disposal would be expected to reduce diarrhoea by 42 percent and that eliminating excreta around the house would lead to a 30 percent reduction in diarrhoea. Accordingly, Mertens *et al.* (1992) in a study of excreta disposal in relation to childhood diarrhoea in Sri Lanka, also reported that children from households where excreta were disposed of in a latrine were less likely to have diarrhoea than children whose families disposed of excreta improperly.

2.3.3. Helminthic Infections

Diseases caused by intestinal helminths are also associated with poor hygiene and inadequate sanitation. They are classified in Categories C (geohelminthiases), D (taeniasis) and E (schistosomiasis) of the unitary environmental classification of water- and excreta-related diseases (Table 2.1). The close relation of helminthic infections (especially the geohelminthiases) with a lack of sanitation and poor personal hygiene habits is even more evident in high-density housing areas (such as the urban slums). In these areas the above factors, together with the widespread habit of not wearing shoes and defecating in watercourses, result in a greater susceptibility to infection.

The main geohelminthiases are ascariasis, ancylostomiasis (hookworm infections) and trichuriasis which are caused, respectively, by *Ascaris lumbricoides* (roundworm), *Necator americanus* or *Ancylostoma duodenale* (hookworms) and *Trichuris trichuria* (whipworm). As shown in Figure 2.6, these infections have been reported to occur at higher levels in Latin America and the Caribbean than in sub-Saharan Africa.

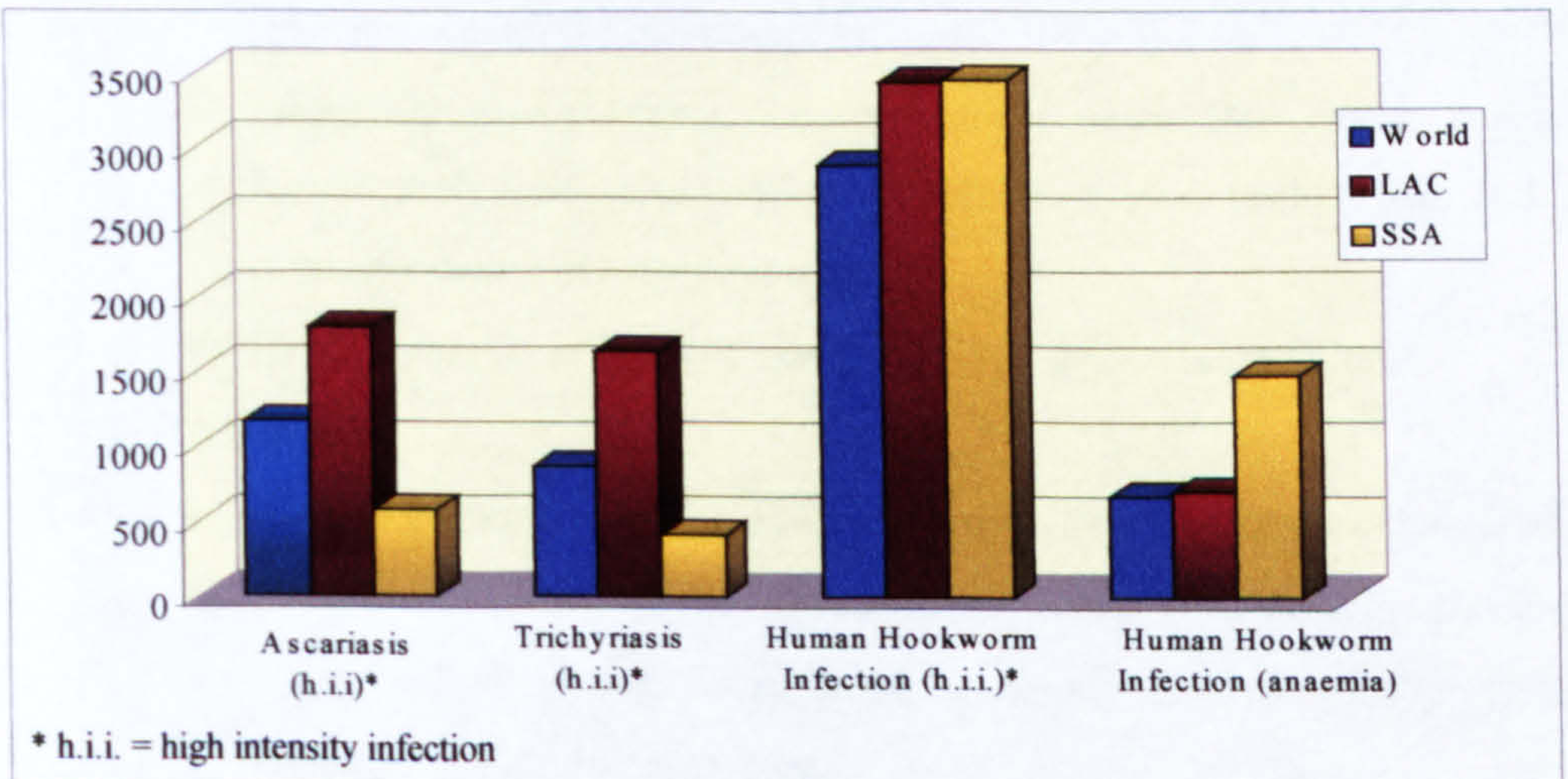


Figure 2.6. - Prevalence rates of geohelminthiases (per 100,000) in 1990. *Source: Murray and Lopez (1996).*

Twenty-five years ago, Wolman (1975) already reported that enteric infections constitute one of the leading causes of diseases and death in central and South America. The author suggested more water supply & sewerage systems, better food preparation and better hygiene comprehension as key points to decrease the burden of these diseases. Additionally, rapid population growth and urbanisation were also indicated as aggravating factors.

Table 2.5 presents the main features of ascariasis, hookworm infections and trichuriasis.

Table 2.5. - Features of geohelminthiases.

Clinical Features	➢ Ascariasis • Transmitted by eggs present in infected excreta disposed in soil, which develop second-stage larvae to become infective. • Human infections occur when infective eggs are ingested (by hands, food, utensils, dust, and so forth) and hatch in the duodenum of infected person. • About 85% of infections are symptomless. • Earliest symptoms are: pneumonitis with cough; dyspnea (shortness of breath); substernal (chest) pain; fever; moderate eosinophilia and blood-stained sputum. • Adult worms in the small intestine may cause: digestive disorders; nausea; abdominal pain; vomiting; restlessness and disturbed sleep. • It has been estimated that a child who has 26 worms may lose 10% of his total daily intake of protein. ➢ Hookworm Infections • Transmitted by eggs present in infected excreta disposed in soil, which in optimum condition hatch developing the subsequent larval stage. • Human infections occur when the third-stage larvae penetrate the skin, usually between toes, on the feet or ankles. • Frequently sympthomless, however acute cases may cause: anaemia with consequently weakness, debility and others; gastrointestinal pain and transient cutaneous and pulmonary symptoms • Grossly anemic individuals may die of high-output heart failure ➢ Trichuriasis • Life cycle, modes of transmission and epidemiologies similar to ascarisis • Symptomless, however may cause slight abdominal pain and diarrhoea. • Heavy infections may cause anaemia, bloody diarrhoea and prolapse of the rectum in malnourished children.
Treatment	➢ Ascariasis and trichuriasis • Chemotherapy ➢ Hookworm Infections • Chemotherapy and Oral iron therapy
Prevention and control	➢ Ascariasis, hookworm infections and trichuriasis • Health education campaigns • Development of basic health services and infrastructure ➢ Hookworm Infections • Use of footwear

(Source: Feachem et al., 1983).

2.4. Physical Sustainability of Sanitation Programmes

2.4.1. Concepts of Sustainability

Sustainable development was defined in 1987 by the World Commission on Environment and Development as: "development that meets the needs of present generations without compromising the ability of future generations to meet their own needs" (WCED, 1987). Sustainability and sustainable development, therefore, became popular since the preparation of the Earth Summit held in Rio de Janeiro in 1992. In that conference, the necessity of nations to sustain their developmental programmes was discussed at a global level. Such discussions gave emphasis to the conservation of resources and ecological systems (the Green Agenda), but also to the need for poverty eradication giving poor people more access to the resources needed for an environmentally healthy life (the Brown Agenda).

Since then, sustainable development has been seen from different angles and a wider range of sectors has adopted it as a target to be achieved. Therefore, specific concepts have been suggested for sustainability and applied in a variety of sectors such as economical, social, cultural, operational, institutional, managerial and so fourth (Pugh, 1996; Hardoy *et al.*, 1992).

Nevertheless, these broader concepts of sustainability have been largely criticised and it is suggested that the term has been inadequately applied (Mitlin & Satterhwaite, 1996; Marcuse, 1998; McGranahan *et al.*, 1996). Generally, the argument is that sustainability is well applied for environmental issues; however, its adaptation to others sectors, such as urban infrastructure and social organisations, is seen as contradictory and inappropriate. Mitlin & Satterthwaite (1996) suggests that human activities and institutions are not appropriately discussed under sustainability, arguing that these sectors are more clearly fulfilled within the *development* component of sustainable development.

Everard (1999), in simple terms, defines sustainability as the capacity for indefinite continuance, whereas sustainable development is the journey that society must necessarily take towards a state of sustainability. This "sustainable journey" is, therefore, what social and infrastructure systems are aiming to establish for the development of sustainable societies. However, a "sustainability deficit", probably resulting from the unsustainable pathways taken by many developed societies, already exists. And, this would be expressed by the exhaustion of natural resources and by social inequalities, which have as a direct consequence the non-accomplishment of basic human needs in the poorer strata of these societies. Therefore, the environment surrounding human settlements in low-income areas of non-developed countries is begging for improvements that are part of programmes being developed under the bandwagon of sustainable development.

Development is, in fact, a dynamic component that in association with sustainability (in terms of urban infrastructure) suggests development based on realistic parameters (technical, financial and social), committed to improvements on human quality of life and without compromising natural resources. This may be understood as just another broad concept, but it allows the implementation of programmes that are more carefully planned, coherent and committed to poverty alleviation. Additionally, according to DFID (1998), sustainable development programmes should also be designed to ensure effectiveness, efficiency and equity.

Consequently, this interpretation of sustainable development and its application for the provision of "human needs" has favoured the development of theories, approaches and action frameworks which support the implementation of infrastructure improvement programmes in low-income areas of developing countries.

2.4.2. Sustainable Sanitation Programmes

In the development of this study, sanitation programmes are considered "the subject" that should be sustained, having as their primary aim to meet users' needs (needs that should be expressed by the users themselves). Therefore, *sustainable sanitation programmes* are expected to be:

- Technically suitable for the characteristics of the area and its users;
- Technically able to function (be operated and be maintained) using viable resources during the totality of its design life, and also being committed to the continuity or upgrading of the system;
- Financially affordable by its users that are "the clients", the primary beneficiaries of the projects and, consequently, the owners of the sanitation system;
- Socioculturally acceptable in order to avoid rejection due to traditions, habits or religious beliefs;
- Health-focused, so as to improve the quality of life and satisfying the user's needs; and

- Environmentally friendly, contributing to the sanitation of the users' immediate environment and not compromising natural resources with effluents or process derived contaminants.

To give a chance for the sanitation programmes to be sustainable, complying with the constraints above, a major factor would be the acceptability and participation of users. The role that communities (users that live in the same area and are involved in the same programme) play in these sorts of programmes has been reported as of fundamental importance for the achievement of the programmes' objectives (Katakura & Bakalian, 1998; Watson, 1995). The significant value of community participation can be identified in the examples of sanitation programmes and approaches discussed next.

2.4.3. Sustainable Approaches

➢ *Strategic Sanitation Approach (SSA) and Demand-based Approach*

Recognising that urban poverty has no easy solution and that urban institutions and local governments of developing countries still have deficient structures for the management of the water and sanitation sector, the UNPD-World Bank Water and Sanitation Programme suggested the adoption of the strategic sanitation approach -SSA (UNPD-World Bank, URL-4, 1998).

This approach aims to support urban interventions fostering investments, operational efficiencies, and the development of sustainable urban services. For this, four principles were set:

- Interventions in water and sanitation should be based on local, effective demand;
- Water and sanitation should be considered economic, as well as social, goods;
- Interventions in water and sanitation must be based on the needs of the community in general, and of women in particular; and,
- Interventions should be incentive-driven and demand-based.

To achieve the SSA goals and according to the principles above, water and sanitation programmes should be based on (UNPD-World Bank, URL-4, 1998):

- Appropriate choice of technology and service levels;
- The breaking down of the sanitation and water delivery system into separate but technically compatible systems, designing the most efficient solutions at the appropriate levels;

- Economic replicability, aiming at full recovery of investments; and
- Responsive institutional arrangements, allowing the users to play a key role in decision-making and management of services.

With regards to the SSA, Wright (URL-5, 1998) commented that its principles help agencies to build capacity and communities to enhances ability in improving the systems. The author also characterises a demand-based approach by basing improvements on potential users' wants, their financial resources capacity and their potential to manage the installed systems. As suggested by Sara (URL-6, 1998), "*the ideal demand-responsive model is the market model, where there exists some level of demand from householders in a community, and services to meet this demand is paid for and contracted out by community members to providers*".

As stressed by Parry-Jones (URL-30, 1999), demand for improved water and sanitation services is a complex concept. Its characteristics are those presented in Table 2.6.

Table 2.6. – Characteristics of "demand" for water and sanitation

"Demand" may be:	"Demand" is always:	"Demand" is NOT always:
▪ expressed ▪ effective ▪ latent ▪ uninformed ▪ unrealistic ▪ biased ▪ created	▪ unique to each project location ▪ dependent on the alternative existing options ▪ dynamic (i.e. will change with time) ▪ different to water and sanitation ▪ dependent on people's willingness to pay for specific options	▪ equivalent to choice ▪ satisfied by the "best" solutions proposed by professional ▪ the same as what people say they "want" ▪ taken into account!

Source: Parry-Jones (URL-19, 1999)

The three main tools for assessing demand are the Household (HH) or Revealed Preference Survey (RPS), the Participatory Rapid Appraisal (PRA) and Contingent Valuation Methodology (CVM). These techniques are described in DFID (1998) and discussed at length in Parry-Jones (URL-30, 1999). Each of these techniques seems to be preferred by one or other of the groups of professionals involved with sustainable sanitation programmes (engineers, social scientists and economists). However, the appropriateness and effectiveness of these techniques are still controversial and not fully understood.

The main gain in the introduction of a demand-based approach is, probably, the change in thinking of how sanitation and water programmes should be driven. It promotes the transition from supply-driven programmes (characterised by "top-down" decisions that, at least in developing countries, have been shown to be unsustainable and distant from the reality of the poorest communities) to programmes based on meeting users-expressed needs. Garn (URL-7, 1998) suggests that for this transition be successful, it is required that stakeholders:

- Develop rules that give users the incentive to reveal their demand and give supply agencies the incentive to act on that information;
- Develop implementation procedures that encourage adherence to the rules and transparency in their application;
- Actively monitor performance and test hypotheses; and
- Give regular feedback on performance results to users and supply agencies so they can modify the rules and implementation procedures accordingly.

From what has been said, three main actors may be identified in the process of improving sanitation (and water) in developing countries through a demand-based approach. They are the communities, the government and the providers of services (which may be the private sector, NGOs, government agencies, research institutions and others). For the definition of the roles that should be played by each actors, Sara (URL-6, 1998) suggests the participation model detailed in Table 2.7.

Table 2.7. - Participation of actors in demand-based programmes

Community	Government	Providers
▪ Express demand ▪ Finance (part of) the services ▪ Manages project implementation ▪ Owns, operates and manages water and sanitation services	▪ Facilitator ▪ Sets polices and strategies ▪ Legal framework for access for services ▪ Asset ownership ▪ Registration of entities ▪ Financial policies ▪ Attainment of funds ▪ Sets conditions for efficiency and cost-effectiveness	▪ Dissemination of information ▪ Social intermediation ▪ Training of communities ▪ Consulting services ▪ Supervision of construction ▪ Delivery of all goods, civil works and spare parts

Communities owning, implementing and maintaining infrastructure projects represents a change in the position of stakeholders compared to the traditional participation ladder. Therefore, this change requires adaptations, especially in the way in which the actors are now supposed to interact with each other. Some points have already been presented as to how stakeholders should act in this new perspective; however, the importance of the new position of communities in a demand-based approach is still to be emphasised. Thus, Sara (URL-6, 1998) points out that communities should manage implementation because:

- Incentives are put in the right place (the client is the community and not the government or any other agency);
- Costs are reduced;
- There is a rapid increase in the demand for services;
- There is a greater possibility for co-financing from private sector;
- There is greater opportunity for community capacity-building; and
- Communities "want" to be involved.

A study reported by Katz (URL-8, 1998) on the impact of demand responsiveness (demand-based approach) on the sustainability of rural water systems, provided conclusions that may be also applied to sanitation programmes. Field-based teams in Benin, Bolivia, Honduras, Indonesia, Pakistan and Uganda developed the study over a one-year period and found that the demand-responsive approach at the community level significantly increases the likelihood of water system's sustainability. Another finding was that the existence of a formal organisation to manage the water system, and the training of household members in operation and maintenance are also significant factors. The study suggests that, to be effective, the demand-based approach should include procedures for an adequate flow of information and provisions for capacity building at all levels. Also, the approach should permit the re-orientation of supply agencies, allowing consumer demand to guide the investment programmes.

➢ *The CINARA Approach*

CINARA is a research and development institute of the Universidad del Valle in Cali, Columbia that has developed a model for planning water supply and sanitation investments at the local level. The model was developed to answer problems faced by local governments that lack knowledge about the magnitude and characteristics of the sanitation and water sector at the municipal level, as well as about the possible solutions that may be applied to solve these problems (Restrepo *et al.*, 1998).

The bases of the model are human development theory, systems theory and sustainability of water supply and sanitation projects. The human development theory states that *human development should be centred on people, taking into account basic* *human needs (subsistence, participation, affection, creativity, understanding, identity, protection, leisure and freedom)* (Restrepo *et al.*, 1998).

For the systems theory, the model is systematised putting institutions and settlements at the same level, finding out and expressing needs, setting policies, resources, plans and programmes, resulting in services and goods. This systems approach is illustrated in Figure 2.7.

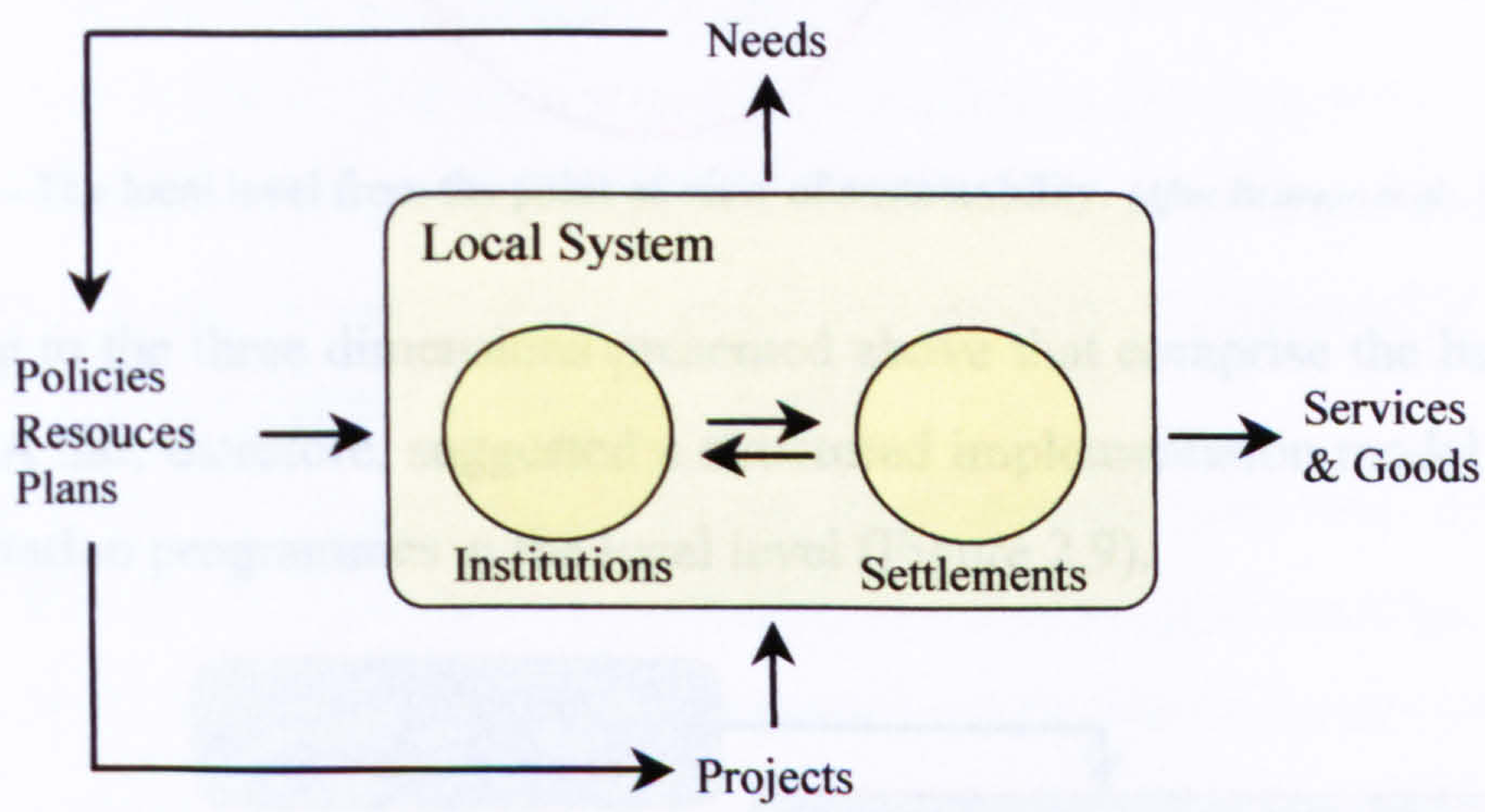


Figure 2.7. - A systems approach: the local level. *(After Restrepo et al., 1998)*

The third basis of the model is the sustainability of water and sanitation projects. In CINARA's perspective, these projects are sustainable when they "provide, over a significant period of time, an efficient and reliable service with a limited but feasible support, using the minimum of resources, including environmental resources" (Duque *et al.*, 1996).

CINARA also suggests that sustainability, in the water and sanitation sector, has three dimensions: community & local institutions, environment, and science & technology (Figure 2.8). The interaction between community & local institutions (first dimension) and the environment in which the community lives (second dimension) results in real or potential risks that may be eliminated or minimised by the efficacy of the third dimension: science & technology. The utilisation of science and technology involves knowledge, skills learning and actions, which would lead to community ownership of the programme and, hence, would consolidate system sustainability.

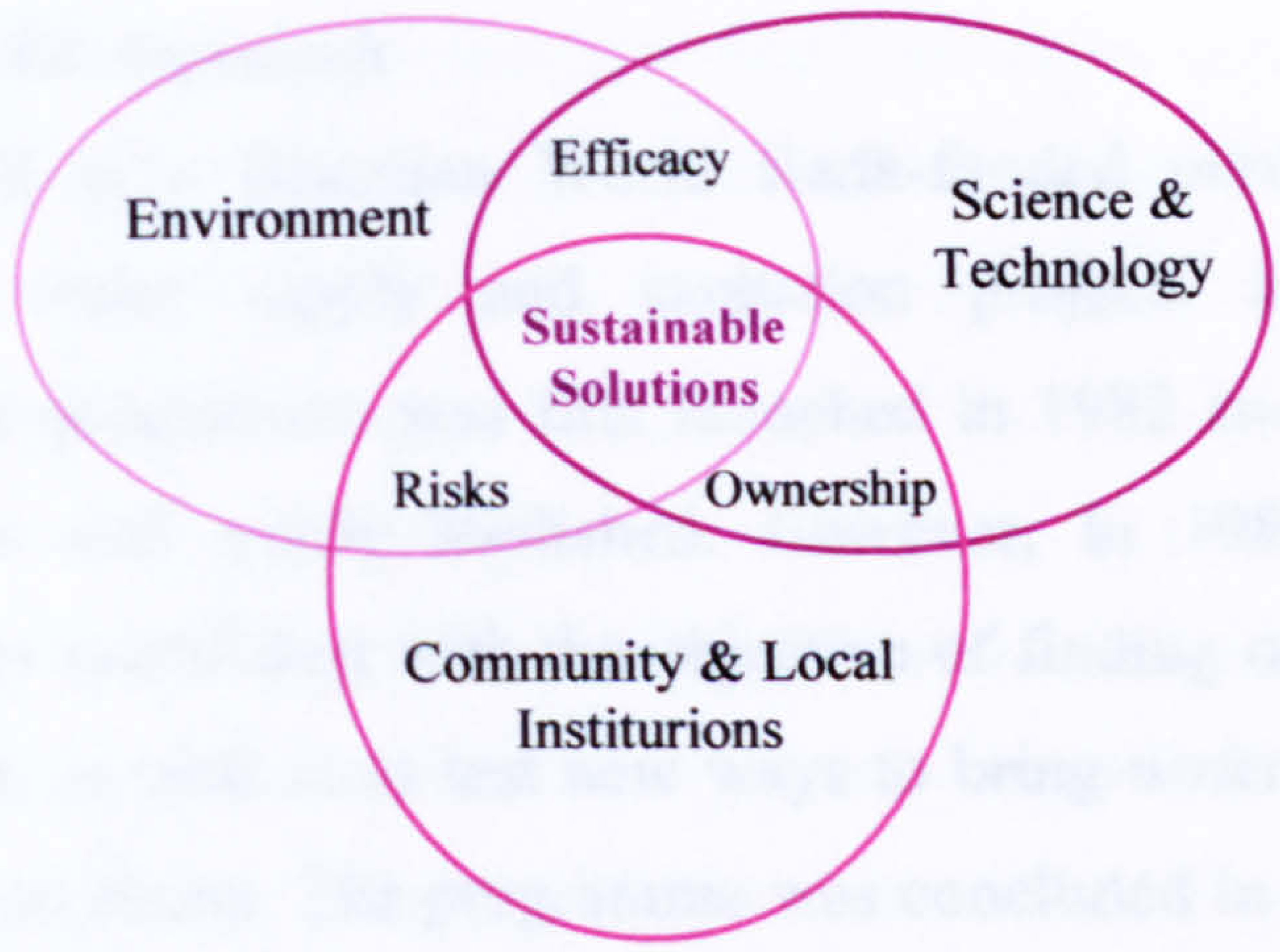


Figure 2.8 - The local level from the point of view of sustainability. *(After Restrepo et al., 1998)*

According to the three dimensions presented above that comprise the basis of the model, CINARA has, therefore, suggested a structured implementation model for water supply and sanitation programmes at the local level (Figure 2.9).

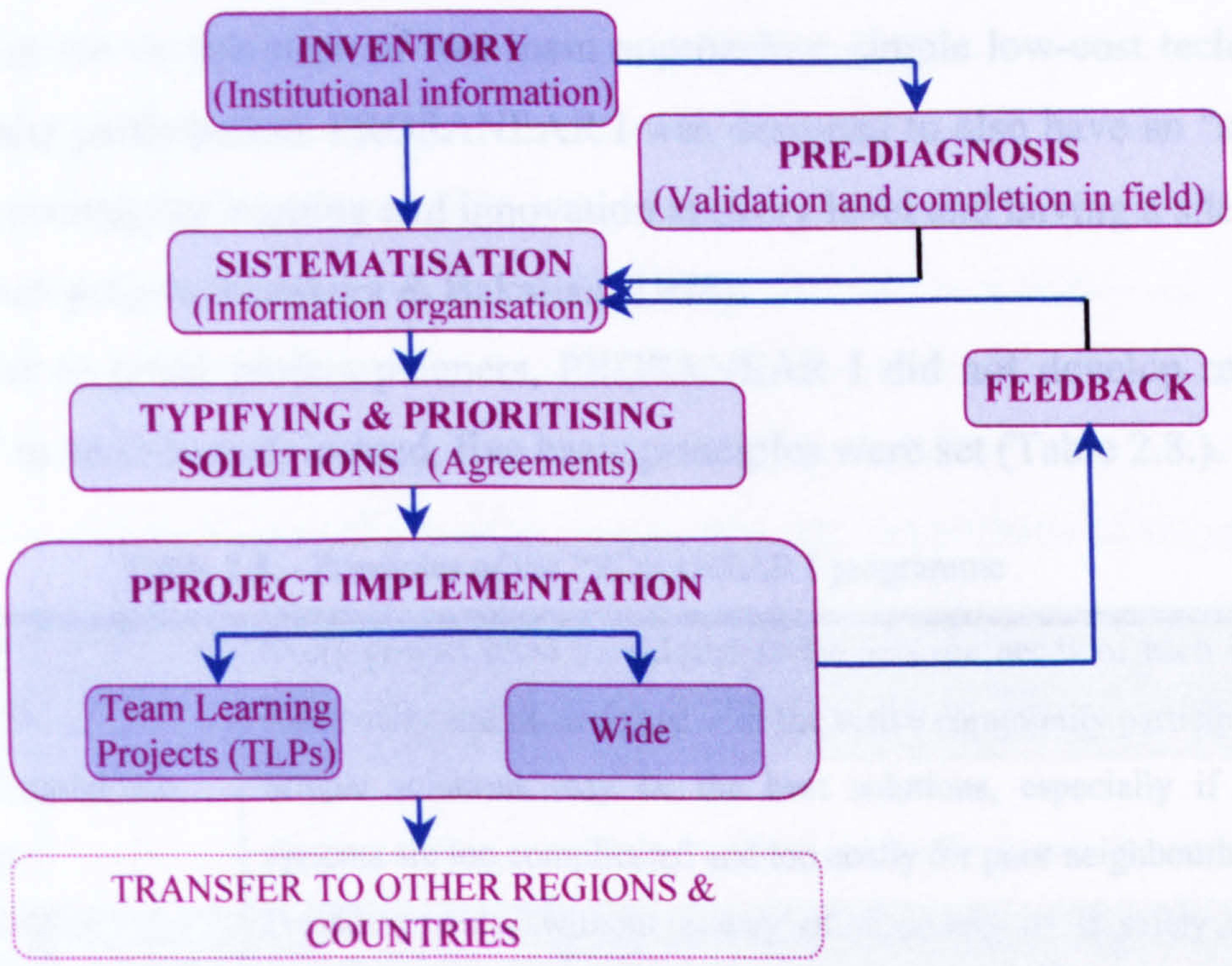


Figure 2.9. - A model for planning water and sanitation investments at the local level. *(After Restrepo et al., 1998)*

The CINARA model was first applied in 112 rural and peri-urban areas of Cali and later in some other areas of Colombia. The programmes are still running, and the results have already shown that, through the model, institutions are recognising the problems identified by the communities. Consequently, institutions are also prioritising and investing in projects that are desired by future users. The projects are planned together, resulting in a better utilisation of resources from the beginning and in the strength of communities as organisations (Restrepo *et al., 1998)*.

➢ *The PROSANEAR Approach*

PROSANEAR is a Brazilian World Bank-funded pilot programme for the implementation of water supply and sanitation projects in low-income urban neighbourhoods. The programme was first launched in 1982 and due to financial and technical difficulties was nearly abolished. However, in 1988, a second version, PROSANEAR I, was established with the objective of finding out what worked in the previous programme, as well as to test new ways to bring water supply and sanitation services into the urban slums. The programme was concluded in 1997, with impressive achievements: one million poor people connected to sewerage systems and 900,000 people to in-house level of water supply in 60 low-income settlements of 17 cities throughout the country (Katakura & Bakalian, 1998).

The PROSANEAR programmes had as their overall goal the delivery of affordable sustainable water and sanitation services to the urban poor, and for that, they were based on the combination of two main approaches: simple low-cost technologies and community participation. PROSANEAR I was designed to also have an "adaptable approach", encouraging learning and innovation at every level and having a site-specific design for each project (Katakura & Bakalian, 1998).

In order to guide project planners, PROSANEAR I did not develop mandatory "guidelines" to be followed; instead, five basic principles were set (Table 2.8.).

Table 2.8. - Principles of the PROSANEAR I programme

▪ Community Participation	Every project must be tailored to the specific needs of each individual community and be designed with the active community participation.
▪ Low-cost Appropriate Technology	Simple solutions may be the best solutions, especially if high-tech systems are too complicated and too costly for poor neighbourhoods
▪ Environmental Protection	Providing water without a way of disposing of it safely can make environmental problems worse. All projects that provided water had to provide sewage collection and disposal as well.
▪ Cost Recovery	Customers will take care of systems they have to pay for. Users were charged for hookups, water used and sewage collected.
▪ House Connection	Household connections are more convenient and equitable than public stand posts in an urban setting.

Based on: Katakura & Bakalian, 1998

The project planners used three main criteria for the selection of the communities:

- Priority was given to urban slums in cities of more than 50,000 people;

- All participating families earned less than three minimum salaries a month, of which at least 40 percent earned less than one minimum salary/month (US$100); and
- Beneficiary families agreed to pay for water and sewerage in accordance with tariff schedules maintained by the water utilities.

For the approval of individual projects, the following criteria were applied:

- Projects must conform with the most appropriate technical and environmental standards for the neighbourhood and represent the cheapest alternative;
- Water project construction costs should be less than US$ 98 per capita and sewerage projects less than US$ 140 per capita; and
- Total investments for bathrooms, drainage and solid waste disposal should not exceed 10 percent of the total cost of the project.

For the management perspective, projects were implemented by *executing agencies* assisted by both *regional* and *national coordinating units*. Thus, the executing agencies were responsible for identifying and assessing candidate communities, establishing a multi-disciplinary project team, building support for the project by community mobilisation, and overseeing the development of technical options, construction, operation & maintenance, training, monitoring and follow-up. The main functions of the regional offices were to facilitate, supervise and monitor local projects, and ensure that the various local projects were moving along in a timely manner. The national office was in charge of planning, monitoring and supervision of all programme advancements. It also was responsible for training and technical assistance to the implementation teams and for providing basic implementation guidelines, model terms of reference and model procurement documents.

Based on the principles, criteria and the organisational model described above, PROSANEAR I was established following the structure presented in Figure 2.10.

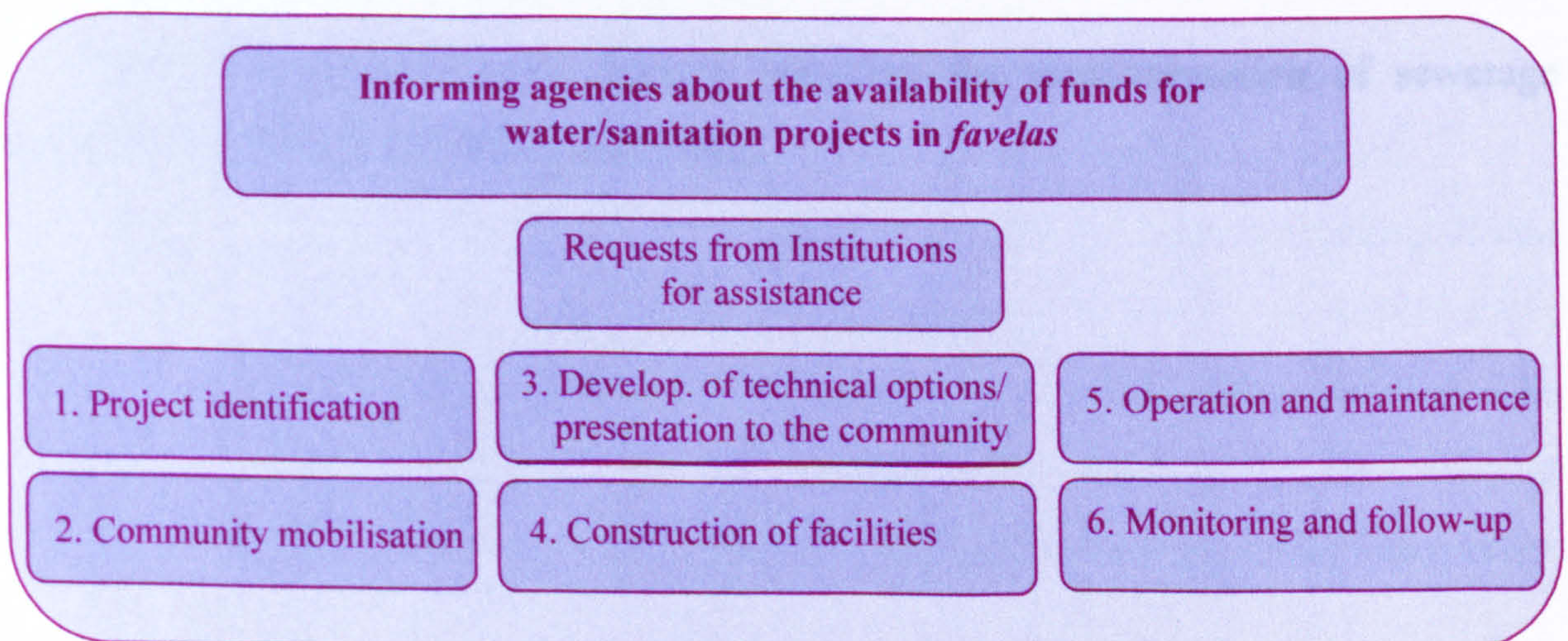


Figure 2.10 - Model for the implementation of PROSANEAR I projects. *Based on Katakura &Bakalian, 1998.*

PROSANEAR I believed that the stronger the community participation and organisation, the greater the chances for the project to succeed. In order to guarantee effective community participation, a framework was developed based on the following four main elements (Katakura & Bakalian, 1998):

▪ *Information Dissemination:*	A continuous feedback in which the community learn about potential activities in the area and the project team about community dynamics.
▪ *On-going Discussions:*	Project teams and communities engaged in regular discussions of community conditions and dynamics.
▪ *Proposal and Decisions:*	Project team and communities moving from discussions to decisions regarding the technical option that suited the particular community.
▪ *Responsibility:*	Project team committed to provide water and sanitation systems that suited the community, guaranteeing the operation of the system and charging fair rates. Users committed to pay for the service, using the system properly and maintaining the equipment.

PROSANEAR I achieved more than its initial objectives: the number of people connected to water systems was fourfold higher than the original target and people served by sanitation systems was 43 percent more than the estimated number. The main lessons learned by the programme are listed below (Katakura & Bakalian, 1998):

- Community participation must start at the very beginning of project preparation;
- Cost recovery and subsidy rules must be set in a clear and transparent manner;
- Formal, long-term arrangements for operating and maintaining the systems must be an integral part of the design; and
- All feasible technical options and their costs must be discussed with the communities.

Table 2.9 presents some features regarding the implementation of sewerage systems in the PROSANEAR I programme.

Table 2.9. - Features of sewerage systems implemented under PROSANEAR I.

State	City	Pop. (000)	Sewerage benef. populat.	Main geograph. situations/ Pop. density	Sewer. Collect. option	Sewage treatment	Const. costs. per capita (US$)
Amazonas	Manaus	1,011	3,523	Flat; Low density	Absorpt. pits		21
Pará	Belém	954	126,411	Flat, subject to floods; High density	Cond.	UASB	232
Ceará	Fortaleza Crato Quixadá Juazeiro do N.	3,049 173	186,452	Flat, river nearby prone to floods; High density Flat, dry; Medium density	Cond.	Stabilization ponds and communal septic tanks	78
Pernambuco	Recife	1,298	8,590	Close to river prone to flood; High density	Cond.	UASB	209
Minas Gerais	Juíz de Fora	386	12,122	Hilly; Low-medium density	Cond.	Communal septic tanks	51
Mato Grosso do Sul	Campo Grande Dourados	526	17,146	Low density	Absorpt. pits Cond.		51
Rio de Janeiro	Rio de Janeiro Angra dos Reis	5,587 149	445,285* 69,744	Hilly; High density Mostly hilly; Low density	Cond. Cond./ Abs. pits	Existing treatm. Plant UASB	87 61
Santa Catarina	Florianópolis Chapecó Joinvile Lages	234 118 388 151	25,896	Medium density Hilly, Low dens. Flat; Low-Med. density Low-density	Convent. Convent. Convent.	 Sep. tank + filter Sep. tanks + filters	59
TOTAL			895,169				

* Estimated / cond.= condominial sewerage *Based on: Katakura & Bakalian, 1998*

2.4.4. Sustainable Steps

The involvement of communities in the improvement of their own needs is presented as a key point for the sustainability of low-income sanitation programmes (i.e. the programmes discussed in the previous section). Therefore, this results in additional steps to the traditional framework applied for the delivery of sanitation projects.

Project ***Identification*** between providers and users has been recognised as one of the first steps, if not the very first, for programmes following a demand-based approach. During this step, communities should express their needs, discuss their problems and set their priorities. The process suggested by this step may face different degrees of difficulty according to the level of organisation existing in the community;

therefore, a multi-disciplinary team, including social scientists, has been reported as being the most appropriate (Watson, 1995).

Project ***Planning*** is the next step, which should already have all the actors involved and supporting the programme (community, executing agencies, financing agencies and others). The presence of multi-disciplinary teams is again emphasised in this step. It is here that communities take their decisions, and for this, the various options should be raised and properly explained to the future users. Next, responsibilities must be allocated to all involved actors with the maximum possible transparency during the decision-making process, especially for issues regarding money (financing and cost recovery) as well as "after-implementation" responsibilities (operation and maintenance of the project).

After decisions have been made and agreements signed, the ***implementation*** step takes place according to defined construction arrangements. This is followed by ***continuity*** actions, mainly characterised by the system's operation and maintenance tasks. The actions suggested by this latter step are of essential importance for programme sustainability. Although it has been advocated that the operation and maintenance tasks (or at least some of them) should be delegated to the communities, the agencies must give them the necessary support. Watson (1995) suggested four key elements to be performed by executing agencies in this post-implementation phase of condominial sewerage projects:

- Staff continuity between the construction and operational phases;
- Specialised condominium maintenance crew;
- Face-to-face contact with residents; and,
- Ongoing network monitoring and repairs, and customer "education".

Taking a vision beyond the implementation of a single sustainable project, the programme continuity step may also include the improvement of other community needs which may be motivated by the programme itself. Nevertheless, these actions should keep the same characteristics: attending to the needs expressed by the community and adopting affordable technological solutions, whilst keeping in mind their requirements for operation and maintenance, as well as for continuity in the educational programme's actions.

2.5. Sustainable Sanitation Technologies

2.5.1. Technology Appropriateness

Sustainable development has increased the concern over the *application, efficiency* and *efficacy* of technologies in urban infrastructure services (particularly, water and sanitation systems). The past records of these services (especially in low-income settlement of developing countries) are full of experiences of failure that have contributed to the well-known health problems as well as to the detriment of the urban environment itself.

Technology ***appropriateness*** is one of the key points to overcome the failure of past programmes. This aggregates technical, socio-cultural and economical parameters, which certainly lead to the selection of alternative low-cost technologies.

Throughout the fieldwork developed for this study, programmes applying different low-cost sanitation technologies were studied. The selected technologies and their main features are, therefore, discussed below.

2.5.2. Simplified (Condominial) Sewerage

Simplified sewerage was first implemented in Brazil based on the review of the design criteria used for conventional sewerage (Bakalian *et al.*, 1994). The innovative part of this system is essentially the adoption of locally based revised standards, instead of the excessive high technical standards that were currently applied. In this sense, a team of engineers from CAERN, the state Water and Sanitation Company of Rio Grande do Norte - Northeast of Brazil, developed the condominial version of the system. Thus, condominial sewerage applies the same design criteria as simplified sewerage; however, it differs in its design layout as well as in the incentive (or requirement) for community interaction with the sanitation programme.

Considering that simplified sewerage was mainly developed in order to reduce the costs due to the conservative design criteria adopted in conventional projects, the concepts presented below compare the parameters of this system with those of conventional systems.

➢ ***Layout***

In conventional design layouts, trunk pipelines should be built in the streets around the house blocks to potentially allow individual connections for all the households.

On the other hand, simplified systems are designed in a way that the wastewater from households in the same block is collected by a shallow and small diameter pipeline and then, delivered to the trunk sewers by a single (or just a few) connection, as illustrated below.

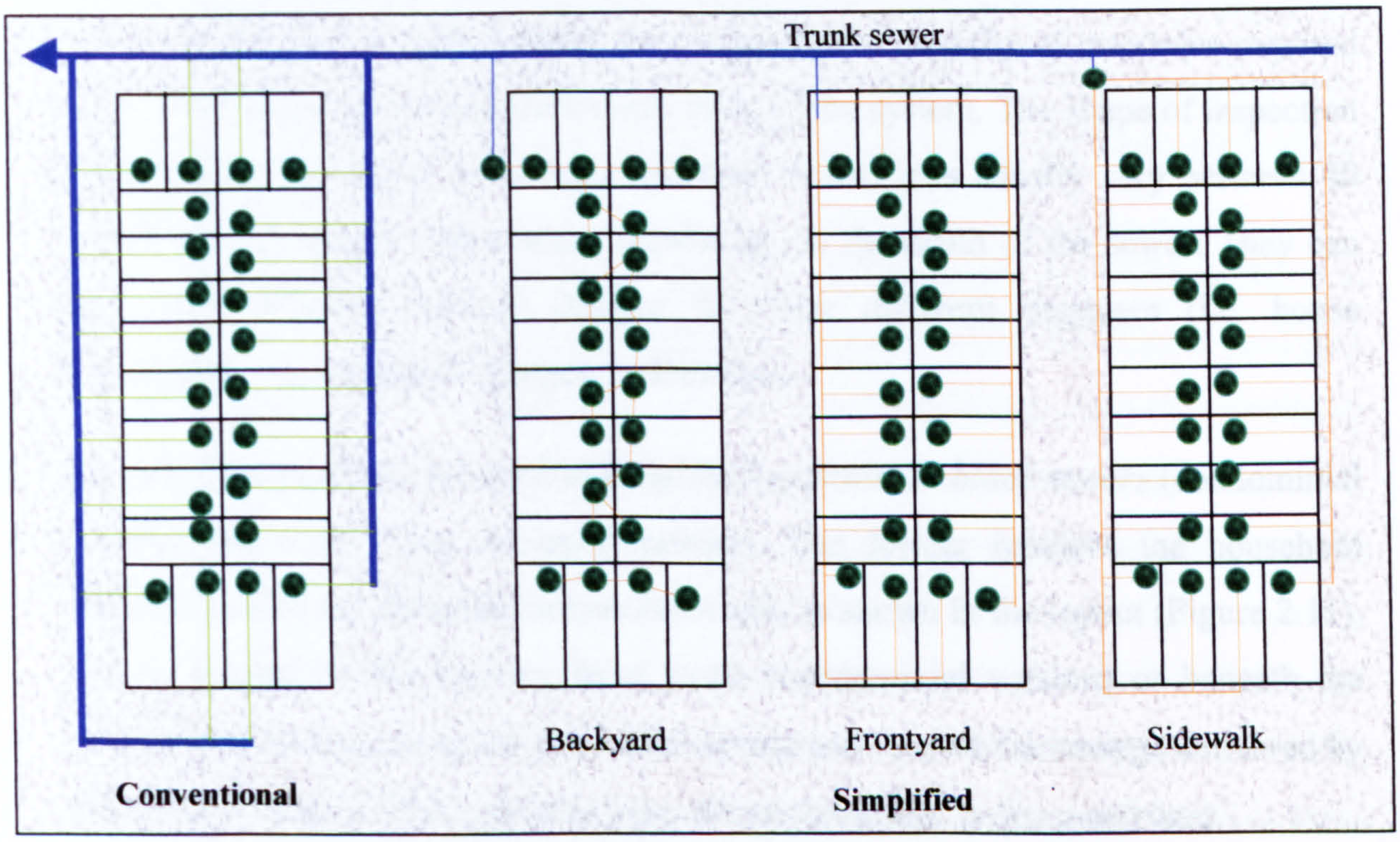


Figure 2.11. - Conventional and simplified sewerage layouts. *Based on Watson, 1995.*

➢ ***Component parts***

- ***House connections:*** Simplified sewerage receives all wastewater generated by the households, i.e. both toilet wastewater and sullage. Essentially, any type of waterseal toilet can be used in this system (pedestal seat or squat pan, normal or reduced flush); however, considering that the system does not require a large quantity of water for its functioning, reduced-flush toilets are preferable. Therefore, connections between the households and the in-block sewer may occur through two pipelines: a 75 mm pipeline connecting the toilet wastewater to the inspection chamber, and a 50 mm pipeline connecting the sullage wastewater to the 75 mm pipeline or directly to the inspection chamber. In areas with low water consumption (up to 50 m^3/day), the installation of a grease/grit trap for the sullage is recommended. Moreover, ventilation pipes should be installed in the house connection pipes; these also serve to ventilate the whole system.

- *Inspection chambers:* These units are used for: house connections with the in-block sewer, changes in direction, changes in slope and maintenance of the sewers. In conventional sewerage, manholes are commonly used, especially for pipeline maintenance; however, in simplified systems their usage is reduced by the installation of inspection chambers. This substitution is possible mainly due to the shallower characteristics of the system; therefore, the manholes are only used where the sewers are laid at greater depth, thus reducing the quantity of manholes required and consequently decreasing the overall costs of the system. The shape of inspection chambers can be square or circular and their dimensions usually vary between 40 and 80 cm (in length or diameter), depending on the depth of the sewer. They can also have different internal designs for their different purposes (i.e. house connections, cleanout and changes in direction).

- *Sewers:* Two pipelines are used in simplified systems: *in-block sewers* (condominial sewers) and *trunk lines* (or main sewers). The former receives the household wastewater through the house connections and, as shown in the layout (Figure 2.11), can be located in the back or front yards (condominial version) or beneath the sidewalks. The trunk lines are laid in the streets and receive the sewage delivered by the in-block sewers. The hydraulic basis for sewer design is discussed later.

- *Pumping stations:* These usually comprise one of the most expensive units in sewerage systems and hence, whenever possible, are not included in the design. Their requirement in projects is very topography-dependent; however, the gradient of the sewers, as well as the boundaries of the area adopted by the systems, also influences the number of stations required.

- *Sewage treatment plant:* Simplified sewers have no hydraulic restrictions for their connection with any conventional treatments plants, which may be the option in areas where there is an existing conventional treatment unit. However, low-cost solutions for wastewater treatment (such as waste stabilisation ponds) are more desirable.

➢ ***Design area***

The simplified sewerage project area usually recommended is, where possible, limited by drainage basins. In fact, this approach may allow the systems to be more easily managed and can also reduce the number of pumping stations required.

➢ ***Depth of sewers***

A number of authors have designated simplified sewerage as "shallow sewerage"; this nomenclature however was changed to avoid confusion with other systems. Nevertheless, the shallow depth at which the sewers are laid in simplified designs is one of its most important characteristics, having direct effects on both capital and O&M costs. Two parameters are mainly responsible for the shallow depth of the sewers: *layout* and *gradient.*

In comparison with conventional systems, simplified sewerage layouts allow a reduction in the overall length of the sewer lines, which is especially true in backyard condominium layouts. The sewer gradient may be directly related to the flow velocity or to the shear stress (as discussed next). The flow velocity is also the parameter adopted in conventional designs; however, simplified sewerage applies this parameter in a less conservative way resulting in a design with a lower gradient.

With the association of these reductions in sewer extension and gradient, the pipelines can be kept shallower, and hence decrease the cost of excavation as well as the number of pumping stations required. Moreover, the in-block sewers are laid in areas without heavy traffic and, consequently, the cover layer over the crown that is required for protection (cover to soffit) of the sewer can be thinner than in conventional sewerage designs.

➢ ***Hydraulic concepts***

Two hydraulic design approaches can be used for the design of simplified sewers: minimum self-cleansing velocity and minimum tractive tension.

The first approach is based on the requirement for a minimum flow velocity in order to avoid the deposition of solids into the pipes. This concept considers that the minimum self-cleansing velocity at peak flow calculated for the system will be enough to carry the solids away, even if this is achieved only once a day. This approach is also applied in the design of conventional sewerage; however, it has a more conservative interpretation. While conventional designs consider the minimum self-cleansing velocity of, at least, 0.6 m/s, sometimes even 1 m/s (Mara, 1996), simplified sewers are designed using 0.5 m/s as the standard value for self-cleansing velocity in order to obtain the main design parameters (sewer gradient and diameter). As shown below, the velocity is directly proportional to a power function of the gradient and inversely proportional to a power function of the peak flow, thus, the lower the minimum velocity, the shallower the sewer can be kept. Nevertheless, the value for peak flow, which was taken as 2.2 l/s in the first trials with condominial systems in Natal, is now 1.5 l/s and this is the standard value stated in the Brazilian code (ABNT, 1988). This approach is currently used in condominial designs with successful examples of application especially in the Northeast of Brazil (Mara, 1996; Sinnatamby, 1986).

The second approach, based on minimum tractive tension, also has the objective of ensuring the transportation of solids. However, this approach is based on the tangential force exerted by the flow of sewage per unit of wetted boundary area. Therefore, the design parameters are now obtained by considering that the minimum tangential force (or minimal shear stress) of 1 Pa is satisfactory for simplified sewerage design (Mara, 1996; Bakalian *et al.*, 1994).

Comparing both approaches, the adoption of minimum tractive tension appears to provide a more economical design. Although, in the examples studied (Mara, 1996; Bakalian *et al.*, 1994), the comparison between both approaches did not result in significant differences for the pipe diameter, the calculated minimum gradients in the second approach were lower than the one calculated by the minimum self-cleansing velocity approach. Moreover, SANEPAR, the state water company of Paraná in the South of Brazil, has simplified systems designed with a minimum shear stress of 1 Pa which have been operating satisfactorily for over 15 years, thus providing a reliable reference for the application of this methodology, which is also adopted in the Brazilian code (ABNT, 1988).

➤ ***Design parameters***

Simplified sewers are designed for open channel flow conditions, based on the properties of a circular section and Macedo's modification of Manning's equation (Mara, 1996).

- ***Peak flow:*** The estimation of peak flow is calculated by equation (ii) for all sections of the network pipeline. As demonstrated in equation (i), equation (ii) is based on: the size of the population (initial/final); the percentage of water consumption that returns as sewage (usually considered a loss of 15 percent due to water usage that is not collected by housing connections - i.e. cooking, gardening, cleaning and others), and, the k_1 and k_2 coefficients of maximum daily and hourly flow variation, respectively. Consideration should also be taken for the inclusion of upstream flows discharging into the sewer as well as for the possibility of groundwater infiltration into the pipes. This infiltration may occur due to imperfections in pipe joint sealing and it is typically considered as 0.2-0.3 l/s/km (Sinnatamby, 1986). Therefore,

(i) $Q = [(C \times k_1 \times k_2 \times P \times w) / 86400] + Q_c + Q_i$

Where, Q = peak flow in a sewer section (l/s)
C = sewage return factor (usually adopted 85%)
k_1 = coeffic. of max. daily flow variation (=1.2)
k_2 = coeffic. of max. hour flow variation (=1.5)
P = contributing population
w = water consumption (l/person x day)
Q_c = flow from upstream flow contributions (l/s)
Q_I = infiltration flow(l/s)

(ii) $Q = [1.8 \times 10^{-5} \times P \times w] + Q_c + Q_I$

- ***Proportional depth of flow:*** This parameter is based on the properties of circular sections and expresses the ratio between the depth of flow in the pipe and the pipe diameter. It is used during the design to check if the depth of flow is high enough to ensure the transportation of solids at peak flow and if it is low enough to guarantee sufficient ventilation at the end of the design life. Therefore, the minimum and maximum values for the proportional depth of flow (d/D) are: $\mathbf{0.2 < d/D < 0.8}$
  - Minimum ➔ 20% of the pipe diameter;
  - Maximum ➔ 80% of the pipe diameter.

1. *Design by self-cleansing velocity:*
   - *Velocity:* This design assumes that a flow velocity of 0.5m/s is enough for the transportation of solids. Therefore, this value is adopted as the self-cleansing velocity applied for gradient and diameter determination.
   - *Minimum gradient:* calculated from the Macedo-Manning equation (iii) (Mara, 1996), from which, the velocity is substituted by the self-cleansing velocity (iv) resulting in an equation for the minimum gradient as a function of the peak flow (v):

(iii) $v = 15.8 \times Q^{1/4} \times i^{3/8}$ Where v = velocity of the flow (m/s)

Q = peak flow (m^3/s)

i = gradient (m/m)

(iv) $I_{min} = (v_{sc}/15.8)^{8/3} \times Q^{-2/3}$

Where I_{min} = minimum gradient (m/m)

v_{sc} = self-cleansing velocity (0.5m/s)

Q = peak flow (m^3/s)

(v) $\mathbf{I_{min} = 0.01 \times Q^{-2/3}}$

Where I_{min} = minimum gradient (m/m)

Q = peak flow (l/s)

2. *Design by minimum tractive tension:*

- *Shear stress:* This approach, which is based on the shear stress expressed by equation (vi), considers that 1 Pa (or 0.1 kg/m^3) is enough to guarantee the transportation of solid particles in simplified sewers at peak flows.

  (vi) $\tau = W \times r \times i$ Where τ = shear stress (kg/m^3)

  W = specific weight of sewage (N)

  r = hydraulic radius (m)

  i = gradient (m/m)

- *Minimum gradient:* To calculate the minimum gradient through this approach, the above equation (vi) is incorporated into Manning's equation (vii) and finally, it provides equation (viii) used to calculate the minimum gradient.

  (vii) $Q = 7.687 \times 10^{-8} \times (1/n) \times (\tau^{8/3}) \times I_{min}^{13/6}$

  Where, Q = peak flow (m^3/s)

  n = Manning's Roughness Coeffic. (= 0.013)

  τ = shear stress (= 1Pa)

  I_{min} = minimum gradient (m/m)

  (viii) $\mathbf{I_{min} = 0.0054 \times Q^{-6/13}}$

  Where, I_{min} = minimum gradient (m/m)

  Q = peak flow (l/s)

Therefore, considering a minimum peak flow of 1.5 l/s (a toilet flush flow), the minimum gradient value can be calculated for both approaches presented:

Approach	Minimum gradient
Self-cleansing Velocity	0.006 (1 in 167)
Tractive Tension	0.004 (1 in 225)

- *Pipe diameter:* Regardless of the approach used for the design of sewers, 100 mm is usually recommended as the minimum diameter for pipes applied in simplified sewerage designs (Sinnatamby, 1986). The diameter of sewers can be calculated by the equation below:

$$D = n^{3/8} \times k_a^{-3/8} \times k_r^{-1/4} \times (Q / I_{min}^{1/2})^{3/8}$$

Where D = pipe diameter
n = Manning's Roughness Coefficient
k_a = coefficient of proportional area ($a=k_aD^2$)
k_r = coefficient of proportional hydraulic radius ($r=k_rD$)
Q = peak flow (l/s)
I_{min}= minimum gradient (m/m)

Sewers in simplified systems essentially require the same operation and maintenance tasks applied in other systems. As suggested by the WPCF (1985), a minimum maintenance programme should include tasks such as cleaning, flushing, repairs and supervision of connections/disconnections. However, it is expected that the shallower characteristic of the sewers allows the implementation of a simpler and cheaper operation and maintenance programme, which may be achieved by the utilisation of less sophisticated equipment that, consequently, requires less skilled labour.

2.5.3. VIP Latrine

The ventilated improved pit (VIP) latrine is an on-site sanitation system. It was developed to avoid the two major disadvantages of traditional (unventilated) pit-latrines, which are foul odours and the attraction of flies, making the system more socially and healthwise acceptable.

VIP latrines are designed to receive just excreta (faeces and urine) without any requirement for water. Thus, the utilisation of water should be totally avoided in personal cleansing activities (Mattos, 1997) and be very limited when cleaning the latrine. This low requirement for water makes the system very suitable for users that do not have an in-house level of water supply; however, this would also constitute one disadvantage because the system requires a separate solution for sullage disposal.

The advantages of this system are its easy construction, its adaptability to diverse types of material, and its usually simple maintenance. As disadvantages, there are possibilities of groundwater contamination and the reduced appropriateness of the system for high density neighbourhoods.

VIP latrines are designed to receive and deposit excreta in the latrine pit where the excreta are digested by the natural biological action of anaerobic bacteria. In two years time the pathogens in the excreta are inactivated and the material accumulated inside the pit can be safely handled.

As said previously, VIP latrines are designed to be odourless and fly-free. The control of *odour* occurs due to the air circulation through the latrine pit and vent pipe. The air is allowed to enter the latrine by the superstructure, then, it goes into the pit through the squat-hole or toilet bowl (which should not be covered) and comes out through the vent pit, guaranteeing air movement and avoiding the risks of odour (see Figure 2.12).

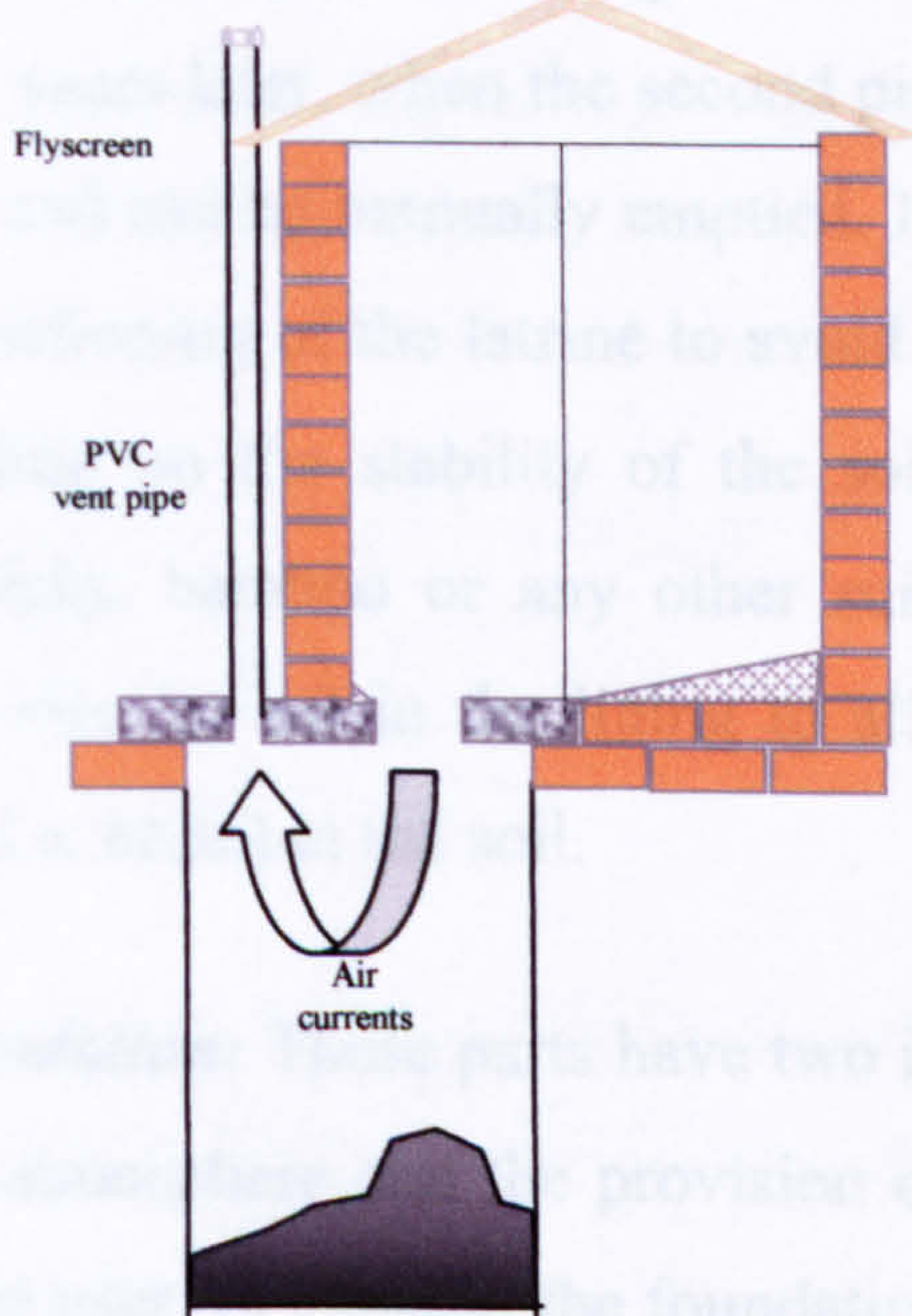


Figure 2.12. - Schematic diagram of a ventilated improved pit latrine. *Source: Mara (1996).*

The *fly control* mechanism is based on two events. Firstly, the flies use the excreta to lay their eggs, being attracted to it by the faecal odours, however, the screen on the top of the vent pipe (where the faecal odour are strongest) does not allow the flies to get inside of the pit for breeding. Secondly, some flies may reach the excreta through the superstructure lying their eggs in the pit, however newly emerging adult flies are attracted by the brightest light to leave the pit. Considering that the latrines are designed not to allow the entrance of light through the superstructure, the brightest light will come from the vent pipe which is covered by the fly screen which therefore keeps the flies inside the pit where they eventually die.

Variations of the basic VIP latrine design alternatives can be adopted to comply with requirements imposed by soil condition (lined/unlined pits), ground water table level (raised/not raised latrines), users' preferences (outside/in-house latrines), economical suitability and institutional support (spiral/rectangular shaped, single/twin pit and emptiable/non-emptiable latrines (Mara, 1985a)).

VIP latrines include the following components (after Mara, 1984):

- ***Latrine pit:*** VIP-latrines may be designed with single or twin pits. Both types are based on: the size of the household, the design life and the solids accumulation rate. Single pit latrines should be designed to have at least 10 years of design life if it is a non-emptiable latrine, whereas an emptiable single pit latrine may have a design life of 2 years and the emptying process must be carried out mechanically. The twin-pit latrine should have at least 2 years of design life. After the first pit is full the second one is used and two years later, when the second pit is also full, the first one will be pathogenically safe and can be manually emptied. It is essential to instruct the users about the proper functioning of the latrine to avoid the utilisation of both pits at the same time. Depending on the stability of the soil, the pit should be lined with concrete blocks, bricks, bamboo or any other suitable material locally available. Free-spaces should also be left in the lining to allow the infiltration of the liquid fraction of excreta (i.e. urine) in the soil.

- ***Cover slab and foundation:*** These parts have two important functions: the isolation of the pit from the atmosphere and the provision of support for the superstructure, the vent pipe and the user. In general, the foundation may be built in a single course of bricks set in cement mortar. The cover slab may be built in a wide range of materials depending on local availability and its capacity of support; however, the most suitable material is reinforced concrete. The shape of the cover slab should follow the same shape of the pit (circular or rectangular) and two holes must be provided: one for the squat-hole or the toilet bowl and the other for the vent-pipe.

- ***Superstructure:*** The superstructure has three different functions: to guarantee the user's privacy, protect the cover slab hole from natural light (which is fundamental for fly control) and channel air through the hole and up the vent pipe. Traditionally, the superstructure entrance is designed with doors; however, it has been reported that doors are frequently left open and consequently do not control flies effectively.

In some African countries, such as Zimbabwe, the use of doors was considered undesirable and a spiral design for the superstructure has become very popular (Morgan & Mara, 1982).

- *Vent pipe and flyscreen:* As discussed before, the vent pipe is responsible for both odour and fly control. It may be provided in different materials such as bricks or bamboo, however a 100 mm PVC pipe is generally used. In any case, the top of the vent pipe must be protected with a flyscreen.

The design of a VIP-latrine is based on the volume of the pit necessary for the accumulation of the excreta from users during the design life of the system, or during the emptying interval. Therefore, the volume of each pit is calculated by:

$$V\ (m^3) = r * P * n$$

Where: r = solids accumulation rate (m^3/person/year);
P = number of users (people);
n = design life or emptying interval (years).

Additionally, some requirements should be followed:

- Cross-sectional area not greater than 2 m^2;
- Distance between the bottom of the pit and the groundwater table level of, at least, 0.5 m;
- A freeboard of 0.3-0.5 m should be added to the calculated depth.
- Solids accumulation rate is usually 0.03-0.06 m^3 per person per year in dry pits and 0.02-0.04 per person per year in wet pits.

2.5.4. Pour-flush Toilets

Pour-flush toilets are also an on-site sanitation system. They consist in the deposition of excreta in a watersealed toilet (bowl or squat pan) that is flushed using a reduced amount of 2-3 litres of water per flush. The flushed wastewater is then discharged into a pit, where the liquid fraction leaches into the soil of unlined pits (or holes left in lined pits) and the solids are retained for consequent bacterial digestion. Problems of odour and fly control are avoided by the waterseal maintained by a trap in the toilet bowl (squat pan).

The pour-flush toilet has the advantage of being a well-tried technology with widespread use in developing countries; it has a low water requirement and is easy to maintain; it is highly social acceptable, has excellent insect and odour control, is easy and safe for use by children, and it may be easily upgraded. On the other hand, pour-flush toilets are not suitable for areas where people use bulky materials for anal cleansing and for soils with low infiltration rates; as in the case of VIP-latrines, pour-flush toilets also have the potential for groundwater contamination and requires a separate solution for sullage disposal.

The toilets in pour-flush systems are usually manually flushed; however, the system can be easily converted to low-volume cistern-flush operation. For that, the two most popular ways are by the Indian squat-pan unit or by the Brazilian pour-flush pedestal seat. In the Indian model, the cistern has a capacity of 15 litres releasing just 1.5 litres per flush. The Brazilian system uses 5 litres of water to flush and the water is deposited in a cistern that is fed by an in-house water supply system (Mara, 1996).

The three main parts that compose a pour-flush toilet system are:

- ***Superstructure:*** An outside structure has the objective of protecting the toilet unit and to provide privacy for its users, however it has no impact on the fly control process as in VIP-latrine systems. It should be built with the floor raised by at least 150 mm in order to avoid the entrance of stormwater and insects (Mara, 1985b). Pour-flush toilets may also be an in-house facility. In both cases, the design should allow easy maintenance and cleanliness.

- ***Latrine unit:*** As discussed earlier, this system requires a waterseal that must have a depth of 20-30 mm in the trap unit. This is to minimise the consumption of flushwater as well as to guarantee the waterseal formation. The wastewater may discharge directly into the leach pit; however, it is more commonly connected to a 75-100 mm pipeline, which is laid shallow at a low gradient, and then discharged into the pit. In cases of twin pit systems, a Y-shaped flow diverter should be included, as shown in Figure 2.13.

- ***Leach pit:*** As with VIP-latrines, the pour-flush systems may be designed with either single or twin pits. In the single pit design, a mechanical emptying process at the end of its design life is required, whereas the twin pit can be safely emptied manually. Leach pits are used for both the storage/digestion of excreted solids and the infiltration of wastewater liquids. For the latter function, the long-term infiltrative capacity of the soil is of essential importance (Mara, 1985b).

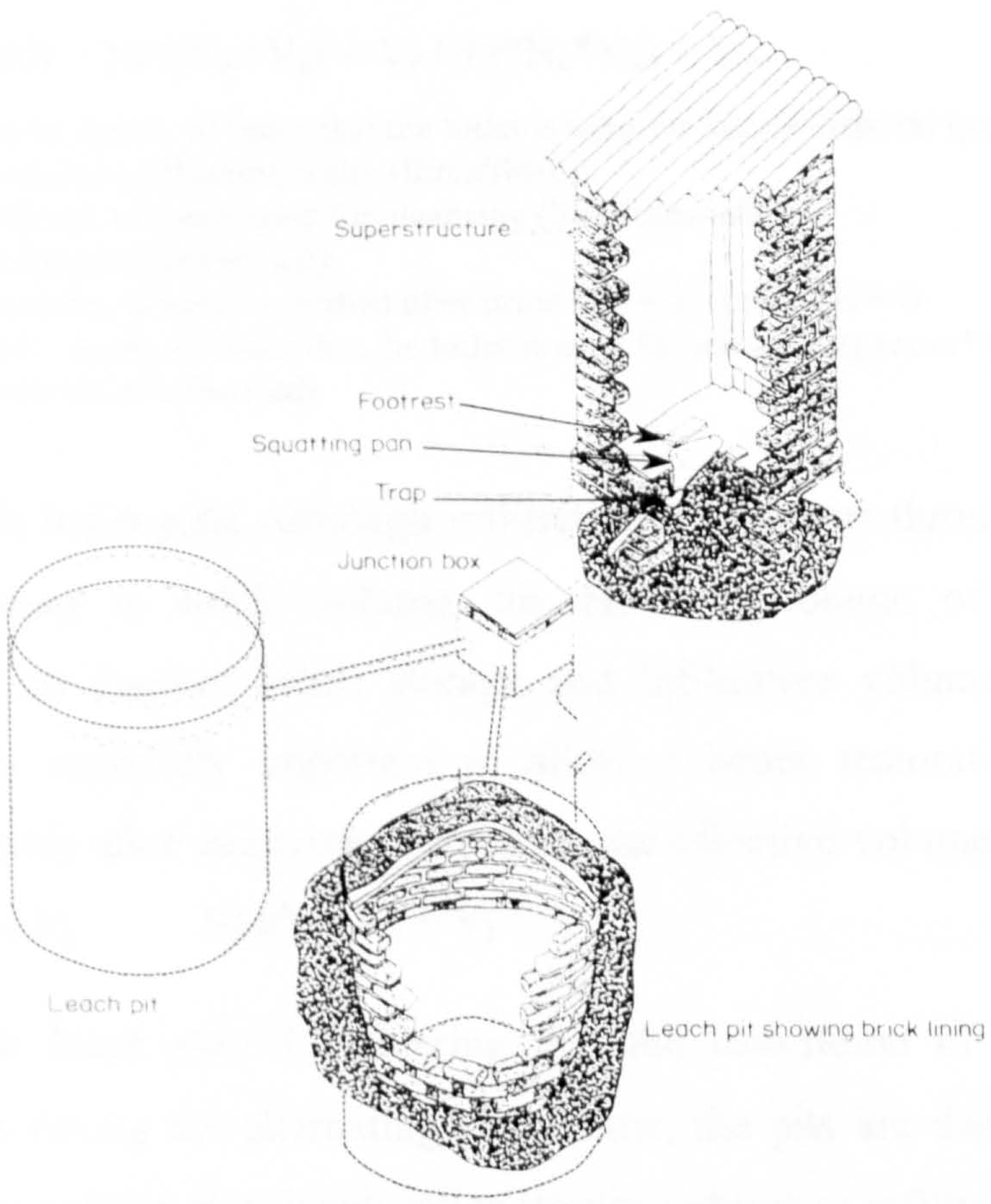


Figure 2.13. - Schematic diagram of a pour-flush toilet. *Source: Mara (1985a).*

The leach pit design for pour-flush toilet systems is based on the volumes required for solids storage and for infiltration. Therefore, the design sequence is presented below (after Mara, 1996):

1. *Solids storage volume*: This volume is calculated in the same way as VIP-latrine pits:

$V_S\ (m^3) = r * P * n$ Where: r = solids accumulation rate (m^3/person/year);
P = number of users (people);
n = design life (years).

2. *Infiltration volume*: This is based on the long-term infiltration rate of the soil, which may be estimated by the *in situ* percolation test or by the long-term infiltration rate of the different types of soil. Therefore, infiltration volume is calculated by the following equation: $V_I = \pi * D^2/4 * h$; $A_I = \pi * D * h$; $A_I = Q/I$

$$\mathbf{V_I\ (m^3) = Q*D/4*I}$$

Where: A_I = sidewall area required for infiltration (m^2);
Q = hydraulic load (litres*capta*day or lcd), discussed below;
D = assumed pit diameter (m);
I = long-term infiltration rate (l/m^2*day);
h = height of the sidewall area (m).

The hydraulic load may be calculated as follows:

$$Q\ (lcd) = N_f*(V_w+V_c) + V_f + (a*N_u*V_u) + V_u$$

Where: N_f = aver. numb. of times that the toilet is used for faeces disposal (person*day);
V_w = volume of flushing water (litres/flush);
V_c = volume of water used for cleansing (litres/cleansing);
V_f = volume of faeces (lcd);
a = constant, if toilet is flushed after urine it is = 1; if not it is = 0;
N_u= aver. numb. of times that the toilet is used for urination (person*day);
V_u = volume of urine (lcd).

- *Design of single leach pits*: Although infiltration also occurs through the sidewall area corresponding to solids volume, the effective volume of single pits is determined by the sum of solids storage and infiltrative volumes. This design consideration is especially important to allow a better restoration of the soil infiltrative capacity after emptying. Therefore, the effective volume of single leach pits is calculated by: $V(m^3) = V_S + V_I$

- *Design of twin leach pits*: Considering that the restoration of soil infiltrative capacity occurs during the alternating usage time, the pits are designed using the greater value for volume calculated: solids storage volume or infiltrative volume.

2.6. Assessment of Sustainable Sanitation Programmes

The assessment of a technology-driven system is usually a straightforward exercise. It is comprised of physical components that are designed to produce certain specific outcomes. Thus, the assessment is based on a limited, but well-defined evaluation of the technology's components ("hard" elements) and their expected performance over its design life. On the other hand, social systems are far more subjective. In systems committed to social achievements and interactions among people, their boundary line is not easily determined. Moreover, interaction with human beings is not at all predictable and "the performance" of the system may be subjected to human behaviours and individual aspirations.

The sanitation programmes in a sustainable development context combine both approaches referred to above. Their performance depends on a physically implemented technology, but also on the active participation of users and their interaction with other stakeholders.

2.6.1. Indicators of Sustainability

Indicators may be defined as *bits of information pointing to characteristics of systems or highlighting what is happening* (Hardi *et al.,* URL-10, 1997). They are used as operational elements for the assessment processes facilitating communication and making the quantification of systems possible (Bell & Morse, 1999; Hardi *et al.*, URL-10, 1997; UN, URL-11, 1997). The importance of indicators, as measurement tools of sustainable development, is stressed by their role in decision-making processes, providing information on issues such as the development of trends and pressure points, the impacts or effects of interventions or policies, the feedback of adjustments models (to speed up or slow down the effects of interventions), and on the milestones achieved or the failures that frustrate progress (UN, URL-11, 1997).

Indicators of sustainability can be used as *explanatory tools*, *planning tools* and *performance assessment tools* (Hardi *et al.,* URL-10, 1997). Indicators can also be divided into variables or functions of variables and classified as qualitative variables (e.g. safe-unsafe neighbourhood, participatory-non-participatory decision making); ranking variables (i.e. best or worst training programme, lowest or highest mortality rate) and quantitative variables (i.e. gross domestic product/capita, water consumption in litres/capita day).

Along with other institutions the United Nations is also concentrating efforts on the development and testing of suitable indicators for sustainability (UN, URL-13, 1999). As a result, a working list with 134 indicators was established covering four aspects of sustainable development: social, economic, environmental and institutional (UN, URL-12, 1996,). These indicators are presented in a Driving Force - State - Response framework, where:

- Driving Force: (also referred to as control, pressure or process indicator) Indicates human activities, process and patterns that impact on sustainable development. Examples are unemployment rate, population growth rate and GDP per capita.
- State: Describes the state of a variable (such as concentration of a pollutant, human population density and income equality)
- Response: Indicates policy options and other responses to changes in the *state* of sustainable development. Examples are infrastructure expenditure per capita, national councils for sustainable development and the proportion of GDP spent on education.

The strongest criticism against the utilisation of indicators to assess sustainable development is probably their attempt to reduce complex and diverse processes into relatively few simple measures, which also makes sustainable indicators (SI) appear as a reductionist set of tools based on quantification (Bell & Morse, 1999).

Although different sets of variables (quantitative, ranking, qualitative) have been suggested, reductionism may be an intrinsic characteristic for the measurement of systems. The process of breaking down complex systems is commonly applied to make systems manageable and assessable. Thus, the question may be how much reductionism should be allowed in the assessment of systems toward sustainable development. An attempt to answer that may be through the way systems are approached.

SIs may allow the collection of data related to components (reduced parts) of a system; however, none of these parts can be approached in isolation. The interaction among parts of the system and between parts and the environment should be present in every stage of the system analysis (conceptualisation, planning or assessment). Thus, more than with isolated indicators, sustainability indicators must be committed to the systems in a holistic perspective, adopting the process of thinking systematically about problems and making the process interactive, participatory and ongoing.

In Bell & Morse (1999), the sustainability indicators are positioned as represented in Figure 2.14. They collect information from the system, making them capable of interpretation and use. The main questions in this model are still the quantity of indicators that should be applied and which indicators are appropriate. As every potential available indicator may not be applied, an element of simplification would be introduced, and the maximisation of relevant information is also essential.

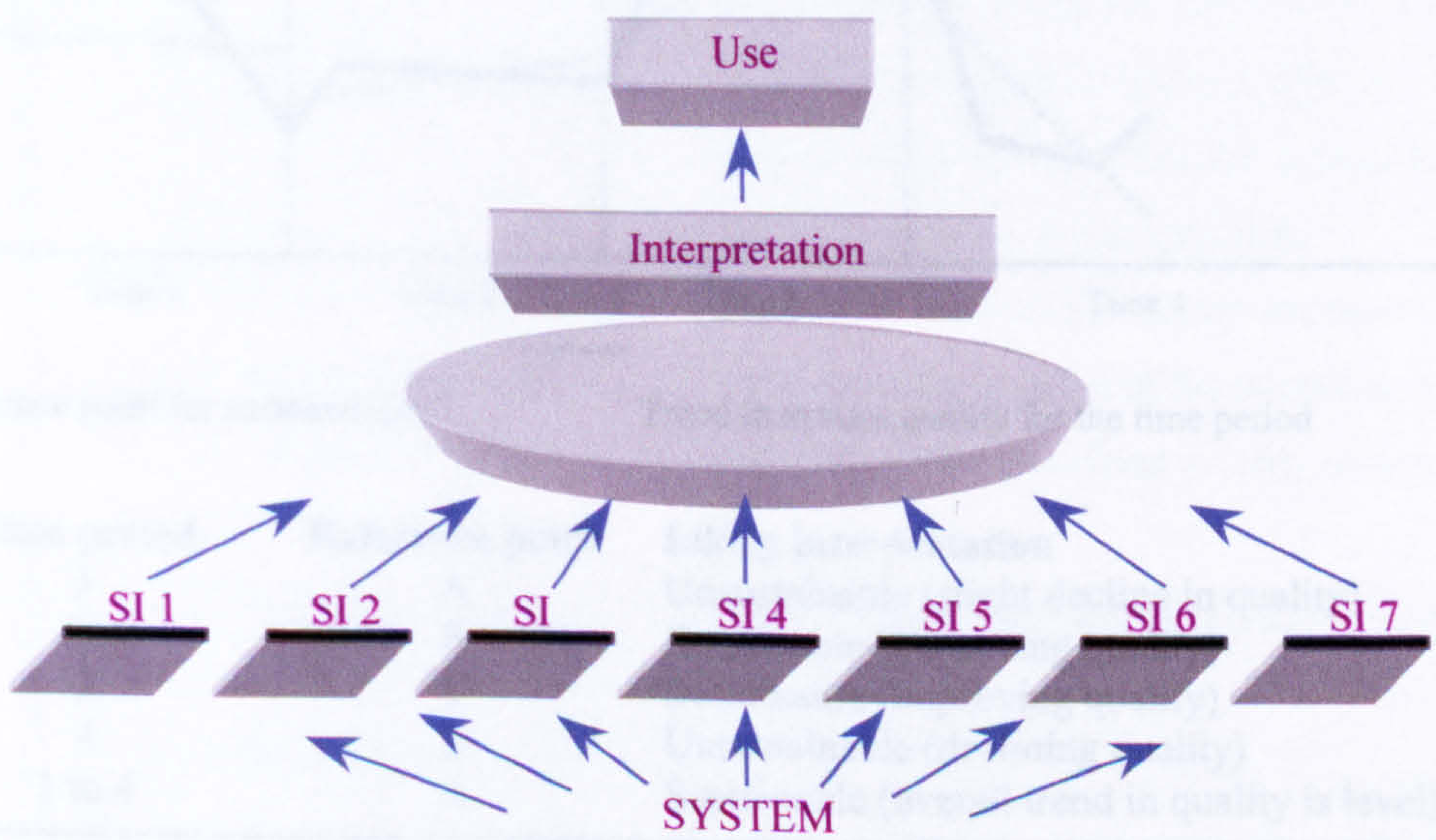
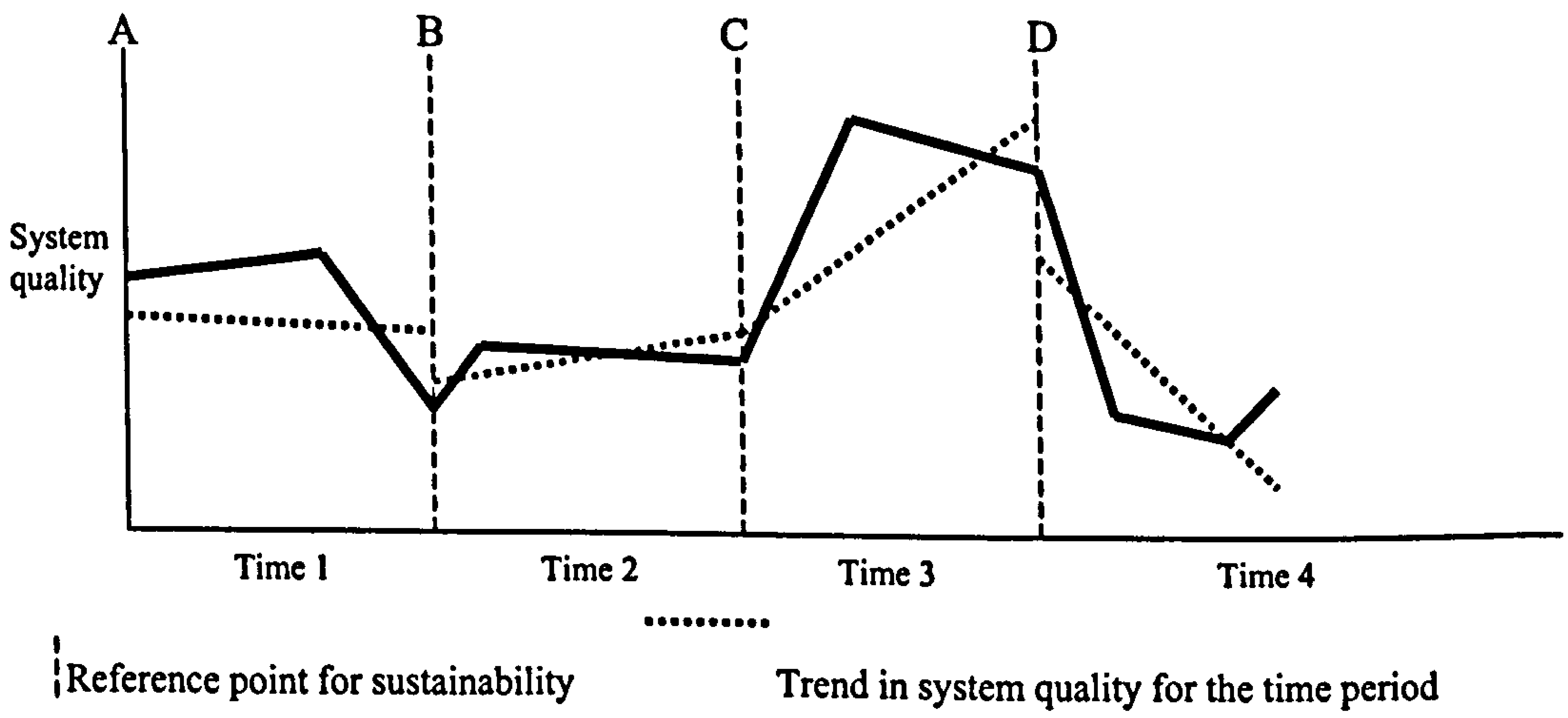


Figure 2.14 - The concept behind sustainability indicators (SIs). *Source: Bell and Morse (1999)*

In the identification of SIs, three elements are present as key issues for the assessment of a system's sustainability. They are space, time and quality (Bell & Morse, 1999). The *spatial scale* defines the boundary of the system. Although it may appear of easy physical determination (a town, a nation, the globe or even a settlement or a community), the elements that should be included inside of the system's limits and the level of "openness" that should be left for interaction (or linkage) of these internal components and outside environment may not be that simple. Also, usually the smaller the spatial scale, the harder it is to draw its limit line.

The *time scale* is a very relative element in sustainability. By definition, it is stated that sustainable development should not "compromise the ability of future generations...", but, as questioned by Bell & Morse (1999), what future generation should be considered (in ten, 100 or 1000 years) ? Figure 2.15. illustrates a variation on the quality of a system used to measure sustainability over time periods. When the reference period for the system assessment is just one of a period of time (1, 2, 3 or 4), different interpretations arise for each period (slightly unsustainable, sustainable, sustainable and unsustainable, respectively). Moreover, if the whole period is taken as reference (period 1-4), the interpretation of the trend will be more or less constant over time. Thus, time (and space, as well) requires a careful selection of reference points to be able to reflect accurately the intended situation.



Time period	Reference point	Likely interpretation
1	A	Unsustainable (slight decline in quality)
2	B	Sustainable (improving quality)
3	C	Sustainable (improving quality)
4	D	Unsustainable (declining quality)
1 to 4	A	Sustainable (overall trend in quality is level)

Figure 2.15. - Importance of the reference point for gauging sustainability. *Source: Bell & Morse (1999)*

The *quality* of the systems (or quality of life, or people's well being) is the third key element suggested. The identification of quality parameters that should be used for the assessment of sustainability make this last element even more controversial than the two previous ones. In fact, if two people assess the same system based on different quality parameters, they may achieve distinct (even contradictory) interpretations.

The elements considered above are identified on the Bellagio principles for assessment toward sustainable development (IISD, URL-9, 1999 – note that this is not the WSSCC Bellagio principles on environmental sanitation, for that see WSSCC, URL-31, 2000). These principles, established in November 1996, are considered interrelated principles, and they are recommended to be applied as a complete set. They were developed as guidelines for assessment processes and include the choice and design of indicators, their interpretation and communication of results. Four main aspects are covered by the principles as shown in Table 2.10.

In summary, sustainability indicators are not just a question of collecting data from parts of a system. Therefore, the process of selection of a set of indicators must be committed with the system as a whole and follow a systematic framework of analysis. Concerning indicators, Hardi *et al.* (URL-10, 1997) stated that,

"Indicators themselves are also the products of a compromise between scientific accuracy and the needs of decision-making, and urgency of action. This limitation becomes quite clear in the social dimension where many of the variables, such as political stability, cultural aspirations and equity, are hardly quantifiable and cannot even be defined in physical terms".

Table 2.10. – Main characteristics of the Bellagio principles

▪ *Principle 1* :	▪ Guiding Vision and Goals	Deal with the starting point of any assessment - establishing a vision of sustainable development and clear goals that provide a practical definition of that vision in terms that are meaningful for the decision-making unit in question;
▪ *Principles 2-5* :	▪ Holistic perspective ▪ Essential Elements ▪ Adequate Scope ▪ Practical Focus	Deal with the content of any assessment and the need to merge a sense of the overall system with a practical focus on current priority issues;
▪ *Principles 6-8* :	▪ Openness ▪ Effective Communication ▪ Broad Participation	Deal with key issues of the process of assessment;
▪ *Principles 9-10*:	▪ Ongoing Assessment ▪ Institutional Capacity	Deal with the necessity for establishing a continuing capacity for assessment.

2.6.2. Physical Evaluation Procedures

During the International Drinking Water Supply and Sanitation Decade (1981-1990), WHO produced a document providing guidelines for a minimum evaluation procedures (MEP) for water supply and sanitation programmes (WHO, 1983).

The document considers three main elements: the *functioning,* the *utilisation* and the *impact* of the facilities. It is also argued that these elements should be evaluated in sequence; there is no point in evaluating impact if the facilities are not appropriately used and, in the same way, there is no meaning in assessing utilisation if the technical system is not working.

The emphasis of the WHO MEP document is on the collection of basic information on the functioning and utilisation of low-cost water supply and sanitation projects. Thus, the document identifies the following steps:

- Decision to evaluate;
- Selection of team leader;
- Establishment of terms of reference (which should define: objectives; project area; design study; methods; organisation and manpower resources; reporting requirements; time schedule, and financial requirements);
- Desk study (project documentation analysis);
- Field visit for planning;
- Decision on focus of the evaluation;
- Collection of data (discussed below);
- Assessment of data;
- Recommendations, report writing and follow-up actions.

The MEP document suggests that there are three main types of data: data on the functioning of the facilities and educating services, data on the utilisation of services and data on the institutional and financial arrangements of the programmes. Table 2.11. summarises the main approaches suggested for obtaining these different types of data.

Table 2.11. – Approaches for data collection in MEP

Type of Data	Approaches	Observations
1. On the functioning of facilities and educational services	▪ Engineering inspection; ▪ Scientific observation; and ▪ Users comments on their perceptions on educational messages and approaches	Opinions and attitude of users should be recorded, but they should be backed up by direct inspection and appropriate laboratory tests.
2. On the utilisation of the services*	▪ Direct observation; ▪ Conversational interview; ▪ Stratified sample; ▪ Information gathering by school children; ▪ Community questionnaire; ▪ Questionnaire survey; and ▪ Workshops.	The selected method (s) for household information (left-side list) should be the least costly approach(es) at reasonably accuracy.
3. On institutional and financial arrangements of the projects.	▪ Desk study (review of documentation); ▪ Interviews	Information may be conflicting depending on their sources. Descentralised sources are likely to be more accurate.

* The document provides further details on the indicated approaches *Based on WHO (1983).*

The items recommended for investigation under the institutional and financial set of data are divided into government and consumer inputs. For the first, the following inputs are used as examples:

- Involvement of consumers in the planning process;
- Promotional and educational programmes;
- Training of project staff (for construction and for O&M);
- Production and delivery of the project components; and
- Construction demonstration and supervision.

For consumer involvement it is suggested that they contribute to:

- The planning process; and
- The construction and O&M in cash or in kind.

Regarding the evaluation of functioning and utilisation of sanitation programmes, the MEP document selected three indicators for functioning (proportion of household that have sanitation facilities, sanitation hygiene and sanitation reliability) and one indicator for utilisation (proportion of people using the facilities). These indicators are detailed next:

1. Indicator of Proportion of Household that Have the Sanitation Facility

The acceptability of the programme is an important factor to improve the sanitation condition of the community as whole, and also for the viability of the programmes. Thus, this indicator consists of a house-to-house survey obtaining the number of households that actually have the facility (i.e. latrine, connection). The indicator can be obtained by the following relation:

$$I\,(\%) = \frac{\text{Number of households having the sanitation facility} \times 100}{\text{Total number of households in the programme area}}$$

It has been suggested that this indicator may be obtained by a house-to-house survey. However, a coverage of hundred percent of the sample in these types of surveys is usually difficult to achieve. Therefore, a minimum percentage sample coverage should be established beforehand (80 percent or above) (WHO, 1983). In addition, the main reasons for why households are not attached to the programme is also expected to be obtained during the collection of data for this indicator.

2. Indicator of Sanitation Hygiene

Facilities that are not kept clean can both discourage people from using them and serve as a focus for the transmission of diseases, whereas the sanitation system has the objective of avoiding them.

This indicator is suggested as best established through physical inspection. However, it is far more subjective than the first indicator and relies on judgements established by the inspector(s). Therefore, a grading system (i.e. good, acceptable, bad and very bad) should be applied for the registration of the data. The aspects to be evaluated will certainly vary according to the type of facility implemented but they should include items such as general cleansing of the toilet area, odour, presence of insects, access to water, presence of lid on the latrine and presence of the water seal, as necessary.

The indicator should be expressed as the proportion of a specific grade for the determined aspect.

3. Indicator of Sanitation Reliability

The requirements of design, construction and O&M services for the applied technology should be properly followed in order to get the best out of the system and stimulate households' participation in the programmes. A house-to-house survey is also applied for this indicator where a "check list" of the technology requirements, containing items such as presence of fly-screen, water seal, system ventilation and emptying interval among others, may be accordingly applied.

4. Indicator of the Proportion of People Using the Facility

Reliable information on the utilisation of sanitation facilities by household members is difficult to obtain. The observation of toilet utilisation is (usually) not physically possible and interviews are not all reliable; people usually state that the facilities are being used even when they are not. Therefore, the MEP document recommends a mixture of interviewing and observation of signals of usage/non-usage in order to draw a more accurate picture of the facility's utilisation.

As in the case of the first indicator (the indicator of acceptability), the reasons for why the facilities are not being used are of great value. Common reasons include inconvenience of the facility's location, unsuitability for younger children, unhygienic conditions and cultural aspects.

Another topic that must be addressed in studies regarding the sustainability of the sanitation programme is the impact of the sanitation system on users' health. A range of factors may influence the state of health in any given community (see section 2.2.3); therefore, the adoption of indicators that will, in fact, measure the health benefits resulted exclusively from sanitation improvements is usually not straightforward. The next section discusses the main implications of the measurement of impact of sanitation programmes on users' health.

2.7. Measurement of Impacts on Public Health of Sanitation Improvements in Low-Income Communities

Assessing the health impacts derived from sanitation (and water supply) programmes presents a series of fundamental problems. These studies have been traditionally based on epidemiological parameters to measure indicators such as incidence rates of diarrhoea/dysentery, prevalence rates of excretion of one or more enteric pathogens, prevalence rates or intensities of intestinal helminthic infections, nutritional status and mortality rates.

Blum & Feachem (1983) analysed the methodology applied in 44 published studies on the impact of water supply and/or excreta disposal on diarrhoea, or on infections related to diarrhoea. They identified at least one methodological problem in each of the 44 studies (which raises serious doubts to the validity of the conclusions presented). The main methodological problems identified were the following:

- Lack of adequate control;
- One to one comparison;
- Confounding variables;
- Health indicator recall;
- Health indicator definition;
- Failure to analyse by age; and
- Failure to record facility usage.

Two cases of *control* problems were found in a number of the studies analysed by Blum and Feachem (1983). These problems were basically the complete absence of an external control sample, and comparability of the control and intervention sample (which was not established prior to the interventions). The *one-to-one comparison* problems were related to studies that select a single control community and compare it to a single intervention community. In these cases, the number of elements in each sample is one; hence, no statistically valid conclusion can be drawn.

Inadequate control of the influence of *confounding variables* was another problem identified. The importance of the control of confounding variables is to avoid those aspects not directly related to the sanitation or water supply projects also influence the health status of the studied population. For example, certain people in the studied community may have easier access to information on health than others (i.e. from TV or radio programmes) and their health conditions may improve due to this sort of information and not necessarily due to the new sanitation facility.

Health indicators that are asked to be *recalled* (such as the number of diarrhoea episodes over a specific period) may present three problems: the variable may not be known by the respondent (the episodes of diarrhoea of all members of the family, for example), unwillingness to divulge the information and a limited ability to remember. A suggestion for the health indicator recall problem is to keep the recall periods as short as possible. Alternatively, the variables could rely on evidence of the infection.

Another methodological problem was related to the *health indicator definition*. The definition of both the disease and the applied indicator should be clear to avoid the impression that measurement of impact is being made on a vaguely defined illness. Environmental impact studies are unevenly distributed among various age groups; therefore the adoption of an *age-specific* approach for the data analysis of the study is necessary. Finally, the last methodological problem discussed for epidemiological evaluation of impact on health from water supply or sanitation improvements is that studies also *fail to record facilitity usage.* Regarding this, it must be remembered that facilities by themselves do not improve the health status of users, which can only be achieved by their proper use. For this, the utilisation of two approaches is recommended: information collected by questionnaire and information collected by observation (Blum & Feachem, 1983).

Cairncross (URL-14, 1999) argues that epidemiological studies depend on the intervention studied and the outcome measured. However, the ideal way suggested to measure the impact of health intervention (double-blind, randomised, controlled trials) is not seen as feasible for sanitation and water supply interventions. Cairncross (URL-14, 1999) states that:

There is no placebo for a pit latrine. Moreover, the unit of intervention usually has to be the community, rather than the household. Besides, it is almost impossible to allocate water supplies and sanitation at random - ethically, politically and practically.

Another factor raised from the discussion of fundamental problems of health impact evaluations is that such evaluations are not an operational tool and the results frequently offer no firm interpretation. Additionally, even if health impacts are satisfactorily detected in an epidemiological study regarding water supply and sanitation projects, no guidance on how the projects may be improved is offered (Cairncross, URL-14, 1999). Therefore, this author suggests that an alternative approach is the evaluation of impact based on patterns of hygiene behaviour, instead of attempting to measure disease rates. The basis for this is that water supply and sanitation projects are usually accompanied by hygiene education programmes that seek to achieve improvements in hygiene practices such as the washing of hands, food and utensils, or the disposal of children's faeces, all of which can be used as parameters for health impact evaluations.

The WHO minimum evaluation procedure (MEP) document (referred to previously) also suggests indicators for hygiene education evaluation (WHO, 1983). As in the case of the evaluation of sanitation projects, hygiene education evaluation is also divided into functioning and usage indicators. The four functioning indicators are related to understanding the language of educational messages, understanding the content of the messages, access to the messages and face-to-face contact with project staff and other educators. In relation to usage, the three indicators suggested are water storage habits, handwashing after defecation and knowledge of oral rehydration. These seven indicators are detailed next (based on WHO, 1983).

➢ *Indicators of functioning*

1. *Indicator for the understanding of the language of the messages*

The overwhelming majority of the target audience must have a full understanding of the educational messages (especially among women's groups). The data for this indicator may be collected by surveying the languages in which a representative sample of the target group is fluent and literate. The assessment is thus realised through the proportion of people (or women) able to understand the languages adopted for the transmission of the messages (which may be spoken, written or graphic languages).

2. *Indicator for the understanding the content of the messages*

The target of this indicator is that the audience should readily understand the content of the educational messages. Data should be collected by asking a representative sample to explain the meaning of some hygiene education messages and the answers may be scored on a three-point scale (good understanding, some understanding and no understanding).

3. *Indicator of access to the messages*

This indicator is given by the proportion of a representative sample in the target group that have access to the media used for the transmission of the hygiene education messages. Additionally, it is also suggested that information be gathered on the periodicity of which they see or hear the messages.

For the assessment of this indicator, a case-specific criterion should be developed to judge whether the financial investments in the selected media is justified or not, in comparison with the percentage of people that are actually receiving the messages.

4. *Indicator of face-face contact with project staff and other educators*

It is assumed that staff in face-to-face contact with the target group can:

- reinforce the messages;
- explain and amplify the messages to suit local situations; and
- give encouragement to those who are modifying their hygiene habits.

The data required may be obtained through a survey of a representative sample to determine the proportion of people who have conversed with educators in the past month. Moreover, the quality and the quantity of these interactions among the target group and educators should be assessed asking people to recall their meetings, identifying the educator met and giving the subject of the conversations.

The answers should be recorded and the assessments made by an analysis of the kind of staff that are more effective and what kind of knowledge and activities are being encouraged.

➢ ***Indicators of utilisation: water storage habits; handwashing after defecation and knowledge of oral rehydration***

The assessment of these indicators aims to identify changes in behaviour. The data required for this assessment can be based on observations (whether the water storage recipients have been kept properly protected and hygienically maintained, or, whether there is water and hand washing material easily available near the latrines). For the indicator of the knowledge about oral rehydration, interviews with mothers should be carried out in order to assess their knowledge on how to prepare the oral rehydration solution, when to give it and how much. This information may be graded on a three-point scale:

- Does not know what oral rehydration solution is;
- Proportions of ingredients or application is grossly wrong; or
- Proportions of ingredients or application is approximately correct.

2.8. Conclusions

Sanitation is a basic need for any community, and a need that has been advocated to be met for every person in the world by the end of 2025 (WSSCC, 2000).

Sanitation may be understood in terms of comfort, but it is primarily a question of health. In the first sections of this chapter, data were given on the number of people that are still suffering from diseases that may be avoided if a sanitised environment is available. However, the simple delivery of a sanitation system is not enough to ensure its proper technological functioning or the expected improvements in health.

As noted by Kalbermatten & Middleton (1998), a "strategic planning" system is required that addresses the technical, financial, institutional and social approaches needed for the sustainability of the service.

The next chapter gives the methodology that will be applied in the field study, which is based on the discussions presented throughout this literature review.

Chapter 3: Methodology

3.1. General Purpose of the Survey

According to Oppenheim (1966), a survey is "a form of planned collection of data for the purpose of description or prediction as a guide to action or for the purpose of analysing the relationships between certain variables".

Considering the aim of identifying conditions most likely to lead to physical sustainability of low-cost sanitation programmes, the general purpose of the fieldwork was the investigation and description of the present conditions of the sanitation programmes selected for the case studies.

Although investigations on the technicalities of the systems were also carried out, the study was principally focused on the strategies for implementation and O&M of the programmes, especially institutional arrangements and programme integration with the beneficiary communities.

3.2. Specific Objectives

During the selection of the case study areas, six sanitation programmes were chosen (section 4.1.). The specific aspects investigated in each case study were:

i. Technical and social conditions for selection of the sanitation technologies;
ii. Technical parameters for the design of the systems;
iii. Financial aspects towards affordability;
iv. Implementation steps and stakeholders participation (consistence of the users involvement on the programmes);
v. Users' acceptability/satisfaction toward the sanitation programme;
vi. Possible social/health improvements brought upon the programmes; and
vii. Operation & Maintenance arrangements.

3.3. Investigation Requirements

The investigation of the aspects specified above would certainly require different approaches. Some of them may be fulfilled just by a *study of the documentation of the programme*, whilst others would require complementary information through *interviews* with stakeholders.

Observation would also be a useful method to collect information on the utilisation of the systems and on their O&M schemes. Additionally, for the measurement of the variables regarding data from the householders' point of view, the utilisation of a *structured questionnaire* seems to be the most appropriate tool.

These social survey methods are well-recognised instruments and are outlined below.

3.4. Social Survey Methods

Among the various social survey methods, the three considered most appropriate for this study were:

3.4.1. Informal Interviews

Informal interviews with key informants usually yield valuable information for social studies, allowing a better understanding of the situation and providing support for the definition of the final design of the survey.

Key informants can be people that in some respect had interacted with the variables to be studied. In the case of the sanitation programmes, the key informants would be the providers (politicians, designers) or would be among the members of the community (especially community leaders). Nevertheless, the main information obtained by these interviews should always be further investigated.

3.4.2. Observation

Observation techniques may be used both as a complementary method and as the main strategy for data collection in a social survey. The *participant observation* technique is based on the immersion of the surveyor in the day-to-day activities of the selected environment, having as its aim to perceive trivial facts related to the variables to be observed.

Controlled observation is applied when the survey aims to compare situations or observe determined behaviours toward the survey variables. In these cases, the surveyor is purely an "observer" and does not interact with either the selected people or the environment. In many cases this technique also requires a control group.

For factual data, however, *direct observation* may be enough to collect the desired information. In such cases, a factual recording form should be available to register the situations observed. This technique is used in nearly all case studies investigated to collect data on the technical inspection of the sanitation systems units.

3.4.3. Questionnaires

A structured questionnaire can be a powerful tool for the collection of qualitative data on social surveys. Therefore, the design of questionnaires must be a carefully planned activity in order to avoid bias, decrease errors and enable the survey to provide reliable answers. To achieve this, the following steps are recommended (Oppenheim, 1966; Nichols, 1991):

1. ***Decisions concerning the data-collection method***: the main options of data collection methods on a questionnaire survey are: the formal interview, the mail questionnaire and self- and group-administered questionnaires. For the selection of the appropriate strategy, the costs demanded by each method, the time scale of the survey and the availability of personnel (trained or available for training sections) to conduct the interviews should also be considered.

2. ***Selection of respondents and how to approach them***: sampling procedures are usually required for the selection of respondents in large-scale survey (see section 3.5). The approach to the respondents should be planned and take into account the strategies for the introduction of the surveyor, explanations on the purpose of the research, confidentiality of responses and anonymity of respondents.

3. ***Questionnaire framework and order of questions for each variable***: the sequence of questions can help to build-up confidence and keep the respondents interested in continuing to provide the answers. The adoption of a framework is recommended starting with general questions and gradually moving on to specific aspects. A "funnelling" framework is also a popular strategy to conduct the sequence of questioning.

4. ***Questions type***: the questions can be written in the form of a list of probable answers or as free-response (open) questions; however, the coding and the processing procedures must be adequate for the adopted type of question. Resources such as probe, skip and filter questions are also useful to increase reliability and make the questionnaire more friendly for both respondent and interviewer.

3.5. Sampling Criteria

The two main classifications for samples are: non-probability and probability samples.

3.5.1. Non-probability sampling methods

The **non-probability sampling methods** provide samples based on the judgement of the surveyor or on the needs of the survey. It is usually adequate for surveys of "hard-to-identify" groups, of specific groups or in pilot situations (Fink, 1995). In such cases, non-probability samples would be appropriate due to the difficulties in obtaining cooperation (or capability for answering the questions) among the potential respondents, or just because of the purpose of the study (i.e. pilot surveys).

The most common non-probability sampling methods are: *Convenience sampling* (where the sampled population is selected according to its availability for interviewing); *Snowball sampling* (when the persons surveyed are requested to indicate other persons for the same survey); *Quota sampling* (applied when it is necessary to estimate the percentage of sampling for different groups); and *Focus groups* (when a small group of a selected population is chosen for pilot trial before a larger survey).

3.5.2. Probability sampling methods

In the **probability sampling methods** all members of the target population have the same (and non-zero) chance to be selected, providing a statistical basis to make the sample a representative part of the target population. The main methods applied for probability sampling are: *Simple random sampling*, *Stratified random sampling* and *Systematic sampling*.

Simple random sampling is an almost unbiased probability method for selection of a sample. In this method, all the members of the target population receive a number that is then matched with the ones in a Random Number Table (Table 3.1.) or other pool tool (i.e. a computer-generated list of random numbers) providing, in this way, the sample population.

In the selection of households for the sanitation programme case studies, for example, the simple random sampling method could be applied by giving the houses sequential numbers on a map containing all households included within the target population. Using a random number table (Table 3.1) a number is chosen as a starting point and, then a direction (horizontal or vertical) is determined for the selection of the sample numbers. Table numbers are matched in sequence (considering just the adequate figure - units, dozens, hundreds or thousands – depending on the size of the sample), defining therefore the households to be included in the sample population.

Table 3.1. - Random number table

7951	2257	3713	2251	8787	0475	1806	4328	0394	5752	9546	6241	6391	6881	2013
3476	4938	3030	1040	7821	8732	0890	0539	0386	0229	4020	6212	8989	4264	8738
2354	6217	6397	4452	9636	1291	4708	8747	3045	4629	4887	4269	1324	1153	6073
0242	7111	8223	6214	9296	4380	4885	5385	0352	3626	5649	3898	6182	4164	9660
7152	4503	4104	3607	5164	1690	9877	6536	5113	2852	5873	8459	0452	0417	1987
8674	0361	6652	0446	3064	6299	1841	8833	2724	0735	0429	8584	7512	5118	7745
5448	3932	2042	0559	0730	9695	1405	5741	4885	9212	4531	0068	2163	7377	4841
0195	0036	5426	6163	6348	6222	6989	4217	8397	7608	5562	2517	6124	6646	4251
8622	2115	2035	3945	5851	9531	8145	5798	8519	0361	9972	7441	1017	3108	6730
9247	3019	3527	7094	6336	6141	4270	8019	2283	1068	7485	7303	1168	6489	8338
7281	7885	5968	0933	7984	0072	0986	6746	7654	3451	4140	3014	0576	9320	9674
9578	3588	6639	0837	2435	1674	6491	7476	9462	3399	7713	8569	7936	2455	5786
0902	3244	1865	0817	2651	3265	9238	3982	9620	4769	2699	8218	0757	2916	4790
6694	7834	6977	2494	6370	2960	6446	3761	7348	2963	9372	2594	9246	5777	3427
3963	8453	2735	2488	7338	7199	0123	1688	4832	5658	2039	0149	2963	7342	6971
9924	5962	8787	2350	7622	6882	3558	0002	5031	2048	5381	7814	6943	4356	9218
7602	8191	8803	9179	9883	6747	6531	4312	1230	1696	3402	0171	7489	4374	5623
8749	6178	1446	6811	0639	2677	1887	1643	2326	9557	0534	9593	5645	0505	9063
7068	2917	7773	7084	4255	8967	9551	1753	3843	4353	0402	0876	8955	0546	3184
9229	3526	3321	8093	2705	5240	6586	6909	2197	2376	0974	2578	4116	4068	2803
9514	5832	3404	1545	7948	0701	3431	0113	8833	8977	6616	4059	6770	5729	4481
7903	5704	0840	4383	2213	5569	7118	7388	1566	5476	5770	1514	0886	8029	2994
3914	2116	0966	6078	6407	2039	1946	6162	2616	0030	7163	8631	8880	2017	1173
1223	2886	8408	8447	8420	8927	6830	6983	6706	7148	6619	7548	0003	9979	1393
0123	3306	3774	2533	1187	9589	6392	7889	7889	1933	9723	3626	8304	0073	6793

To obtain a sample where it would be necessary to measure the variables of more than one group identified within the target population, it may be necessary to use the *Stratified random sampling* method to obtain a representative number of members from each group. For this, the different groups are identified and samples are determined as simple random samples for each of them.

The *Systematic sampling* method is based on the selection of each n^{th} element of the target population, which should be arranged in sequence. For the example of the sample of households, a map containing all members of the target population would be obtained and then a walking orientation should be defined for the survey. A starting point is defined and then each n^{th} household is selected for the sample.

Following this methodology, a situation commonly observed is that selected households may not be available for inclusion in the survey. In this case, other alternatives should be previously specified, such as the selection of the previous or the following household in the sequence (but keeping the original one as the basis for the selection of the next household). The systematic sampling method should not be used, however, if repetition occurs within the target population or if it is arranged in intervals.

3.6. Summary

Considering that the case studies selected for this survey are not to be directly compared with each other (the objective is rather to provide a picture of each one), the same research approach was not always applied for the aspects investigated in the different Case Studies.

The research approaches were mainly applied as suggested on Table 2.11 and were based on the descriptions presented in this Chapter. The specific applications of the methods are further described in the Case Studies Results (Chapter 4); nevertheless, the table below (Table 3.2) presents a summary of the methods applied for the aspects investigated in each Case Study.

Table 3.2. – Summary of the Methods Applied for Investigation of the Aspects Assessed

Aspects investigated	Case Study 1	Case Study 2	Case Study 3	Case Study 4	Case Study 5	Case Study 6
Technology's Selection	Doc. Review Interviews	Doc. Review	Doc. Review Interviews	Doc. Review	Doc. Review	Doc. Review
Design	Doc. Review	Doc. Review	Doc. Review	Doc. Review	Doc. Review	Doc. Review
Financ.Aspec	Doc. Review	Doc. Review	Doc. Review	Doc. Review	Doc. Review	Doc. Review
Implementat.	Interviews	Doc. Review	Interviews Quest.survey	Doc. Review Quest.survey	Interviews Doc. Review	Interviews Quest.survey
Acceptability /satisfaction	Quest.survey	Quest.survey	Quest.survey	Quest.survey	Quest.survey	Quest.survey
Social/health improvem.	Observation	Quest.survey	Quest.survey			Observation Quest.survey
O&M arrangements	Doc. Review Interview Observation Quest.survey Tech. Inspec.	Doc. Review Observation Quest.survey Tech. Inspec.	Doc. Review Interview Observation Quest.survey Tech. Inspec.	Doc. Review Observation Quest.survey Tech. Inspec.	Doc. Review Interview Observation Quest.survey Tech. Inspec.	Doc. Review Interview Observation Quest.survey Tech. Inspec.

Chapter 4: Case Studies

4.1. Introduction

Considering the objective of identifying the characteristics by which low-cost sanitation programme is more likely to succeed, this study was based on six low-cost sanitation programmes developed in Brazil.

The case study areas were selected in order to cover different technologies (on-site and off-site systems) and different arrangements for community/institution participation and for O&M of the systems. Therefore, the selected sanitation programmes were:

4.1.1. On-site Systems

➤ **Case Study 1**

Study developed in a low-income urban area known as Peixinhos Triangle in the city of Olinda (NE Brazil). The sanitation project implemented there was based on VIP latrines for the deposition of excreta and microdrainage channels for sullage collection. This project was an initiative of the city of Olinda prefecture and its implementation started in 1982 as part of a larger programme for the development of community infrastructure, which also included actions on: drainage, solid waste collection/composting and street paving among other social programmes.

➤ **Case Study 2:**

Also developed in a low-income urban area, this study was focused on a pour-flush toilets programme in the Favela Aero Rancho in the city of Campo Grande (West central of Brazil). This sanitation intervention was part of the PROSANEAR programme (discussed in Section 2.4.3) and was implemented in 1993/4 under the management of the State Water and Sanitation Company of Mato Grosso do Sul (SANESUL).

4.1.2. Off-site Systems

➤ **Case Study 3**

This study was developed in the community of Rocas/Santos Reis (Natal – NE of Brazil), which is known as the first experience applying the condominial sewerage technology. This project dates from 1982 and had CAERN (the State Water and

Sanitation Company of Rio Grande do Norte) as its implementing agency. CAERN has also been responsible for operating and maintaining the system since its implementation.

- **Case Study 4**

This case study was centred in the Vila Planalto sanitation project (Brasilia – Federal District of Brazil), which was one of the first experiences of CAESB (the Water and Sanitation Company of Brasilia) in adopting the condominial sewerage technology (1991). Additionally, information was obtained on two innovations adopted by CAESB: the implementation of condominial sewerage in high-income areas of the city and the implementation of "100% plastic" condominial systems.

- **Case Study 5**

This study was initially developed in the low-income urban area of Mangueira, in Recife, but then expanded to cover another 12 locations that also have had condominal sewerage systems implemented through the same programme of the prefecture of Recife. For the management arrangements of this sanitation programme, the prefecture of Recife acted just as the executing agency and COMPESA (the State Water and Sanitation Company of Pernambuco) was the agency responsible for the O&M of the systems. The transition from the prefecture to COMPESA had not been the same for all 13 systems and this led to different solutions that have directly influenced the performance of the systems.

- **Case Study 6:**

The focus of this study was on the SISAR programme (an Integrated System for Rural Sanitation) in the State of Ceara (NE of Brazil), developed by CAGECE (the State Water and Sanitation Company) and by the German Bank KfW. This programme implemented sanitation systems based on condominial sewerage and waste stabilization ponds, and septic tanks and leach pits in 45 districts of the State, from which was selected four for the development of this study. The O&M of the system was arranged to be the communities' responsibility through the local residents' association and without the participation of CAGECE.

Figure 4.1. shows the location of the case studies in relation to the map of Brazil.

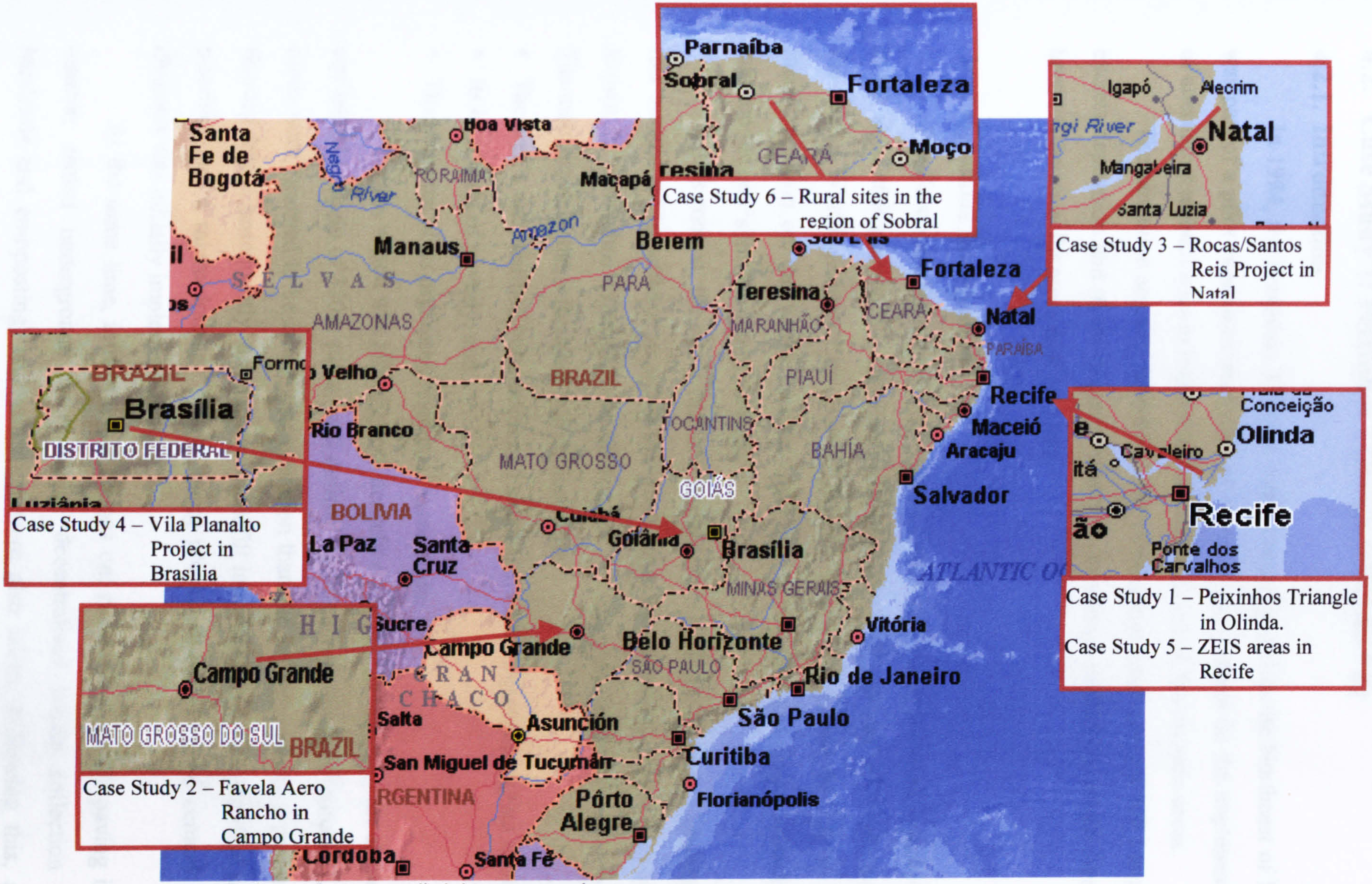


Figure 4.1. Map of Brazil showing the Case Study locations

4.2. Case Study 1: Peixinhos Triangle (Olinda-PE)

4.2.1. Introduction

In 1984, the Peixinhos Triangle community, located in the Northeast of Brazil, was part of a pilot experience promoted by its local government on the implementation of alternative technologies to improve basic infrastructure in low-income areas.

The sanitation solution adopted by the programme was based on VIP latrines for excreta deposition and micro-drainage channels for sullage collection, which have now been in operation for more than 15 years.

➢ **Programme Background**

The Peixinhos Triangle is a poor peri-urban area located in Olinda, a coastal city in the state of Pernambuco – Northeast of Brazil. In 1982, the city of Olinda received the title of World Heritage City from UNESCO. This event placed the city in an "in focus" position on the world tourism route and also motivated local politicians to develop the city's infrastructure services.

In this context, the city's mayor launched a programme for the improvement of low-income urban settlements using low-cost alternative solutions. Therefore, the area known as "Peixinhos Triangle" was chosen for the implementation of a pilot project. The main reasons that influenced this choice were:

- The area's well-defined boundaries and small size (240 households at that time),
- Its high level of poverty, and
- The presence of an organised residents' association.

The area, which was already very densely occupied, has approx. the shape of an equilateral triangle of 350m sides, well defined by three main roads (Figure 4.2). These roads were reported to be at a higher elevation than the houses creating a permanently flooded area. Consequently, drainage and landfill interventions were identified as main priorities and a micro-drainage system using precast fibre-reinforced cement mortar channels was initially implemented.

At the same time, infrastructure actions on: road and sidewalk paving in soil-cement; sealed underground water tanks; decentralised refuse collection (small handcarts and composting) and sanitation were also taken. Following this, actions started to be also developed on urban agricultural production potential, employment and income creation, housing, health services and sanitary education.

Figure 4.2. Map of the Peixinhos Triangle area.

- **The sanitation project**

The sanitation project, the focus of this study, was based on VIP latrines for the deposition of excreta, and on sullage collection through precast fibre reinforced concrete channels connected to the micro-drainage system. For the selection of this technology, a study was carried out to identify the existing sanitation solutions in the community. As a result, it was found that (Greenhalgh, 1984):

a) All houses appeared to have some form of excreta disposal, but many toilets were inadequate (both structurally and hygienically), and sullage was invariably directed to the streets;

b) Most households had a conventional glazed earthenware flush toilet bowl, although some had installed a roughly moulded type of toilet bowl ("rustic bowl");

c) Bowls were manually flushed (generally only after defecation). The volume of water used for flushing was estimated from 0 (rustic bowls) to 60 l/house/d (manually flushed toilets).

d) Leach pits were the adopted excreta disposal technology. Many pits did not function satisfactorily. The population perceived the failure of the pits in terms of aesthetics and inconvenience, and not in terms of health hazards.

e) Pits were always manually emptied with the pit contents usually being buried in a hole dug next to the pit for this purpose.

f) No sewer line existed in the vicinity and, although one of COMPESA's sewage treatment works (trickling filters) was located in the suburb, the investments costs needed to reach this were beyond the financial resources of URB-Olinda.

Therefore, the Greenhalgh (1984) study concluded that:

a) The introduction of VDR's was likely to have little effect on pit functioning (10 out of the 28 unflushed bowls surveyed were found to be in use with failed pits).

b) For the adoption of an improved flush system nearly all households would require the construction of a new leach pit.

c) Not all households had space available for a new leach pit site.

It was therefore decided to convert the existing flush toilets to a dry system, adopting a standard single pit VIP latrine. At the beginning, 5 VIP latrines units were built and used as a "shop-window" for the promotion of the technology among the householders. A total of 40 units were reported to be built during the implementation phase of the programme (until 1984).

4.2.2. Study Methodology

Considering the objective of collecting data on aspects such as the technical implementation and operation, social aspects, health benefits, and, institutional arrangements of the programme, five different methods were applied during the study.

Analysis of the documentation of the project was the first approach used. However, the Peixinhos Triangle project was developed very informally, where the actions were implemented as the ideas came up, with very little documentation being produced. This aspect made the second selected method – **interviews** – even more important. The interviews provided two different levels of data: one from the professionals who planned and implemented the programme (nearly the only source for institutional data) and the other, informal interviews with the local people.

Field observation was the next method applied. Its utilisation was justified by the possibility of obtaining a general feeling on the current sanitary situation and to probe information gathered during the interviews. The other two methods applied were a **survey questionnaire** and a **technical inspection** of the sanitation units.

The whole community (households placed in the physical limits of the area) was considered the target population for the study. This population was randomly sampled using the simple random sample design methodology (section 3.5.2).

In the early stage of the identification of the project site, three different situations relating to the households and the sanitation programme were observed. They were:

(1) Households that had a VIP latrine built and it was still in use;

(2) Households that had a VIP latrine but it was no longer in use; and

(3) Households that had never participated in the programme.

Therefore, the first draft of the **questionnaire** was adapted for each situation and this resulted in three questionnaires printed on different coloured papers (Annex 1).

The questionnaires were divided into sections as described below:

Group 1 – households that had had a VIP latrine built which was still in use:

Section I - Identification

Section II - Socio-economical Aspects

Section III - Water Supply and Usage

Section IV - Community Participation

Section V - Sanitation Technology Adopted (VIP latrines)

Group 2 – households that had had a VIP latrine built but which was **no longer in use**:

Section I - Identification *(same as questionnaire 1)*

Section II - Socio-economical Aspects *(same as questionnaire 1)*

Section III - Water Supply and Usage *(same as questionnaire 1)*

Section IV - Community Participation *(same as questionnaire 1)*

Section V - Technology Adopted by the Family in substitution of the VIP latrine

Group 3 – households that had **never** participated in the sanitation:

Section I - Identification *(same as questionnaire 1)*

Section II - Social-economic Aspects *(same as questionnaire 1)*

Section III - Water Supply and Usage *(same as questionnaire 1)*

Section V - Technology Adopted by the Family in substitution of the VIP latrine *(same as questionnaire 2)*

The **sanitation inspections** occurred at the same time as the application of the questionnaires. For this, three different inspection sheets were designed, one for each type of questionnaire:

Group 1 –	**Section I -**	The VIP latrine
	Section II -	Sullage collection
Group 2 –	**Section I -**	The VIP latrine
	Section II -	Sullage collection
	Section III -	Solution adopted by the family
Group 3 –	**Section III -**	Solution adopted by the family

Considering that only 40 VIP latrine units were reported to be installed during the implementation phase of the programme (Greenhalgh, 1984), a parallel "non-probability" survey (second survey) among the households that were not part of the sampled population but were still using the VIP latrines was also carried out. These households were identified, interviewed and the VIP latrine units were inspected following the same procedures as the households of group 1 of the sampled population.

4.2.3. Study of the project documentation

The main sources of information were the people who worked on the implementation of the programme, and three documents: the Peixinhos Triangle Pilot Project for Urbanisation, the PhD thesis of Eng. Greenhalgh (1984), who implemented the sanitation system, and a report from Eng. Rego (1987). These constitute the basis for the description of the project presented next:

- **Design of the VIP latrines**

The standard VIP latrine adopted was a single pit unit designed to serve five people for five years having a working volume of 0.76 m^3 and a 0.3 m freeboard. The possibility of designing double pit VIP latrines was discarded due to: the high ground water table (the pit contents were expected to be a very liquid slurry requiring pumping for emptying, anyway); the financial limitations of the project; and, the difficulty in integrating double pits with the existing facilities.

The pit was lined with three precast unreinforced concrete rings and the cover slab was built in reinforced concrete using nine 4.6 mm diameter bars running in each direction and leaving two 100 mm holes: one for the toilet bowl inlet and the other for the vent pipe (Figure 4.3).

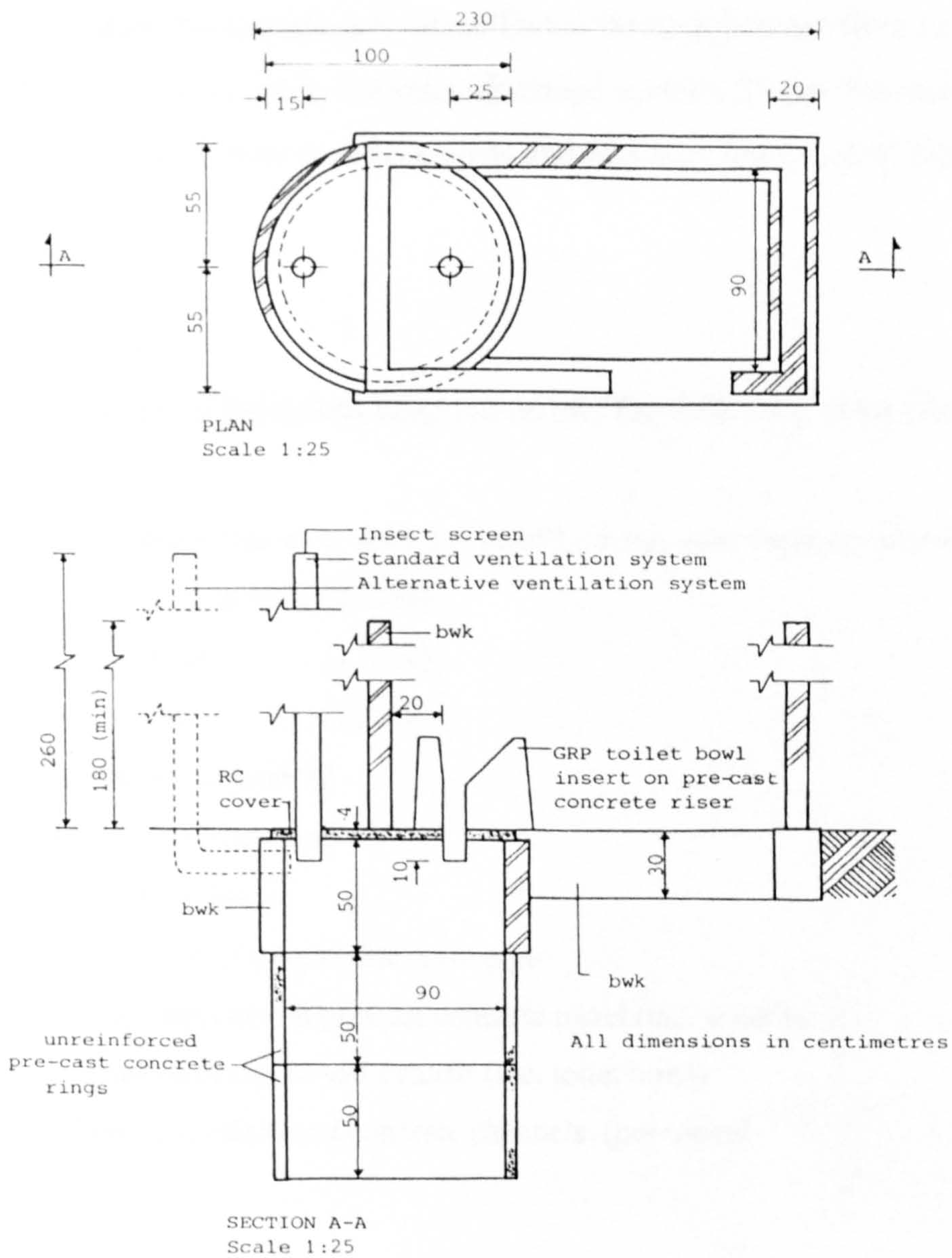


Figure 4.3. Details of the standard VIP latrine *(after Greenhalgh, 1984)*

➢ Toilet Bowl

Considering that the squatting position is not socially acceptable in the area, a toilet bowl was specifically developed for this programme. This bowl was produced in glass-reinforced plastic and secured to a precast concrete riser with cement (Plates 4.1 and 4.2).

➢ Pit Emptying

The pit emptying process was designed to occur at 5 yearly intervals. The removal of the contents, which were expected to have slurry-like consistency due to the high ground water table, should be done mechanically. For that, the residents should contact the council services to arrange for emptying under hygienically secure conditions.

➢ Sullage Collection

The sullage was designed to be collected through precast fibre reinforced cement mortar channels connected to the microdrainage system. These channels were designed as uncovered units in order to reduce costs and facilitate households' maintenance (Plate 4.3).

➢ Project Costs

The Triangle of Peixinhos Programme had the following costs (Rego, 1987):

Total Investment (inc. all projects, i.e. landfill, paving, solid waste, sanitation...)	US$ 53,387
- Olinda City Hall (75.1%)	
- SUDENE (17.7%)	
- FIDEM (7.2%)	
Investment per household	US$ 110
Investment per inhabitant	US$ 26
Direct unitary costs	
- the pit for 5 people (inc. vent pipe)	US$ 21
- superstructure in pre-cast concrete panel (inc. toilet bowl)	US$ 53
- superstructure in soil-cement (inc. toilet bowl)	US$ 34
- pre-cast reinforced concrete channels (per metre)	US$ 1

Plate 4.1. Glass-reinforced plastic toilet bowl

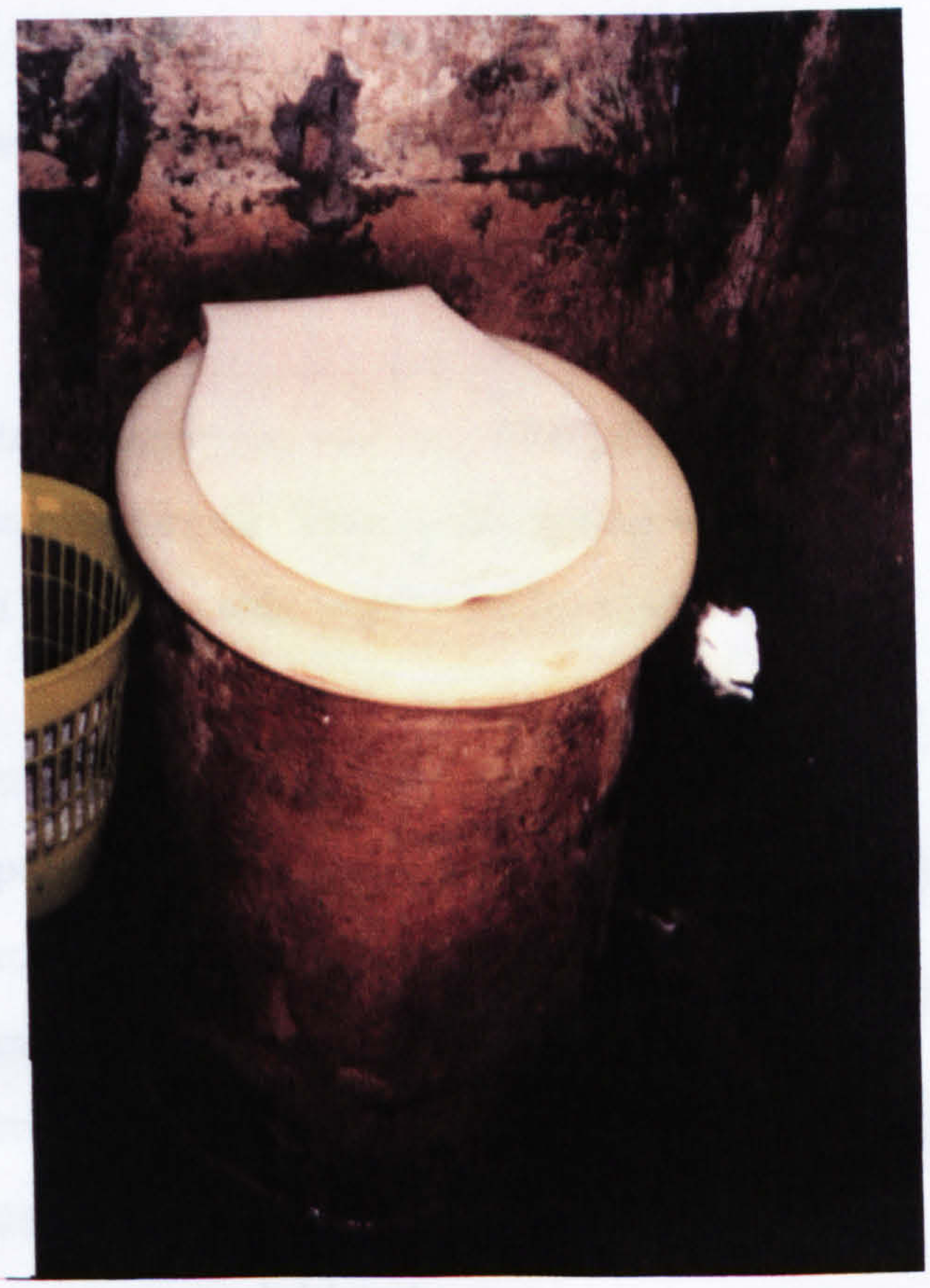


Plate 4.2. Pre-cast concrete riser to secure the toilet bowl

Plate 4.3. Channel for microdrainage and sullage collection

4.2.4. Interviews

Through interviews, information was collected on institutional participation and community organisation:

- **Institutional participation**

The prefecture is no longer acting in the programme and very few people from its staff were able to give information about the programme. Thus, information was mainly obtained from the engineers S. Cuentro and R. Rego, who were initially responsible for the development of the programme.

Initially, the programme comprised the drainage and the sanitation projects, then a solid waste collection and a composting project were also incorporated. Many ideas were then also incorporated into the programme, increasing its dimension and resulting in actions for the social and health development of the community.

The financial resources were very limited and innovative ideas were required in order to effectively achieve improvements. Hence, after identification of the main problems, actions on drainage, landfill and paving were initiated.

According to Cuentro, the programme was developed with high level of motivation and collaboration between both the staff and the residents, emphasising the importance of community participation in the planning and implementation phases. Nevertheless, the actions were taken to solve existing problems, and, at least in regard to the sanitation project, no plans were drawn for further actions or upgrading.

Currently, there are no institutions acting in the programme.

- **Community organisation**

Based on the information available, the Peixinhos Triangle community had a well-organised residents association at the time of the programme (1982). Currently, the city of Olinda have a good structure for the support of residents associations; however, the Peixinhos Triangle association is no part of this and is no longer an active institution.

The process to have a residents association in Olinda starts inside the community, which organises itself and funds the association. Then, documents must be signed, a physical space should be provided and the chairpersons are elected. Thereafter, these associations are recognised as institutions and should have the responsibility to represent and act for the benefit of the communities. Together, the associations constitute FECOMO (Federation of the Olinda residents associations), having as its chairperson Mr. Joãozinho, who is also employed by the public services secretariat of the Olinda prefecture and acts as a facilitator between the communities and the prefecture sector responsible for the implementation of programmes and the delivery of infrastructure services.

Mr. Joãozinho participated in this community study and it was discovered that the Peixinhos Triangle residents' association has no participation in the FECOMO. The residents do not have any participation in the local association and the chairperson does not develop any activity. Some residents informally interviewed expressed the desire of re-starting the activities of the Peixinhos Triangle association, but they complained that the chairperson kept the documents and did not allow any mobilisation.

This situation represents a serious problem for the functioning of the association, leaving the community without either representation outside the community (i.e. in the prefecture) or internal organisation.

4.2.5. Field observation

➢ **General aspects of the area**

The majority of the houses in the area are still typical of the construction of low-income areas in Brazil. However, improvements such as residences with two floors and the presence of air conditioning equipment can be readily seen on the main streets. The main thoroughfare is the Rua do Cajueiro, where these housing differences can be seen (Plate 4.4). This street was paved during the project implementation using paving stones (rather than soil-cement, the material generally used in the project for paving).

The Travessa do Cajueiro is the second main street and it still has the soil-cement paving placed during the programme (Plate 4.5). This type of pavement is also found on the pedestrian access and has been repaired by few householders.

The solid waste composting unit is not in operation and is being used just as a refuse deposit (Plates 4.7 and 4.8). The collection system, using small handcarts, is still in operation; however, the presence of household waste on the streets and inside the drainage channels can be observed.

With regard to the drainage channels, two unemployed residents of the community do periodic services. They informed that approximately once a month they are called by residents to clean the drainage channels and are paid about 0.50 to 1.00 reais per household. In spite of that, just a few sections are kept clean having the water flow freely running. The majority are clogged, poorly maintained, having household waste, rats and pipes suggesting the discharge of excreta. Moreover, the material removed from the channels (basically, solid waste and sludge) is usually deposited in the place that use to be the composting unit. Plates 4.6 and 4.9 to 4.12 illustrate these situations.

➢ **The sanitation project units**

Through the field observation it was noticed that nearly all the latrines identified had some kind of operational or maintenance problem.

The absence of the vent-pipe was a common failure in the functioning of the latrines. Although a number of residents claimed that the vent pipe had never been installed, there was evidence that the vent pipes had been installed but later stolen or removed by the residents themselves for some other use. Among the latrines that had vent pipes, they were frequently not vertically positioned and the flyscreens were missing (Plates 4.13 and 4.14).

Some latrines were also found without appropriate openings for ventilation in the superstructure (also in Plate 4.13). Plate 4.15 shows the designed openings for ventilation in the superstructure. Another aspect observed was the presence of toilet bowl covers and the misinformation among the users on the operation of the system. Plate 4.16 shows a vent pipe hole covered by bricks.

One abandoned VIP latrine was also found in the site (Plates 4.17 and 4.18).

4.2.6. Survey questionnaire

➢ **General Considerations**

Two surveys were carried on during this study. The **first** was the random sampled survey with a sample size of 64 households (Table 4.1. presents the summary).

Table 4.1. – Households included in the first survey

Group	No. of houses	%
Group 1 – households that are still using the VIP latrines	3	5
Group 2 – households that are no longer using the VIP latrines	9	14
Group 3 – households that never participated in the programme	36	56
Houses used just for commerce	11	17
Residents not possible to be interviewed	5	8
Total	**64**	**100**

Plate 4.4. Rua do Cajueiro, the main thoroughfare of the site.

Plate 4.5. Travessa do Cajueiro, paved in soil-cement at the time of the programme implementation

Plate 4.6. Broken section of drainage channel

Plate 4.7. The entrance of the composting unit

Plate 4.8. Interior of the composting unit.

Plate 4.9. Clogged drainage channel

Plates 4.10. Presence of solid waste in the drainage channels

Plate 4.11. Presence of rats in the channels

Plate 4.12. Discharge of excreta into the drainage channel

Plates 4.13. and 4.14. Details of a vent-pipe found with one of the latrines – note the tin blocking the vent-pipe and the positioning of the pipe.

Plate 4.15. The original ventilation designed for the latrines

Plate 4.16. Brick covering the vent-pipe hole.

Plates 4.17. and 4.18. Abandoned VIP latrine unit

The houses used just as commerce were located on President Kennedy Avenue and were not interviewed (none of them had a VIP latrine and were considered as having a very different behaviour than the households). Therefore, the houses categorised in groups 1, 2 and 3 above were interviewed making a total of 48 households (representing 75% of the original sample).

Based on the information that 40 VIP latrines were installed and that just 12 latrines where found in the random sample survey (3 latrines from group 1 and 9 latrines from group 2), a **second survey** was carried out aiming to find the remaining 28 units. Thus, a further 15 units were found (14 that are still in use and one abandoned latrine). Table 4.2. summarises this information.

Table 4.2. –VIP latrines implemented by the programme

VIP latrines		No. of units
Latrines found in the first survey:	still being used	3
	no longer in use	9
Latrines found in the second survey:	in use	14
	abandoned	1
Not found		13
Total		**40**

➢ Results from the Random Sample Survey

❑ Socio-economical aspects

As shown in Table 4.3., the average number of people per household was 5.13 and only 4% of the householders take part in the residents association.

Table 4.3. – Socio-economic aspects

Variable	Group 1 (out of 3)	Group 2 (out of 9)	Group 3 (out of 36)	Total (out of 48)
Mean No. of people living in the houses	5.67	5.22	5.06	5.13
Mean No. of people employed[1] per house	1.00	1.67	1.83	1.75
Families living in the site for > 14 years	1	5	18	24
No. of rented houses	0	1	3	4
Households with TV	67% (2)	100% (9)	92% (33)	92% (44)
Households with radio	100% (3)	100% (9)	89% (32)	92% (44)
Participants in a residents association	0	0	6% (2)	4% (2)

[1] – The occupation of the employed people suggests a range of 1 to 3 Brazilian minimum wages (R$ 136.00 approx. US$ 80.00 per month – exchange rate R$ 1.00 = US$ 1.70)

❑ Water supply level

Households in group 1 presented the lowest percentage of in-house level of service (67% presented a yard tap level of water supply) as shown in Table 4.4.

Table 4.4. – Water Supply Service

Variable	Group 1 (out of 3)	Group 2 (out of 9)	Group 3 (out of 36)	Total (out of 48)
Household served by COMPESA	100%	100%	100%	100%
Level of service: yard tap	67% (2)	11% (1)	14% (5)	17%
in-house	33% (1)	78% (7)	78% (28)	75%
collected from neighbour	0	11% (1)	8% (3)	8%
Water shortage: every day	33% (1)	22% (2)	36% (13)	33%
every week	0	45% (4)	17% (6)	21%
rarely/never	67% (2)	33% (3)	47% (17)	46%
Home treatment for drinking water: boil	0	11% (1)	8% (3)	8%
filter	67% (2)	33% (3)	22% (8)	27%
buy mineral water	0	45% (4)	50% (18)	46%
chlorine	0	0	6% (2)	4%
none	33% (1)	11% (1)	14% (5)	15%

❑ Community participation in the sanitation programme

This section was applied just for group 1 and 2 (households that built the latrines). Nevertheless, only 45% (5 families) of the interviewed householders were living in the area at the time of the implementation of the programme.

The main finding regarding the participation of the community was that the prefecture decided on the technology applied, provided the material and built the units. The main reasons reported to have positively influenced the acceptance of the technology were its low cost and the community's need for appropriate sewage disposal.

Only two families (out of five) remembered having received any advice on using the latrine and none remembered having paid anything (although in the second survey it was found that 5 households – out of 14 – remembered having "paid" 2-5 cement bags).

❑ Technology adopted by the sanitation programme (VIP latrines)

This aspect was just applied for group 1 (3 households), therefore, the results will be presented together with the results from the second sample.

- **Solid waste deposition**

As demonstrated by Table 4.5., 81% of the households were still having their solid waste collected by the prefecture in small handcarts.

Table 4.5. – Disposal of solid waste

	Group 1 (out of 3)	Group 2 (out of 9)	Group 3 (out of 36)	Total (out of 48)
collected by the prefecture	100% (3)	89% (8)	78% (28)	81% (39)
deposited on the main road	0	11% (1)	11% (4)	11% (5)
deposited in the former composting unit	0	0	3% (1)	2% (1)
didn't answered	0	0	8% (3)	6% (3)

- **Technology adopted by the families (not VIP latrines)**

Among the families not using the VIP latrines, the high majority adopted leach pits or septic tanks as their sanitation solution, having also, water sealed toilet bowls. The septic tanks effluent were discharged into the drainage channel and 3% of the householders interviewed were discharging their sewage directly to the channels.

As a way to improve the sanitation conditions of the site, the majority of the households indicated the cleansing of the drainage channel and the adoption of an off-site sanitation system. Table 4.6. presents these results.

Table 4.6. – Aspects regarding the technology adopted by the families not using VIP latrines

Variable		Group 2 (out of 9)	Group 3 (out of 36)	Total (out of 45)
Excreta disposal:	leach pit/ septic tank (sealed toilet)	100% (9)	97% (35)	98%
	direct connected to drainage channels	0	3% (1)	2%
Sullage deposition:	leach pit/septic tank	0	3% (1)	2%
	drainage channels	100% (9)	94% (34)	96%
	don't know	0	3% (1)	2%
Satisfaction:	yes	67% (6)	58% (21)	60%
	no	0	25% (9)	20%
	more or less	33% (3)	17% (6)	20%
How to improve:	clean the drainage channels	11% (1)	33% (12)	29%
	close the channels (put covers)	33.5% (3)	17% (6)	20%
	adopt off-site sanitation system	33.5% (3)	28% (10)	29%
	nothing	22% (2)	11% (4)	13%
	didn't know	0	11% (4)	9%

➢ Results from the Second Survey

This section presents the results of the second VIP latrine survey (14 units) together with those of group 1 (3 units), a total, therefore, of 17 units.

❑ Technology Selection

As presented by Table 4.7, the low-cost characteristic of the system attracted over half of the users.

Table 4.7. – Acceptance of the system

Why agreed with the system	No.	%
The system already existed when the family moved to the house	3	18
It was cheap	9	53
Saw the system functioning in other house	3	18
Don't know	2	12
Total	**17**	**100**

❑ Technology usage

100% of the interviewed householders said that all members of the house, including children, adults and elderly people used the VIP latrine units. They also declared that there was no other place where the excreta had been deposited.

❑ Technology operation and maintenance

The main problems reported by households were of bad smell (59%) and insects (23%).

53% of the VIP latrine users had never emptied their pits. As shown in Table 3.8., 23% of the householders emptied their pits manually, in spite of the recommendations for the utilisation of mechanical equipment.

Table 4.8. – Pit emptying and sludge disposal

Pit emptying	No.	%
Manually	4	23
Mechanically	2	12
Never	9	53
Don't know	2	12
Total	**17**	**100**

Sludge deposition	No.	%
Buried	4	23
Drainage channels	1	6
Vacuum tanker	1	6
Never emptied	9	53
Don't know	2	12
Total	**17**	**100**

Also about the O&M, 3 households had painted the VIP latrine superstructure and 2 households had changed the vent pipe. No household said that it had changed the flyscreen.

Regarding educational messages concerning the maintenance of the VIP latrines, 41% of the householders remembered have had received messages from the prefecture and 5% from neighbours.

4.2.7. Technical inspection

The results of the technical inspection were as follows:

- **Inspection Sheet Group 1 plus Second Survey**
  - **Inspection of the VIP latrines**

Number of units:	17 VIP Latrines	
Latrine Type:	100% single pits located outside the houses	
Cover slab (floor):	100% made in concrete 59% were cracked 1 case reported of collapse	
Sanitary bowl:	76% project designed type 24% flush toilet bowls 71% with bowl covers	
Superstructure:	82% presented cracks on the walls 71% did not have door	
Ventilation:	12% had openings in the superstructure for ventilation 65% had vent pipes, of which:	 18% had the pipes high above the roof 36% had flyscreens 82% used 100mm diameter pipe 18% used 150mm diameter pipe
Hygiene conditions:	23% good 59% acceptable 12% bad 6% very bad	
Presence of facilities for handwashing:	24% yes 76% none	

- **Inspection of the sullage disposal**

Sullage connected to channels:	82% of households connected the sullage from the kitchen 82% connected the sullage from the clothes washing facility 76% of households connected the sullage from the bathroom
Presence of sullage around the house:	65% with sullage in the backyard
Sullage channels conditions:	24% were clogged 18% with household waste 35% cracked

➢ **Inspection Sheet Group 2**

- **Inspection of the VIP Latrines**

Number of units:	9 VIP Latrines
Latrine Type:	56% single pits located outside the houses 22% single pits located inside the houses 22% do not remember
For what are the units being used now:	67% nothing 11% as a store 22% destroyed

- **Inspection of the sanitation facility adopted by the family**

The technologies adopted by the households were leach pits or septic tanks discharging into the drainage channels.

Number of units:	9 units	
Hygiene conditions of the sanitary unit:	44.5% good 44.5% acceptable 11% very bad	
Presence of facilities for handwashing:	67% yes	33% none

- **Inspection of the sullage disposal**

Sullage connected to the channels:	100% of the households connected sullage from the clothes washing facility 100% of the households connected sullage from the kitchen 100% of the households connected sullage from the bathroom

Presence of sullage around the house:	44% with sullage in the backyard
Sullage channels conditions:	33% were clogged 56% with household waste 44% cracked

- **Inspection Sheet Group 3**

  - **Inspection of the sanitation facility adopted by the family**

As in the case of group 2, the technology adopted by the households was leach pits or septic tanks discharging into the drainage channels. However, one household (out of 36) admitted discharging the excreta direct to the drainage channels.

Number of units:	36 interviewed households
Hygiene conditions of the sanitary unit:	36% good 47% acceptable 11% bad 6% very bad
Presence of facilities for handwashing:	58% yes 36% none 6% don't know

  - **Inspection of the sullage disposal**

Sullage connected to channels:	97% of the households connected sullage from the kitchen 100% of households connected sullage from the cloths wash facility 92% of the households connected sullage from bath
Presence of sullage around the house:	28% presented sullage in the backyard 72% did not present sullage around the house
Sullage channels conditions:	56% were clogged 50% presented household waste 36% cracked

4.2.8. Summary of the Results

- **Technology applied**

VIP latrine technology for excreta disposal is considered simple to implement, to use and to operate. In the Peixinhos Triangle sanitation project, the adoption of this technology appears to have been determined by two main aspects: the possibility of integrating the new system with the existing (failed) facilities and the financial limitation of the programme.

The selection of the material used for the component parts of the system was supported by local production. The application of fibre to reinforce the precast cement parts as well as the development of a specific toilet bowl for the system illustrates, therefore, the experimental facet of this programme.

As noted in Section 2.4.3, the ventilation of VIP latrines is the mechanism responsible for fly control and absence of foul odours; however, only 65% of the latrines still had the vent-pipes of which only 18% had pipes high above the roof and just 36% still had a flyscreen (none had the flyscreen changed, which is supposed to occur every 5 years).

The adoption of a single pit design is justified by the lower capital costs required and the unavailability of space in comparison with double pit latrines. However, the mechanical emptying process required by single pit latrines relies on the support of institutions (councils, community associations, etc), which should not be a problem if the programme is well integrated and the actors are participative; nevertheless, this requirement makes the operation and maintenance of this simple technology dependent not only on the householders but also on the institutional arrangements for the programme. Therefore, the majority of latrine users (53% of the households) had never emptied the pits and only 12% had done it mechanically.

➢ **Sociocultural aspects and community organisation**

The participation of the community was reported to have been intensive during the implementation phase. However, considering the sanitation project itself, only 40 latrines were installed (out of 240 households) suggesting that the technology was not fully accepted by the community.

On first walking around the site, a common opinion among residents on the streets was that the VIP latrines were being substituted by "proper toilets" and that the few remaining units were there only because "the users had no money to replace them yet". In fact, it was observed that the community perceives the latrines as a "primitive" system, attributing to them the cause of foul odour. Another important aspect for the lack of satisfaction among the users was the absence of water-sealed toilets. Generally, in the public or work places with which this low-income peri-urban residents interact, it is common to have sealed toilet bowls. Therefore, the direct discharge of the excreta gives the idea to a number of residents that the latrines are a "dirty" system.

The latrines that were found to be functioning well were apparently installed in the poorest households, whose owners claimed to be very satisfied with them; however, this just represents a tiny proportion of the community.

➢ **Health and educational aspects**

A characteristic commonly observed in low-income areas is the moving in and out of the resident's families. This "movement" requires intensive continuity of educational programmes to supply the new residents with the information necessary for proper use and maintenance of the system installed (only 45% of the sample population were living in the area during the time of the implementation of the programme).

Considering the Triangle of Peixinhos infrastructure programme, as a whole, improvements can be identified in the living conditions of the households. However, due to the limited number of VIP latrines built in the community, health benefits from the sanitation project are very localised and biased due to the interaction among residents that are sharing the same public environment.

4.3. Case Study 2: Favela Aero Rancho (Campo Grande-MS)

4.3.1. Introduction

This study was focused on the sanitation programme implemented in 1993/4 in the favela Aero Rancho. The site is 28.2 ha in areas and is located in the Southern part of the city of Campo Grande (capital of the State of Mato Grosso do Sul in West Central Brazil). The favela Area Rancho was one of the areas selected to take part in the PROSANEAR programme (a World Bank funded programme to deliver water supply, sanitation and hygiene education following a community participation approach).

4.3.2. Programme Background

Traditionally, Brazilian Sanitation Companies have not given sewerage systems the same priority that is given to the water sector. SANESUL – the Water and Sanitation Company of the State of Mato Grosso do Sul, was not an exception. According to Diretriz/SANESUL (1995), SANESUL was imbued with the "water culture", with almost all its technicians and directors concerned only with water supply issues.

Therefore, it is not surprising that the majority of the population of Campo Grande (about 450.000 inhabitants in 1996) is not served by sewerage systems and that the adoption of on-site sanitation solutions, mainly septic tanks followed by infiltration pits, is a natural option among householders.

With respect to the domestic solutions, Diretriz/SANESUL (1996) reported that although there were construction limitations and a lack of operational actions, 57% of the domestic on-site systems over 2 years old had never failed. This emphasises the suitability of on-site sanitation systems for the city of Campo Grande, which is supported by three main factors:

- The ground water table level is over 4 m deep in about 90% of the city;
- The favourable geomorphological conditions; and
- The medium to low population-density, even in urban areas due to regulations set for land occupation conditions.

Therefore, the adoption of on-site technologies seems to be a well technically supported option for sanitation in Campo Grande, and this was considered through the opportunity of implemented sanitation systems under the PROSANEAR programme.

Following the criteria set by the PROSANEAR programme, the sanitation actions that took place in Mato Grosso do Sul were centred in two cities: Dourados and Campo Grande. The sanitation system implemented in Dourados adopted the condominial sewerage technology complemented by in-house sanitary installations, and, for the sites in Campo Campo, the option was for the on-site technology based on pour-flush toilets.

The areas selected in Campo Grande were the favelas Aero Rancho and Los Angeles and surroundings (Los Angeles plus four smaller areas: Centro Oeste, Meninas, Macaúbas and Campo Nobre). These areas were characterised by (SANESUL, 1992):

- Lack of infrastructure necessary for provision of basic living standards such as sanitation, health, urban transport, paving and education;
- Population mainly composed of migrants from rural areas;
- Highly unhealthy environments aggravated during the rainy season when solid wastes and sanitary effluents were visible on the streets;
- Water consumed in the areas was mainly from shallow wells shared by neighbours. Health risks resulting from this source were considered high due to: inadequate deposition of excreta, inadequate domestic storage (utilisation of large tin containers without covers), utilisation of rusty receptacles and presence of insects.

- Lack of hygiene regarding both personal and domestic practices was identifiable;
- Violence was a common concern, especially vandalism caused by youth gangs; and
- Community organisation was found to be dispersed and restricted mainly to religious and sports (football) groups;

The size, population and density of these sites are given in the table below (SANESUL, 1992):

Table 4.9. – Profiles of the PROSANEAR programmes in Campo Grande

Locality	Project Area (ha)	Actual Population (hab)	Population for Saturated Area (hab)	Actual Density (hab/ha)	Saturated Density (hab/ha)
Favela Aero Rancho	28.20	1,770	2,560	62.78	90.78
Los Angeles and Surroundings:	220.98	8,027	14,811	36.38	67.02
Los Angeles	125.04		7,137		57.08
Centro Oeste	31.45		2,292		72.88
Macaubas	26.51		1,703		64.24
Campo Nobre	20.00		1,483		74.15
Meninas	17.98		2,196		122.14

The Aero Rancho favela (the focus of this study) is a narrow band, about 300 m long, following the bank of the Anhaduí ravine. The land slope ranges from 0 to 10% and the soil infiltration capacity was 40 to 60 $l/m^2/day$. The level of the ground water table varied from 4 to 7 m below the surface and the site had neither paving nor drainage.

4.3.3. The Sanitation Project

The project implemented in Favela Aero Rancho comprised a conventional water supply system with individual house connections, a pour-flush toilet sanitation system (including a sanitary unit kit) and social programmes on sanitary education and community development.

The sanitation system adopted was the double pit variant, in which the pits should work in alternating periods (see Section 2.5.4.). Therefore, while one pit receives the effluent from the household, the other one "rests" for enough time to digest the deposited excreta and restore the soil infiltrative capacity. It was also agreed that the first pit of the double pit scheme would be constructed during the implementation phase (having its material and construction schedule included in the programme's scheme), and, the householders would be responsible for the provision of the second pit.

The sanitary kit, provided by the programme, consisted of a reduced flush toilet bowl (VDR), a 5 litre flushing device, the design and the material for the construction of the superstructure (bricks, door and roof), a shower, a water-sealed drain and the connecting pipes. This material was not equally distributed; rather, the families received them according to their individual demand.

The educational aspect of the programme was planned and implemented following a community development approach. It demanded the formation and training of a team of community workers that orchestrated the mobilization introducing the sanitation project, the educational messages and the development of community-based activities.

4.3.4. Study Methodology

The data collected for Aero Rancho was based on: **study of the documents of the project** (supplemented by informal interviews with professionals that had worked on it), a **survey questionnaire** and **technical inspections** of the sanitation units.

During the **study of the documentation** information was collected on the institutional arrangements of the project, its costs, the technical parameters applied and the social/educational activities developed.

For the **survey questionnaire** and the **technical inspections**, the whole community (households in the physical limits of the area) was considered the target population for the study. The questionnaires were applied in a sample of households selected systematically; therefore, a map of the area was obtained containing the main streets, pedestrian accesses and the houses. A walking orientation was defined, with each fifth house in the walking line of the surveyor being interviewed. The size of the sample obtained by this method was therefore approximately 20% (N = 76).

The questionnaire applied here (Annex 2) contained the following sections:

Section I - Identification / Social Economic Aspects and Level of Water Supply

Section II - Technology Usage, Functioning and Satisfaction

Section III - Health and Educational Programmes

The technical inspections were carried out at the same households and it was based on the fulfilment of a factual inspection question-sheet containing the following parameters: location of the sanitary unit (inside or outside); presence of flushing device; ventilation of the pit; sealing of the pit cover, if single or double pit; presence of grease trap; connection to discharge rain water into the pit; and if the sullage was openly or pipe-connected to the pit.

4.3.5. Study of the project documentation

The activities related to the implementation of PROSANEAR in Aero Rancho had been reported in a series of documents considering: (a) the primary characterisation of the area (May 1992), (b) the implementation of the programme (1993/4), (c) the development of field activities and (d) the appraisal of the programme 14 months after implementation (March 1996). Thus, this material provided knowledge on the arrangements of the programme as well as a basis for comparison with the data obtained by this study.

➢ **General Considerations**

The number of families reported to be living in the area by the end of the implementation of the programme (Oct/1994) was approx. 510 and the number of the sanitation units built was 465 leach pits and 377 sanitary units. However in the PROSANEAR/SANESUL (1997) report the number of houses in the area were reduced to about 460 and during this study it was about 400 households.

Big changes in the community area during the implementation of this programme were reported. Nevertheless, from the end of the implementation to the present time (nearly 5 $^{1}/_{2}$ years) no significant improvements could be noticed. The streets were still not paved and the drainage system had not been constructed. Empty plots and houses that had started to be built but not completed were found, as well as abandoned properties. A general view of the site is shown in Plate 4.19.

➢ **Institutional Arrangements**

PROSANEAR in Campo Grande (favela Aero Rancho) had 50% of its costs financed by the World Bank, 25% covered by the "Caixa Econômica Federal" (Brazilian Federal Savings Bank) and the remaining 25% by SANESUL.

The programme was managed by SANESUL under the rules and approval of the PROSANEAR team. For the development of the activities, the following arrangements were made:

- ***For the Water System:*** Private firms were employed to construct the system. The O&M was the strict responsibility of SANESUL. However, in late 1999 SANESUL lost the concession to operate in the city of Campo Grande, which now has its water and sanitation sector run by the municipal government.

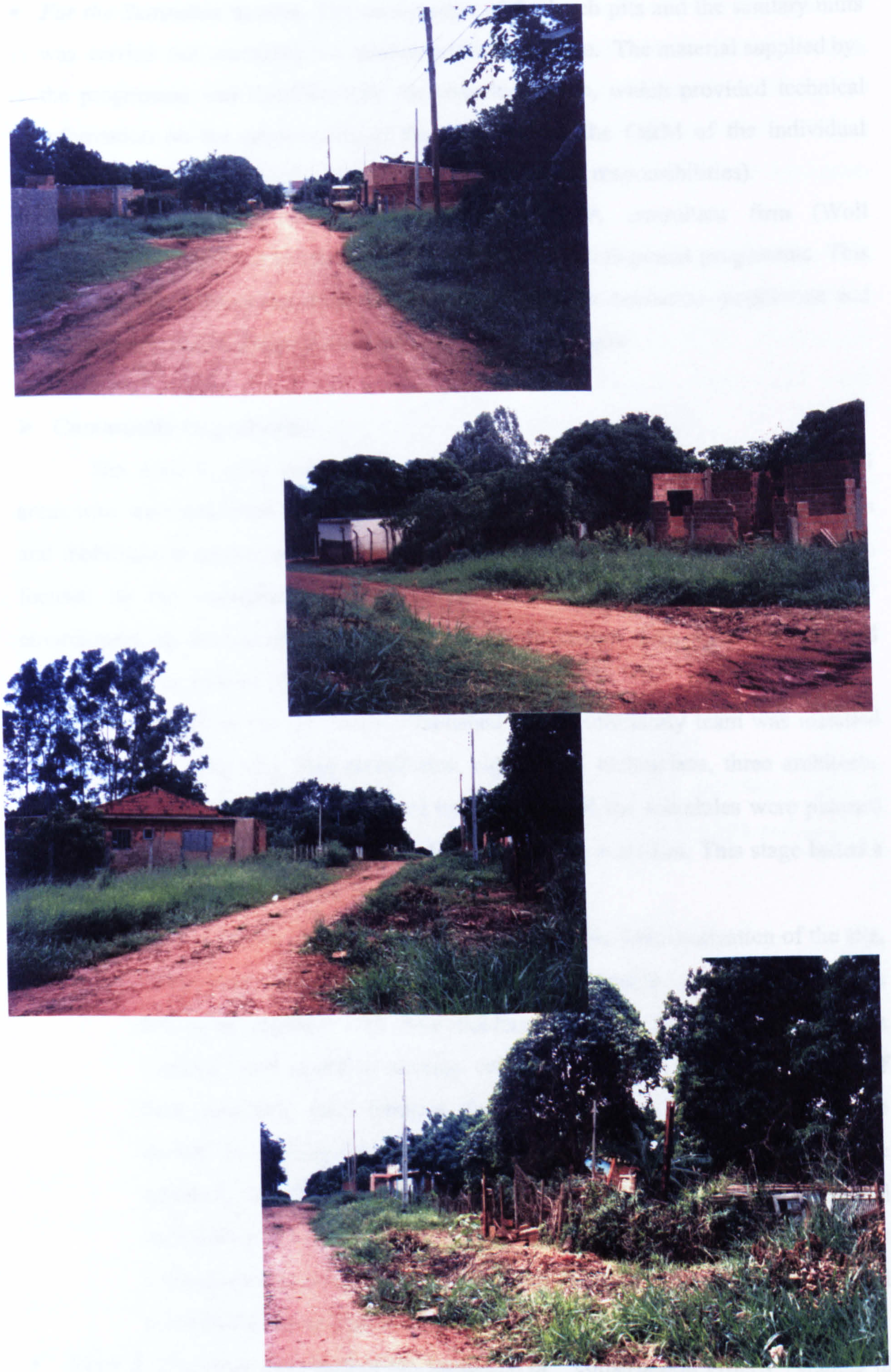


Plate 4.19. General views of the Favela Aero Rancho area

- *For the Sanitation System:* The construction of the leach pits and the sanitary units was carried out according to a resident self-help scheme. The material supplied by the programme was distributed by the consultant team, which provided technical information on the construction of the units and on the O&M of the individual systems (that were also set to be under the householders' responsibilities).
- *For the Community Participation Programme:* A consultant firm (Woll Consultoria) was hired to implement the community development programme. This included the mobilisation of the community towards the sanitation programme and the delivery of environmental/sanitary educational messages.

➢ **Community Organisation**

The Aero Rancho community was mainly composed of migrants from rural areas who were described as being dispersed. Therefore, the community participation and mobilization actions were targeted on a community development strategy, which focused on the strengthening of the householders' identification with their new environment, on the growth of self-esteem and on citizenship. This work was managed in four stages, as follows (SANESUL/PROSANEAR, 1992):

- *Stage 1*: An office was physically established and a community team was installed consisting of a field coordinator, eight social technicians, three architects, six sanitation technicians and ten trainees. All the schedules were planned and the field team was trained for the coming activities. This stage lasted a month (July - August 1993).
- *Stage 2*: In this period, the focus of the work was on the characterization of the site, recognising and updating information previously obtained. This was developed together with householders following the concept of "action research" and aimed to develop citizenship and the "historic process" of these originally rural families. Social Groups and Institutions were also invited to participate; these were religious people working with the migrants, health and the movement for housing, and also the municipal secretariats of health, social security and housing. For the meetings, the community was divided into groups of 50 families and the meeting were just carried on when at least 60% of the families were present to the sections.
- *Stage 3*: This stage consisted of the formation of "construction groups", signing of the Participation Agreement and the elaboration of the timetable for the

construction of the units of the system. Householders with experience of civil construction works composed the "construction groups", which approved the designs and the proposal for self-help construction. The groups received training and were made responsible for the spread of the designs among the other householders (facilitating the acceptance of the sanitation programme by the community).

- *Stage 4*: The sanitation programme was physically implemented at this stage. The community development activities were also carried out and these included: meetings for health, alternative medicine and diet education; presentations on AIDS; school groups for adult literacy; women's groups; solid waste removal activities; sports, cultural and religious meetings.

The activities related to sanitary education were reported to have been carried out during all stages of the implementation. However, as criticised in IBAM (1997), the messages were very focused on community development and the actions directly related to the sanitation project, such as the need to construct the second pit and the importance of the reduced flush devices (VDR), were not fully incorporated by householders. Criticisms were also made against the process of technology selection, which seems to have limited community participation in the "decision taking" process.

The consulting firm responsible for the development of the activities related to community participation completed its work by the end of October 1994 and no more actions were been developed or given continuity.

4.3.6. Design of the Project Units

➢ **Water Supply**

The system designed to supply water to the community was based on the existing main ring of the water supply system of Campo Grande (the Guariroba system – 1400 l/s and 400 mm pipe diameter). Therefore, an interconnection was installed using a 150 mm pipeline delivering the flow calculated for the site (6.4 l/s – adopting a per capita consumption of 120 l/person/day).

Because of the lack of appropriate storage reservoirs, it was decided to install a central reservoir. The volume of this unit was based on 20% of the average daily flow. Thus a standard mild steel reservoir with a capacity of 50 m^3 was adopted (SANESUL, 1992). Consequently, individual in-house water storage tanks were not considered for this programme. However, in the 1996 appraisal of the system, it was found that, in spite of the reliability of the water supply system, one of the main requests of the householders was for a subsidy to acquire domestic water storage tanks. The householders justified this by saying that the high pressure in the system was causing problems in the domestic hydraulic appurtenances (valves, taps, etc), which were usually of very low quality (PROSANEAR/SANESUL, 1996).

➢ **Leach pits**

PROSANEAR adopted the leach pits for the Favela Aero Rancho based on the results of a pilot experience developed by Dr. Stephen Greenhalgh in low-income areas of Campo Grande, in 1986. He tested the double leach pit as a sanitation solution that would provide a final disposal for the household effluent. This was motivated by the inappropriate destination given to the sludge removed from septic tanks by companies specialised in mechanical emptying in the city.

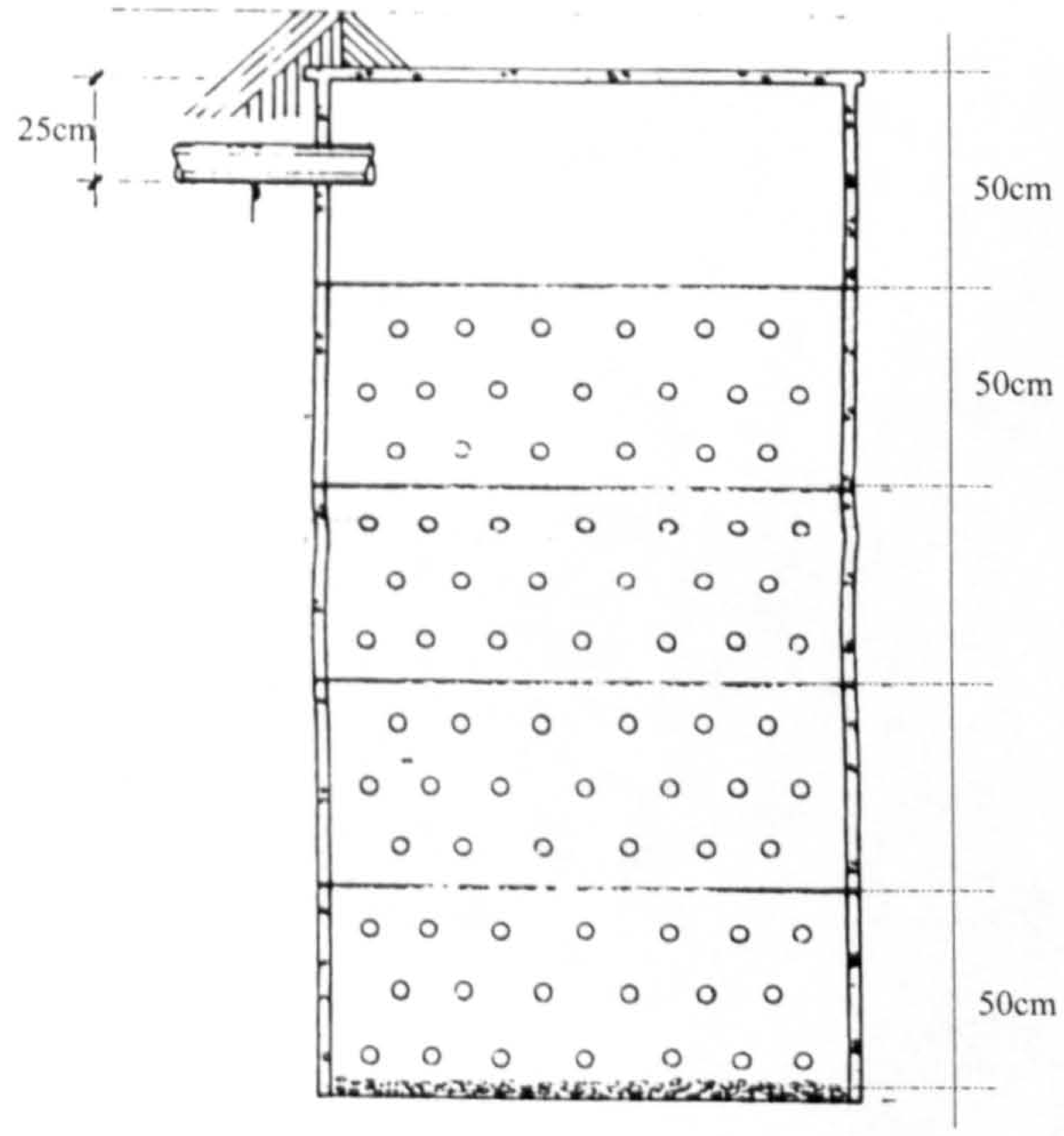
Although this study had not been fully concluded, the PROSANEAR team visited the area after 8 years of functioning and found that even the first pit had still not exhausted its capacity (Diretriz/SANESUL, 1996).

Moreover, Greenhalgh also found that, for the soil conditions of Campo Grande, pits measuring 1.20 m diameter and 2.50 m deep had not exhausted their capacity in 5 to 6 years of operation, and, even so, they can restore their soil infiltrative capacity in no more than a year if kept out of use. It was also reported that after this "rest" period, the material leftover inside the pit was just a 5 cm layer of completely digested sludge. The dimensions and design of the leach pit are shown in the Figure 4. 4. and Plate 4.20.

➢ **The superstructure**

The superstructure was designed to accommodate the toilet bowl and the flushing device, also, some households used it as a shower area (Figure 4.5).

A common complaint among householders was related to the small width of the door (50 cm). Problems were also reported regarding the low-volume flush unit (bowl and flushing device): aesthetically, the small size of the units was not easily accepted by users; and the non-availability of spare parts for the flushing device in the local market encouraged householders to substitute the low-volume model for conventional ones or to continue manual flushing of the system.



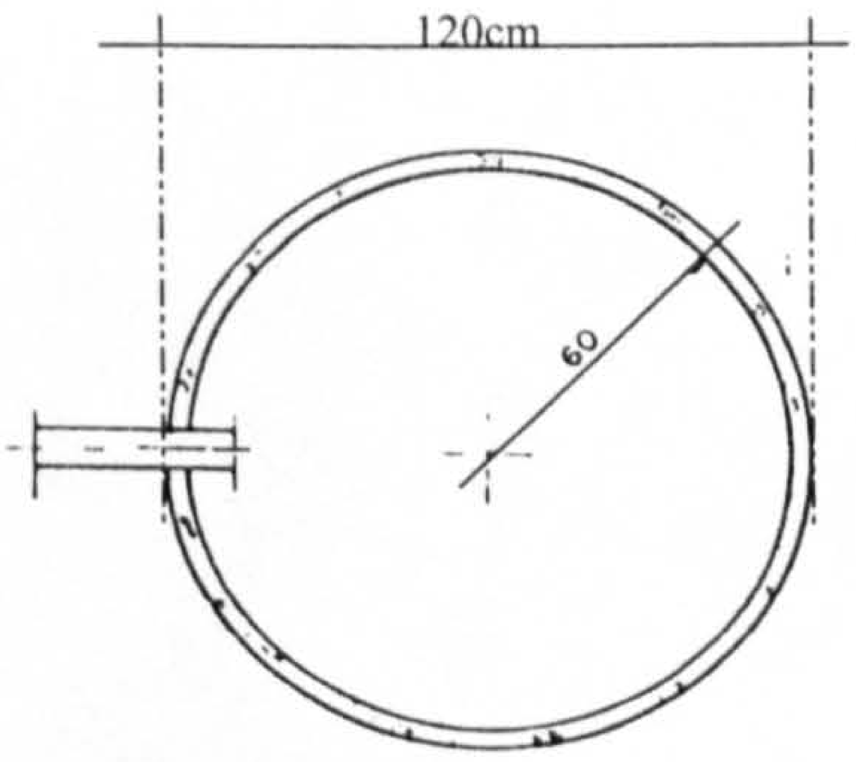
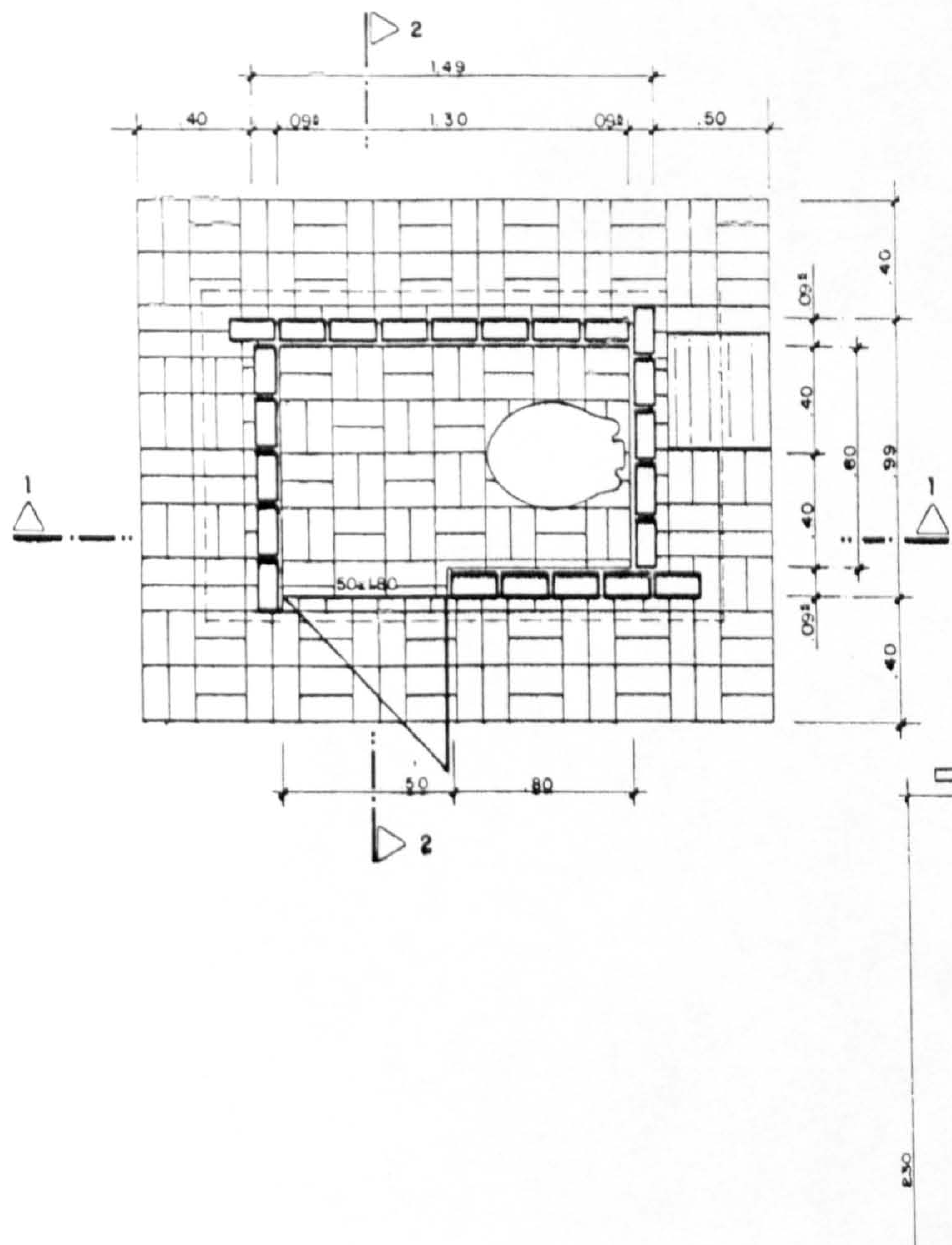


Figure 4.4. Design of the leach pit



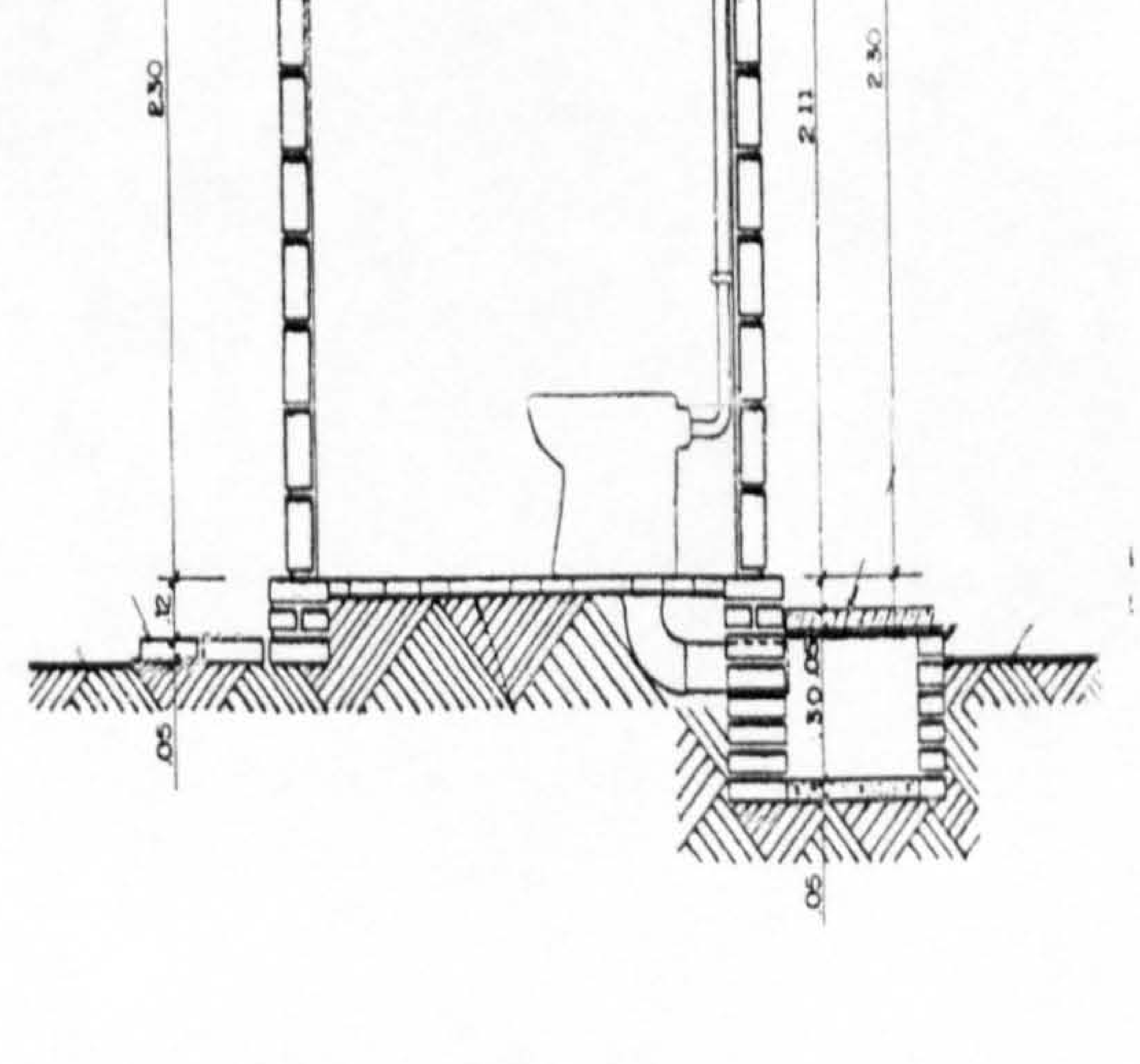


Figure 4.5. Plan and Elevation views of the superstructure

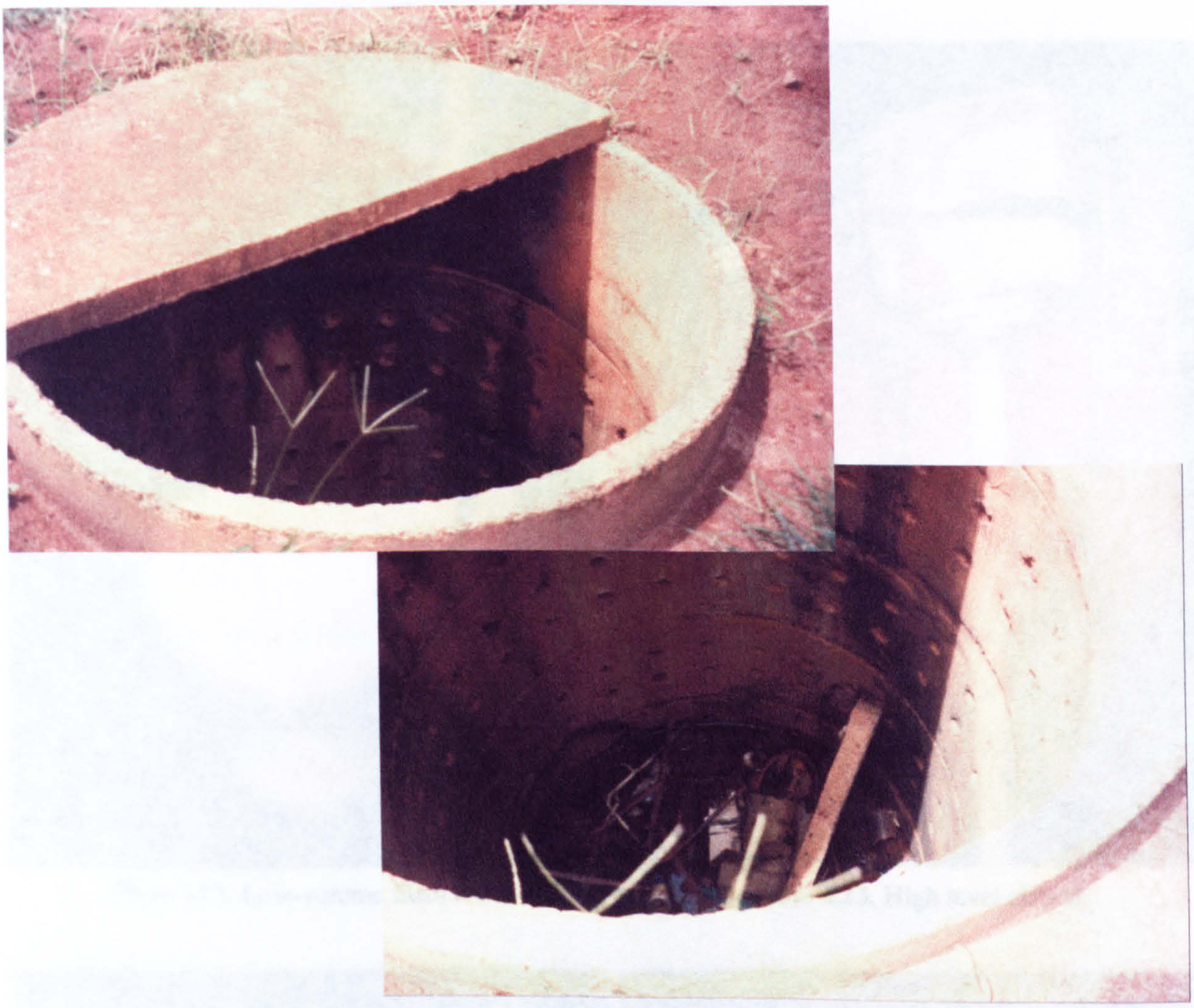


Plate 4.20. Leach pits found in Aero Rancho

Plate 4.21. A view of a typical superstructure

Plate 4.22. Low-volume flush toilet

Plate 4.23. High level cistern

Plate 4.24. Shower inside of the superstructure

Plate 4.25. Shower drain

➢ **Connections**

The proposed connections between the superstructure and the pits followed the scheme shown below:

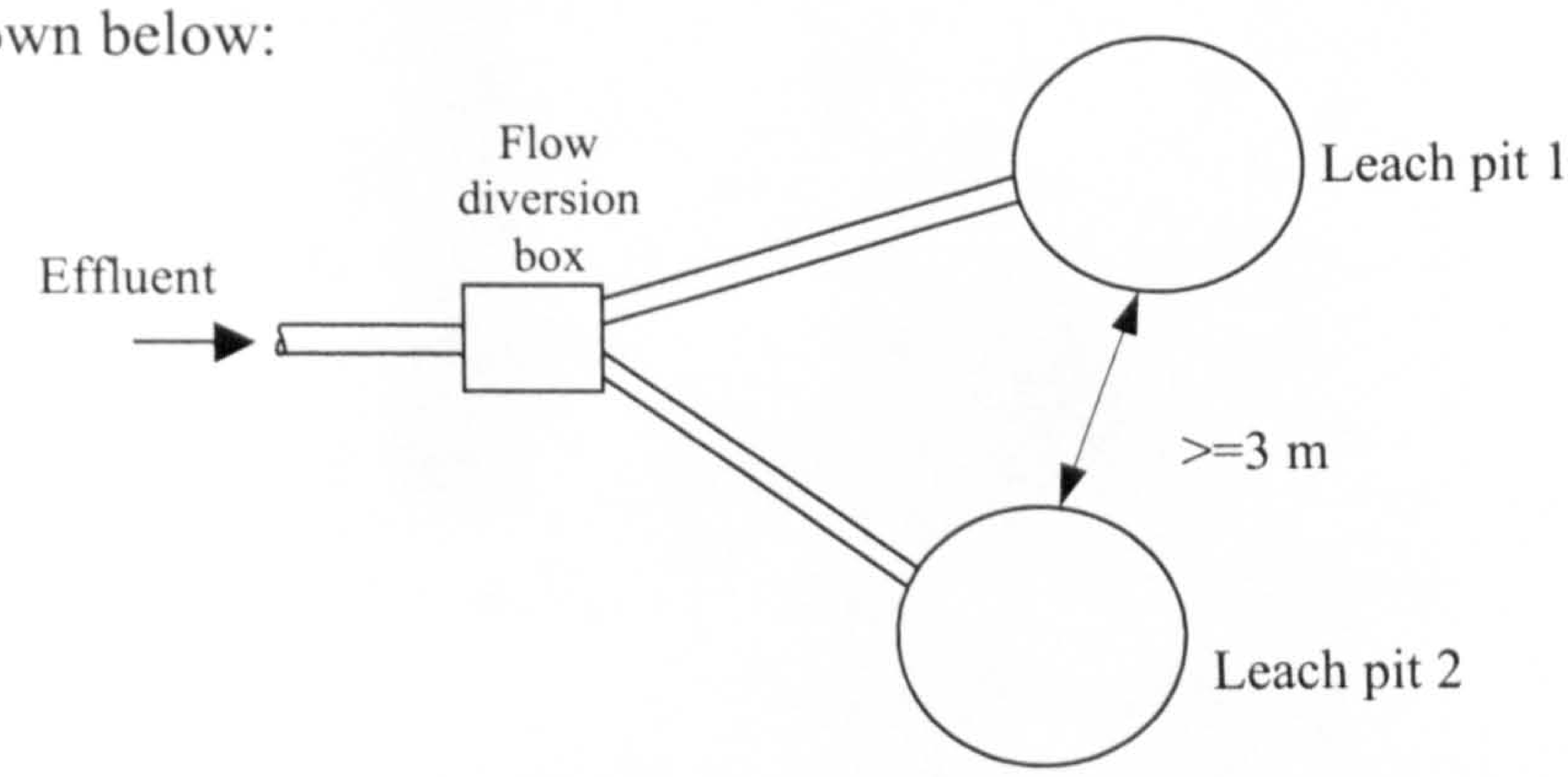


Figure 4.6. Double pit scheme

➢ **Project Costs**

As discussed earlier, the World Bank, CEF and SANESUL financed the costs of the Aero Rancho programme. Therefore, the four main groups of costs were: the water supply system, the leach pits, the sanitary units and the social projects. Based on data from IBAM (1997), Table 4.10 presents the costs.

Table 4.10. – Costs of the Aero Rancho Programme

	Final Costs		Costs per Capita*	
	R$	**US$**[**]	**R$**	**US$****
Water Supply	204,433.12	243,372.76	84.30	100.36
Leach Pits	47,921.08	57,048.90	19.76	23.52
Sanitary Units	82,293.38	97,968.31	33.94	40.40
Social Projects	125,368.07	149,297.70	51.70	61.55
Total	**460,015.65**	**547,637.67**	**189.70**	**225.83**

* Costs per capita based on the pop. of 2,425 inhab. (pop. at the end of the project implementation – Feb/1995)
** Applied the mean exchange rate of Feb/1995, that was 0.84 (URL-21)

4.3.7. Survey questionnaire

➢ **Section I – Identification / Socio-economic Aspects and Water Supply**

❑ **Socio-economic aspects**

Regarding social-economic aspects two variables were measured: the number of householders, the family monthly income and the time the families were living in the site.

The average number of householders was 5.05 persons per household, and their income levels were as shown in Figure 4.7.

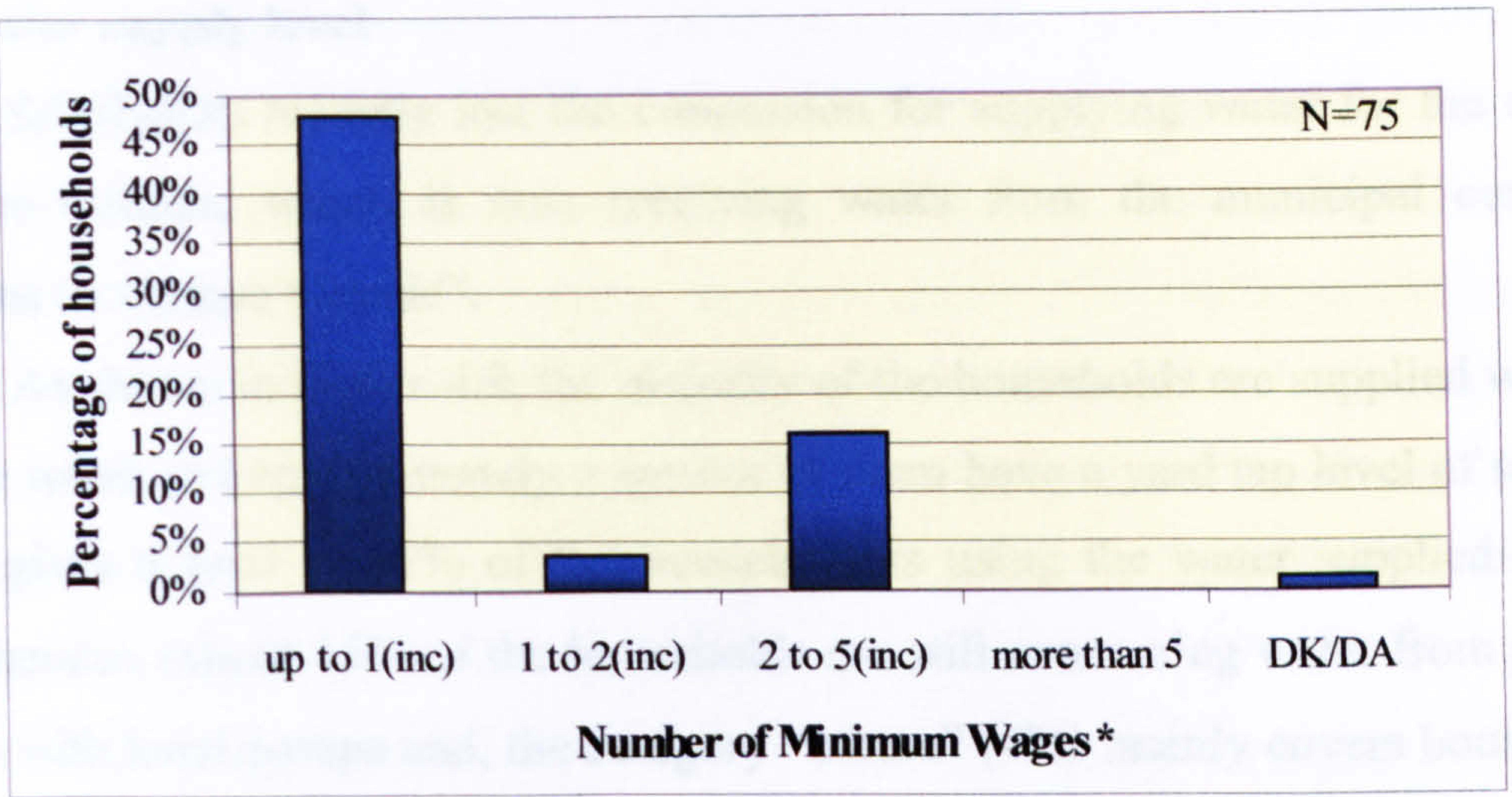


Figure 4.7. Monthly family income in Aero Rancho in Mar/2000
(*The Brazilian Minimum Wage was 136.00 reais (approx. US$ 80) on 28/03/00)

Included in the first category (up to 1 MW) are families with all working-age members unemployed. This represents the main category found in the location, thus 48% of all the families in the community. In the category of families earning between 1 and 2 MW are 35% of the households, giving a total of 83% of the households earning ≤ 2 minimum wages per month. The percentage of families that didn't know/didn't answer this question was 1.3%.

In the survey carried out by SANESUL in 1996 (PROSANEAR/SANESUL, 1996), 38% of the families earned up to 1 MW and 30% between 1 and 2 MW.

Regarding the time that the families had been living in the site, Figure 4.8. shows that approx. 68% of the families had been living in the area since before the implementation of the sanitation programme.

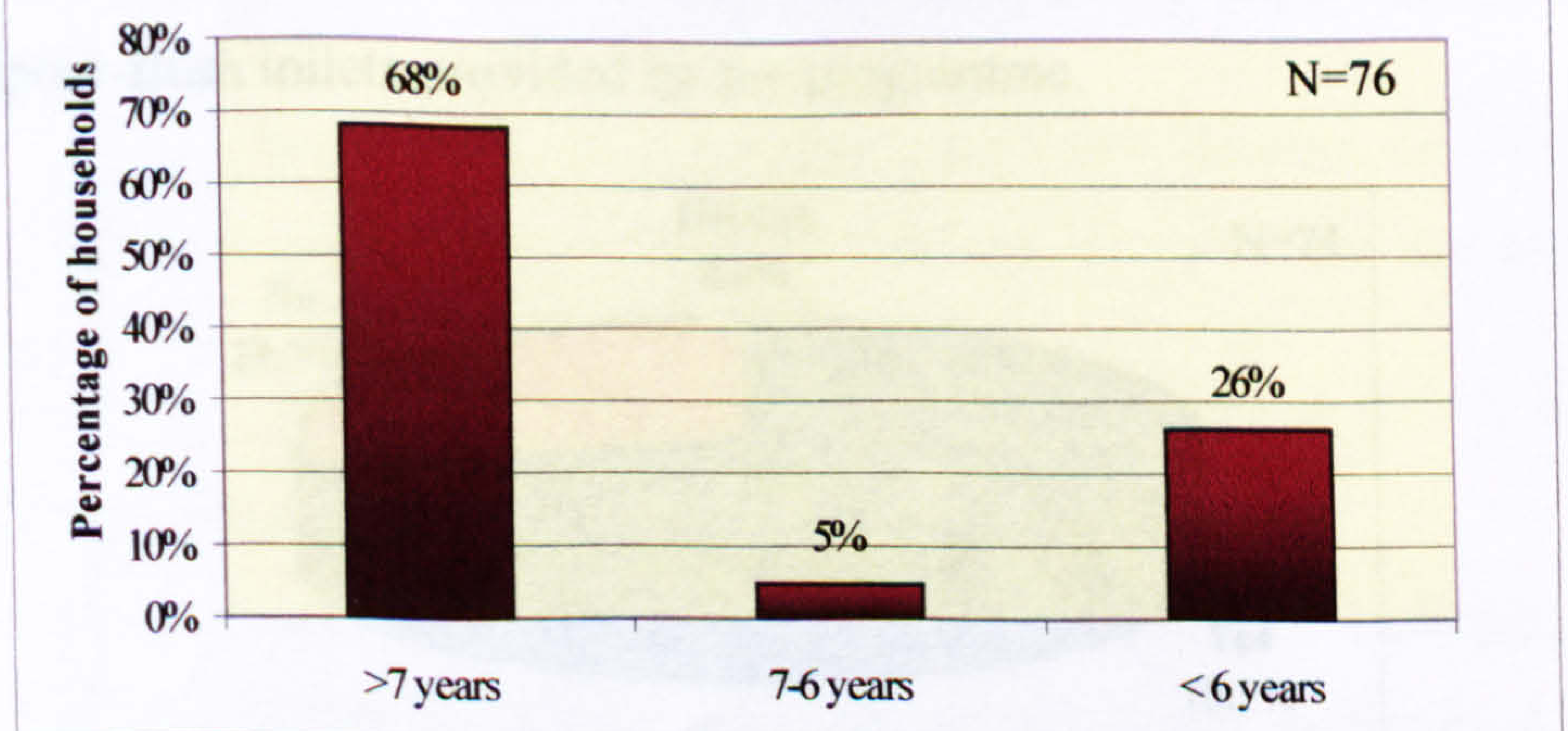


Figure 4.8. Time the families are living in the Aero Rancho area

- **Water supply level**

SANESUL recently lost the concession for supplying water for the city of Campo Grande, which is now receiving water from the municipal company "Aguas de Campo Grande".

As shown in Figure 4.9, the majority of the households are supplied with in-house water and approximately a quarter of them have a yard tap level of service. This gives a total of 81% of the householders using the water supplied by the programme. About 15% of the households are still consuming water from private wells with hand pumps and, the category "others" (4%) mainly covers households that had their water supply cut off due to non-payment (the water currently used by these families is mainly collected from friend's/relations' houses).

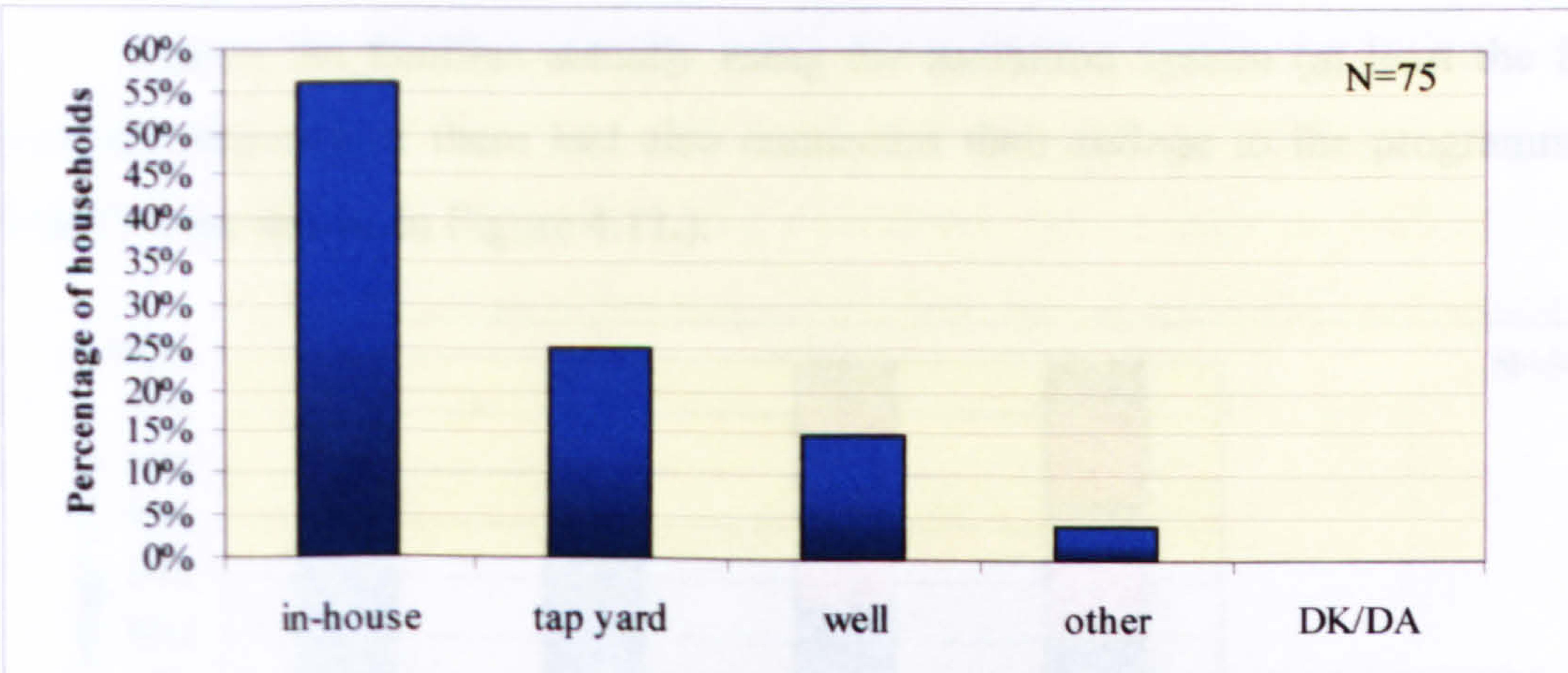


Figure 4.9. Level of water supply in Aero Rancho

➢ Section II – Technology Usage, Functioning and Satisfaction

- **Technology usage**

As shown in Figure 4.10, about 70% of the sampled population are actually using the pour-flush toilets provided by the programme.

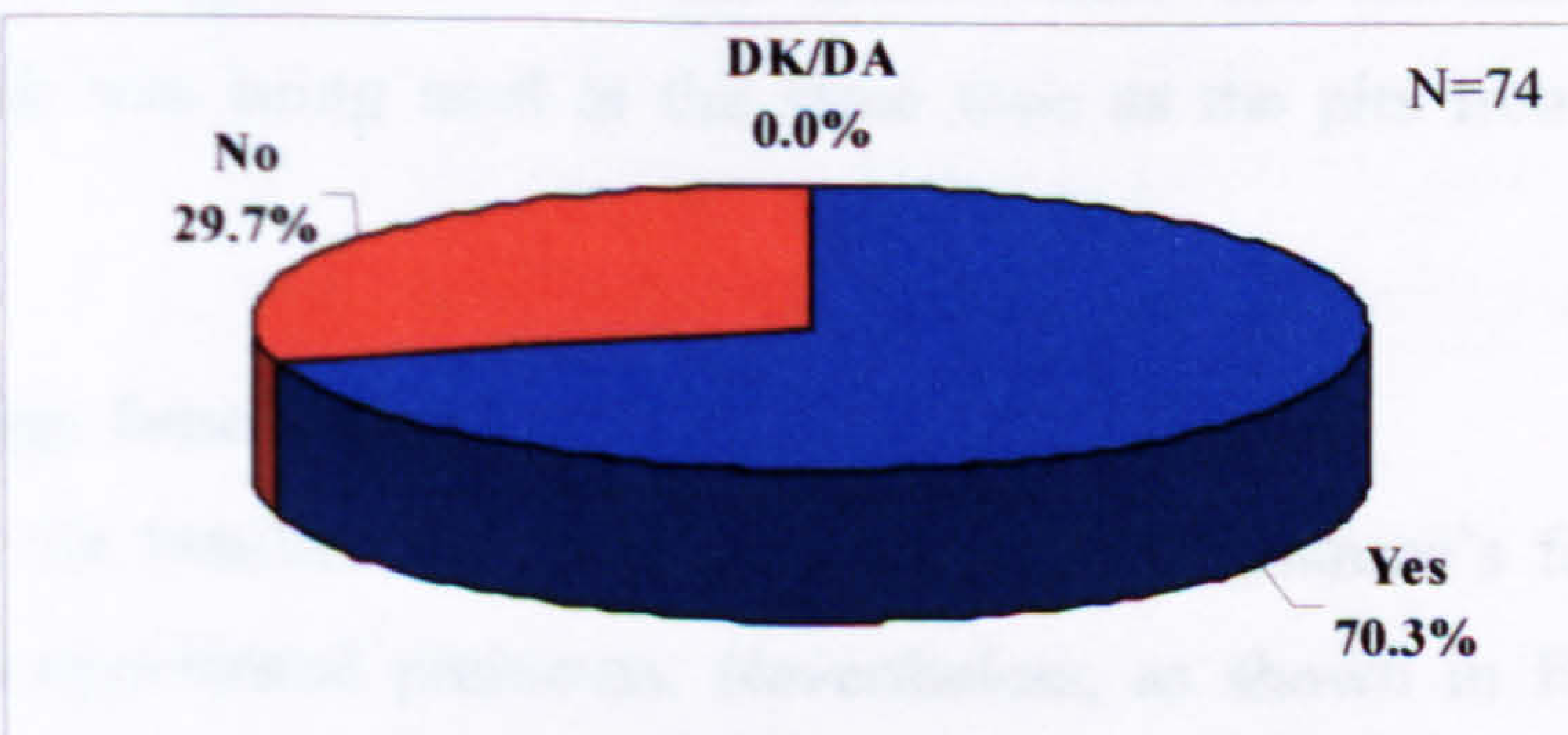


Figure 4.10. Percentage of Households using the system.

Considering the families not using the facilities provided by the sanitation programme, 13% of them had never heard about it (they moved into the area after the implementation of the programme and did not find any sanitation solution already implemented on their plots; therefore nearly 100% of them constructed a leach pit on their own). Another 13% of non-users had received the material and constructed the facility; however, the pits collapsed and were abandoned. The new sanitation solutions provided by these families were that 50% of them constructed another single leach pit and the other 50% dug a dry pit.

Finally, the great majority of the non-users families (approx. 74%) had constructed pits outside the sanitation programme scheme. The sanitation solution adopted by about 95% of them was a leach pit and 5% built a dry pit.

Among the families actually using the sanitation system (at least the first pit), the majority of them had also connected their sullage to the programme's leach pit (as shown in Figure 4.11.).

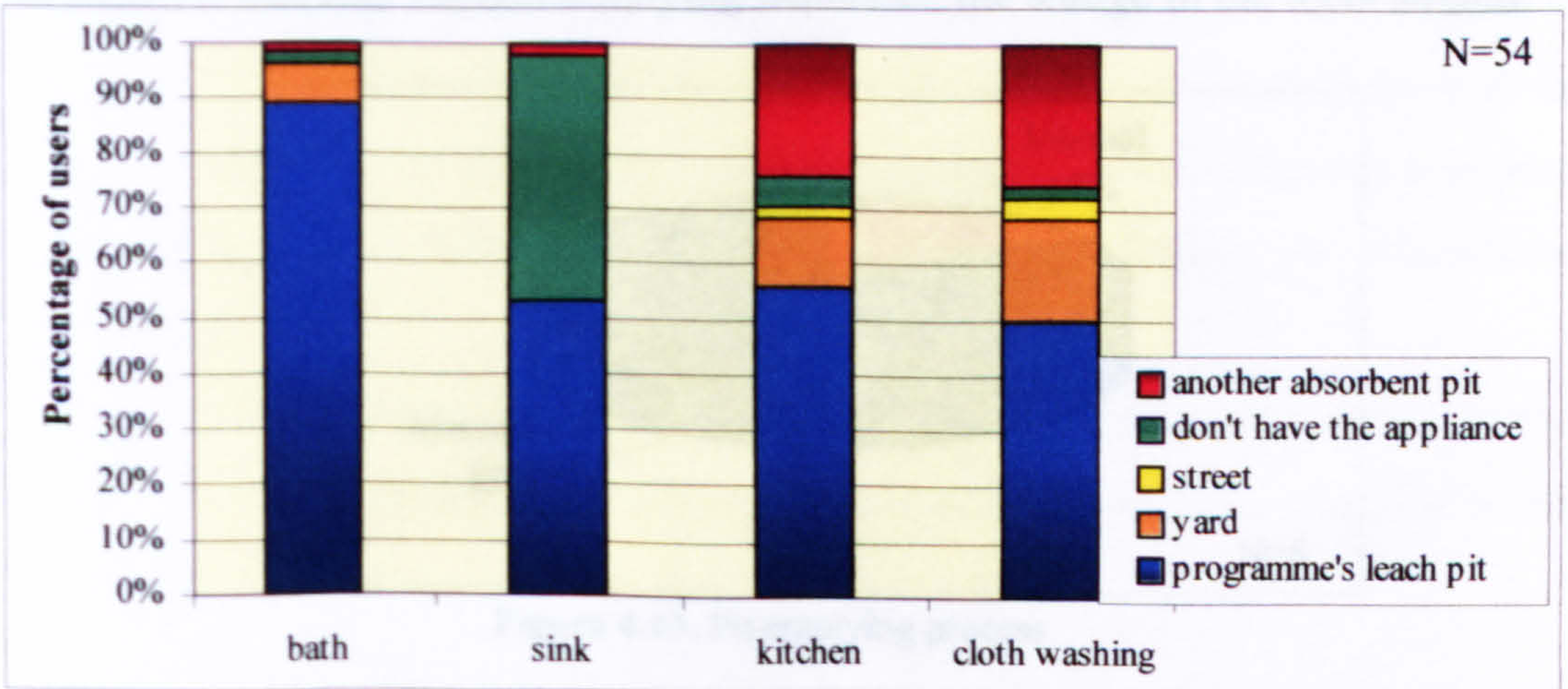


Figure 4.11. Sullage disposal among households participating in the sanitation programme.

From this, approx. 28% of the householders had another pit to receive sullage, which was being used at the same time as the pits from the sanitation programme.

- **Technology functioning**

Out of the families that built the sanitation programme's facilities, 82.5% have had no operational problems. Nevertheless, as shown in Figure 4.12, the main problems have been related to the pits getting full. The solutions given by these families (17.5% of the families that built the unit) were: 10% went for the double pit scheme, 30% abandoned the system and built another pit and 60% emptied their pits and continued to use them.

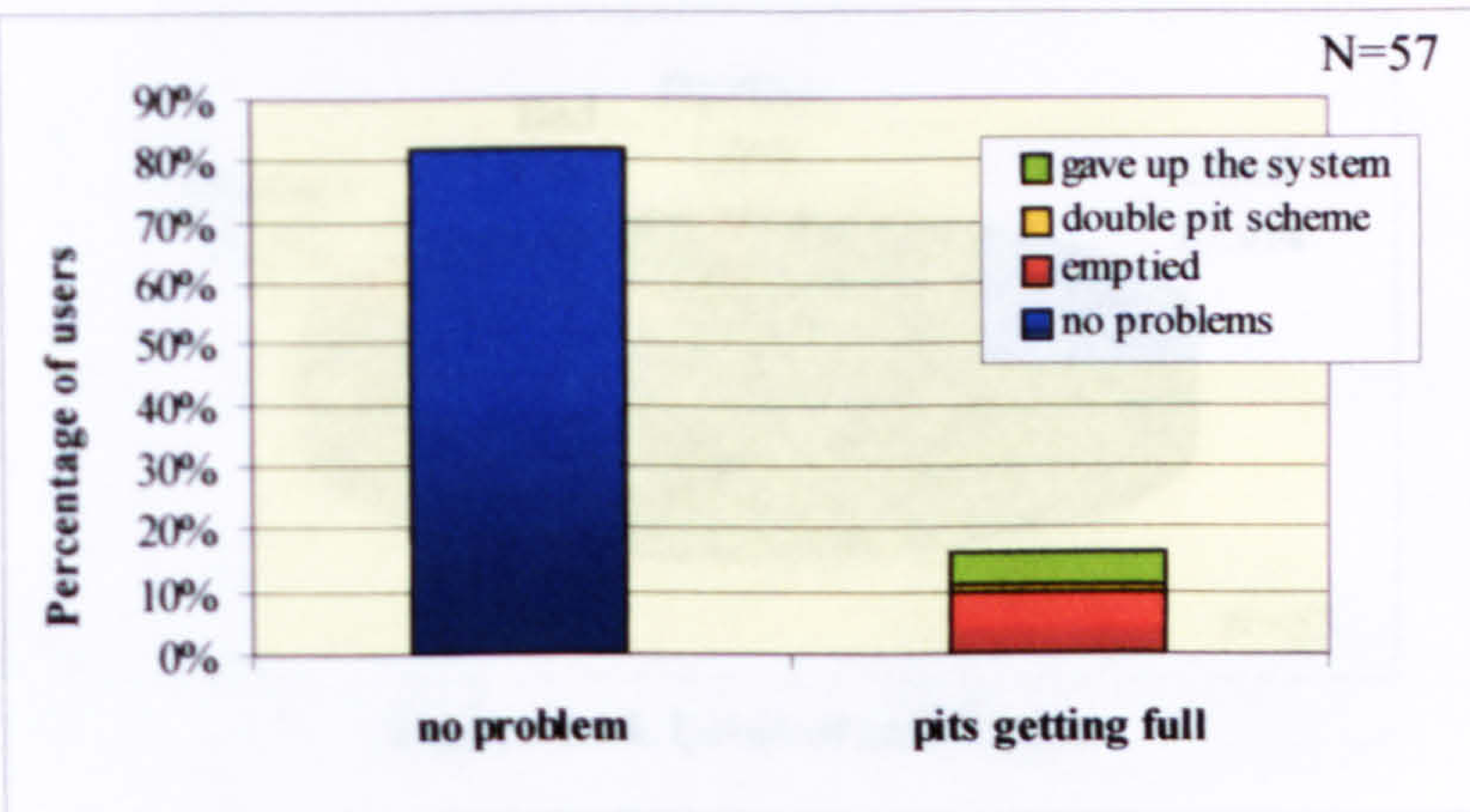


Figure 4.12. – Functioning problems with the leach pits

Considering the families that had had emptied their pits, all had done it just once. As shown in Figure 4.13, 83% of them employed mechanical emptying (hired vacuum tanks services) paying on average R$ 36 (approx. US$ 21) each. The families that had manual emptying deposited the sludge in the local stream.

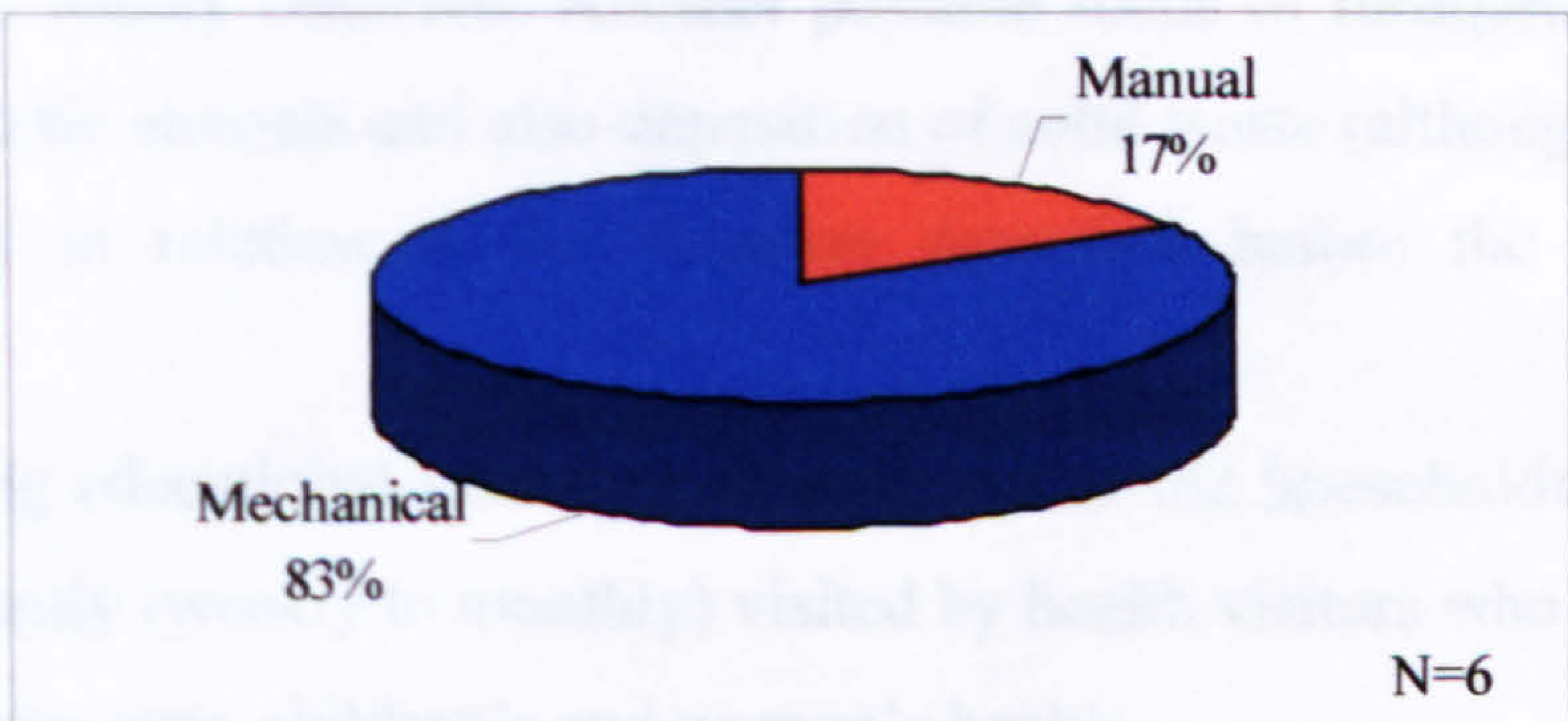


Figure 4.13. Pit emptying process

Regarding the other units of the system, there were complaints about the size of the superstructure door. Families were also not satisfied about the low-volume flush toilets. They complained that the high-level cistern was made of poor material and often broke down. Moreover, to substitute their spare parts was not a straightforward job, mainly due to the non-availability of these materials on the market.

➤ **Technology satisfaction**

The great majority (77.4%) of the families in Aero Rancho said that the sanitation system implemented in the community was a good system; 13.2%

classified it as average and just 7.5% expressed that the system was bad. The percentage of didn't know/didn't answer was 1.9%.

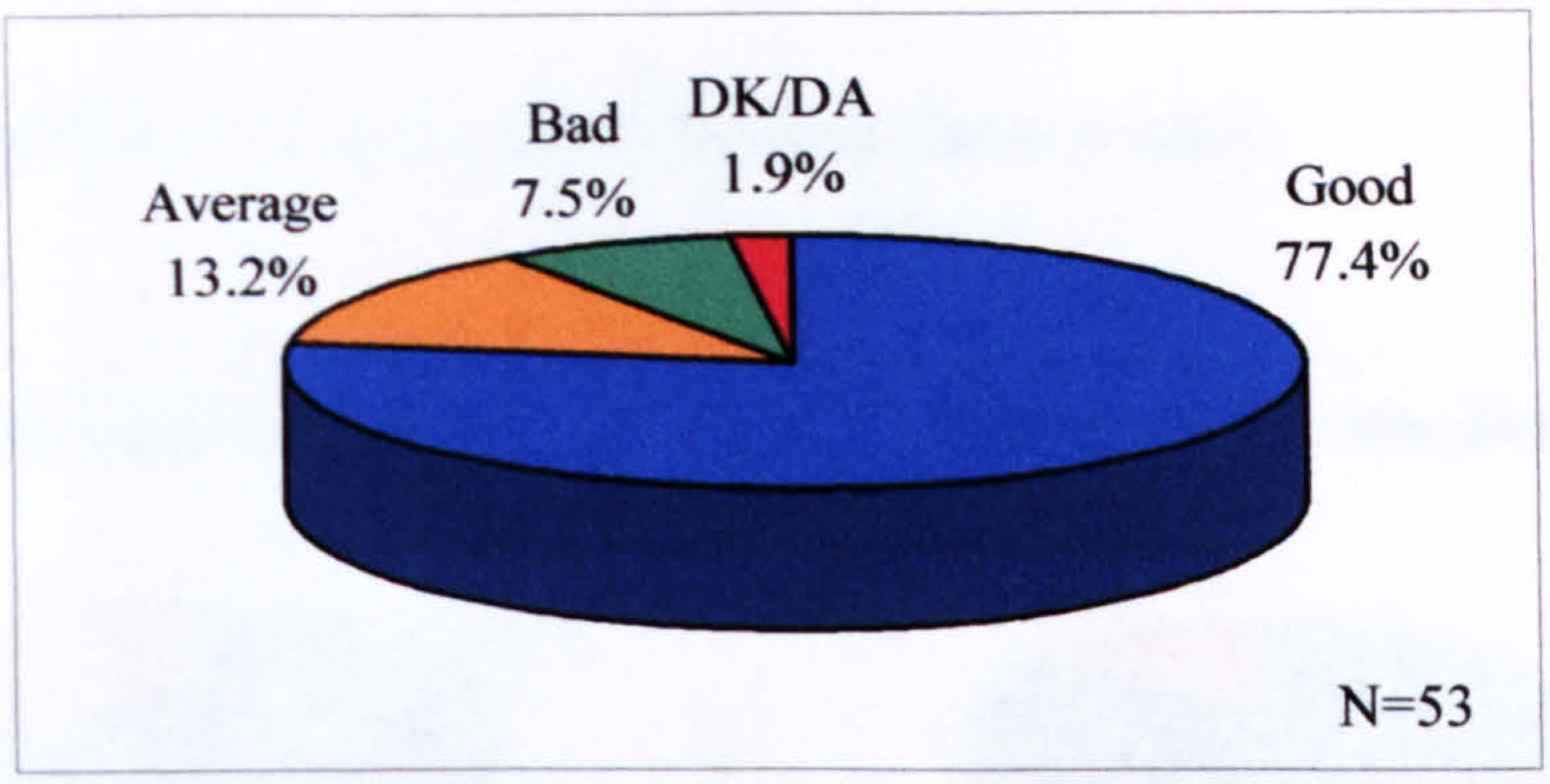


Figure 4.14. Level of satisfaction

- **Section III – Health and Educational Programmes**

When householders were asked whether they experienced any malodour form the pits, 92% answered no. The presence of mosquitoes was indicated by 72% of the families interviewed; however, they associated this with the rainy season. In fact, water deposited in the streets and in the house yards surrounded by vegetation was widely observed. Another possible focus of mosquitoes was the faeces of domestic animals and also deposition of solid waste (although it appears to be reduced in relation to the situation described before the educational programme).

Regarding educational messages, about 60% of the householders said that they are frequently (weekly to monthly) visited by health visitors who give advice on hygiene, water care, children's and women's health.

4.3.8. Technical inspections

Among the families that had participated on the Aero Rancho sanitation programme, 70% have their bathroom (sanitary unit) built inside their houses and 15% have no flushing devices connected to their toilet bowls.

Vent pipes where found in 53% of the leach pits and just 10% of them were properly protected.

Just 6% of the families had opted for the double pit scheme (had built their second pit), and 37% had the sullage from the kitchen sink passing through a grease trap before reaching the pit.

Rainwater was observed to have direct access to the pits in 4% of the households and sullage was being openly discharged in 10% of the houses.

Figure 4.15. and Plates 4.26 to 4.30 illustrate these results.

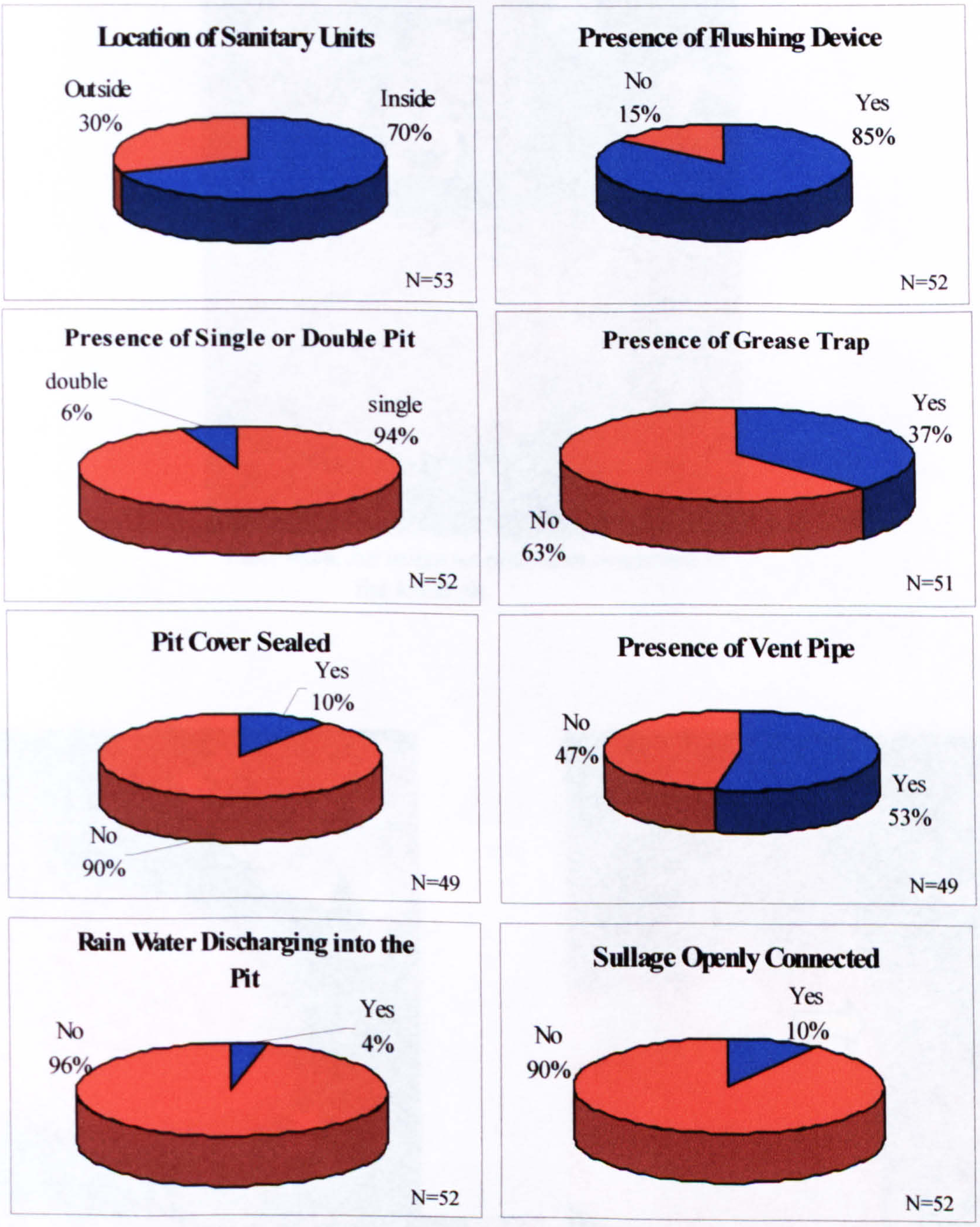
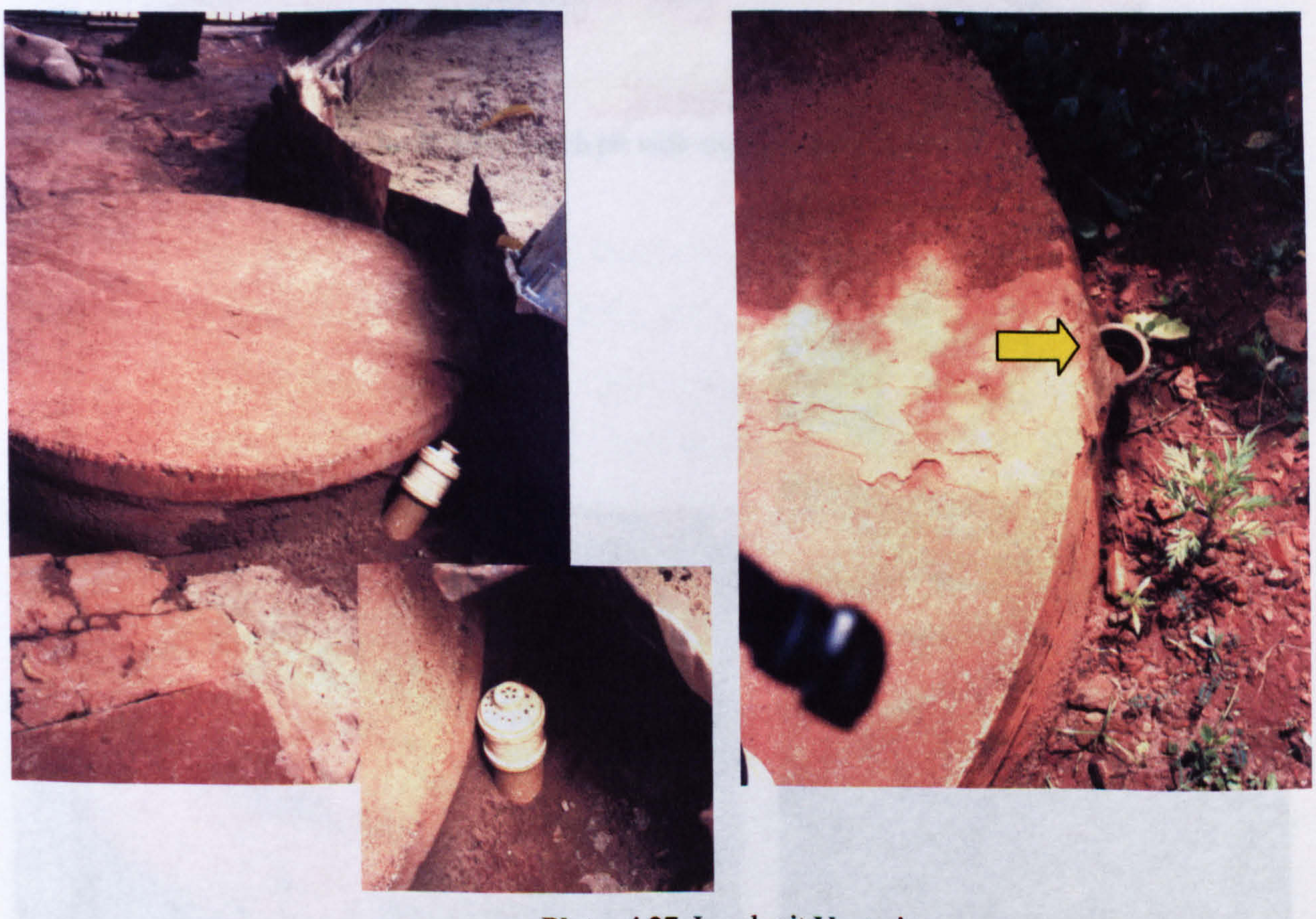


Figure 4.15. Results of the technical inspections

Plate 4.26. An in-house bathroom connected to the leach pit



Plates 4.27. Leach pit Vent pipes

Plate 4.28. An improvised pit cover

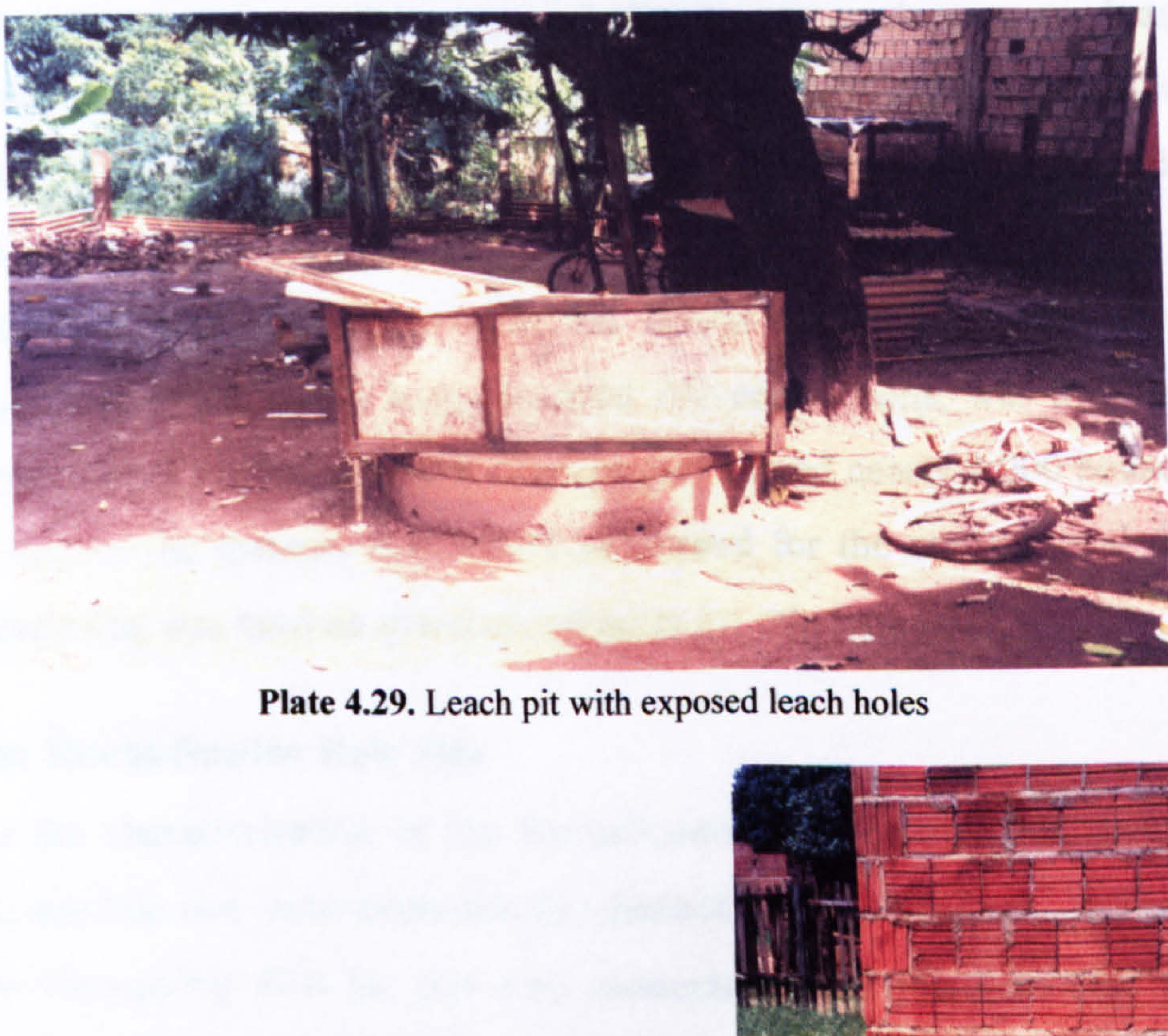


Plate 4.29. Leach pit with exposed leach holes

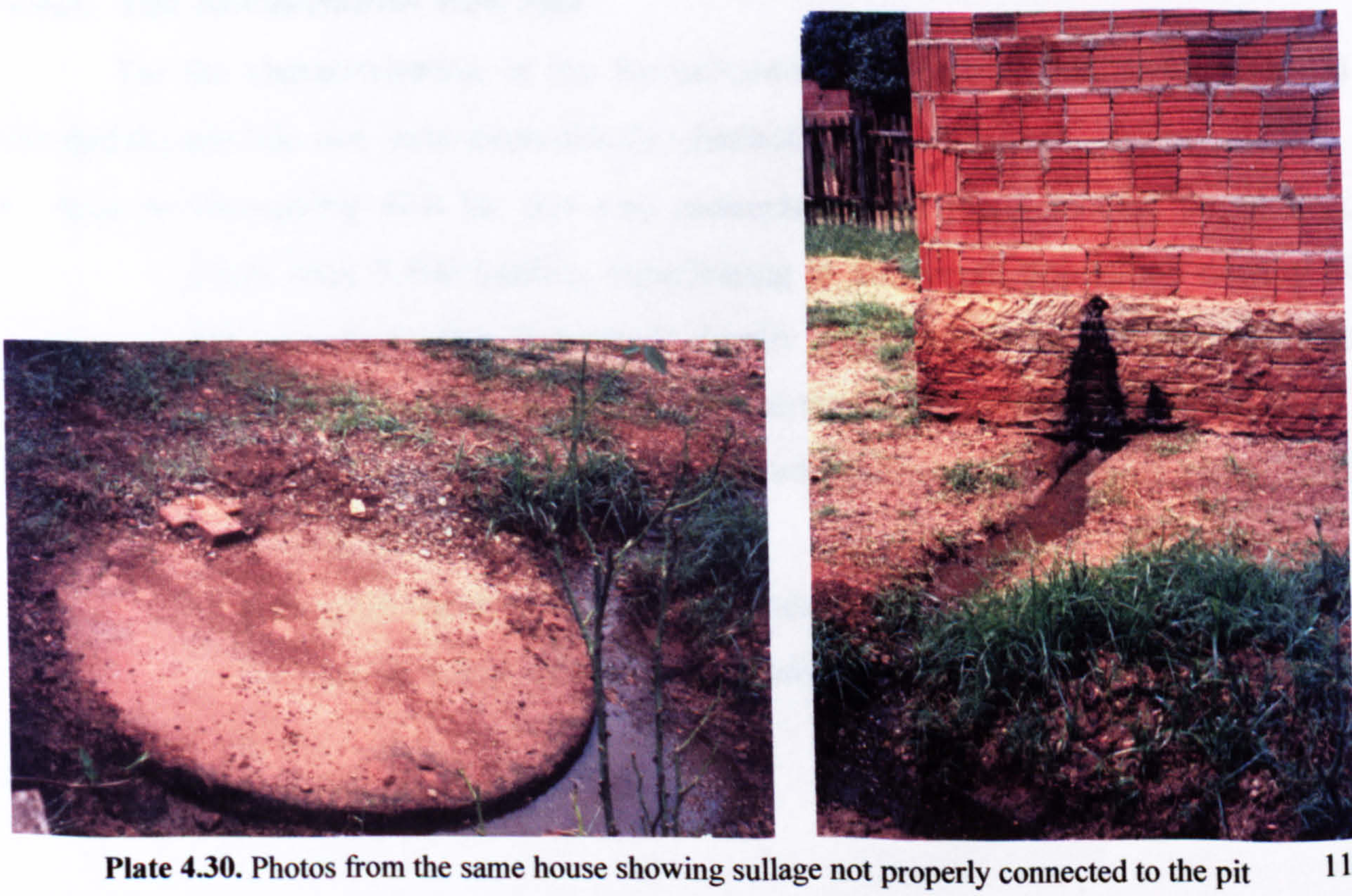


Plate 4.30. Photos from the same house showing sullage not properly connected to the pit

4.4. Case Study 3: Rocas/Santos Reis (Natal-RN)

4.4.1. Introduction

CAERN – the State Water and Sanitation Company of Rio Grande do Norte – is recognised as the company that implemented the first condominial sewerage system. This was in 1980 and the area chosen was the Rocas/Santos Reis district in the city of Natal – capital of the State of Rio Grande do Norte, NE of Brazil (Figure 4.1).

4.4.2. Background

In the early 1980's, CAERN obtained a loan from the World Bank to provide 750 conventional sewerage connections in the area of Rocas Santos Reis.

According to CAERN's president at the time, Mr. Josemar de Azevedo, there was a great motivation among the company's directors to produce as much as possible with the resource obtained; thus, the occasion was considered a great opportunity to put into practice the technical and social parameters introduced by the emerging ideas of the condominal sewerage.

Therefore, after agreement with the World Bank, the initial conventional sewerage project, which would have provided 750 connections, was transformed into the first condominial sewerage system. This project served nearly 3,000 households and used only half of the material that would be needed for the conventional design (the material remaining was used on sewerage projects for other areas).

4.4.3. The Rocas/Santos Reis Site

For the characterisation of the Rocas/Santos Reis district, Sinnatamby (1983) divided the site into two socio-economically distinct areas:

- Area A: Occupying 42.8 ha, this area concentrates the lower income population. There were 3,100 families contributing to an overall population density of 345 persons/hectare (saturation density estimated to be 350 per ha). The general urbanisation and settlement characteristics were:
  - Irregular, unplanned urbanisation with narrow non-aligned roads, with plots of minimal dimensions;
  - A variable topography with elevations between 3 and 20 m;
  - Housing of a low standard of construction, frequently having no lateral space.

- Area B: This was characterised as a high-income area. It covered 22.4 ha and had a population of 700 people (population density of 32 per ha). The urbanization of the area was characterised by:
  - Modern, regular urbanisation with wide roads and large plot sizes;
  - Relatively flat topography;
  - Housing units of a very high standard of construction.

The area defined as "area A" became the focus for the development of the condominial sewerage programme and further investigations found that (Sinnatamby, 1983):

- The location of all sanitary facilities and plumbing fixtures were concentrated at the back of the house;
- Approx. three quarters of the houses were found to have the floor level below that of the road (as much as -1.50 m in some cases);
- Over 90% of the houses had an individual toilet that housed a conventional sanitary bowl (area also used for bathing). Toilets were usually manually flushed using 8 to 10 litres of water;
- Three quarter of the houses had a yard tap level of water supply;
- The common solution for the disposal of excreta was leach pits;
- Sullage was usually discharged by natural drainage to the streets by means of channels and pipes (where this was not possible, sullage was accumulated in tins that were emptied many times a day);

4.4.4. The Sanitation Programme

➢ **The "Quadra 90" experience**

The implementation of Rocas/Santos Reis sanitation programme in 1980 was based on a "pilot block experience". The aims of this "testing phase" were to investigate at pilot scale the technical and social feasibility of the system, and also to use this pilot block as a "shop window" for the acceptability of the system by the householders living in the other blocks of the locality.

For the selection of the appropriate block for the pilot study, the following parameters were adopted (Sinnatamby, 1983):

- It had to be statistically and characteristically representative of the area;

- It should have access to an area which could be utilised for treating and disposing of the collected sewage;
- It should be centrally located to facilitate the access of other members of the community wishing to observe and monitor the operation of the system.

Based on the above, the block known as "Quadra 90" filled the requirements and was chosen for the study. It is a small block covering an area of 2,291 m^2 with 28 plots irregularly distributed. The block population was 132 people and the population density was 576 persons per hectare (357 persons per hectare when considering half the width of the surrounding roads).

Quadra 90 had the condominial "back-yard" system implemented following the steps described below (Sinnatamby, 1983):

- A meeting with the households of the block aiming to: explain the general sanitation conditions necessitating interventions; appeal for cooperation; describe the proposed solution; make the potential users conscious of their responsibilities; exchange ideas and opinions; get permission to undertake a door-to-door survey; and get agreements on: undertaking another meeting; the responsibilities of each person; the costs of the system and tariff policy; the allowance of members of the community to observe the system, and, that CAERN would repair any damages caused to the properties;
- Visits to each house in order to obtain information on: the location of the source of sewage and sullage; the type of plumbing fixtures; the level of the house in relation to that of the road; and the methods used to dispose rainwater, excreta and sullage;
- Visits to each house to mark the location of the inspection chamber (in consultation with the occupants of the house);
- Levelling of the defined points;
- Design of the system; and
- A second meeting for the approval of the scheme by the members of the block.

A small firm of contractors (that was required to employ local workers as much as possible) executed the project without major problems. For the treatment of the collected sewage, a treatment plant consisting of a communal septic tank and drainfields was provided nearby (about 100m away).

By the completion of the experimental system, in December 1981, the total investment cost per household was calculated as US$ 149.10 and a very high level of acceptance among householders was observed.

➢ **Expansion of the programme**

The expansion of the programme to the remaining residential blocks was greatly benefited by the experimental study. Indeed, the positive impact of the pilot scheme increased the level of awareness of all community members on the importance of the system, and also provided an *in loco* understanding of the technology adopted.

Therefore, the same methodology used for the implementation process of the pilot study was used for the expansion of the programme, which covered 97% of the community. The execution was then completed and the system has now been in operation for almost 20 years.

The others physical improvements observed in the area since the period described above, was that the streets had been paved with paving stones and many of the houses had been refurbished (see Plates 4.31 and 4.32).

4.4.5. Study Methodology

The data collected for the present study were based on: a **survey questionnaire**, a **technical inspection** of the sanitation units, and **observation** of maintenance works. This was further complemented by informal **interviews** with professionals working on the system.

For the **survey questionnaire** and the **technical inspections**, the whole community (households placed within the physical limits of the area) was considered as the target population for the study. The questionnaires were applied in a sample selected systematically, having each tenth house interviewed. The size of the sample obtained by this method was therefore approx. 10% of the total number of houses in the area (N=362).

The questionnaire (Annex 3) comprised five sections, as follows:

Section I - Identification/ socio-economical aspects
Section II - Level of water supply
Section III - Community participation
Section IV - Technology usage, functioning and satisfaction
Section V - Educational programmes and public health

The technical inspections were carried out at the same time as the questionnaire survey and at the same households. These inspections were based on the completion of a factual inspection question-sheet containing the following parameters: sealing of the inspection chambers; damaged (broken) inspection chambers; if there was open wastewater flowing to the system; and rainwater discharging into the sewers.

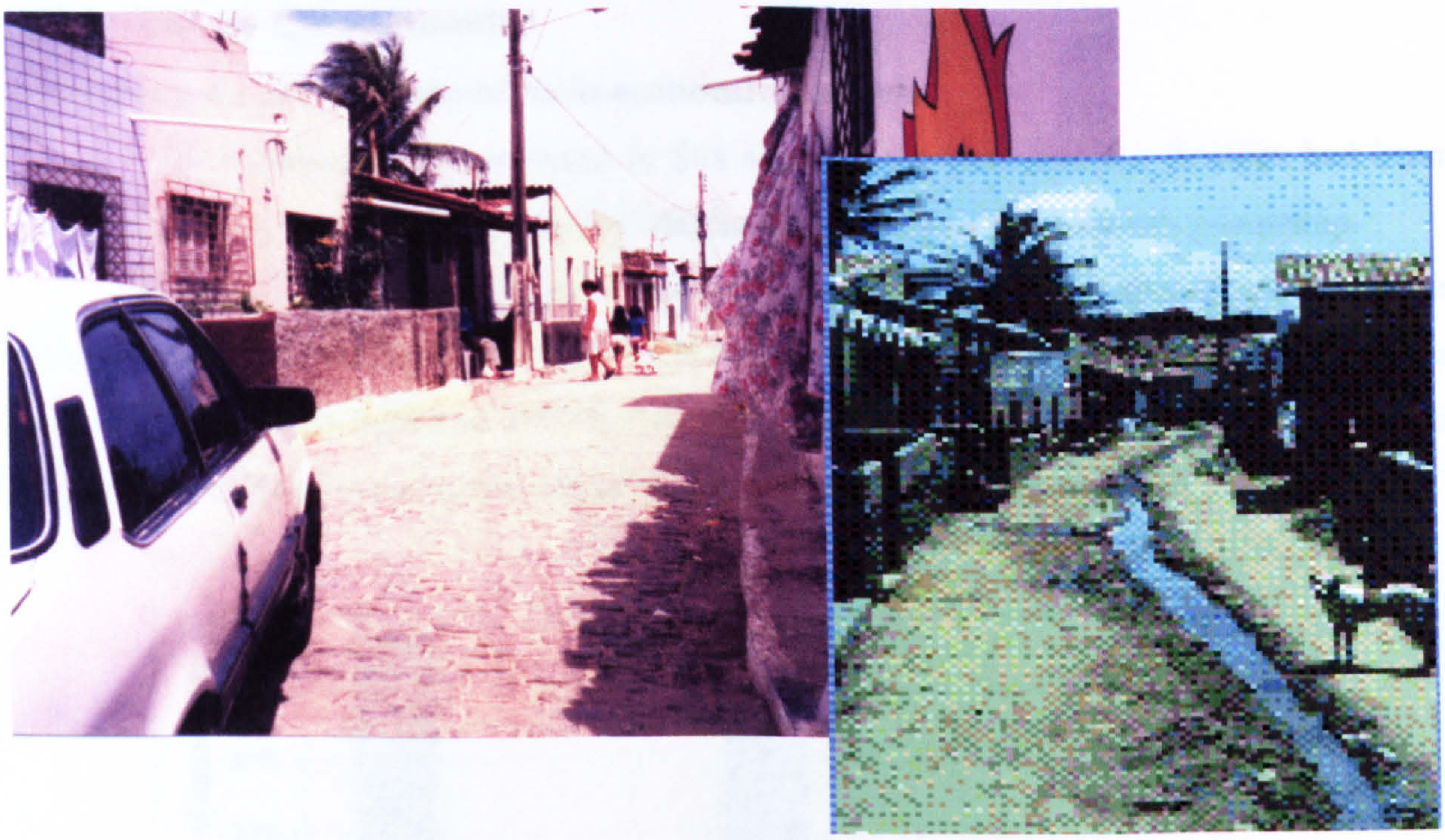


Plate 4.31. The same street before the sanitation system (1980 - right) and during the field study (2000)

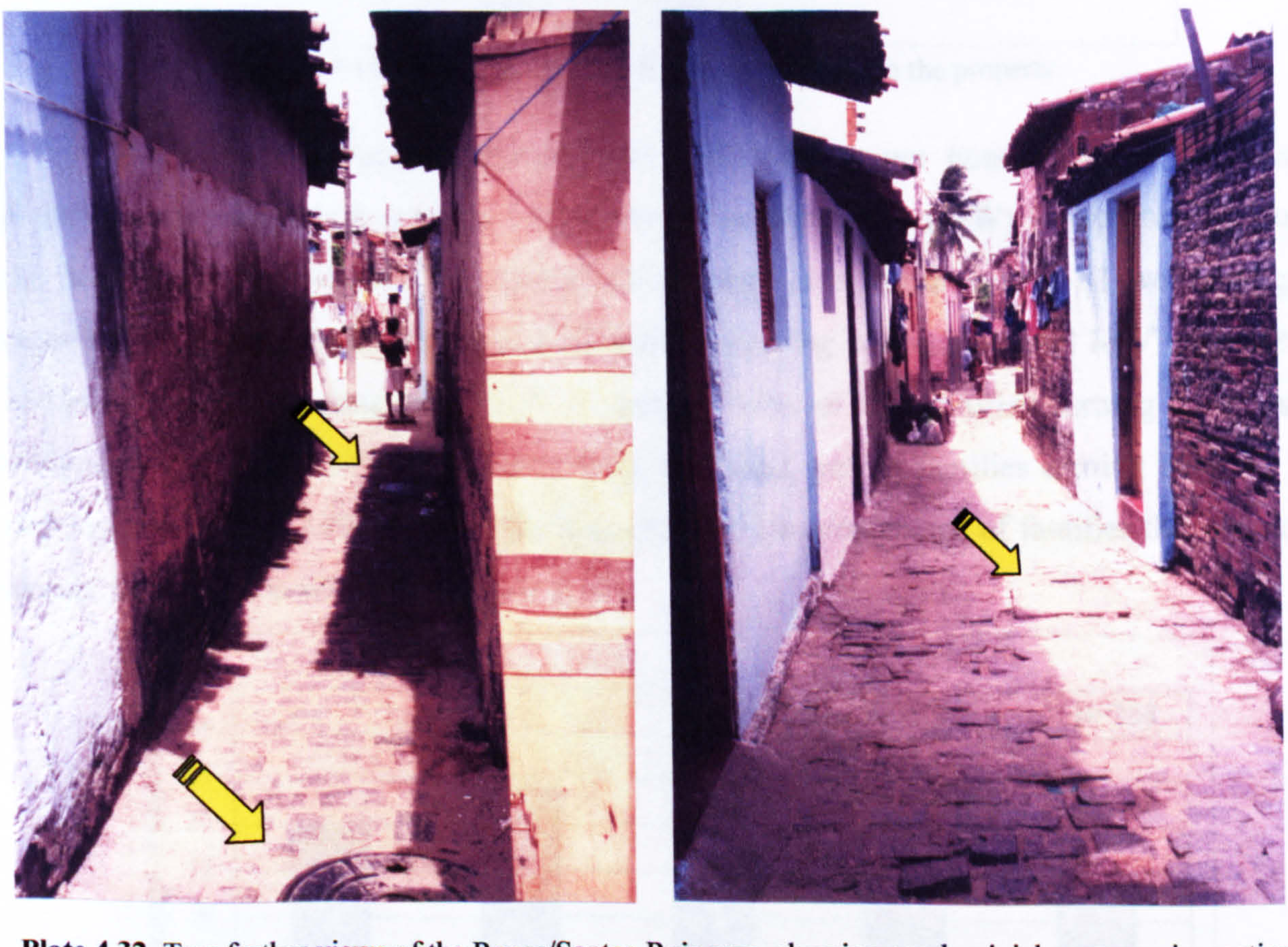


Plate 4.32. Two further views of the Rocas/Santos Reis area, showing condominial sewerage inspection chambers

4.4.6. Survey Questionnaire

➢ **Section I – Identification/Socio-economic Aspects**

Four variables were measured in this section: the time that the families had been living in the site; the occupation density; the families' income and property ownership.

Thus, 47% of the families had been living on the plot for more than 20 years (before the system started to be implemented). 2.5% had moved in during the implementation of the project (7 to 8 years ago) and 50% had moved in after the sanitation system was put into operation (14.4% of these moved in during the last 2 years), as shown in Figure 4.16.

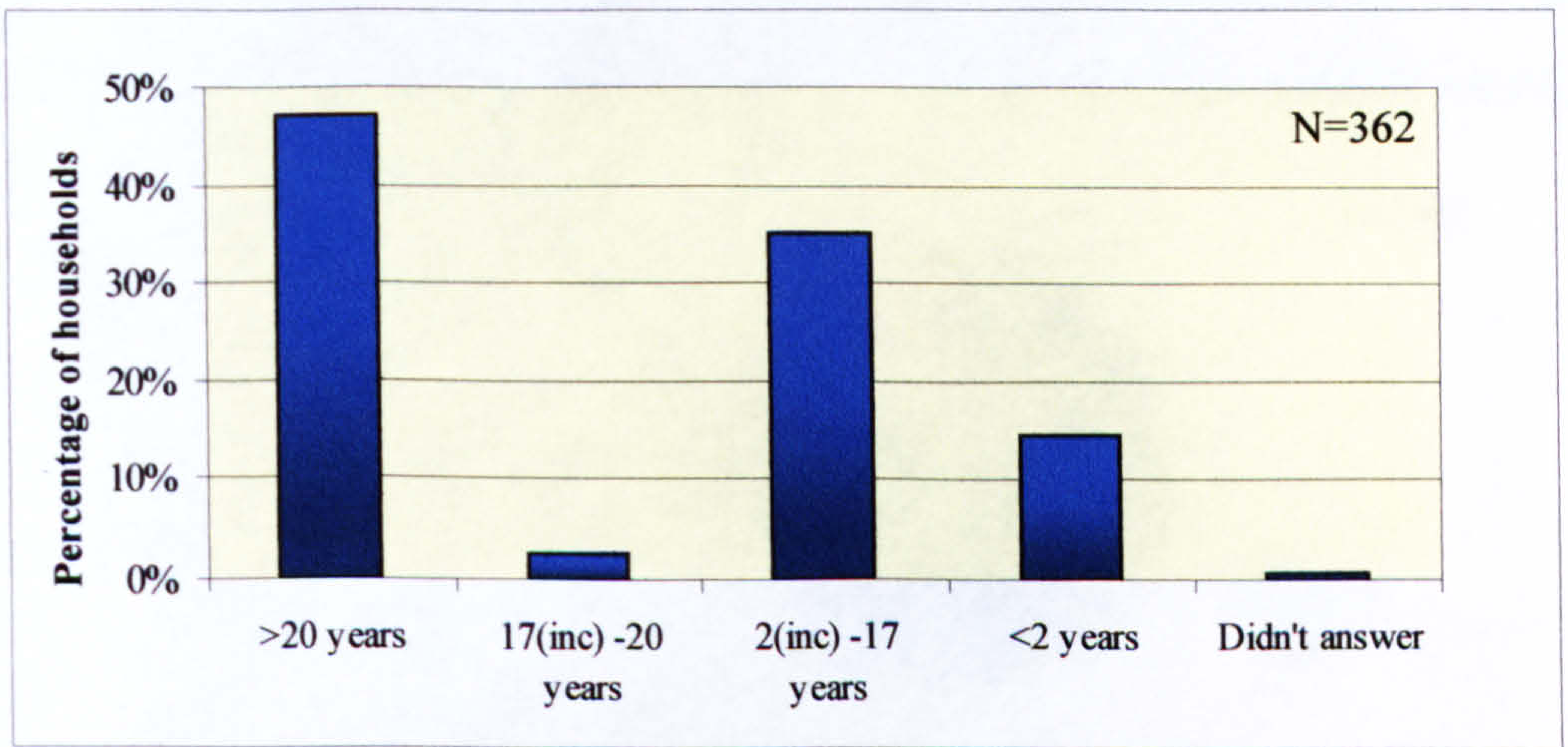


Figure 4.16. Time that the families had been living in the property.

The average occupation density was 4.72 persons per household and the joint monthly family income was up to 1 Brazilian Minimum Wage (MW) for approx. 20% of the households (included in this classification were also families with all working-age members unemployed). In the category of families earning between 1 and 2 MW were 24% of the households leading to a total of approx. 44% of the families earning 2 or less minimum wages per month. The main category found was of families earning between 2 (not included) and 5 MW (30% of the households). The percentage of families that did not answer this question was 14% (Figure 4.17).

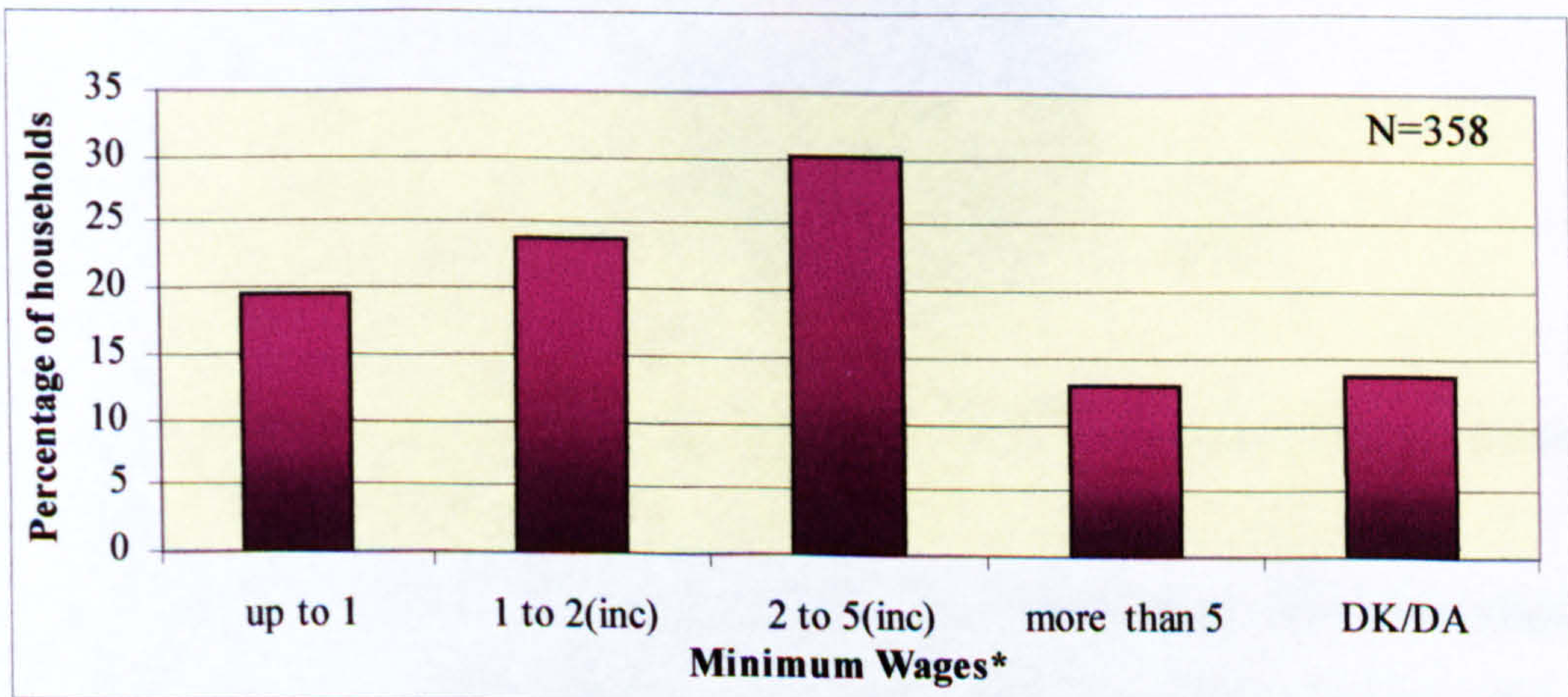


Figure 4.17. Monthly Family income
(*The Brazilian Minimum Wage was 136.00 reais (approx. = US$ 80.00) in 28/03/00)

Regarding the property ownership level, the results revealed that approx. 74% of the householders owned their houses.

➢ **Section II - Level of Water Supply**

The community is fully served by CAERN water supply systems and there are no families using other sources of water.

Sinnatamby (1983), in a characterisation study of the area, reported that 75% of the households had a yard tap level of supply. This study, however, revealed that the percentage of households with this level of supply had decreased to 12% and that, as shown in Figure 4.18, 88% of the houses now have an in-house level of water supply.

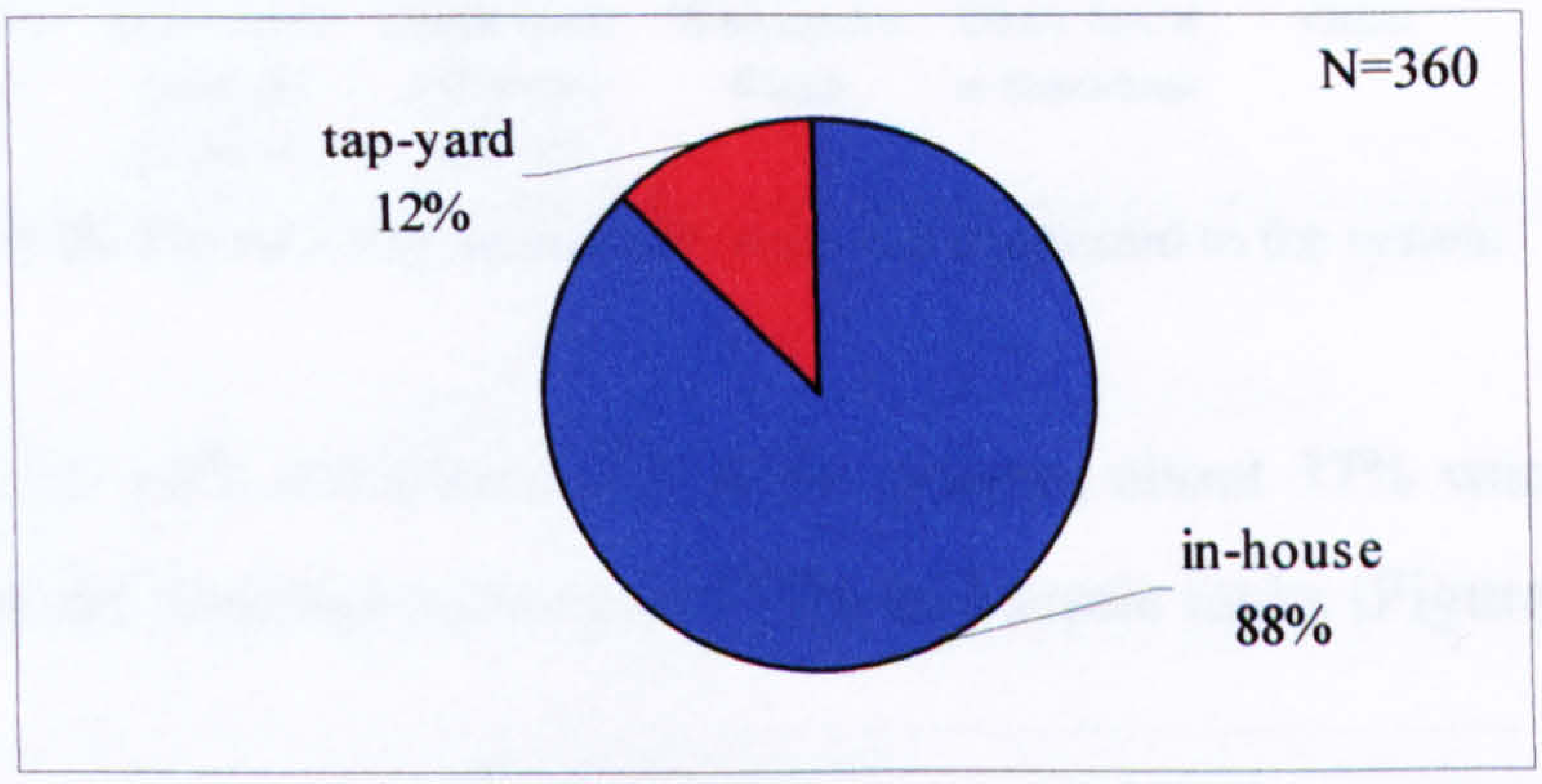


Figure 4.18. Level of water supply

➢ **Section III - Community Participation**

As shown in Figure 4.19, approx. 83% of the population surveyed were currently connected to the condominial sewerage system. Among the remaining 17%, 2% didn't know/didn't answer whether the house had a sewerage connection or not, and 15% said that they were not connected to the system.

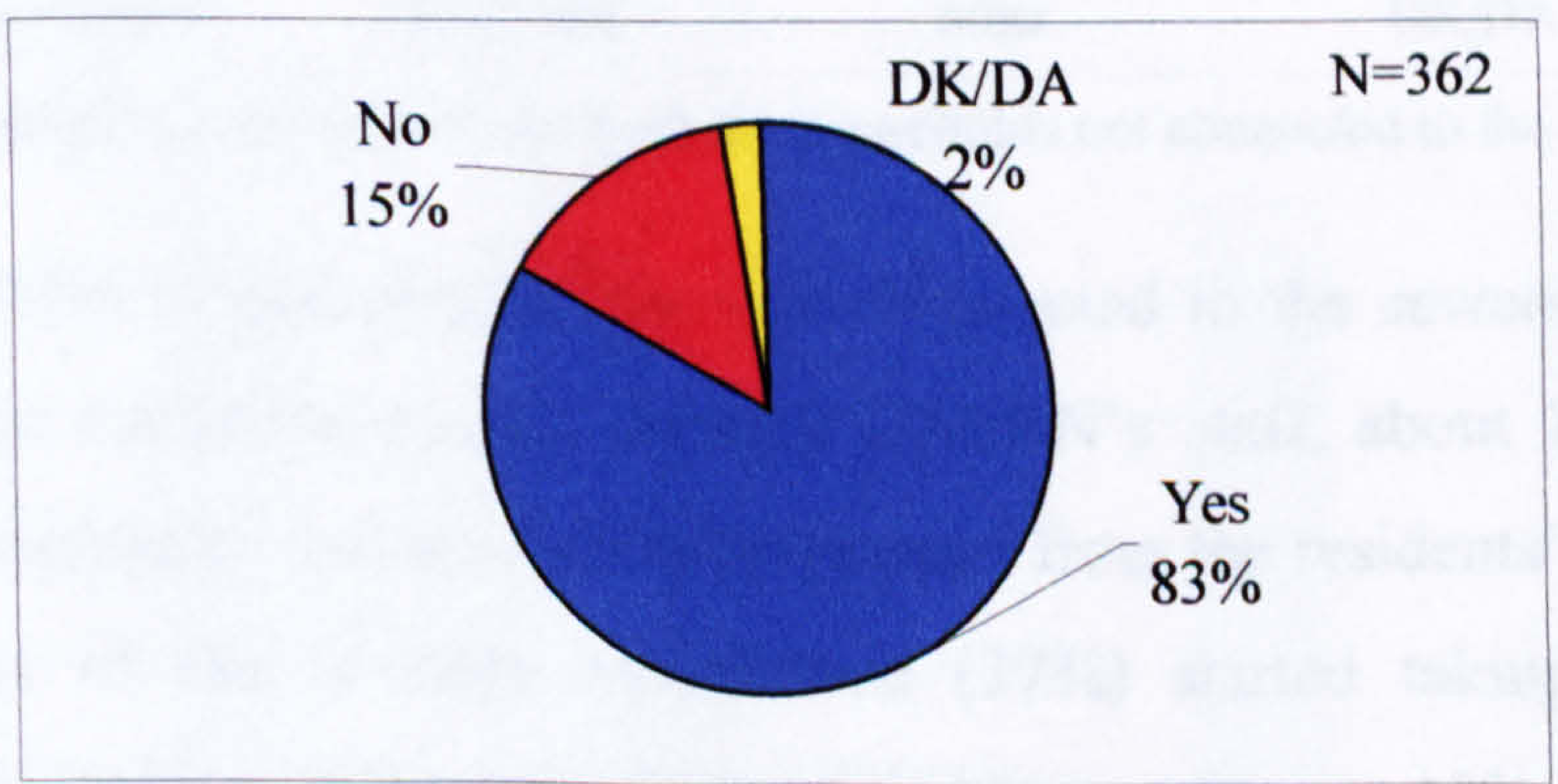


Figure 4.19. Level of house connections to the condominial sewerage system

The reasons why these 15% of the households had no connections to the sewerage system are shown in Figure 4.20; thus, 25% of them said they did not think that it was important to have sewerage and 23% said they did not know about the programme; 12.5% explained that they were waiting for CAERN to connect their wastewater to the system and 29% didn't know/didn't answer the question.

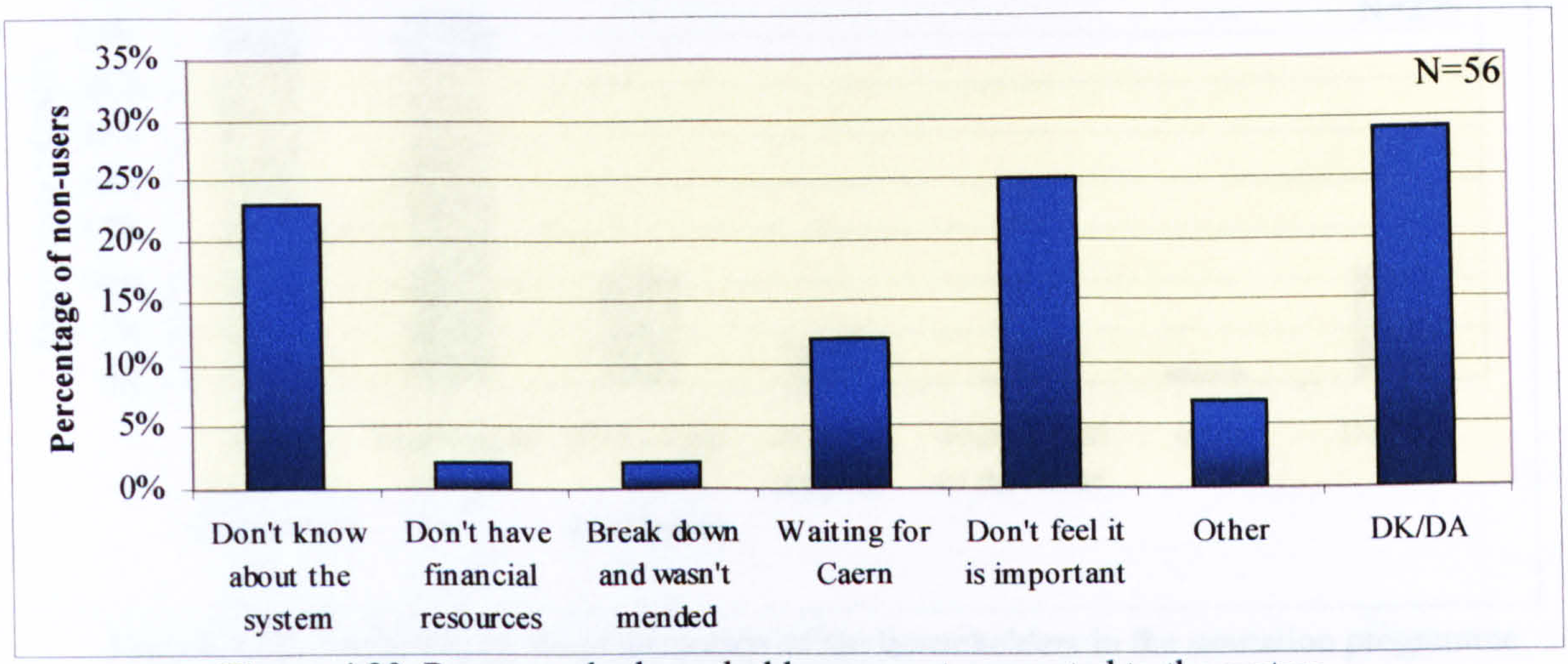


Figure 4.20. Reasons why households were not connected to the system.

Considering the 15% not connected to the system, about 37% was disposing of their wastewater into the drainage system and 39% had septic tanks (Figure 4.21).

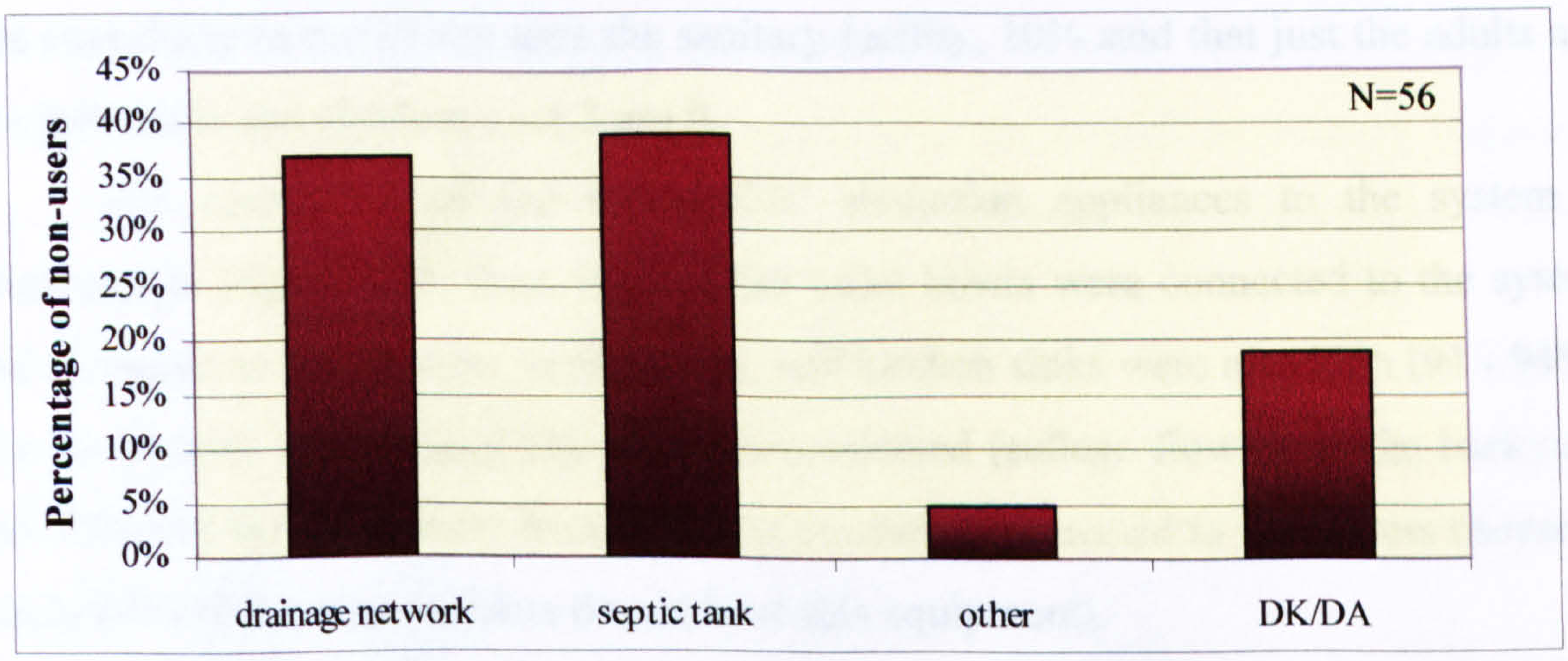


Figure 4.21. Destination of wastewater from the households not connected to the system.

Among the 83% of households that were connected to the sewers, nearly 46% became aware of the sanitation system through CAERN's staff, about 11% said that they were told by neighbours and nearly 4% by persons from the residents' association.

The majority of the families interviewed (37%) started taking part in the programme at the beginning of the implementation phase, whereas 11% said that they starting participating just after seeing the system functioning. Figure 4.22 also shows that only 4% of the households accepted the system since the meeting stage and that less than 1% made the connection when they moved into the houses. About 36% said that the houses were already connected to the system when they moved in and 11% did not answer the question.

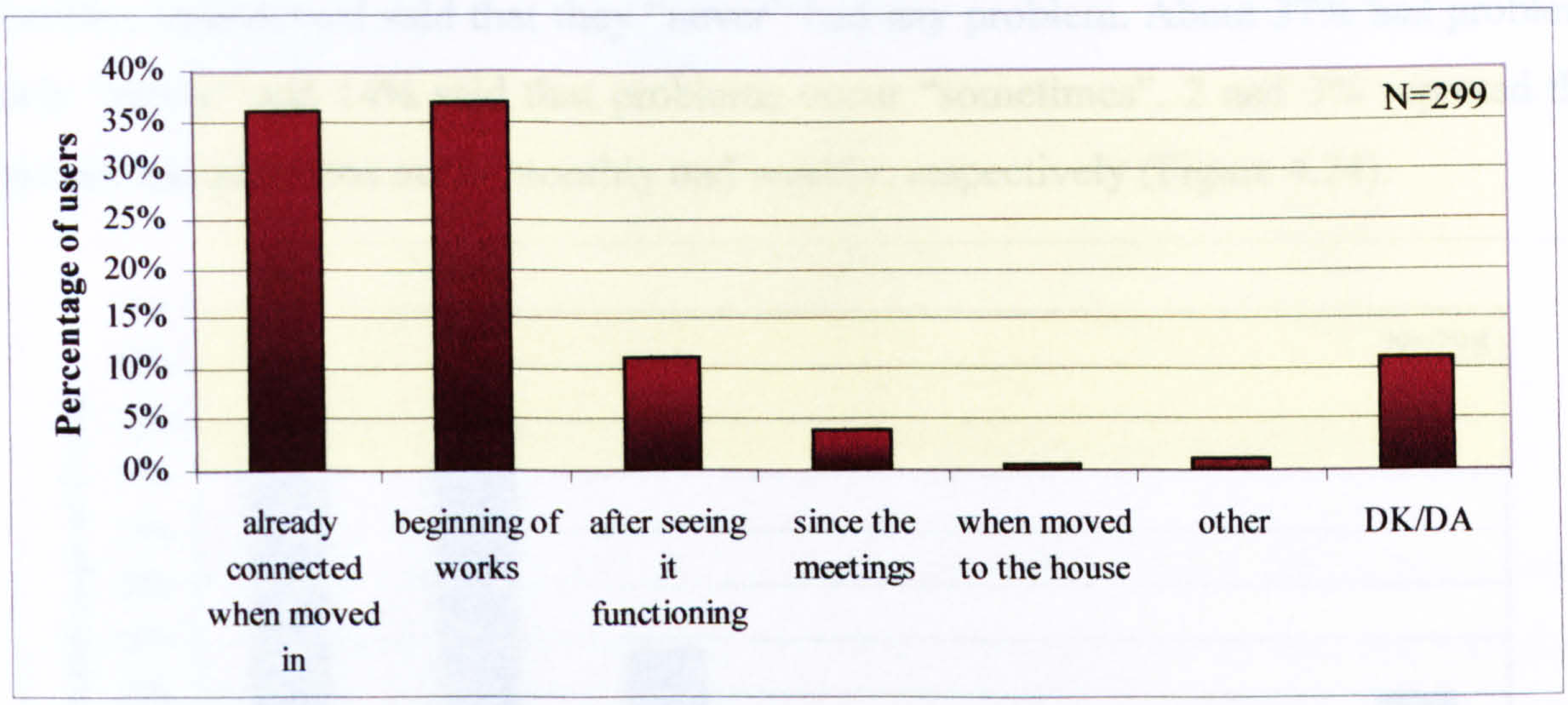


Figure 4.22. Beginning of the participation of the householders in the sanitation programme

➢ **Section IV - Technology Usage, Functioning and Satisfaction**

❑ **Technology usage**

Regarding the utilisation, 85% of the households connected to the system said that everybody in the family uses the sanitary facility, 10% said that just the adults and 5% that adults and children over 5 use it.

The connection of the households' sanitation appliances to the system is illustrated in Figure 4.23; thus, 98% of the toilet bowls were connected to the system and connections for showers, wash basins, and kitchen sinks were also high (91 - 94%). For the laundry tanks, about 5% were not connected (sullage flowing to the backyard) and 30% had the wastewater from washing machines connected to the sewers (however nearly 68% of the householders do not have this equipment).

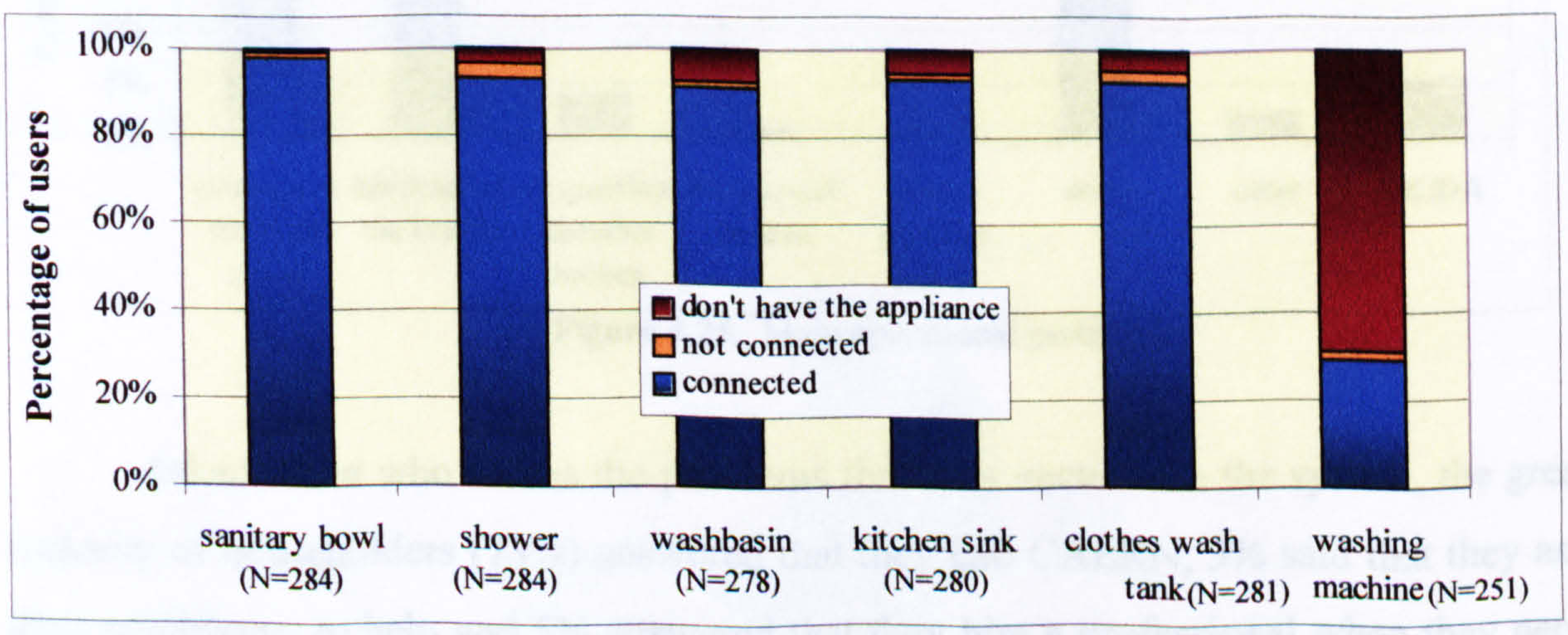


Figure 4.23. Household appliances connected to the system.

- **Technology functioning**

Regarding the frequency of failures in the condominial sewers, 40% of the families interviewed said that they "never" had any problem. About 37% had problems only "rarely" and 14% said that problems occur "sometimes". 2 and 3% reported that operational problems occur monthly and weekly, respectively (Figure 4.24).

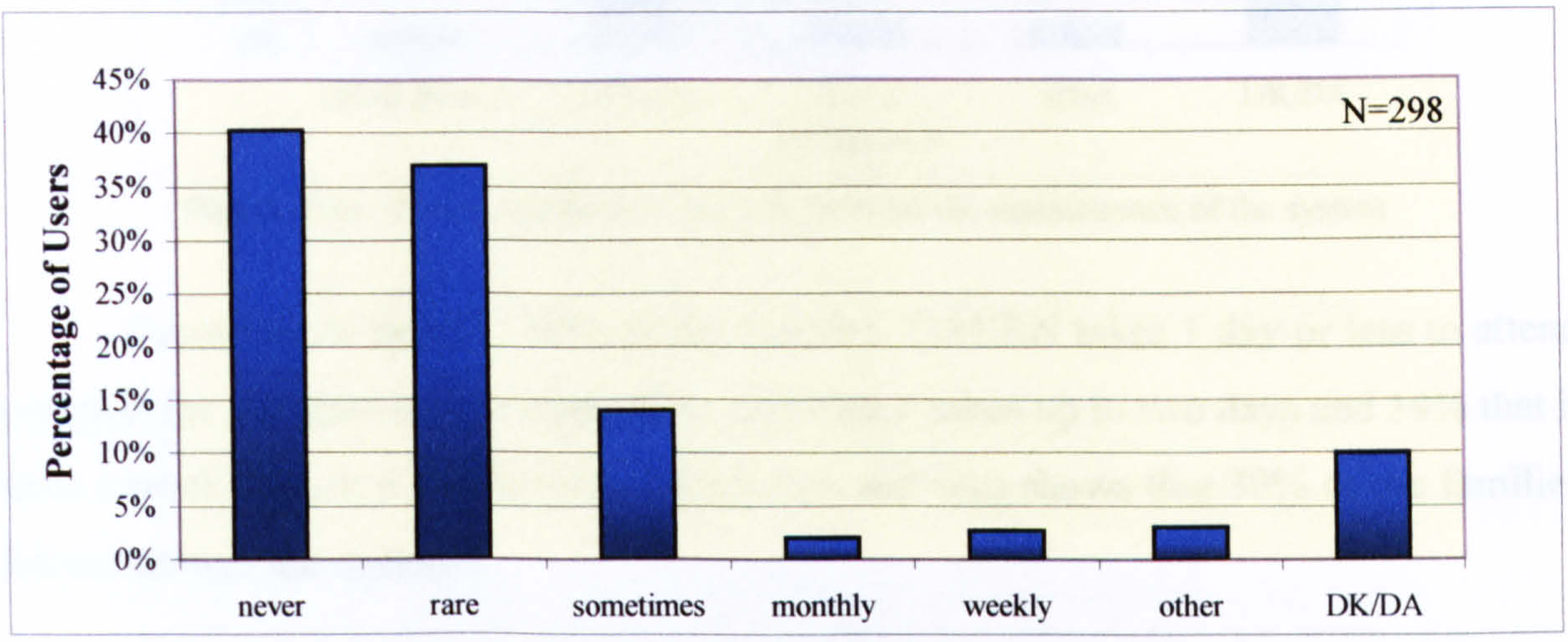


Figure 4.24. Frequency of problems.

Among householders that reported some functioning failure, 36% said that such problems were related to blockage in the main sewer and about 22% to blockage in the condominial sewer. Approx. 4% reported problems related to broken inspection chambers and 1% (each) related to a broken main or condominial sewers (Figure 4.25).

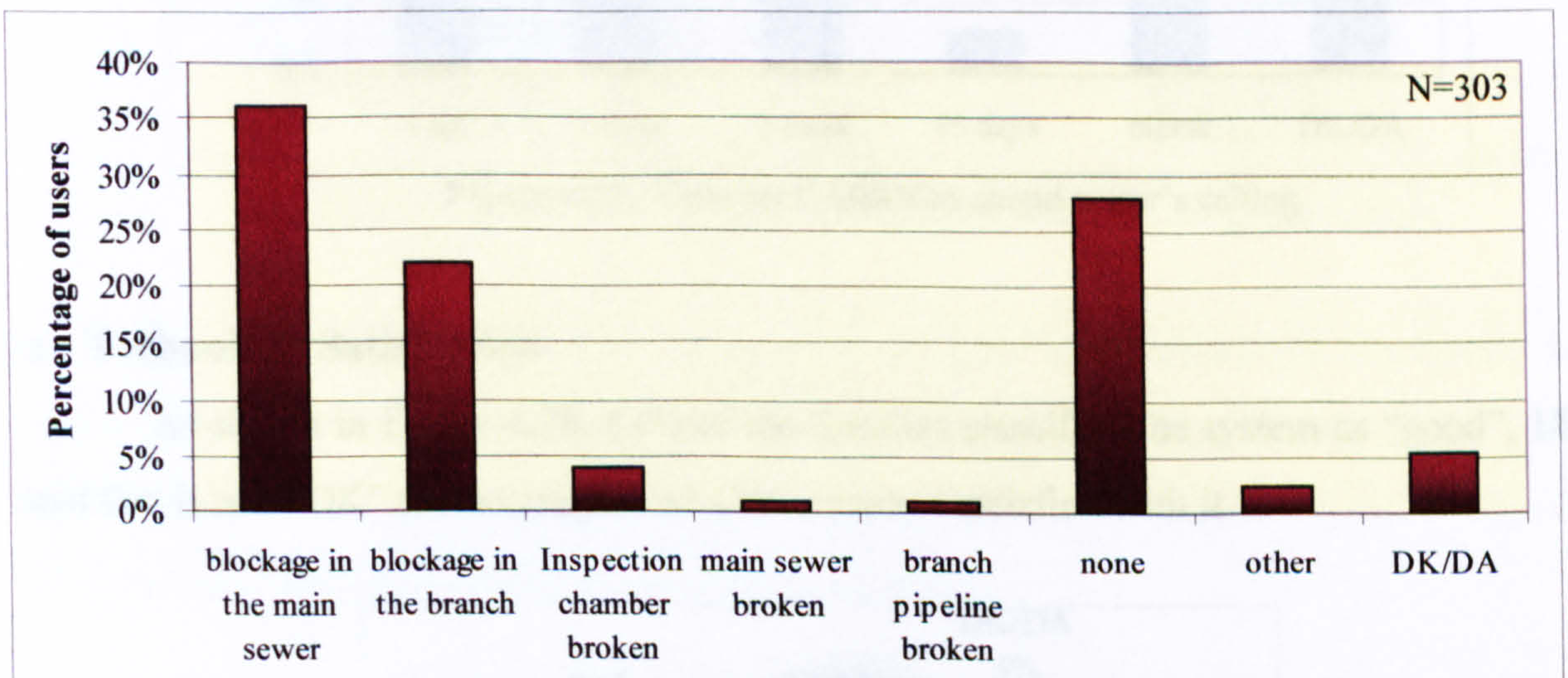


Figure 4.25. Main operational problems.

Asked about who solves the problems that may occur with the system, the great majority of householders (73%) answered that they call CAERN; 3% said that they ask their neighbours to help and 5% answered that they hire a professional when they need to mend anything related to the system (Figure 4.26).

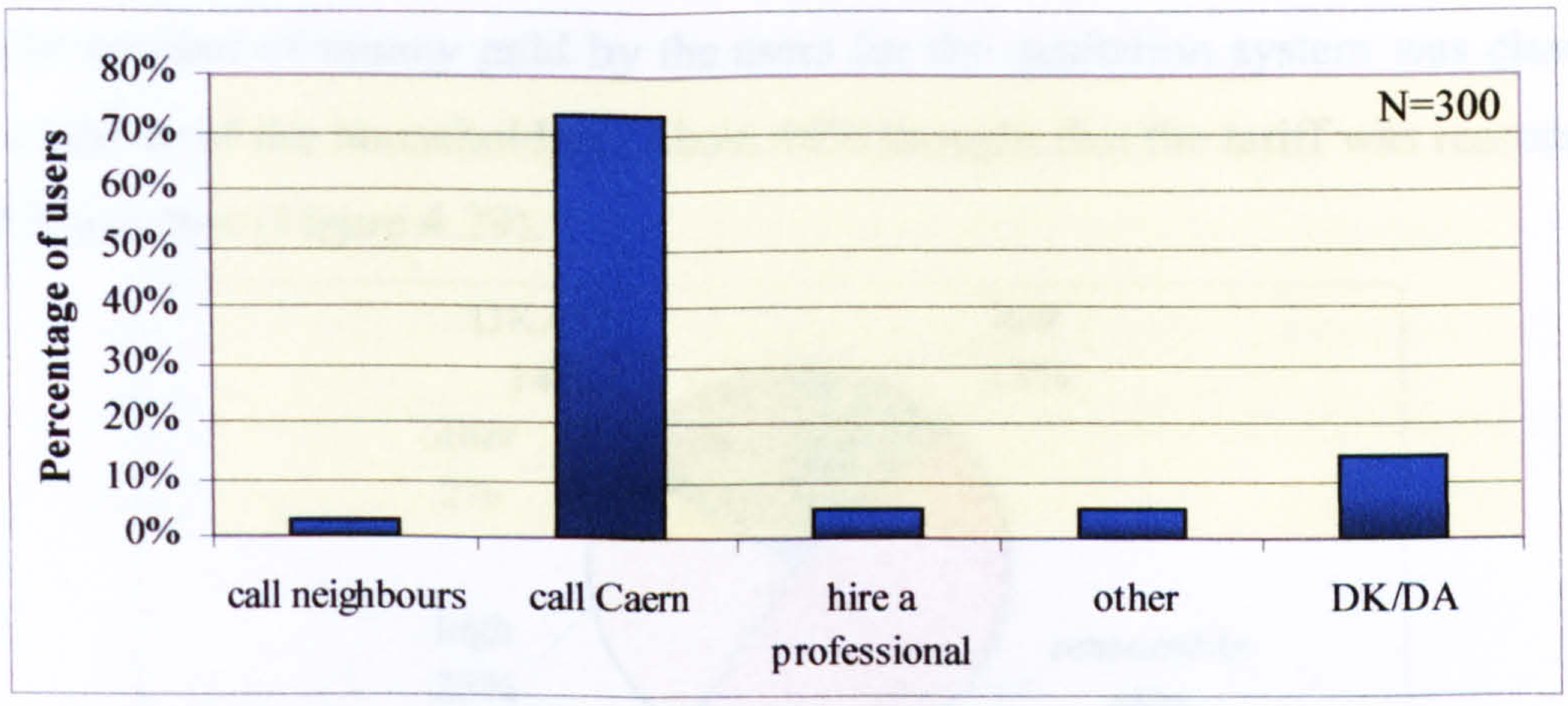


Figure 4.26. Person/institution called to perform the maintenance of the system

According to approx. 20% of the families, CAERN takes 1 day or less to attend a request for maintenance services; 23% said that it takes up to two days and 14% that it takes a week. Figure 4.27 illustrates these data and also shows that 30% of the families did not answer the question.

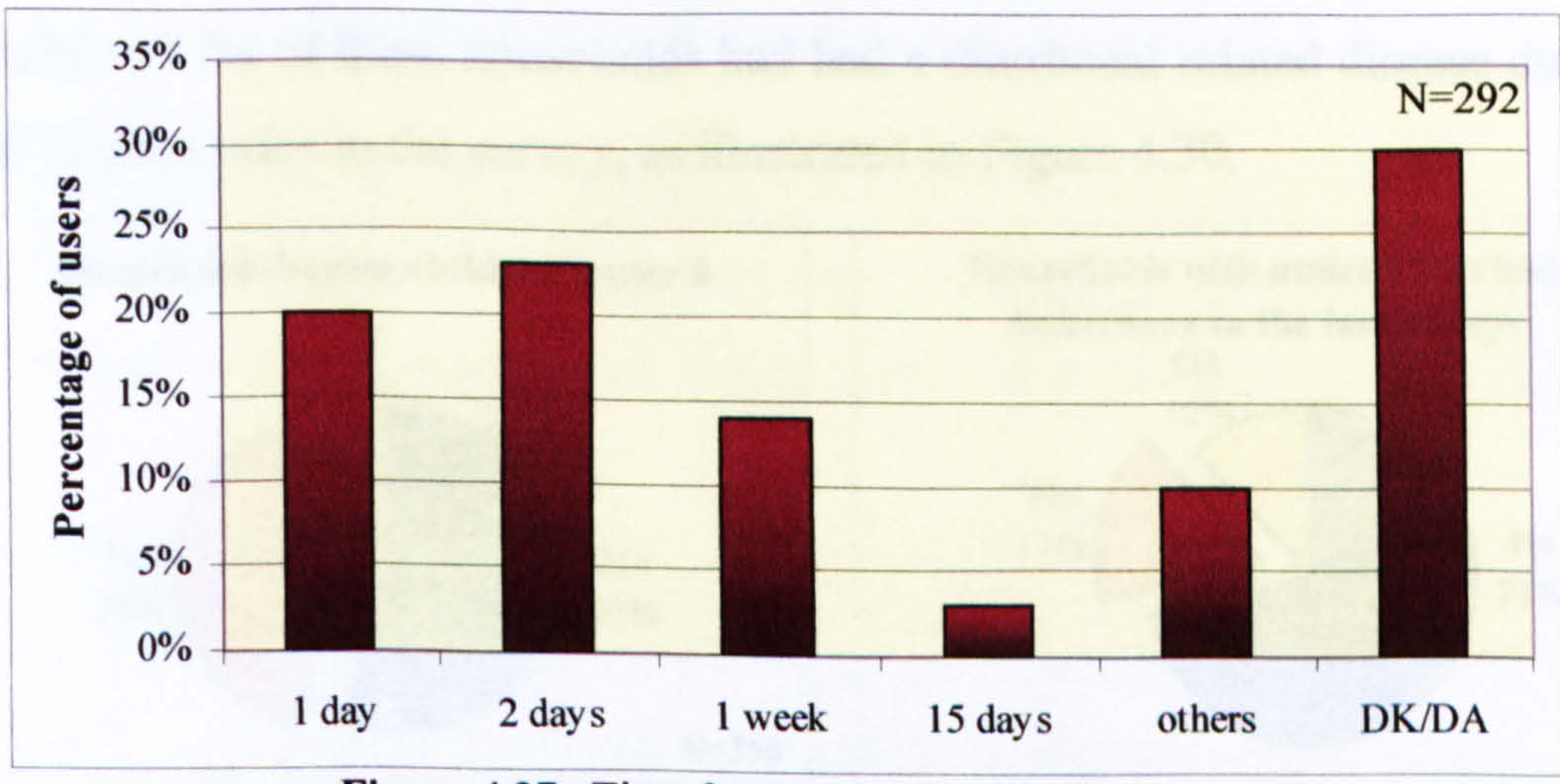


Figure 4.27. Time for CAERN to attend a user's calling.

- **Technology Satisfaction**

As shown in Figure 4.28, 63% of the families classified the system as "good", 18% said that it was "OK" (i.e. average) and 14% were not satisfied with it.

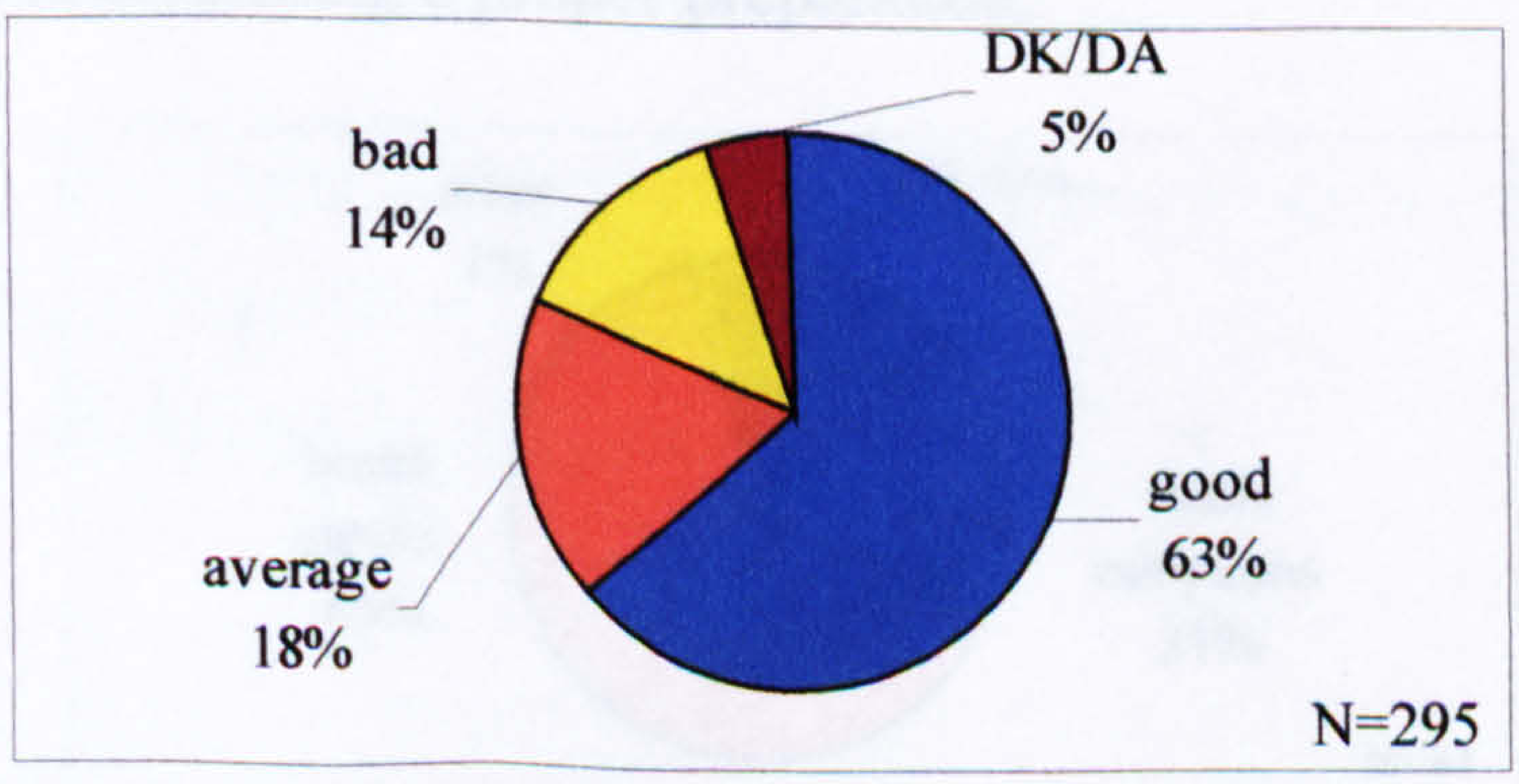


Figure 4.28. User satisfaction with the condominial sewerage system.

The amount of money paid by the users for the sanitation system was classified as high by a quarter of the householders. About 46% thought that the tariff was reasonable and 13% that it was low (Figure 4.29).

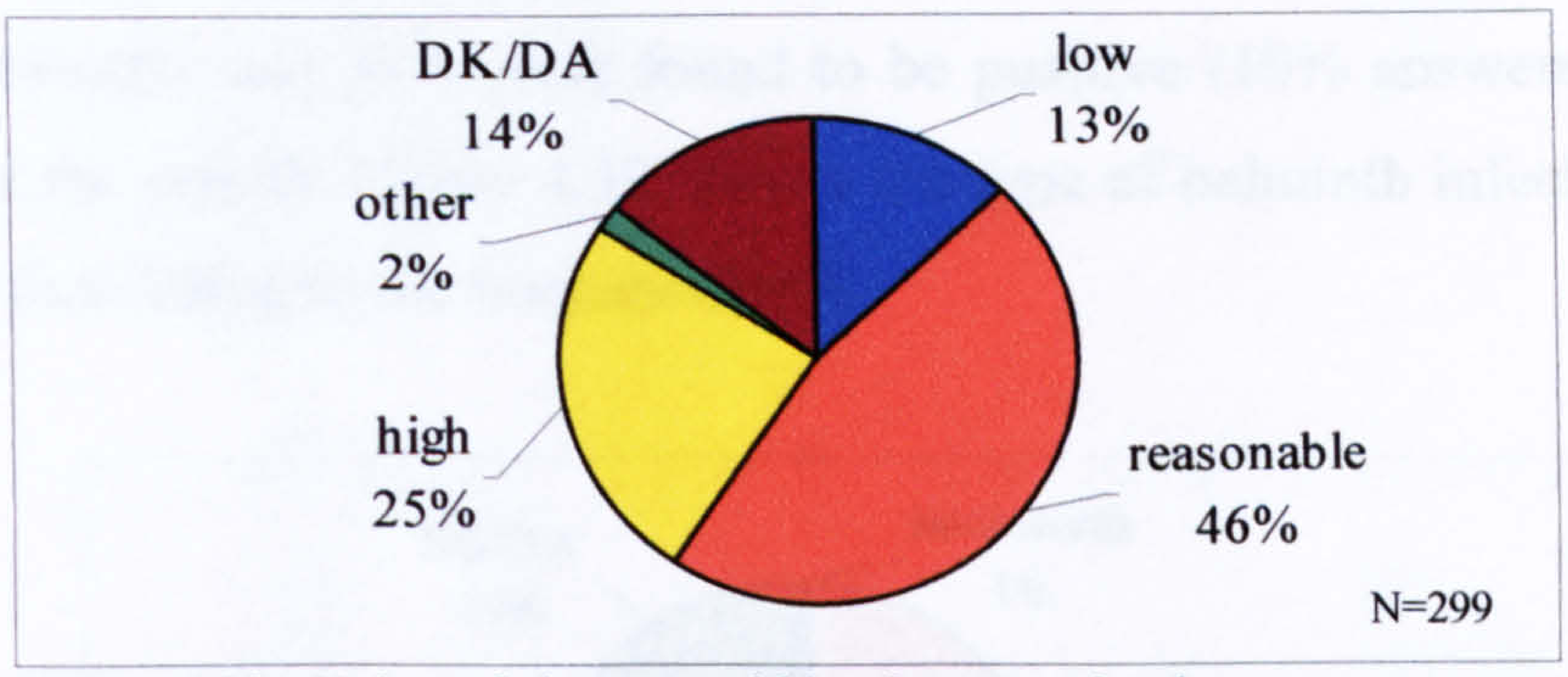


Figure 4.29. Value of charges paid by the users for the sewerage system.

➢ Section V - Public Health and Educational Programmes

The results of the household survey showed that 38% of the households had at least one child up to 5 years old. Considering just the families having "under 5's", at least 1 child in 17% of these households had had a diarrhoeal related disease during the period of 15 days prior to the survey, as illustrated in Figure 4.30.

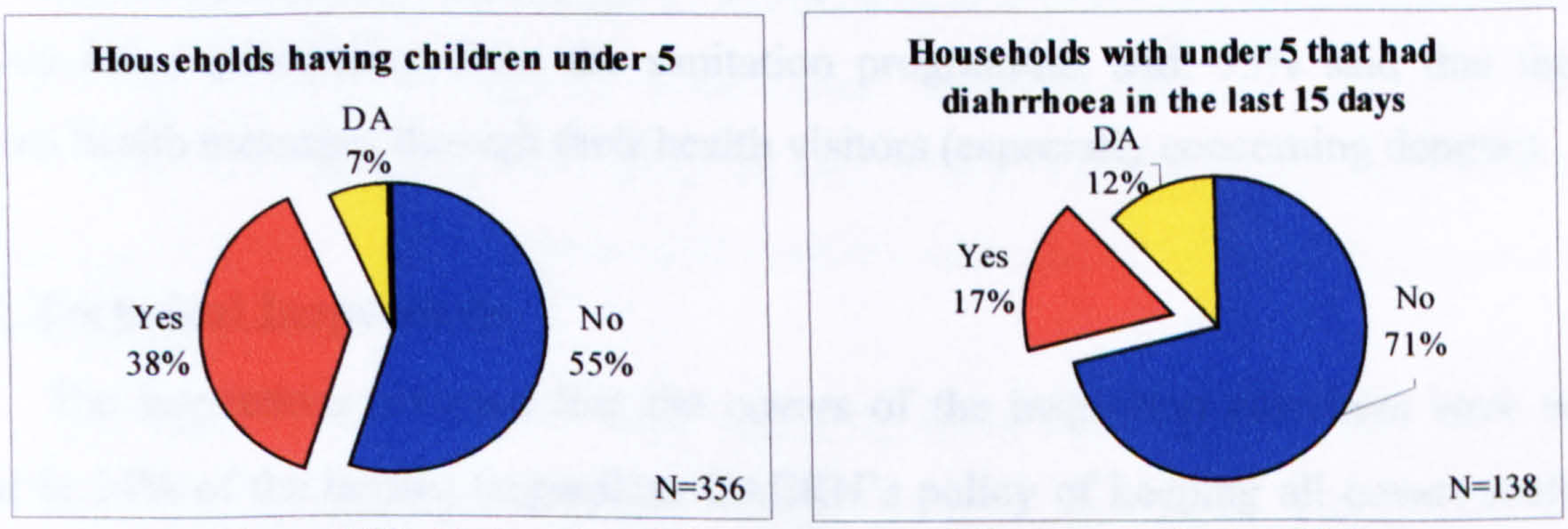


Figure 4.30. Under 5's and the occurrence of diarrhoea in the last 15 days.

In 88% of the households interviewed at least one member of the family had heard about Oral Rehydration Solution (ORS). Figure 4.31 shows the source by which the householders obtained this information. When asked how they make the ORS, 92% of them succeeded in describing a proper preparation.

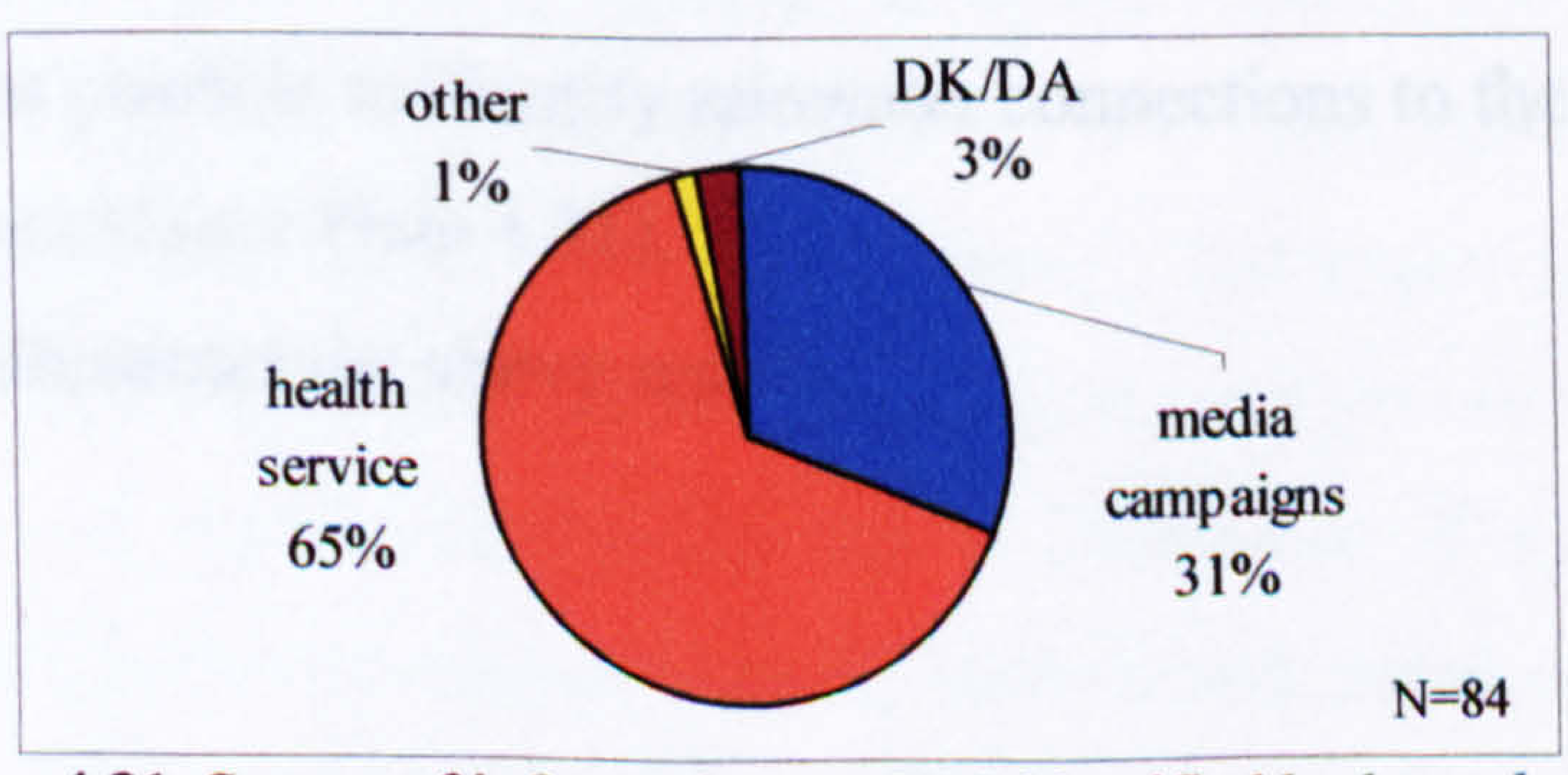


Figure 4.31. Source of information on ORS identified by householders.

It was also found that 64% of the households had at least 1 child under 15 years of age. These households provided a sample of 442 children "under 15", and from this, they reported that 59% had had their faeces tested for helminth infections during the previous 12 months, and 31% were found to be positive (10% answered that they did not remember the result). Figure 4.32. shows the type of helminth infections among the "under 15's" (according to the householders).

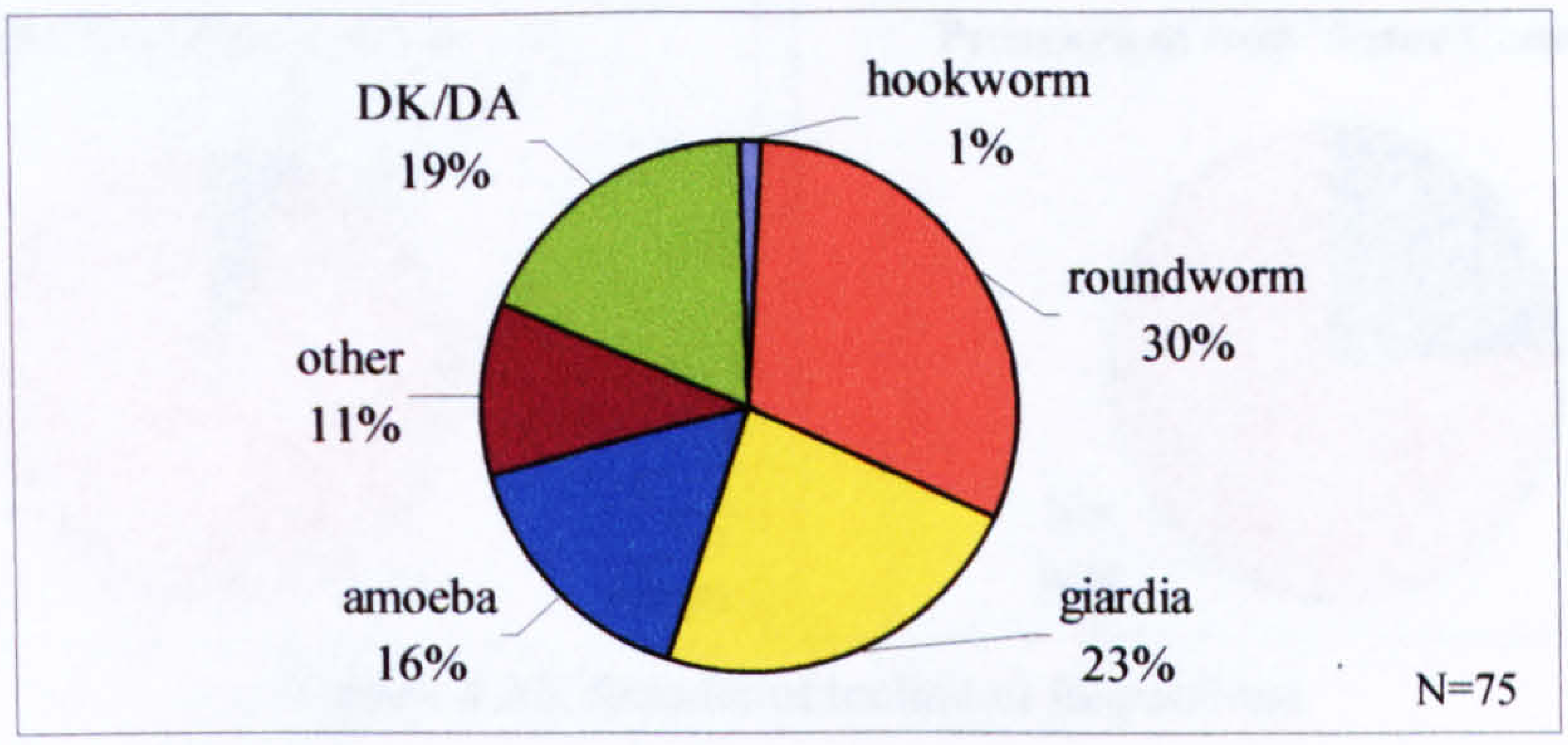


Figure 4.32. Helminths identified in children under 15.

Regarding educational programmes, only 15% of the households recalled having received some information from the sanitation programme, and, 55% said that they received health messages through their health visitors (especially concerning dengue).

4.4.7. Technical Inspections

The inspections revealed that the covers of the inspection chambers were not sealed in 14% of the houses (regardless CAERN's policy of keeping all covers sealed with mortar).

It was also observed that 12% of the inspection chambers had some level of damage either to the box itself or to the covers.

Regarding the house connections, in only 1% of the households were they found to be inadequate, with open wastewater flowing over the ground to the inspection chamber.

Finally, it was possible to identify rainwater connections to the system in 24% of the households inspected (see Plate 4.31).

Figure 4.33 illustrates the above results.

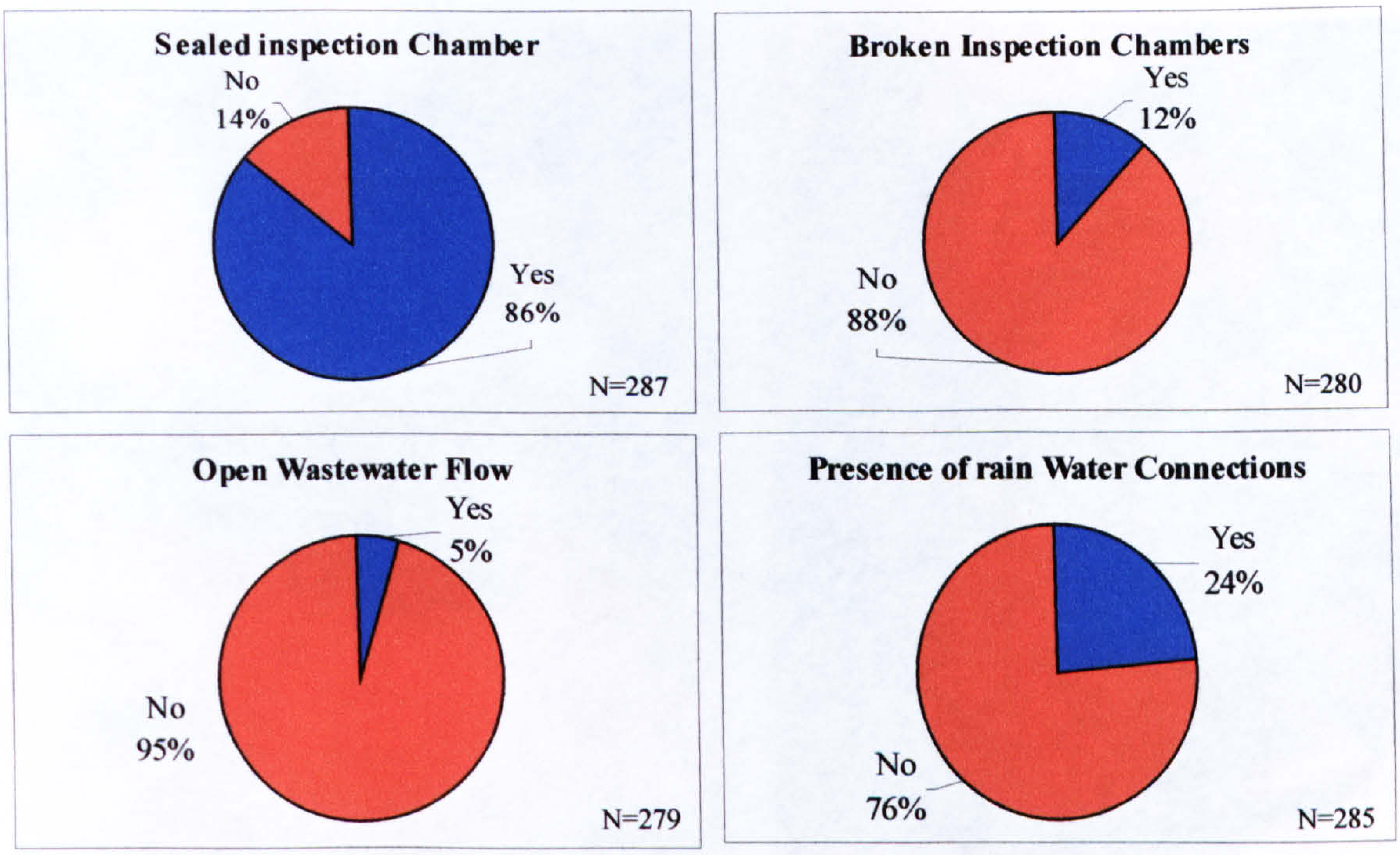


Figure 4.33. Results of technical inspections

4.4.8. Maintenance activities

The maintenance of the system of Rocas/Santos Reis is CAERN's responsibility and was being carried out through an on-site office. However, the Rocas/Santos Reis office was due to close just a week after the end of this field study (September/1999). This decision was taken by the directors of CAERN who were implementing a policy of centralising maintenance services.

The on-site office was, by then, receiving about eight calls per day from the local users for maintenance services related to both the water supply and the condominial sewerage systems. These calls were also being made by telephone, but mainly in person as the office was conveniently located in a corner of one of the inner residential blocks. The engineer responsible for the local office said that all calls are usually seen to in a period of up to 1 day. For sewer maintenance, the local crew was equipped with a vacuum tanker (Plate 4.33) in addition to its normal tools.

The main maintenance service carried out by the crew is, according to the staff, unclogging the condominial sewers and the need for it is often waste dropped into the sewers (leftover food, plastic bags, clothes and stones). The sequence of photos shown in Plates 4.34 and 4.35 illustrates the performance of the crew on two occasions.

In an update of the results carried out in December 2000, members of the residents association and householders randomly interviewed said that no difference had been noticed on the quality of O&M services since the office had been moved.

Plate 4.31. Entry hole for the discharge of stormwater into the inspection chamber.

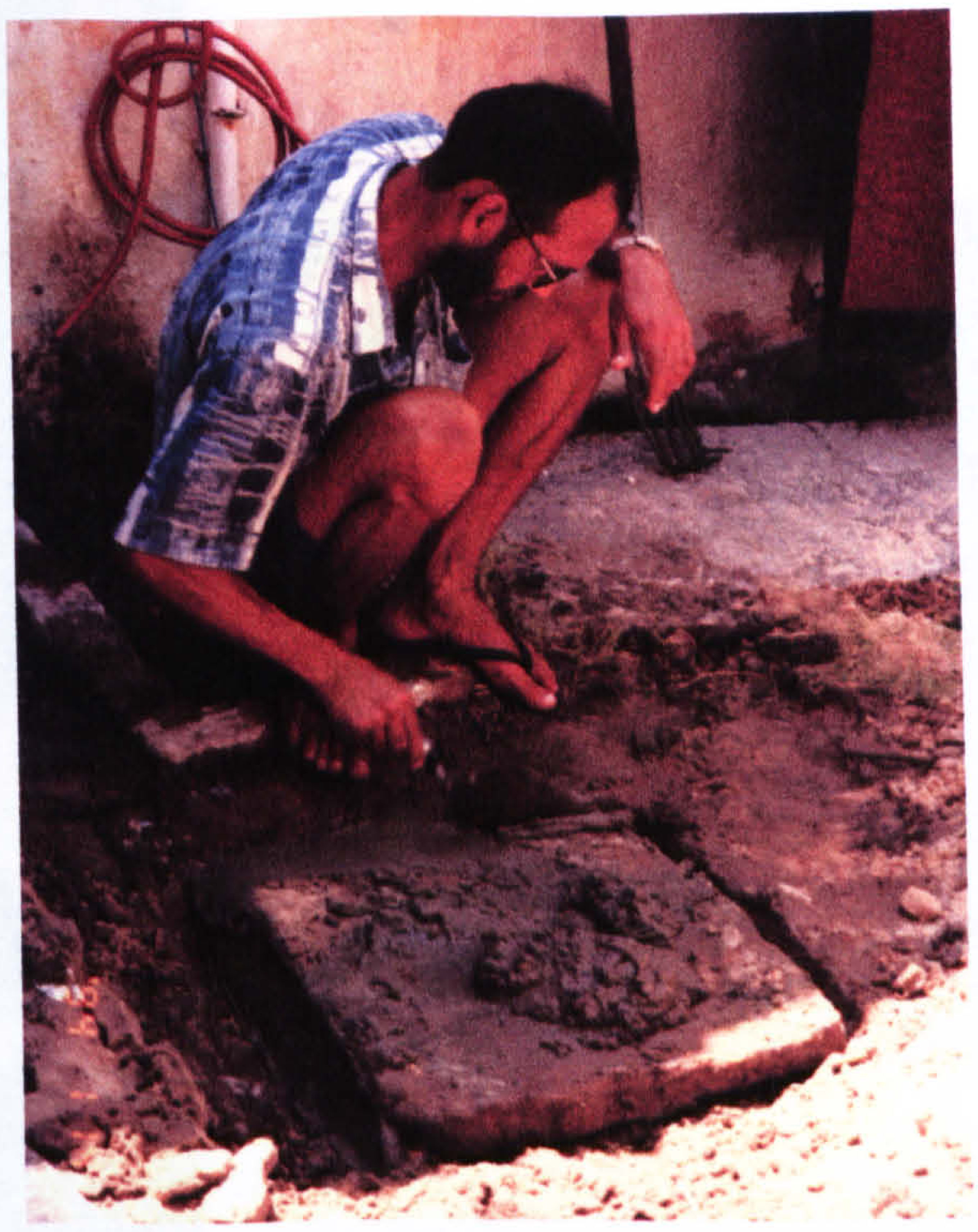


Plate 4.32. A CAERN crew member re-sealing the inspection chamber cover after a maintenance service.

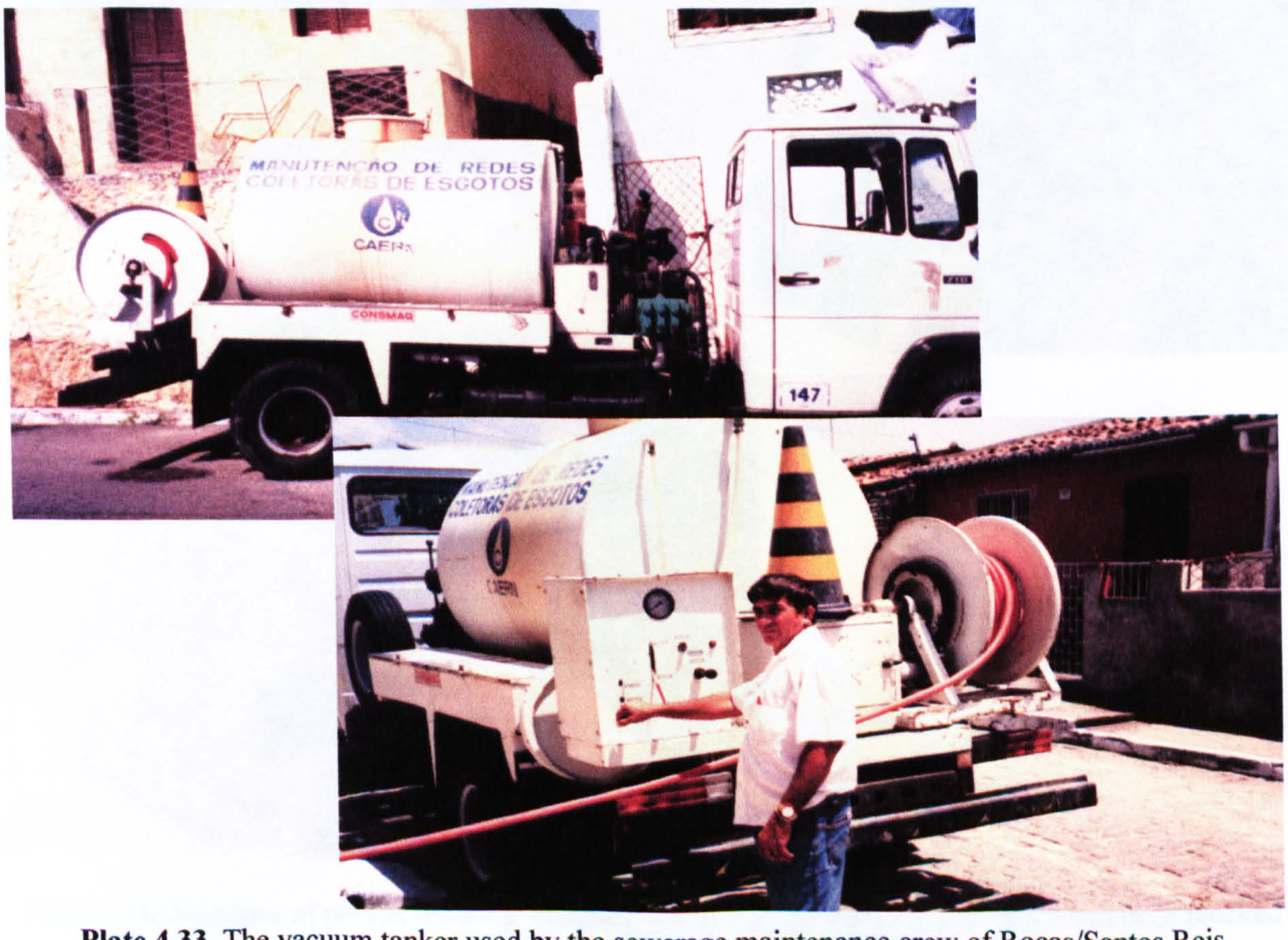


Plate 4.33. The vacuum tanker used by the sewerage maintenance crew of Rocas/Santos Reis

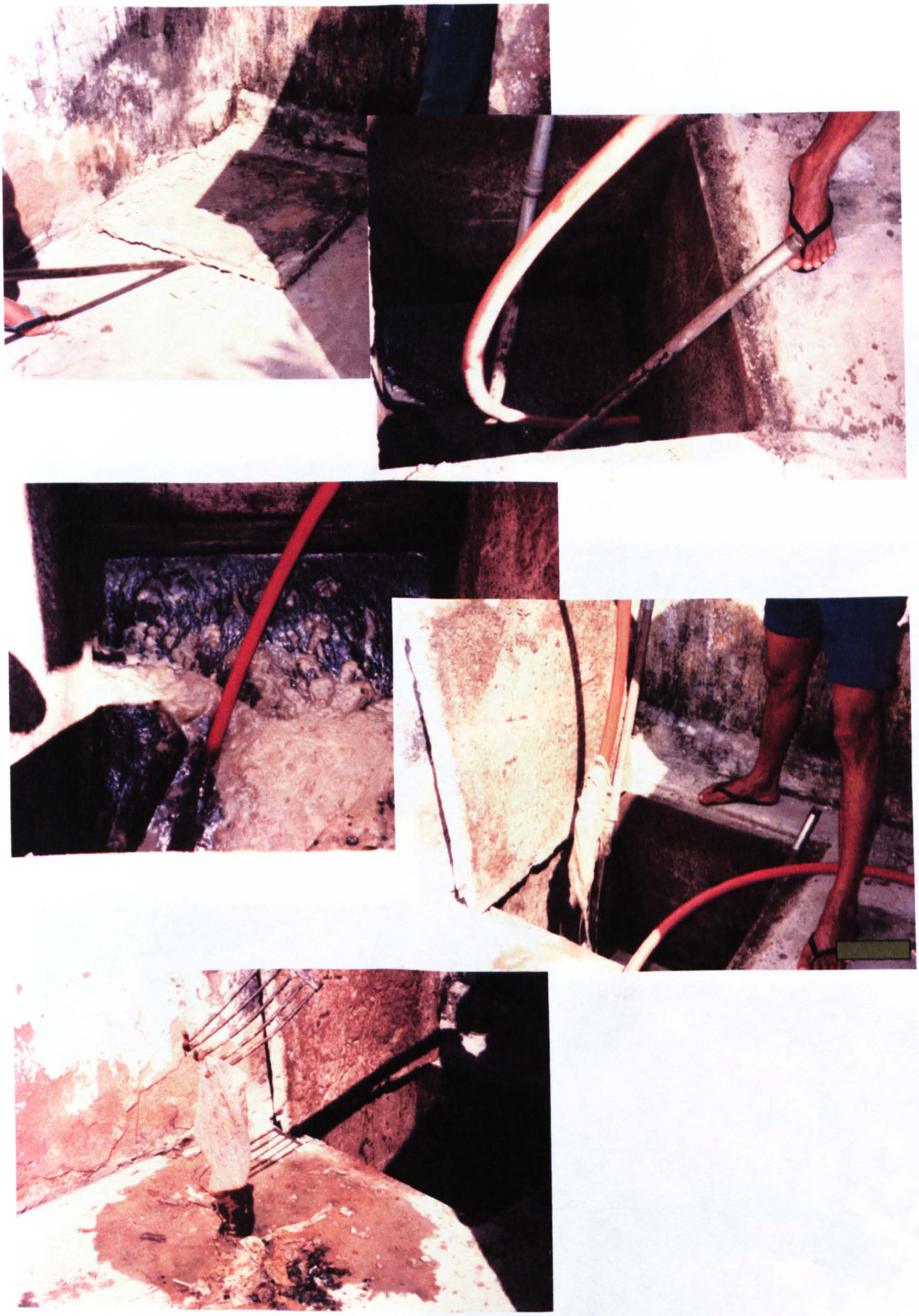


Plate 4.34. Sequence of photos showing cleaning out of a condominial sewer which had been blocked by a piece of cloth and a plastic bag.

Plate 4.35. Cleaning out another condominial sewer – this time the cause of the problem was solid waste and stones inside the sewer.

4.5. Case Study 4: Vila Planalto (Brasília-DF)

4.5.1. Introduction

In the 1990's, CAESB – the Water and Sanitation Company of Brasília (the capital city of Brazil) – made large investments in sanitation and adopted the condominial system as its sewerage technology of choice in the Federal District (Brasília and its satellite cities – see Figure 4.1).

4.5.2. Background

The Federal District has approx. 2 million inhabitants and through its investments in the 1990's, CAESB had provided condominial sewerage for 121,000 households (1,134,574 people). This resulted in the construction of 1,328,498 m of condominial sewers, 667,485 m of main sewers, 15 new treatment plants and 24 pumping stations. With these numbers, CAESB achieved 90% coverage for sewerage services and 63% of the sewage collected receives treatment.

Considering that the figures for the Brazilian population served by sewerage system is under 40% and that for the treatment of the sewage collected is 10%, CAESB is in fact considerably ahead of the majority of the State Sanitation Companies in Brazil.

➢ **CAESB's Condominial Philosophy**

CAESB's experience with condominial sewerage started in the early 90's when the company began to acquire knowledge and experience in condominial projects. This led the company to develop its own methodology for the implementation of this technology. Based on Neder (1999a), the methodology developed by CAESB for the condominial systems follows the basic guidelines presented below:

The key points:

- The involvement of all sections of the company linked to the projects;
- The philosophy of the condominial systems rooted in the daily life of the company;
- The utilisation of the normal structure of the company (avoiding isolated groups);
- The complete understanding of the technology by everyone involved in the project;
- The technology was introduced by the directors as a company policy, and this led to a gradual assimilation by the technical group and also to the acceptance of the technology as a hallmark of the company;

- Community participation before and during project implementation (householders must understand and approve the system beforehand and sewer layout designs must be flexible enough to allow adaptations according to users' demands).

The methodology:

- Basic project for initial planning of the work, for financing and for bidding;
- Community mobilisation works;
- No distinction made between project phase and installation works. The executive project should be developed at the same time that the installation works advance. For this, a project team is based on the site.

Basic project steps:

- Preliminary data (urbanisation plans, topography of the area and project parameters);
- Reconnaissance of the area;
- Layout of the networks and pre-dimensioning;
- Budget and survey of material;
- Bidding for the services.

Executive project/installation phase teams (all teams work simultaneously):

- **Team for community mobilisation:** responsible for all the work related to the householders' meetings and, also, for the letter of agreement where the families agree with the rules of the project (maintenance responsibilities and charging policy) and define the condominial sewer layout.
- **Team for the creation of service agreements:** responsible for collecting the information necessary for the discussion with the householders (options for sewers layout, interferences, depth, etc). They are also responsible for the development of service agreements for the solutions adopted by the householders.
- **Team for the development of executive project:** responsible for the adaptation of the basic project to the service agreements for the condominial sewers.
- **Team for monitoring the work and contracts.**

Charging policy:

- Users will be charged for both the connection to the system and for its use;
- The amounts charged are based on the level of the user's participation in the implementation phase and also on the responsibilities accepted by them for the maintenance of the system;

- The resources obtained through the connection charges (referring to the costs of the condominial sewer, which represents about 27% of the costs of the overall system) should be totally reinvested in new sanitation projects;
- The connection charge is based on the real costs of the condominial sewer per plot (users that opt for self-construction will not be charged for connection);
- The tariff for the utilisation of the system is based on the water bill and set according to the users' option for the condominial sewer layout. For the backyard layout the tariff is 60% of the water bill (in this case users have the responsibility to maintain the units located in their plots). For the sidewalk and for the front yard layouts, users are charged 100% of the water bill;
- 11% of the tariff revenue is transferred to the same fund as that for the connection charges, and is supposed to be used in reinvestments for sanitation system.

Following the methodology described above, CAESB has been implementing condominial systems with total average costs of US$ 27 per resident and of US$ 16 per meter of network (which is much lower than other experiences reported).

The first condominial project implemented by CAESB following the above methodology was the Santa Maria Project (July/1998). However, CAESB's experience in condominial sewerage dates from 1992 when the company implemented and started to operate seven condominial projects (Areal-QS6/8/10, M-Norte, Bairro Veredas, Expancao/1a. Etapa, Vila Jardim Roriz, QNP/QNQ, and QNH).

4.5.3. The "100% Plastic" System

CAESB's confidence in condominial systems has certainly contributed to innovations. This is reflected not only in the managerial sector of the projects (as discussed above), but also in technical aspects. An example of this is the 100% plastic condominial system that is being tested by the company in full-scale projects.

The so-called "100% plastic" condominial system is a project in which the whole network (pipes and appurtenances) is made of PVC. The utilisation of PVC pipes for sewage is, of course, widespread; the main innovation, therefore, is in the network appurtenances provided in such material. These units are the TILs (an acronym in Portuguese for Tubes for Inspection and Cleansing) and all the necessary connections (bends, adaptors, connections, etc).

The TILs available are:

- *Condominial TIL*: this is used in place of the traditional inspection chambers. These are available for 100 mm diameter pipelines and have three entrances (that receive the household wastewater and the sewage from the previous plot) and an outlet for the next connection. Figure 4.34 illustrates the design of this unit.

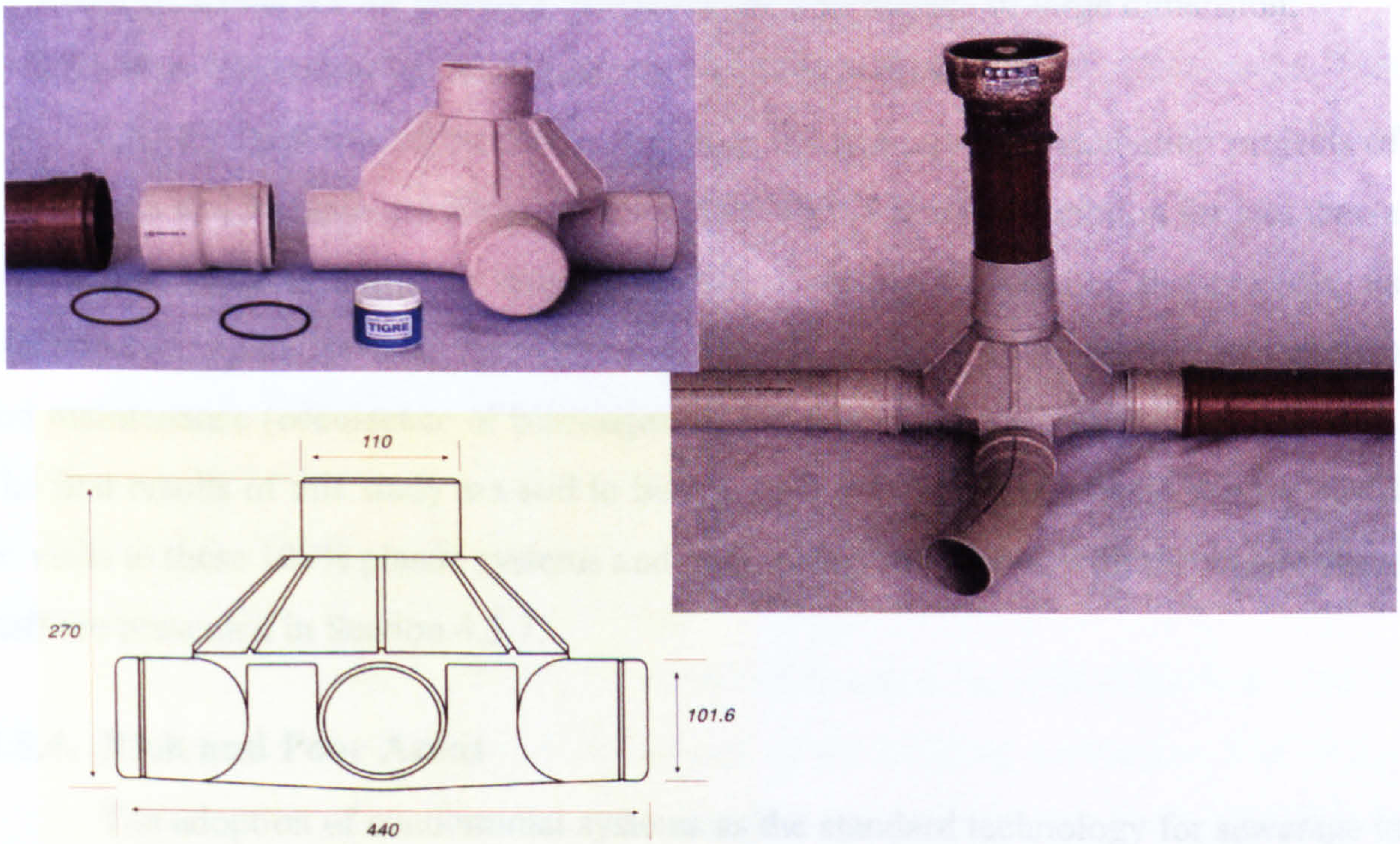
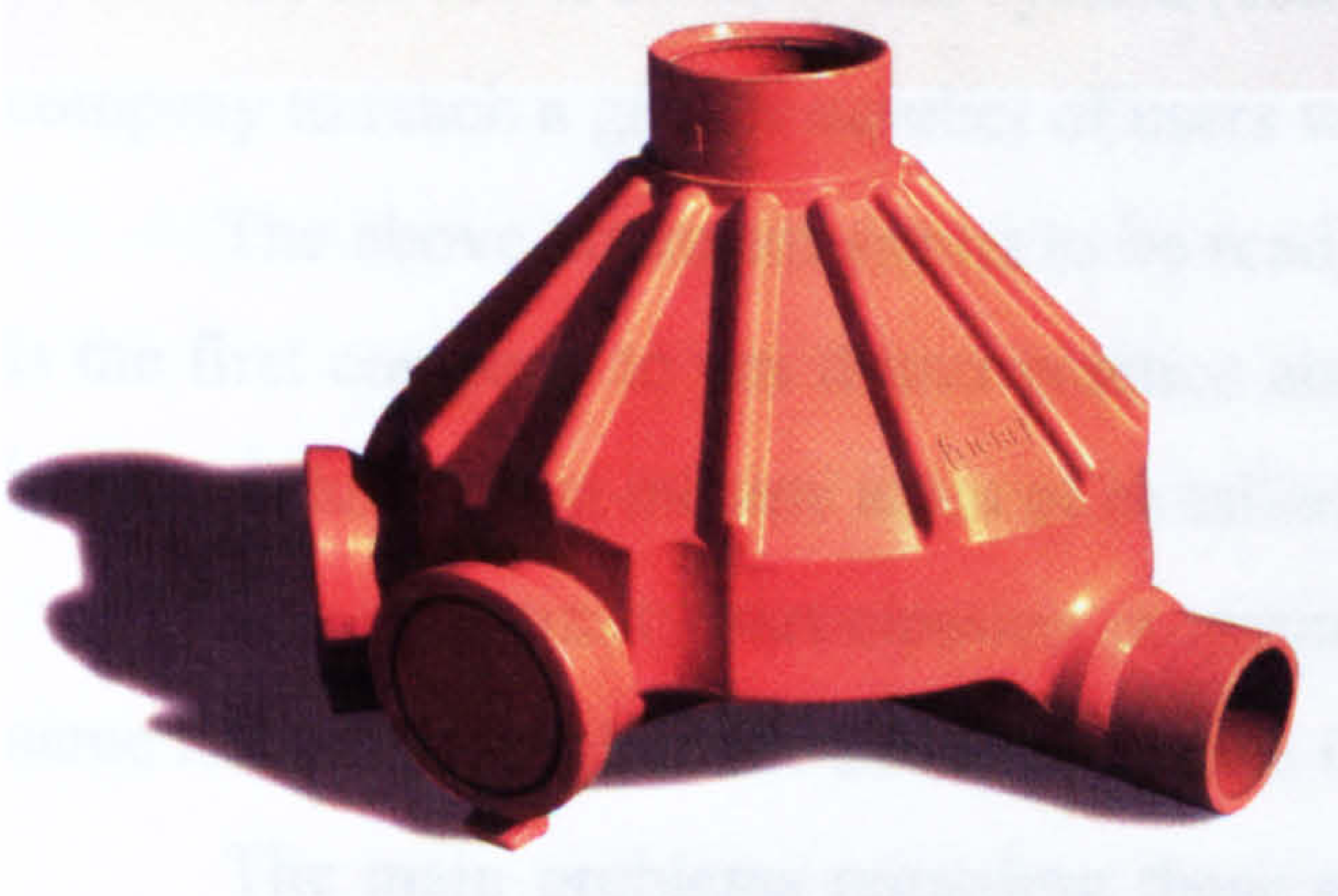


Figure 4.34. 100% plastic condominial TIL

- *Radial TIL*: This unit was developed to substitute traditional manholes. Its shape and dimensions are as presented in Figure 3.35.



DN nº	DL nº	C mm	h mm	Massa kg
150	200	870	610	16
*300	250	1000	980	45

* πρεσεντσ 3 εντρανγεσ

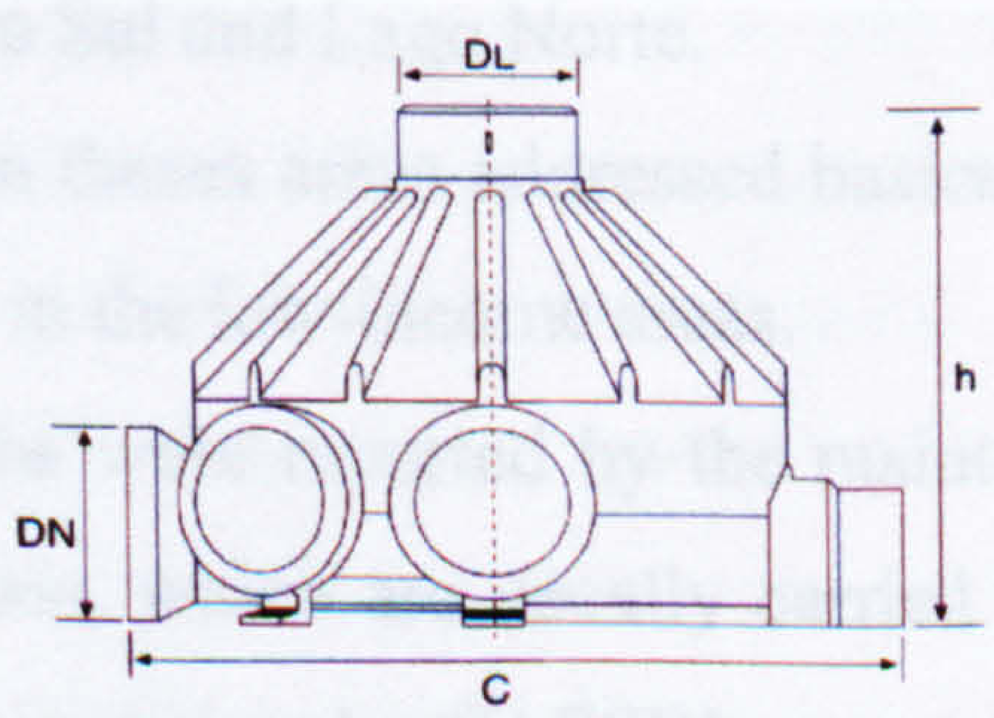


Figure 4.35. 100% plastic manhole

The material described is produced by TIGRE® (URL-19), which claims the following aspects as the main advantages of the 100% plastic over the traditional units:

- Quicker and easier installation (leading to lower costs);
- Higher hydraulic performance and resistance for compression tension;
- Impermeable and easier to clean;
- Reduced access for the entrance of solid waste and objects of large dimension;
- Lightness facilitating the transportation, handling and storage.

CAESB used the 100% plastic condominial system in the sanitation projects of Samambaia and Recanto das Emas. These systems have been in operation for less than a year and a study is currently being undertaken aiming to monitor the projects, its execution (comparative analysis between the 100% plastic and the traditional systems) and maintenance (occurrence of blockages on the sewers, as well as, the related costs). The first results of this study are still to be reported. Nevertheless, considerations based on visits to these 100% plastic systems and on informal interviews with the maintenance staff are presented in Section 4.5.7.

4.5.4. Rich and Poor Areas

The adoption of condominial systems as the standard technology for sewerage in the Federal District of Brazil has been applied independently of socio-economic conditions. CAESB understands that the low-cost characteristic of the condominial sewerage does not make it applicable just to low-income communities. Considering that the technology works well (based on the company's own experience) and is technically appropriate for the site characteristics, the company is applying it universally. Moreover, the lower costs of this system (compared to conventional solutions) allow the company to reach a greater number of users with the same budget.

The above argument seems to be readily acceptable; however, CAESB probably is the first company to put it into practice and had implemented condominial sewerage in two of the highest income areas of Brasília: Lago Sul and Lago Norte.

The community participation programme in theses areas addressed basically the same issues and applied the same rules, than those in the low-income areas.

The main problems regarding these systems were reported by the maintenance staff as been related to poor household connections, which are usually carried out by workers contracted by the householders and not executed under CAESB's supervision.

Regarding the acceptability of the system, a point of concern of the high-income users was about the charging policy, specially the link between the water and sewage bills. These users wish to have their sewerage bills not connected to water consumption, arguing that an elevated percentage of the water does not return as sewage (it is used for swimming pools and watering the gardens). CAESB did not accept this as an argument for changing policy and similar rules to those in low-income areas were being applied.

The access of the workers to the properties was another point of discussion. This was negotiated and the systems had been implemented without major problems. Plates 4.38 and 4.39 show condominial sewerage implemented in these areas.

4.5.5. The site studied

The area selected for this study was Vila Planalto. It is a well-situated area in Brasília, located within 5 minutes from the city's Central Bus Station in the Administrative Region I, between Alvorada Palace (official residence of Brazil's president) and Planalto Palace (the President's office).

Vila Planalto emerged during the period of construction of Brasília (late 1950's). The area originally accommodated the workers of the building companies. The houses were constructed using wood and were of different sizes: in the peripheral areas (where the higher income professionals lived) the houses had large yards and the occupation was of low density; in the central area (occupied by lower income workers) the houses were smaller, and had a much higher occupation density.

The site remained after the end of the works and was the origin of the Vila Planalto district. The physical division is still identifiable with the houses in the peripheral areas having middle class characteristics (some of them still preserve the original wooden construction, but houses recently re-built are easily identifiable), and the majority of the low-income families still occupy the inner areas (with in many instances having more than one family sharing the same plot).

Vila Planalto is now increasing its value as a residential area: it is well located; has the majority of its streets paved; electricity and public lighting; drainage, water and sewerage services; local food suppliers, drugstores, a health centre and a school.

The selection of Vila Planalto for this study was mainly motivated by having its condominial sewerage among the ones with longer period of operation, its easy access and a manageable community size. The Vila Planalto condominial sewerage project dates from November/1991 and the system was in operation by February/1993.

Plates 4.38. The physical contrast between low- and high-income areas in Brasilia. In both, CAESB had implemented condominial sewerage.

Plate 4.39. The inspection chamber of a backyard layout condominial sewer integrated to the garden design of a property in the high-income area of Lago Norte.

4.5.6. Study Methodology

Data from the Vila Planalto's sanitation project were collected through: **project documentation**, a **survey questionnaire**, **technical inspections** of the sanitation project units, **observation** of maintenance works, and complemented by informal **interviews** with professionals working on the system.

For the **survey questionnaire** and the **technical inspections**, the whole community was considered the target population for the study. The questionnaires were applied in a sample selected systematically, with each fifth house being interviewed. The size of the sample obtained by this method was therefore of approx. 20 percent (N=157).

The questionnaire (Annex 4) was composed of four sections:

Section I - Identification
Section II - Level of Water Supply
Section III - Community participation
Section IV - Technology Usage, Functioning and Satisfaction

The technical inspections were based on the fulfilment of a factual inspection question-sheet containing the following parameters: presence of grease trap; sealing of the inspection chambers; damaged (broken) inspection chambers; if there was wastewater openly connected to the system; and the presence of connections to discharge rainwater into the sewers.

4.5.7. Results Concerning the 100% Plastic System

As discussed earlier, a study is still being carried out to compare the productivity of the 100% plastic networks to that of the traditional condominial systems.

Nevertheless, according to CAESB's field staff, the implementation phase of these projects occurred without notable problems and workers did not have serious trouble in dealing with the new materials. On the other hand, problems were reported on the household connections that, in spite of the instructions delivered by the community participation team (Annex 5), not all users had followed the appropriate instructions for connecting of the household sewage to the TIL unit. Thus, causing linkages in such connection points and loss of mechanical resistance of the units.

The crew responsible for the maintenance of the "100% plastic" is based on-site. This maintenance team appears to be working well with the new materials and seems to have understood the characteristics of the system, its experimental condition and the need to overcome possible practical problems.

An example of solving field practical problems is the adaptation made on the covers of the condominial TIL. As shown in Plates 4.40 and 4.41, the upper part of the TIL consists of a neck and the cover, which has a "donut" shape that is filled with mortar to make it heavier and more protected from unauthorised openings. The hole in the inner part gives support for opening in cases of maintenance services. In practice, the problem with this design was the easy removal of the white plug covering the inner hole, making the access to the network not difficult enough (especially for kids playing nearby) and allowing the entrance of both soil and rainwater. The solution given by the crew was to change the ring shape of the covers, making the mould for the mortar without the inner hole. To make the removal of the covers possible, a wad was introduced into the centre of the mortar, giving support to a key that can be used to lift the cover (Plate 4.42).

Considering the reduced diameter of the TIL covers, it was anticipated that there would be a reduction (compared to the traditional system) in the demand for maintenance services caused by the deposition of solid waste into the system. Nevertheless, maintenance services for unclogging of the network are still required and the utilisation of the traditional equipment to solve these blockage problems is no longer appropriate. The steel cable (wire) is still being used but only to facilitate the displacement of the deposited material causing the blockage (Plates 4.43). Thus, to push the material into the pipeline, a pressurised water jet is necessary (Plate 4.44).

The water jet used for this service is a small unit installed in the back of a van (Plate 4.45). To carry out the operation, water from a nearby household is used, avoiding the need for transportation of water tanks. The amount of water used during the operation is quantified and deducted from the user's water bill.

Although the water jet equipment appears to be efficient, the conditions for such maintenance services have to be improved. As described above, the water jet pushes out the clogging materials, but due to the limited access to the condominial TIL units, the removal of this is not always possible. The common procedure is to push the material until it reaches a manhole, which has a wider opening allowing its removal. However, these materials causing the clogging may have to be moved along the whole length of the sewer, which although usually not very long, can in some cases be over 100 m in length.

Plate 4.40. In sequence, the condominial TIL unit; soil compaction during the network implementation phase; and the anchorage (protection) of the upper part of the TIL unit.

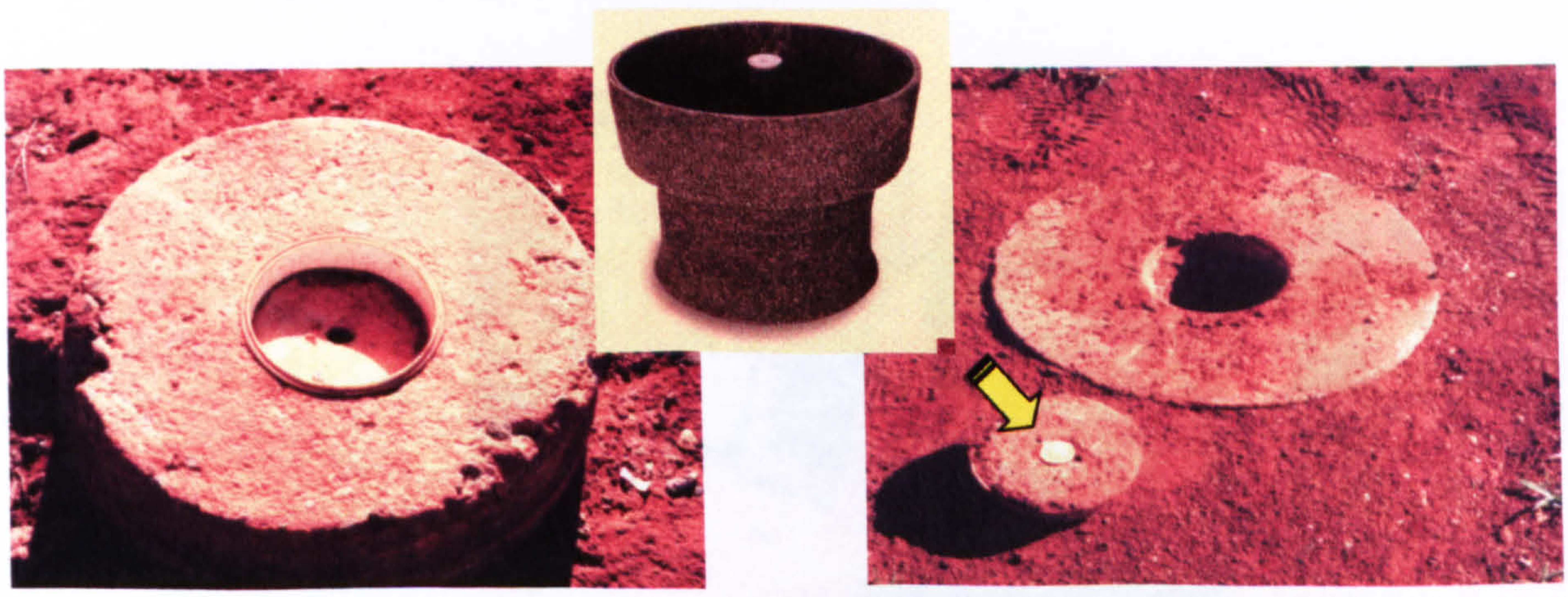


Plate 4.41. The upper part of the TIL (centre); a cover found on-site without the white plug (left); and a cover with the white plug (right)

Plates 4.42. The new mould for the mortar weight and the key to lift the covers

Plate 4.43. A member of the maintenance crew using a steel cable to displace clogging material

Plate 4.44. The utilisation of the water jet to clear clogging material

Plate 4.45. The water jet equipment being connected to a user's tap

Plate 4.46. CAESB's production of traditional inspection chambers

Plate 4.47. Different shapes of the bottom of inspection chambers.

Another consideration regarding the maintenance of the 100% plastic condominial systems is that it limits the performance of simple maintenance tasks by the users (as it is encouraged or even required in the traditional condominial sewerage programmes).

Although the final report of the study on the 100% plastic condominial system are still to be presented, as said earlier, the financial viability of these systems is still being questioned. The prices of the units given by the industry had increased considerably, probably due to the industry vulnerability to economical circumstances. Moreover, given the high standards that CAESB has achieved in the production of traditional inspection chambers (Plates 4.46 and 4.47), the traditional condominial system are still been seen as a very attractive option (Luduvice, 2001).

4.5.8. Vila Planalto – the case study

➢ **Community Organisation**

The mobilisation of the Vila Planalto community followed basically the main ideas of the now standard methodology applied by CAESB (Section 4.5.2.). Thus, householders were invited to the meetings by the mobilisation team, who presented the sanitation programme, explained its rules and gave the information necessary for the householders' decision making process.

The meetings took place in one of the residences and were organised in order for householders within each residential block to discuss their condominial sewer. A total of 73 meetings occurred during this mobilisation phase.

In spite of the delivery of information regarding all aspects of the programme, cases of misunderstanding on the charging policy scheme were noticed among the householders during this survey. Users asked about when they are going to stop paying for the sewerage system, suggesting that it was understood they would have to pay (by instalments) for the connection fee, but not for the use of the system. The unwilliness of these users to pay for the service was also observed, and a common argument heard was that "the government must pay for the running costs of the system".

➢ **Design basis**

Vila Planalto is situated in two hydraulic basins; thus, the sanitation system was designed considering this topographical condition which led to a system with two networks. The first is on the main basin and has the majority of the household connections. Its effluent is directed to a pumping station that discharges into the second network through a 150 mm pipeline. The final effluent (collected in the last manhole of the second basin) is then diverted to a 300 mm diameter outfall discharging into a pumping station on the North Sector of the city and finally pumped to the North Sewage Treatment Plant.

The system was designed for a population of 9,000 and the per capita contribution adopted was of 160 l/person/day. The coefficients K_1 and K_2 were taken as 1.2 and 1.5, respectively, and the sewage return factor as 0.8. The condominial sewers were all of 100 mm diameter built in PVC pipes and having a minimum cover to soffit of 0.3 m. The main sewers were built with 150 mm ceramic pipes and a minimum cover to suffit of 1.00 m was adopted.

➢ **Survey Questionnaire**

❑ **Section I – Identification**

Two variables were measured in this section: the time the families had been living in the house and the occupation density. Therefore, 62% of the families were found to be living in their houses for more than 8 years (before the system started to be implemented); 11% had moved in during the implementation of the project (7 to 8 years ago); and 26% moved in after the sanitation system was put in operation (Figure 4.36). As to the occupation density, this was 6.1 persons per household.

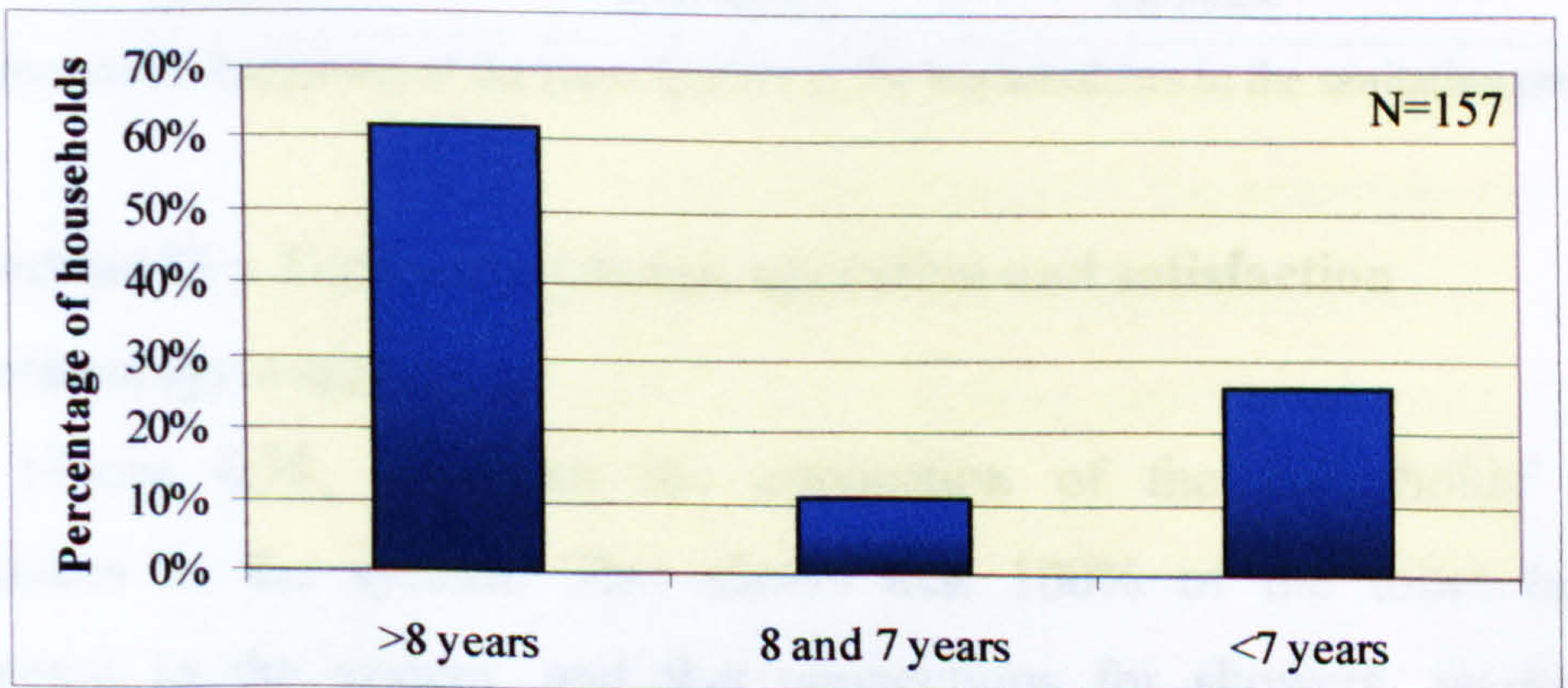


Figure 4.36. Time the families had been living in the house

❑ **Section II - Level of water supply**

The community is fully served by CAESB's water supply system and no families were found using any other sources of water. Moreover, nearly all the households (99.4%) have an in-house water supply level, and only 0.6% has a yard tap level of supply.

- **Section III - Community participation**

About 99% of the population surveyed are currently connected to the condominial sewerage system. The remaining 1% (two interviewed households) adopted septic tanks as the final destination for wastewater. One of the families explained that once the construction of their new house is finalised they will connect its wastewater to the condominial network.

38% of the Vila Planalto families say that they started taking part in the programme since the meeting stage. Figure 4.37 shown that about 27% of the households accepted the system only when the construction works began and 1.5% did it just after seeing the system functioning. About 15% said that the houses were already connected when they moved in and 7% provided the connection after moving in to the house.

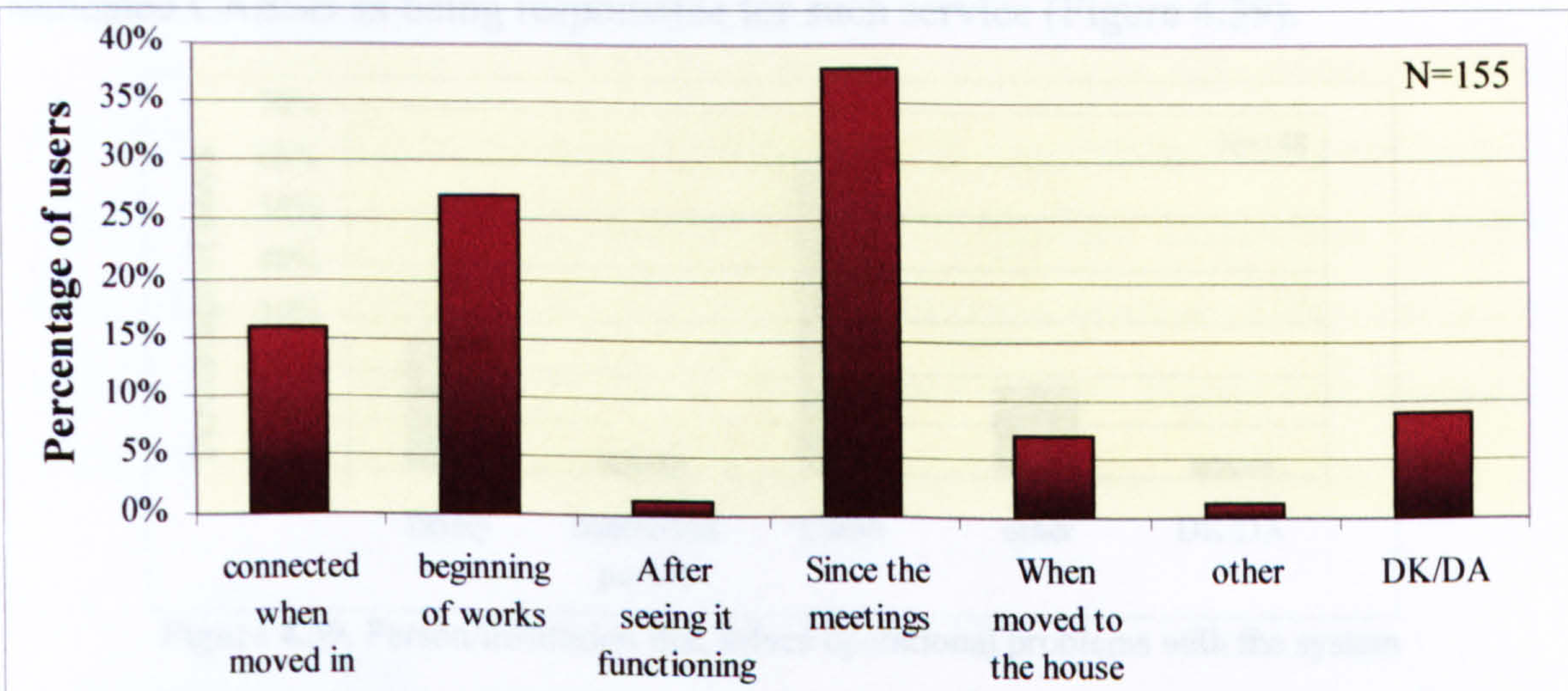


Figure 4.37. Beginning of the participation of the householders in the sanitation programme

- **Section IV - Technology usage, operation and satisfaction**
  - **Technology usage**

Figure 4.38. illustrates the connection of the households' sanitation appliances to the system. This shows that 100% of the toilet bowls were connected to the system, and that connections for showers, washbasins and kitchen sinks were also very high (more than 98%). For the laundry wash tanks, about 5% were not connected (flowing to the backyard) and 56% of the households had the wastewater from washing machines connected (however nearly 40% of the householders did not have this equipment).

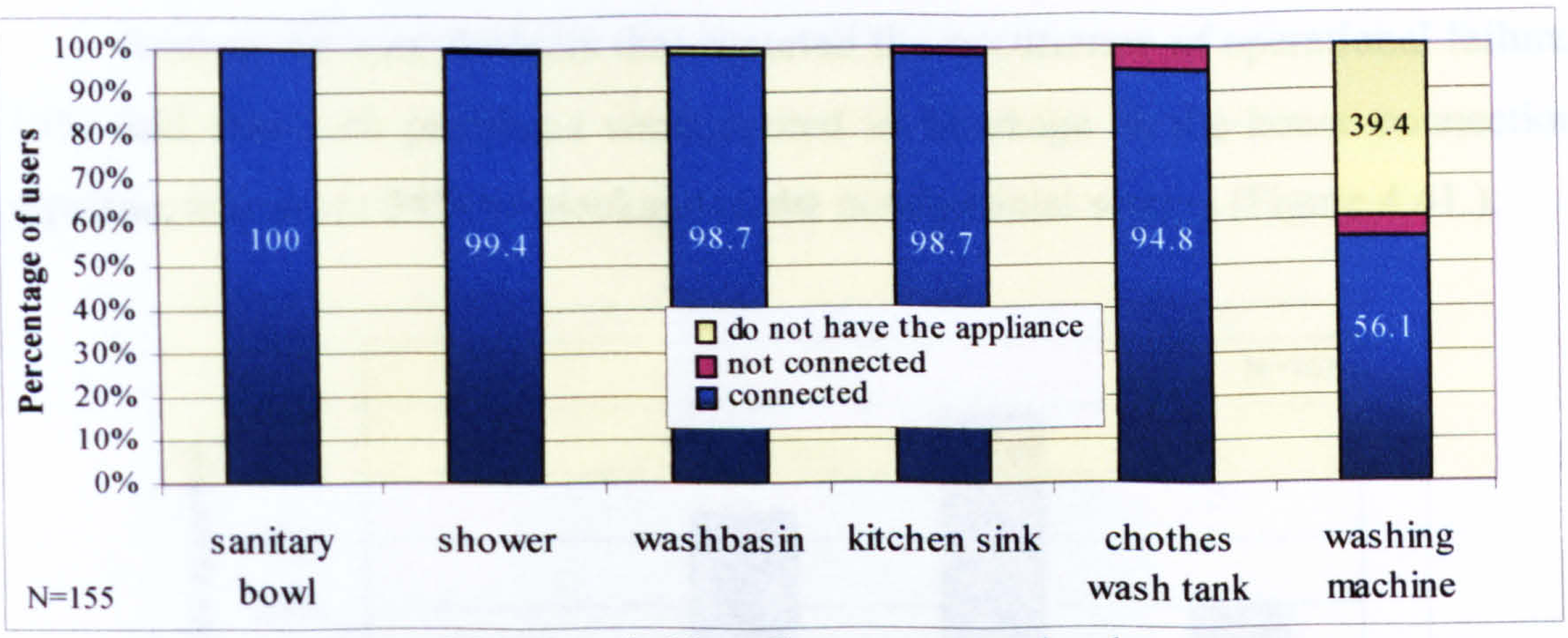


Figure 4.38. Household appliances connected to the system.

- **Technology operation**

Regarding the maintenance of the condominial sewers, only 23.5% of the households said that they were performing such activities. The majority (54.3%) indicated CAESB as being responsible for such service (Figure 4.39).

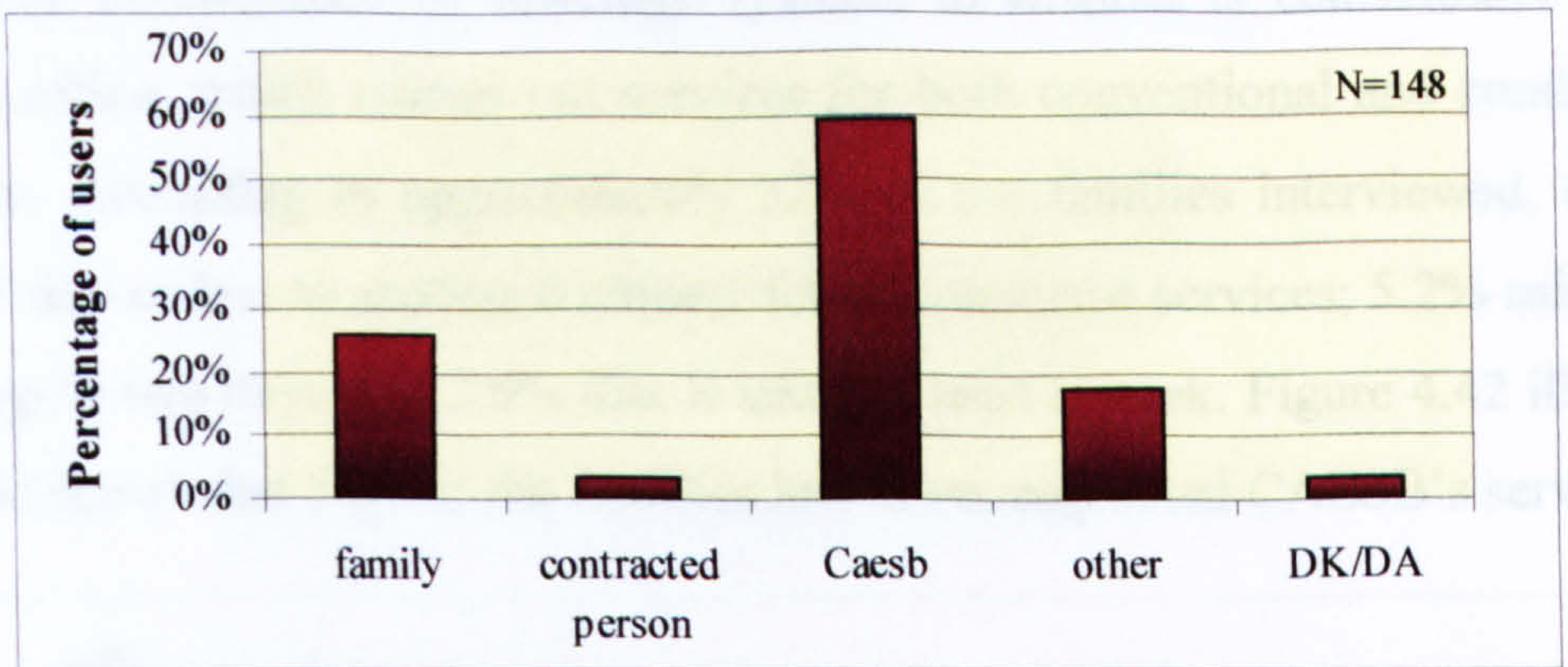


Figure 4.39. Person/institution that solves operational problems with the system

Regarding the frequency of failures, nearly half of the families interviewed said that they "never" had any type of problem with the sewerage system. About 29.5% had problems only "rarely", 13.5% said that problems occur "sometimes" and 6.4% reported that they are "always" having operational problems with the condominial system (Figure 4.40).

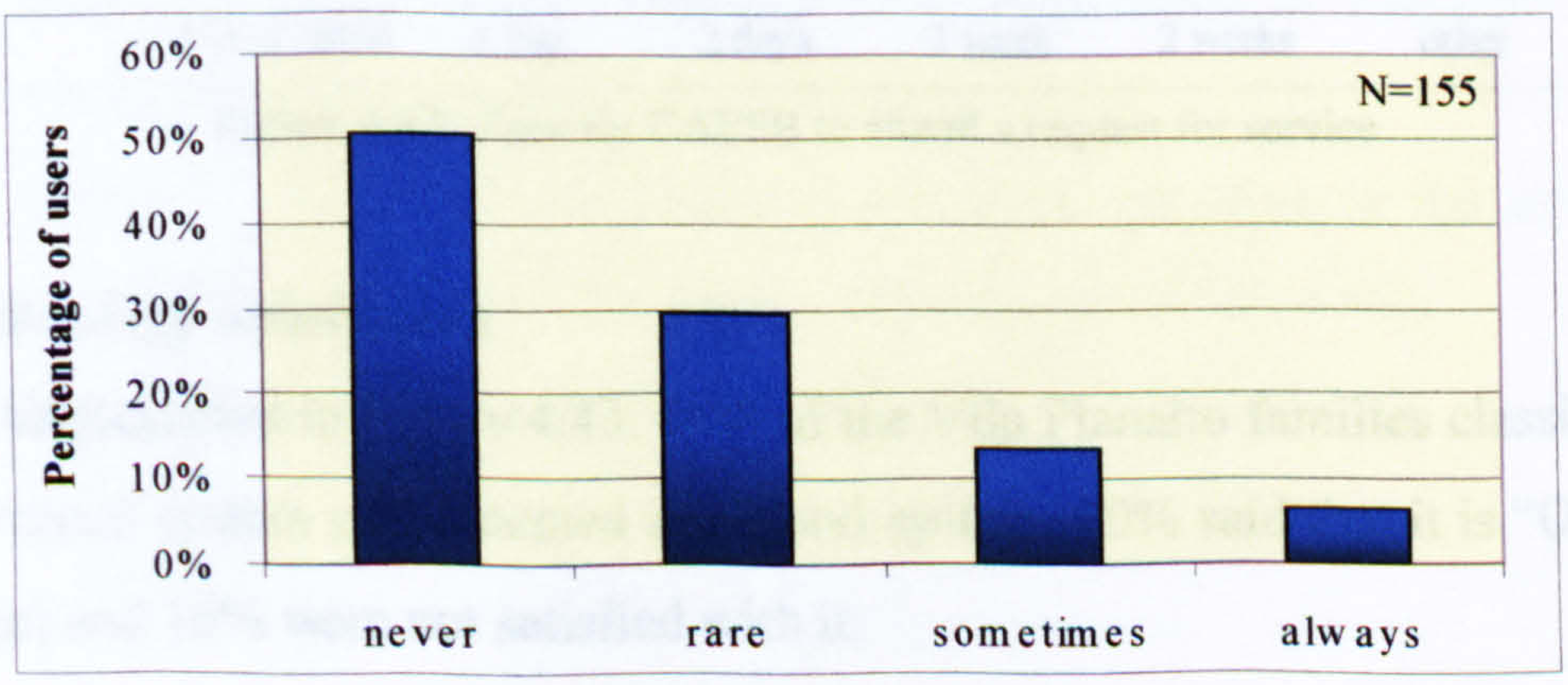


Figure 4.40. Frequency of problems

Among the householders that reported the occurrence of operational failure, 15% said that such problems were related to blockage in the house connection pipeline, and about 34% to blockage in the condominial sewers (Figure 4.41.).

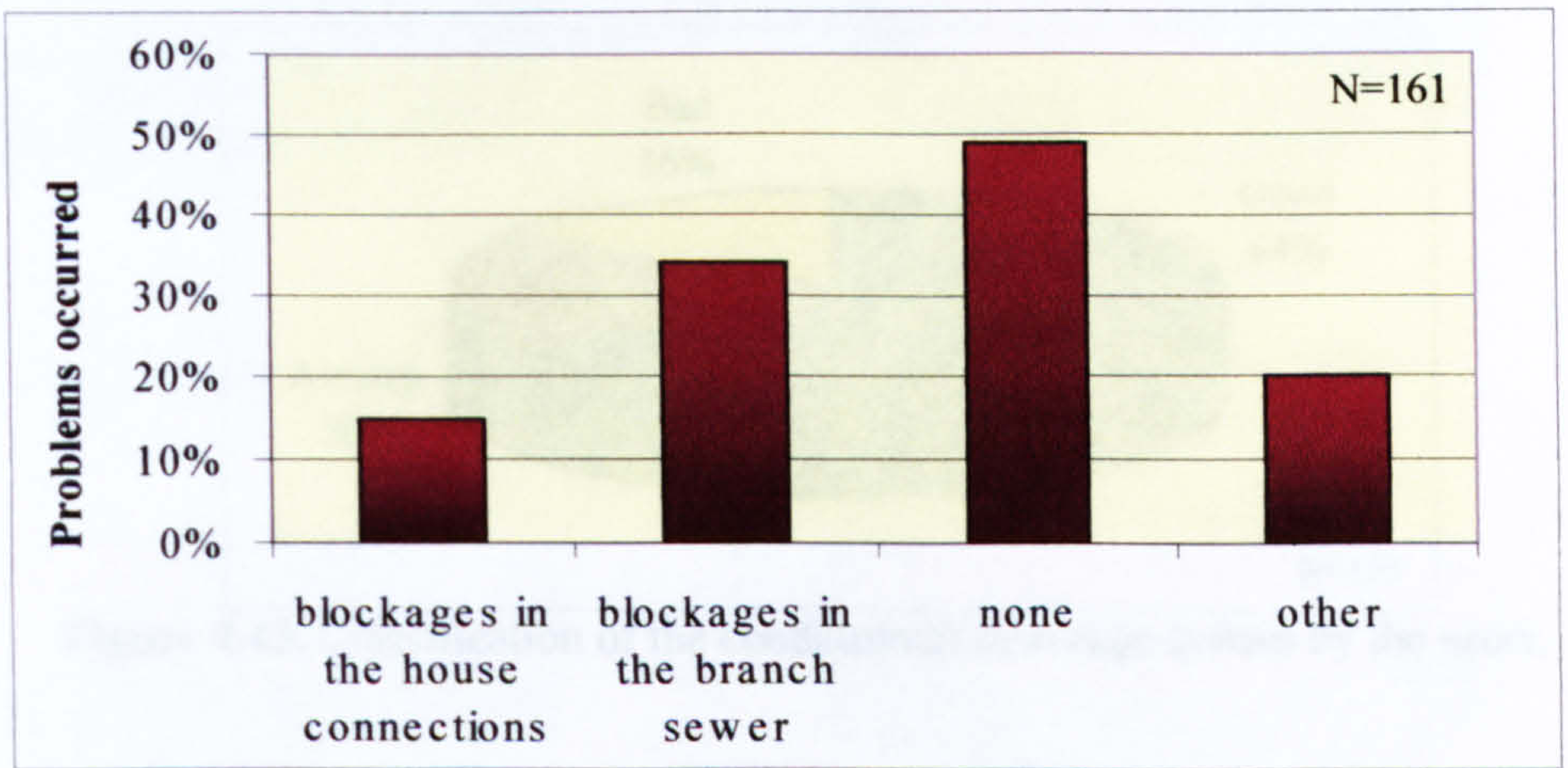


Figure 4.41. Types of problems

The maintenance of sewerage systems in Brasília is concentrated in one central office, which carries out services for both conventional and condominial systems. According to approximately 32% of the families interviewed, CAESB takes 1 day or less to answer a request for maintenance services; 5.2% said that it takes up to two days and 2.6% that it takes at least a week. Figure 4.42 illustrates this and shows that 58% of the families had never requested CAESB's services.

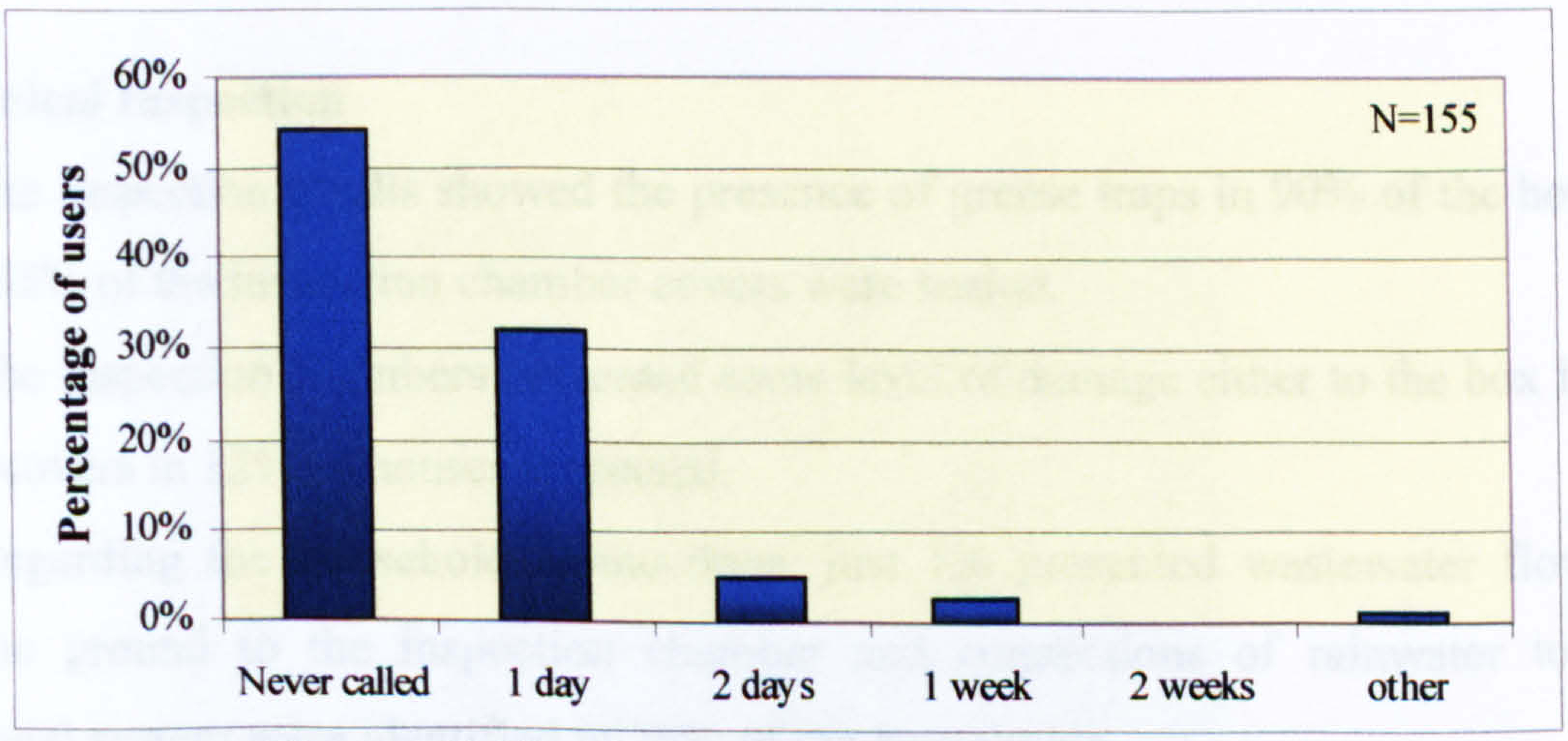


Figure 4.42. Time for CAESB to attend a request for service

- **Technology satisfaction**

As presented in Figure 4.43, 64% of the Vila Planalto families classified the condominial system implemented as a good system, 20% said that it is "OK" (i.e. average) and 16% were not satisfied with it.

The amount paid by the users for the sanitation system was classified as high by over half of the householders interviewed. About 38% thought that the price of the sewerage tariff was reasonable (Figure 4.44).

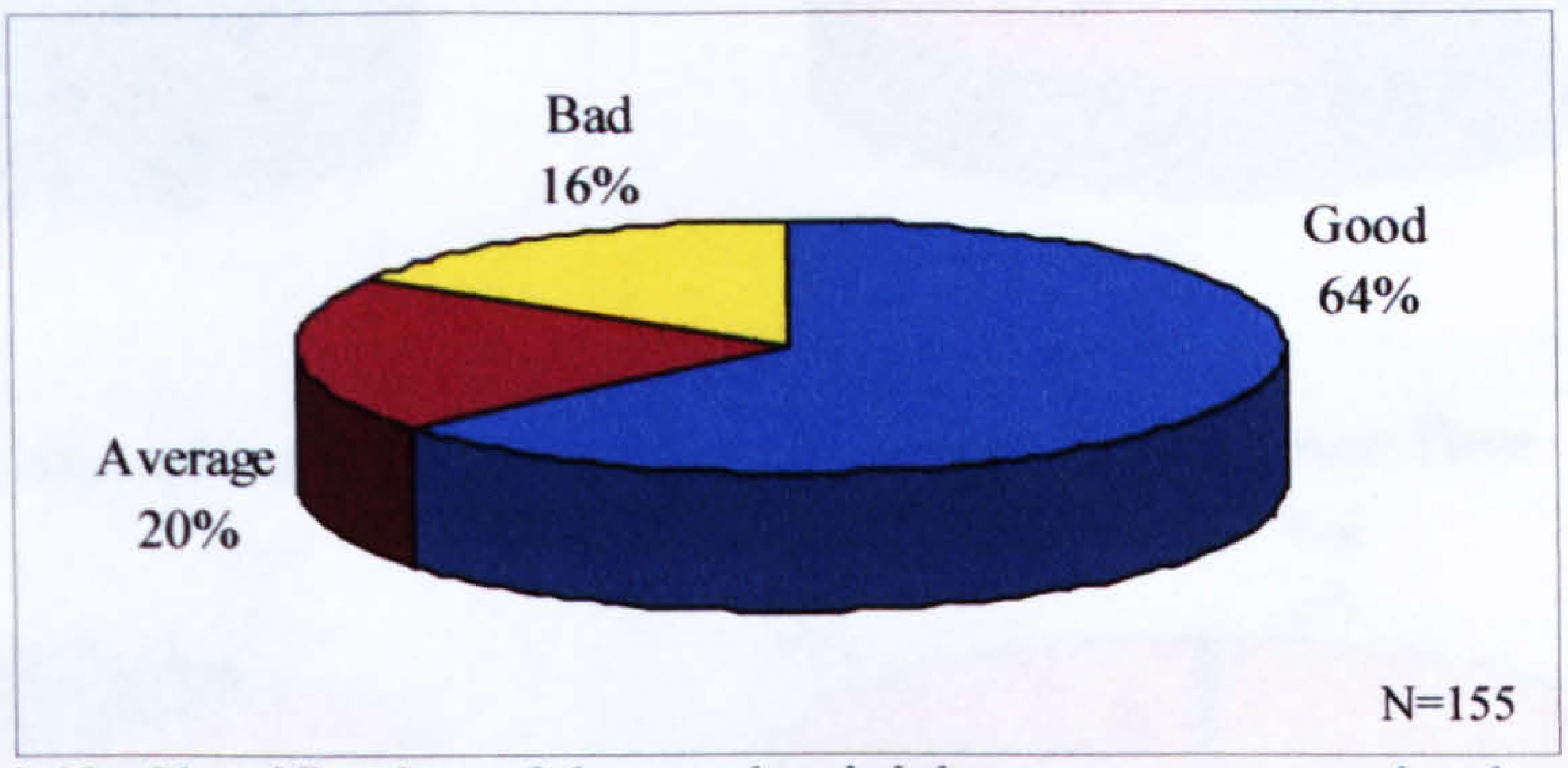


Figure 4.43. Classification of the condominial sewerage system by the users.

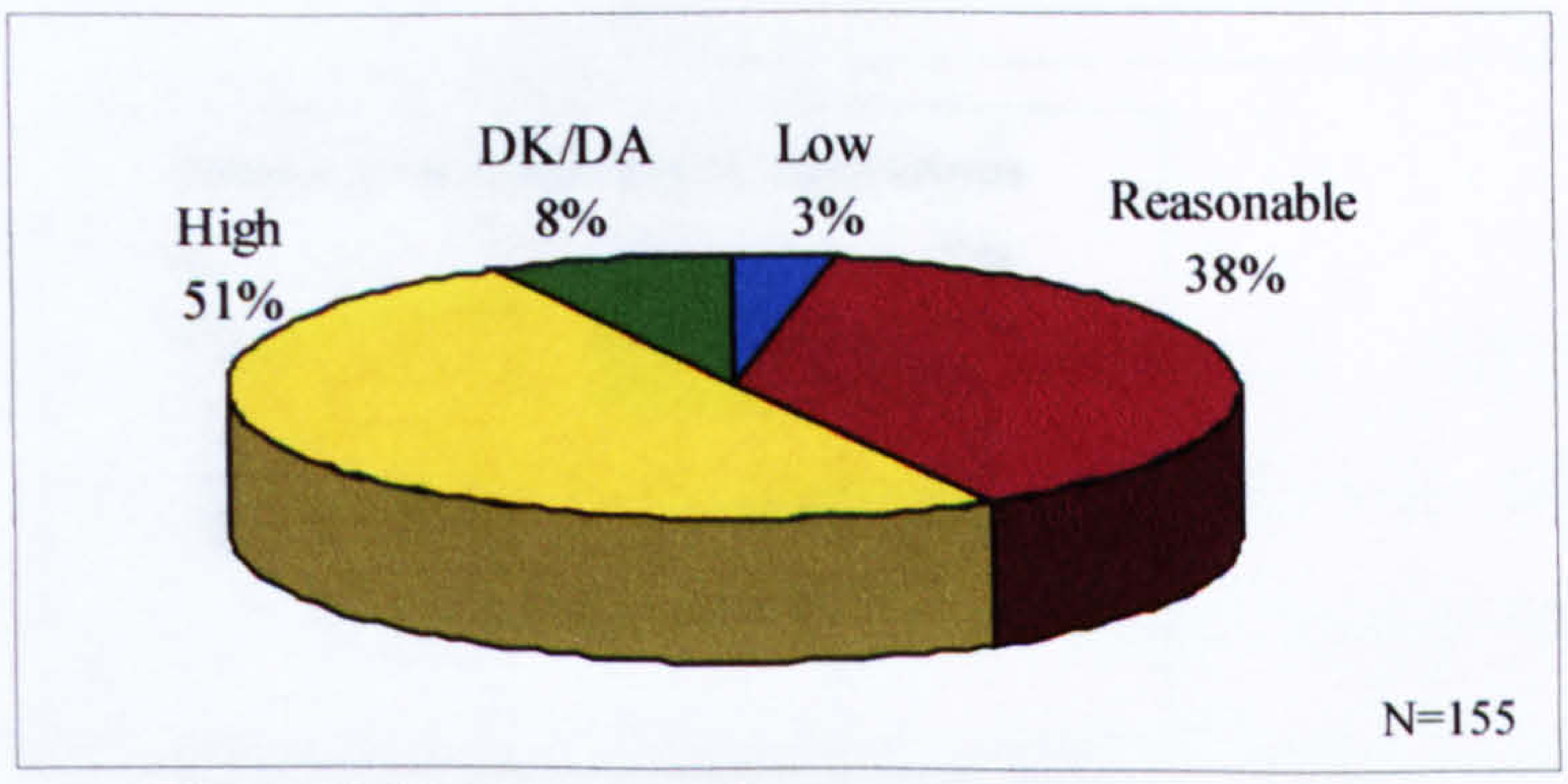


Figure 4.44. Amount of money paid by the users.

- **Technical Inspection**

The inspection results showed the presence of grease traps in 90% of the houses and that 45% of the inspection chamber covers were sealed.

The inspection chambers presented some level of damage either to the box itself or to the covers in 12% of houses inspected.

Regarding the household connections, just 1% presented wastewater flowing across the ground to the inspection chamber and connections of rainwater to the condominial system were identified in 26% of the households.

This seems to be a great contributor to problems occurring in the sewers, as observed in a manhole overflowing after a night of heavy rain (Plate 4.48).

The technical inspection information is summarised in Figure 4.45.

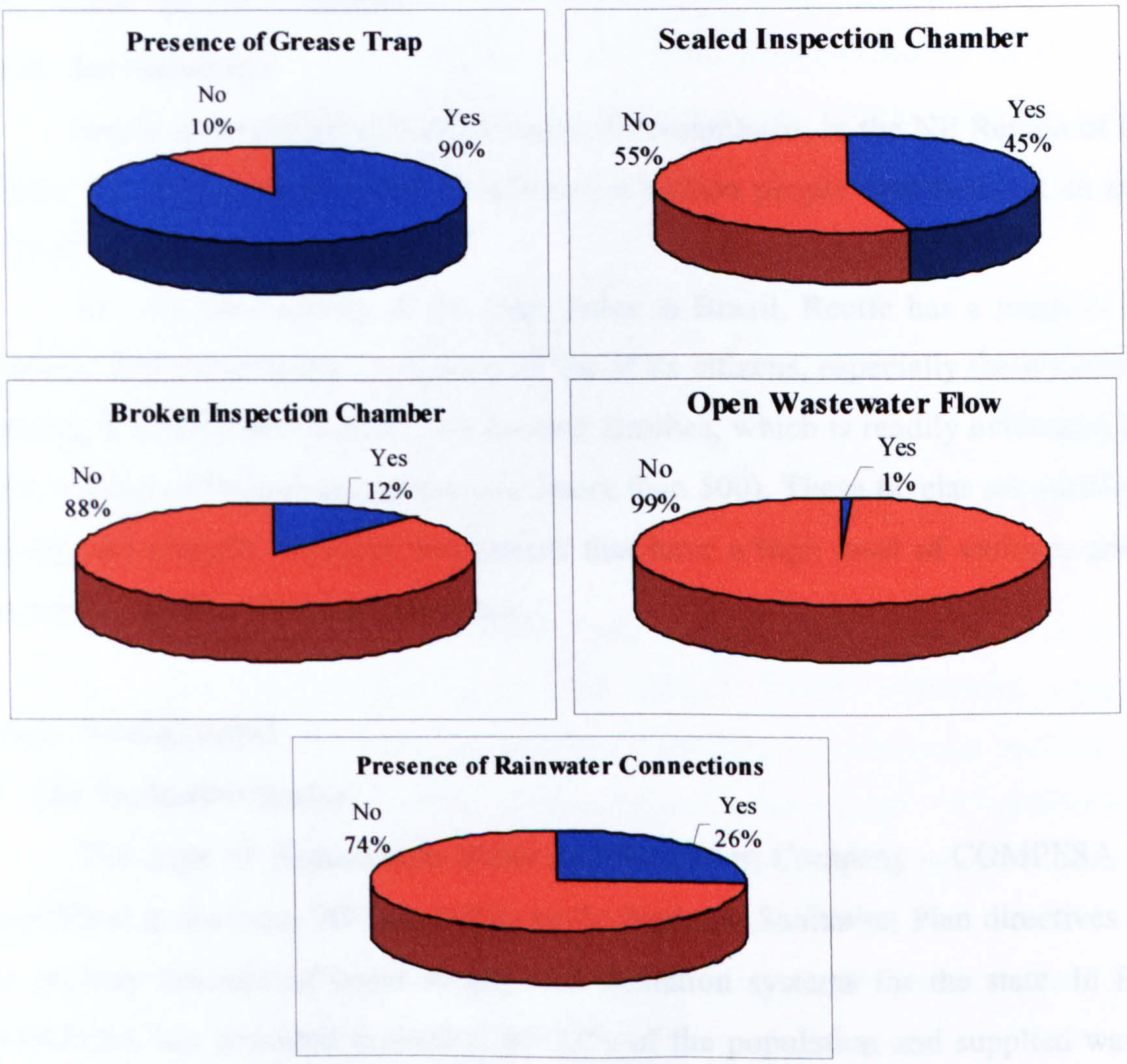


Figure 4.45. Results of technical inspections

Plate 4.48. Overflowing manhole after a rainy night

4.6. Case Study 5: Recife

4.6.1. Introduction

Recife is the capital city of the state of Pernambuco, in the NE Region of Brazil (Figure 4.1). It has a population of approx.1.4 million people distributed in an area of 220 km^2.

As with the majority of the large cities in Brazil, Recife has a range of urban problems that compromise the quality of life of its citizens, especially the poorest ones. Housing is a major problem for low-income families, which is readily evidenced by the great number of favelas around the city (more than 500). These favelas are usually high density and illegally occupied settlements that have a high level of violence and lack any type of basic housing infrastructure.

4.6.2. Background

➢ **The Sanitation Sector**

The State of Pernambuco Water and Sanitation Company – COMPESA – was established in the early 70's according to the National Sanitation Plan directives and is the primary operator of water supply and sanitation systems for the state. In Recife, COMPESA has provided sanitation for 25% of the population and supplied water for 90% (however due to a water shortage during the period of this study (Jul 1999), the city was undergoing a water rationing of 1 day with water and 9 days without).

Until the early 80's, COMPESA was practically the only organisation receiving financial resources for investments in the sector. However, since the end of the military regime (early 80's), municipal governments have been also able to invest. Then, the Prefecture of Recife, through its Urbanisation Company – URB Recife – started to apply physical and financial resources for the *implementation* of sanitation programmes.

These programmes are based on municipal law No. 15,547/1991, which established that for the city of Recife, the condominial sewerage technology is the standard sanitation technology to be adopted for implementation of new systems.

Considering the difficulties and the complex characteristics found in the favela areas, URB has launched a programme of community participation, so establishing a channel between the low-income communities and the prefecture, and having as main objective the urbanisation (infrastructure services) and legalisation of these areas.

➢ **Community Participation: the PREZEIS programme**

The law for occupation and utilisation of urban areas, defined by the Prefecture of Recife in 1983, divided the city into four zones and set specific regulations for the utilisation of each one of them. Three of these were: the Industrial, the Residential and the Green zones. The fourth zone is known as Special Zone of Social Interest (ZEIS) and is constituted by settlements (favelas) that had already been consolidated as residential areas. Although families have been living in these favelas for over 15 or 20 years, they are illegal, they do not own the plot that their houses are built on and the houses are not serviced by any infrastructure services. Therefore, the PREZEIS – Plan for Regularisation of the Special Zones of Social Interest – has the objective of legalising these areas and providing support for their development and urbanisation.

In order to be transformed into a ZEIS, and consequently to be included in the PREZEIS programme, the settlement must have a formal community organisation institution. Thereafter, the following steps must be taken: *A community meeting for the discussion of the programme and the production of a request paper ➔ submission of the request to URB ➔ authorisation by the mayor ➔ a law voted and approved by the Local Assembly Members transforming the area into a ZEIS.*

As a ZEIS, the community has its representatives participating in the PREZEIS Forum, which is also composed of engineers, lawyers, social assistants and NGO's consultants. The PREZEIS Forum is where alternatives to guarantee land ownership and the development of infrastructure services are turned into actions.

Community representation in the PREZEIS is carried out by two members of each community, who are elected by the residents, plus two alternates. They receive a monthly stipend from the prefecture as a financial support to keep their participation on track. Initially 27 ZEIS were defined, but soon it increased to 61.

4.6.3. The areas studied

The Mangueira ZEIS was chosen as the case to be studied. Its sanitation system had been in operation for only a year, but it is the largest (servicing 3098 residences) system implemented by URB. Another relevant aspect of the Mangueira sewerage system is the arrangements established for its O&M, in which a private company contracted by COMPESA carries out the tasks for both sewers and treatment plant.

However, by the time the study was initiated, URB-Recife was starting a survey to know more about the condominial systems already implemented in 13 ZEIS areas (including Mangueira). Therefore, both studies were connected and a committee constituted by URB, COMPESA, two NGO's (Fase and Etapas) members had been formed; thus it was possible to expand this case study to also include a further 12 areas.

Table 4.11 presents the areas studied, the number of families served by the systems, the date the systems started functioning and the destination provided for the effluents collected.

Table 4.11. – The areas studied

ZEIS	No. resid.	Beginning	Effluent destination
Vila Sao Miguel	1476	1996	Integrated system (conventional STW)
Vila do Vintém	87	1994	Integrated system (conventional STW)
Poço da Panela	193	1996	Integrated system (conventional STW)
Mangueira	3098	Jun/1998	Isolated system (UASB + polishing lagoon)
Joao de Barros	208	Dec/1995	Integrated system (conventional STW)
Beirinha/Rua do Rio	846	Jan/1999	Isolated system (UASB)
Mustardinha	2932	Dec/1998	Integrated system (conventional STW)
Marrom Glace	201	Dec/1998	Integrated system (conventional STW)
Tamarineira	237	Ago/1994	Integrated system (conventional STW)
Água Fria		1996	Integrated system (conventional STW)
Córrego São José	1138	1996	Integrated system (conventional STW)
Coronel Fabriciano		1993	Isolated System (Septic Tank)

➢ Models applied for Operation and Maintenance

Although the prefecture of Recife (through URB) has been implementing sewerage systems, it does not have either the tradition or the physical structure for the O&M of the systems. Therefore, according to the arrangements made, URB would be responsible only for the implementation of the systems, with COMPESA then being responsible for operation, maintenance and payment collection.

Considering that condominial systems require intensive community participation, the responsibility for the tasks inherent to the systems was distributed among the actors as presented in Table 4.12.

Table 4.12. – Responsibility for the System's Tasks

Task	Implementation Stage	O&M Stage
House connection	User	User
Condominial sewers (backyard, front yard, sidewalk)	URB	User
Main sewer	URB	COMPESA
Pumping stations and STWs	URB	COMPESA
Services		COMPESA

Regarding the household connections, the initial agreement established that it was under householders responsibilities; however, in the middle of 2000 URB decided to provide the connections.

Throughout the study, six different situations (*models)* were identified regarding the O&M conditions of the systems. These *models* are presented below:

Model 1 -	***Conventional:***	Systems operated and maintained by COMPESA, which applies the company's normal structure (centralised offices attending both the condominial systems and the traditional (conventional) systems of the city). The ZEIS under this model are: *Vila Sao Miguel*, *Vila do Vintém* and *Poço da Panela*.
Model 2 -	***Decentralised:***	In this case, COMPESA hired a private company to develop the O&M tasks. This company has an on-site based office to attend to the users' complaints. The only area found under this model is the *Mangueira* ZEIS.
Model 3 -	***Participatory:***	In the *Joao de Barros* ZEIS the system is being managed by the community through its residents' association.
Model 4 -	***Situation of Transition:***	Three ZEIS are undergoing a transitory process, where the implementation stage has just been finished and COMPESA is analysing the systems for their acceptance. These areas are *Beirinha*, *Rua do Rio*, *Marrom Glace* and *Mustardinha*.
Model 5 -	***Situation Undefined:***	These areas had its sanitation systems concluded years ago and COMPESA has not yet taken over the systems. They are *Tamarineira*, *Água Fria* and *Córrego São José*.
Model 6 -	***Situation of Rejection:***	The system in the *Coronel Fabriciano* ZEIS was rejected by COMPESA and has no "actor" responsible for its O&M.

4.6.4. Study Methodology

➢ **The general study**

The data obtained by the ZEIS study were collected through two methods: **technical inspections** and the application of a **survey questionnaire**.

A group of COMPESA technicians carried out the technical inspections of the systems producing data on their physical and operational characteristics. These data were based on documentation of the company and field observation.

The questionnaire was designed to get information from the community's point of view and it was applied in a sample selected systematically, with each third house in the walking line of the surveyor being interviewed (for the smaller systems) and each fourth house for the larger systems (Mangueira and Mustardinha). The size of the sample obtained by this method was therefore approx. 33% and 25%, respectively.

The questionnaire (Annex 6) contained six sections. The first section was for the identification of both interviewee and residence, obtaining also information on family size and income. Section 2 was comprised of questions relating to the sanitation system and the residence, whilst Section 3 covered issues relating to the sanitation system and the community. Sections 4 and 5 focused on the maintenance activities and, finally, Section 6 obtained information on the sanitation service charging scheme and the willingness of the users to pay for it.

➢ **The Mangueira project study**

In Mangueira, the collection of data was based on **interviews, field observation, technical inspections** and the URB's **survey questionnaire.**

Interviews were carried out with the technical personnel of COMPESA, URB, SIRCAL (the private company hired by COMPESA for O&M tasks) and community leaders. From these interviews it was possible to reconstitute the arrangements made for the implementation of the project as well as for its maintenance.

Field observations and technical inspections consisted of visits to the site, which were in their majority accompanied by community leaders and the technical crew responsible for maintenance. It was also possible to obtain records of the maintenance activities carried out in the area during its first year of operation (Jun 1998 - Jun 1999).

4.6.5. General Study

➢ **Socio-economical aspects**

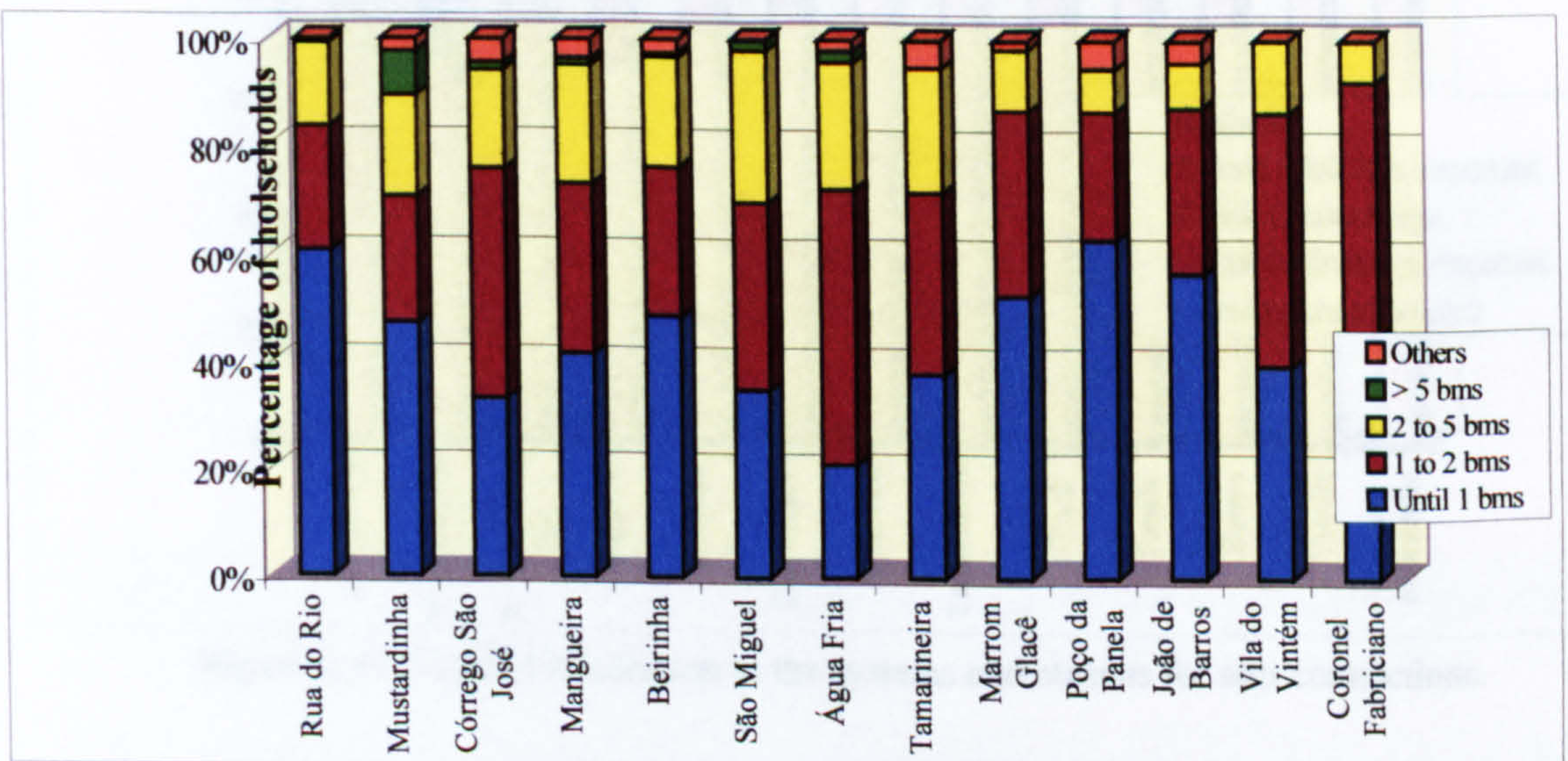


Figure 4.46. Family incomes

In five out of the 13 areas, more than 80% of the families earn a maximum of two Brazilian minimum salaries. In the other seven areas, about 70% had monthly earnings of up to two minimum wages with a small proportion of families earning more than five BMS's (Figure 4.46). Regarding family size, about 64% of the households presented more than 4 people living in the house.

➢ **System usage and functioning**

About the utilisation of the sanitation systems, the ZEIS "Coronel Fabriciano" and "Vila do Vintém" had 100% of their houses connected to the system (Figure 4.47.). However, these connections were provided by URB, and therefore they did not follow the established agreement (users responsible for house connections). On the other hand, the "João de Barros" ZEIS had also a high rate of users connected to the systems (96.9%) and this can be attributed to the involvement of the community in the implementation of the programme.

The area with the lowest connection rate was "Rua do Rio". The implementation of the system in this area was only finalised in the year of this survey – 1999, (which is also the case for the "Beirinha" and "Mustardinha" areas). Therefore, it is probable that users may not have had enough time to obtain the necessary resources for the connections (which is expressed in Figure 4.47 as lack of financial resources). Within the "others" category, some of the householders were still preferring their old solutions for wastewater disposal.

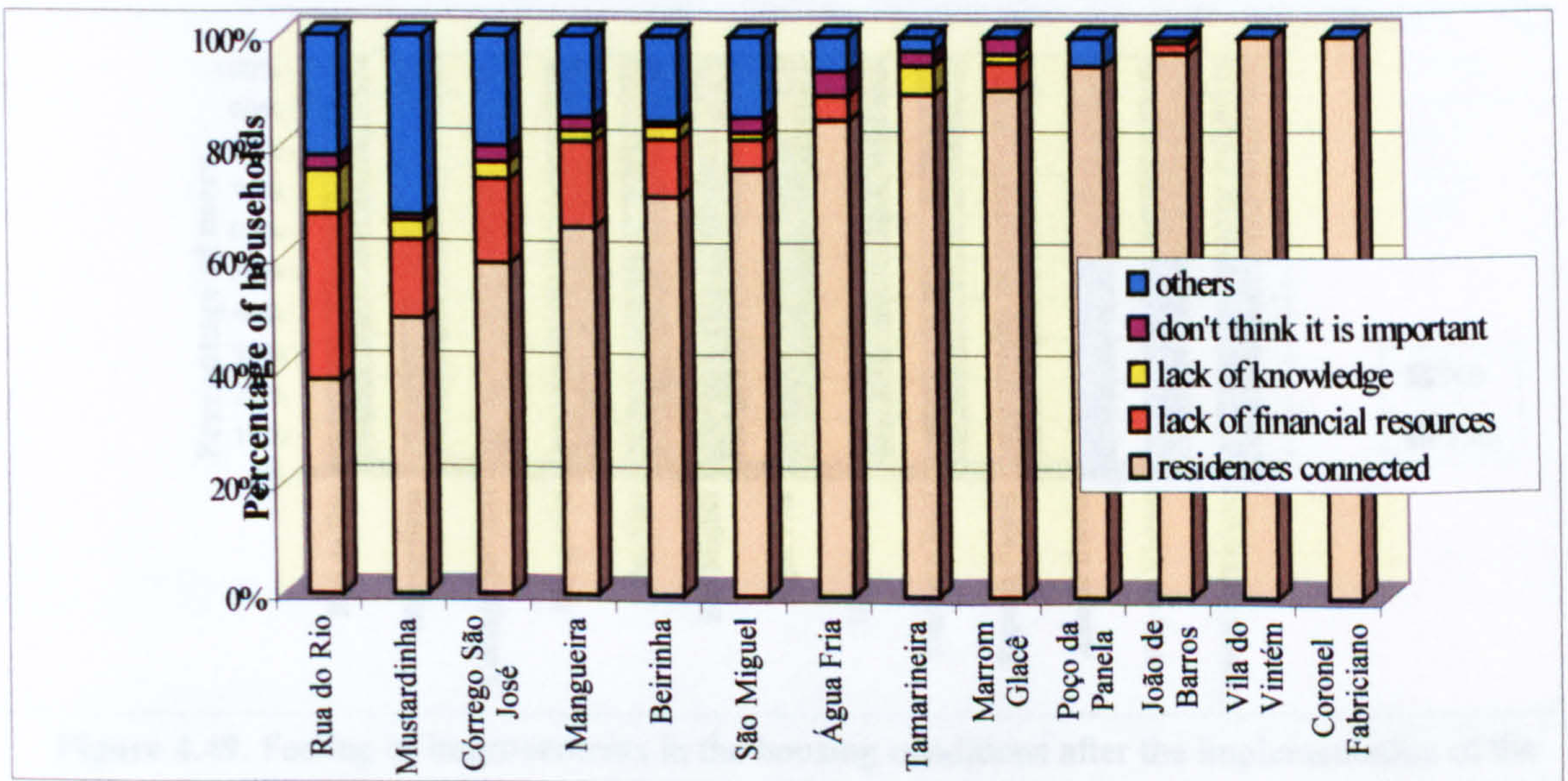


Figure 4.47. Rates of connection to the systems and reasons for non-connections.

Figure 4.48 shows that among the households connected to the condominial systems, over 20% had not yet connected both excreta and sullage. This suggests that, although these households had invested in their connections, they still prefer their old solution for one or other type of wastewater, which would not make sense if the users had in fact been well informed about the system and perceived it as a reliable solution.

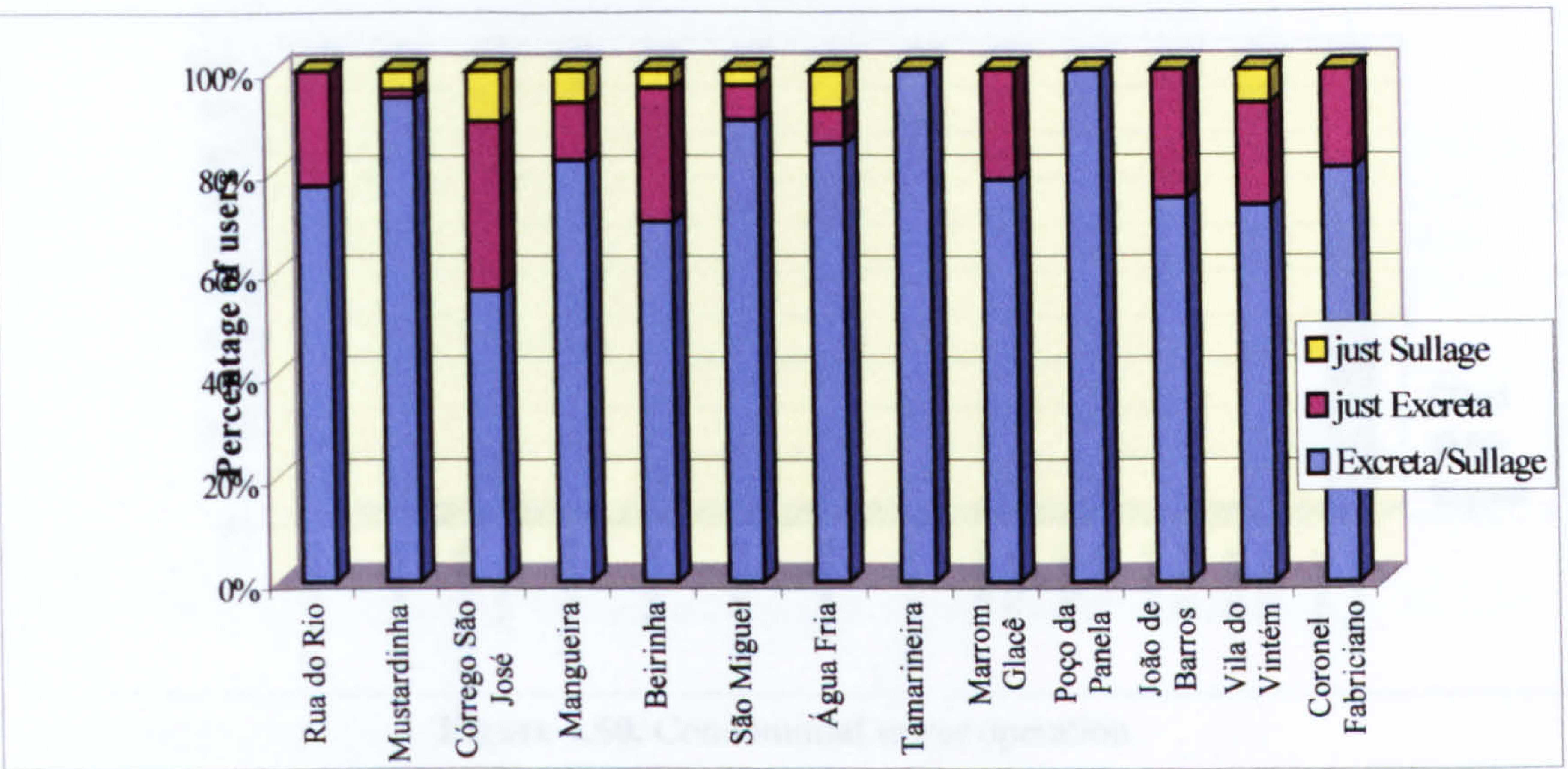


Figure 4.48. Wastewater connected to the system

Information collected in January 2001 for updating the data collected in 1999, shows that URB is now providing the household connections to the sanitation system in some of the areas, including Beirinha, Rua do Rio, Mustardinha and Mangueira.

Regarding improvements, more than 80% (on average) of all households connected to one of the 13 systems believe that the living conditions of the houses had been improved by the implementation of the sanitation system (Figure 4.49).

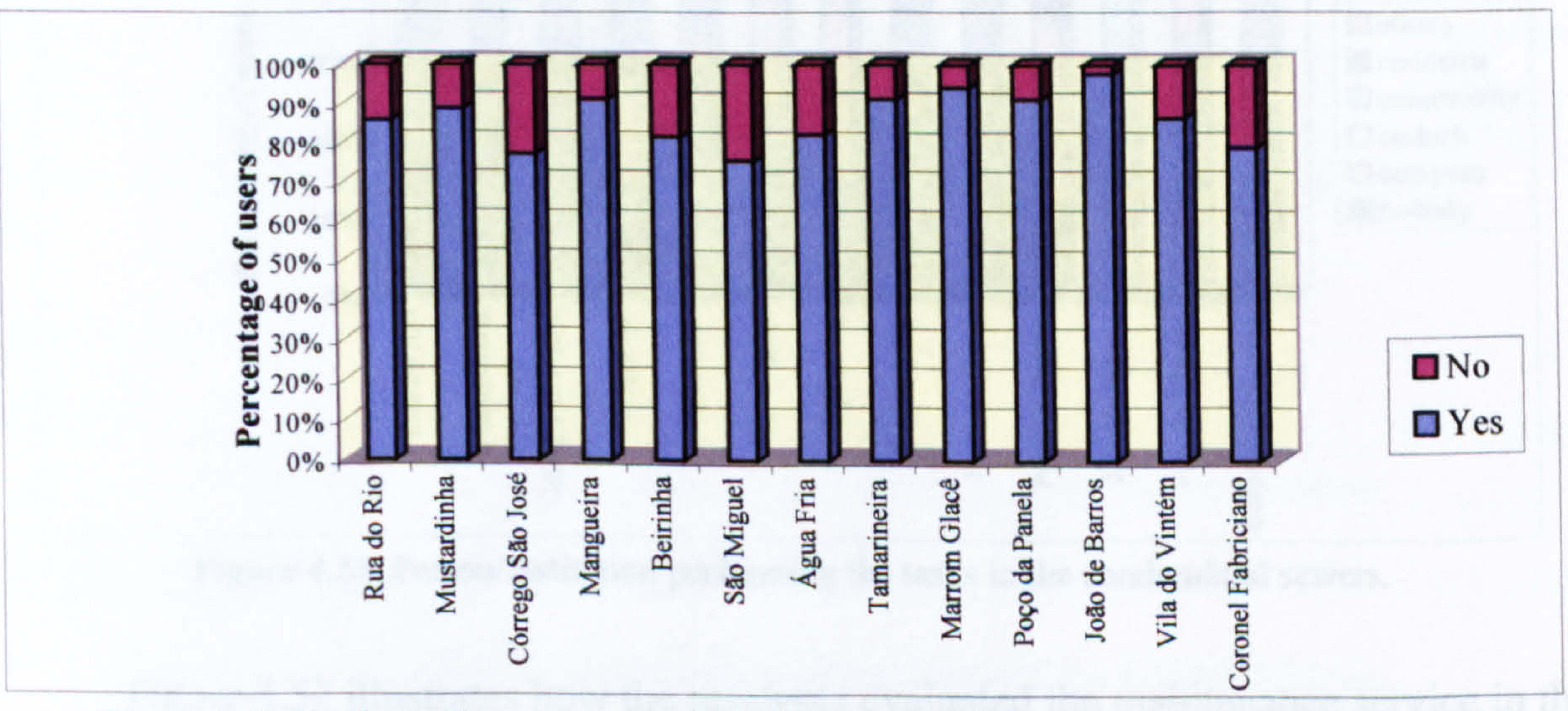


Figure 4.49. Feeling of improvements in the housing conditions after the implementation of the sewerage system.

Regarding the functioning of the condominial sewers, in eight out of the 13 communities it was considered "good" by more than 70% of the households. The main concern in this aspect was in the ZEIS Coronel Fabriciano, where only 35% of the householders considered the functioning of the condominial sewers "good" (Figure 4.50).

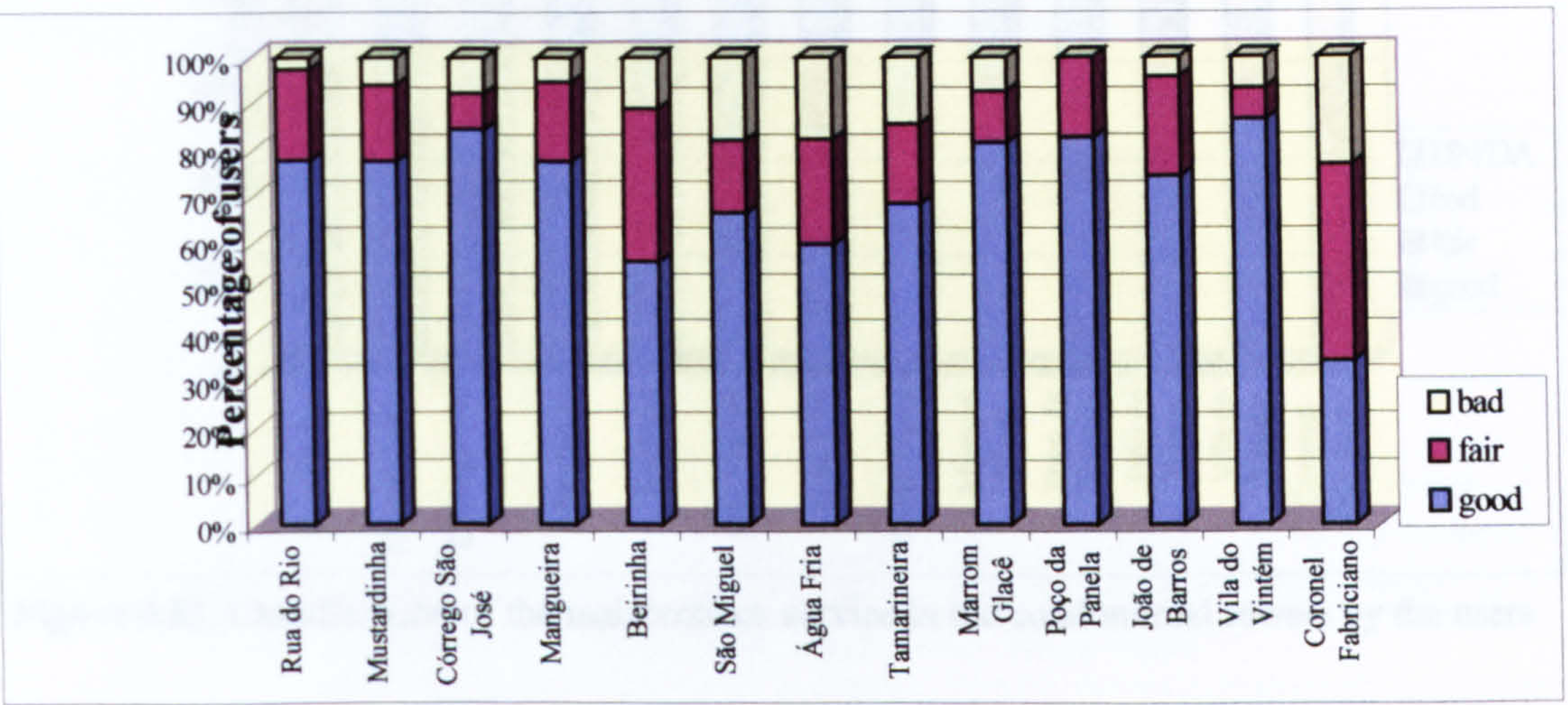


Figure 4.50. Condominial sewer operation

➢ **Maintenance services**

Regarding "who does" the maintenance of the condominial sewer (Figure 4.51), COMPESA was carrying out such activities in the majority of the areas. In the Joao de Barros ZEIS, approx. 60% of the households recognised the presence of a community organised group for the maintenance tasks required by the condominial sewers.

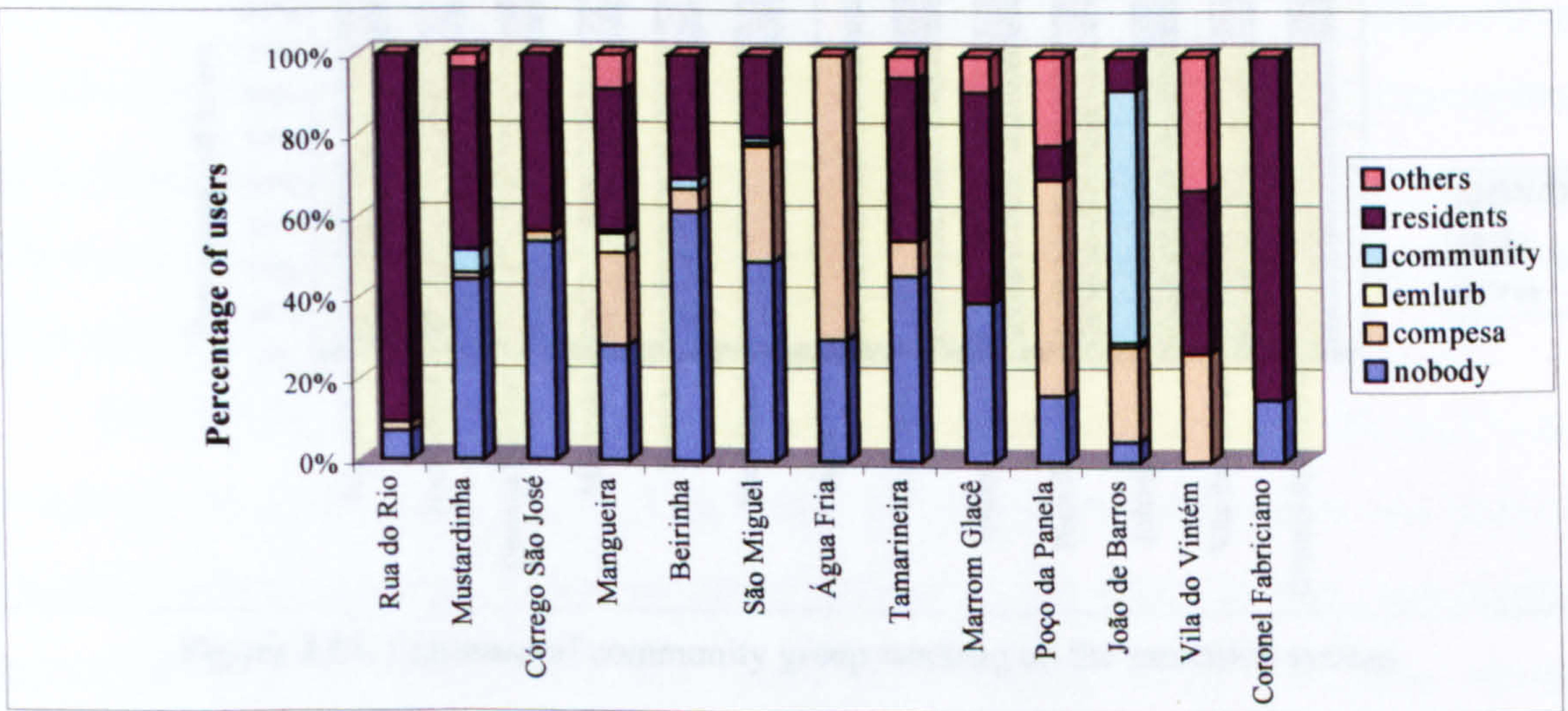


Figure 4.51. Person/institution performing the tasks in the condominial sewers.

Figure 4.52 illustrates how the residents evaluated the maintenance service in the condominial sewers. In the majority of the areas, however, high percentages of answers in the category "didn't know/didn't answer" were obtained, which may express a lack of involvement of the users within the system. The João de Barros ZEIS (the one maintained by a community group) presented the highest percentage of satisfaction with the maintenance of condominial sewers.

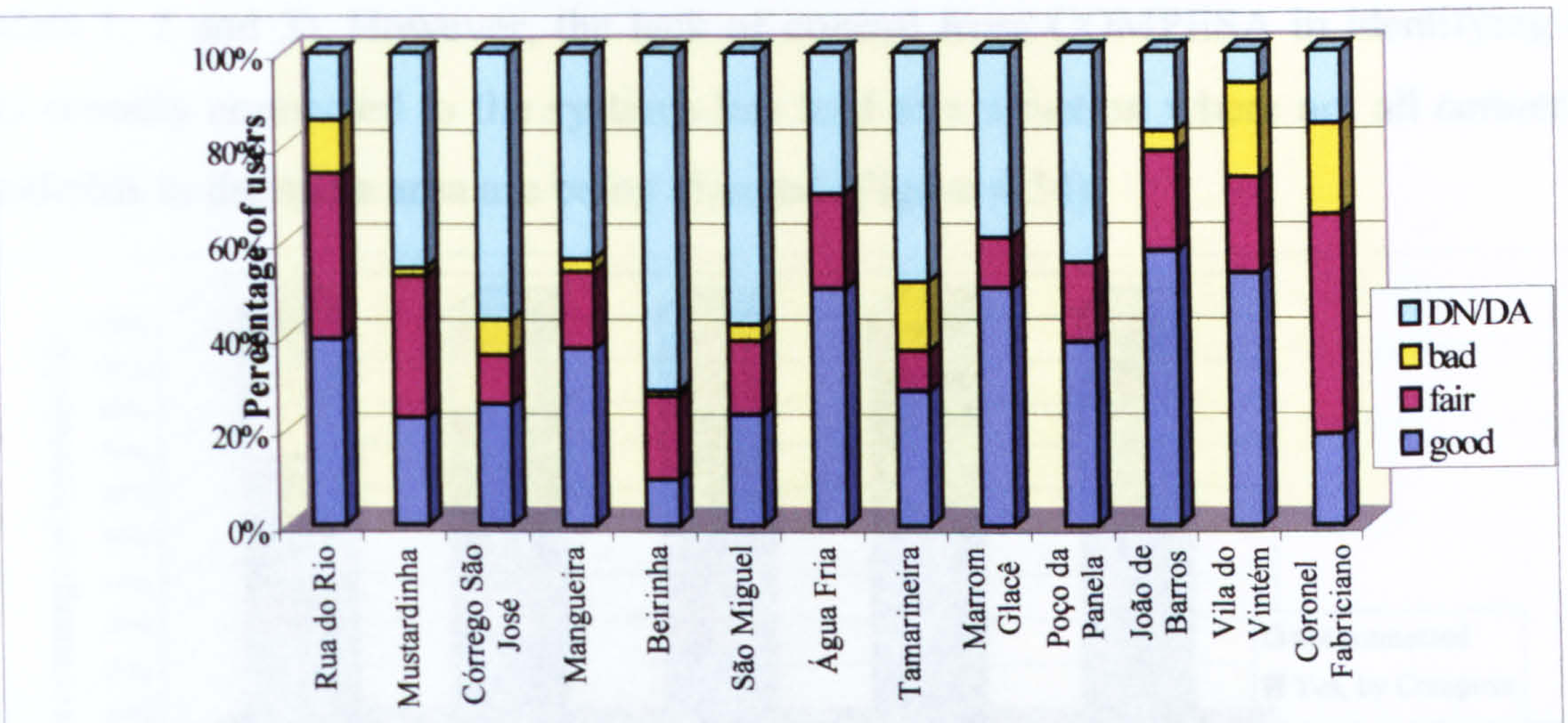


Figure 4.52. Classification of the maintenance service in the condominial sewers by the users

➢ Community participation

As previously introduced, only the João de Barros ZEIS had an organised group working on the community sanitation system (*model 3 – participatory*). As shown in Figure 4.53, some of other ZEIS also indicated the presence of similar community groups; however, the activities of these groups were not systematic or organised.

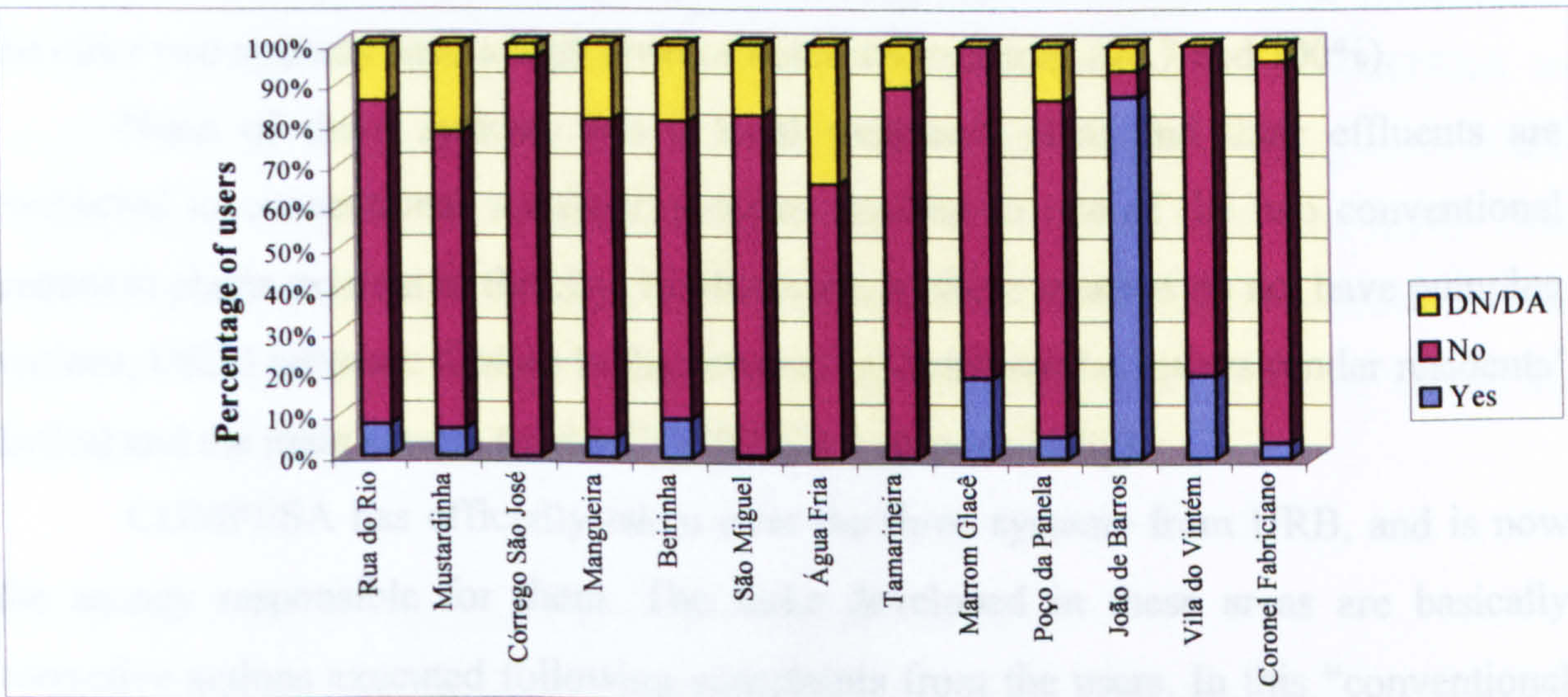


Figure 3.53. Existence of community group working on the sanitation system

➢ Willingness to pay

The charging policy for sanitation systems adopted by COMPESA is:

	Flowing to a treatment plant	Discharged without treatm.
Conventional systems	100 % of the water bill	80% of the water bill
Condominial systems	50% of the water bill	40% of the water bill

Only five out of the 13 systems are being charged by COMPESA. These are the Vila São Miguel, Poço da Panela, Vila do Vintém, Mangueira and João de Barros (models 1, 2 and 3). However, the lack of control from COMPESA in identifying the users actually connected to the systems has lead to a situation where not all connected households in the same area are being charged (Figure 4.54).

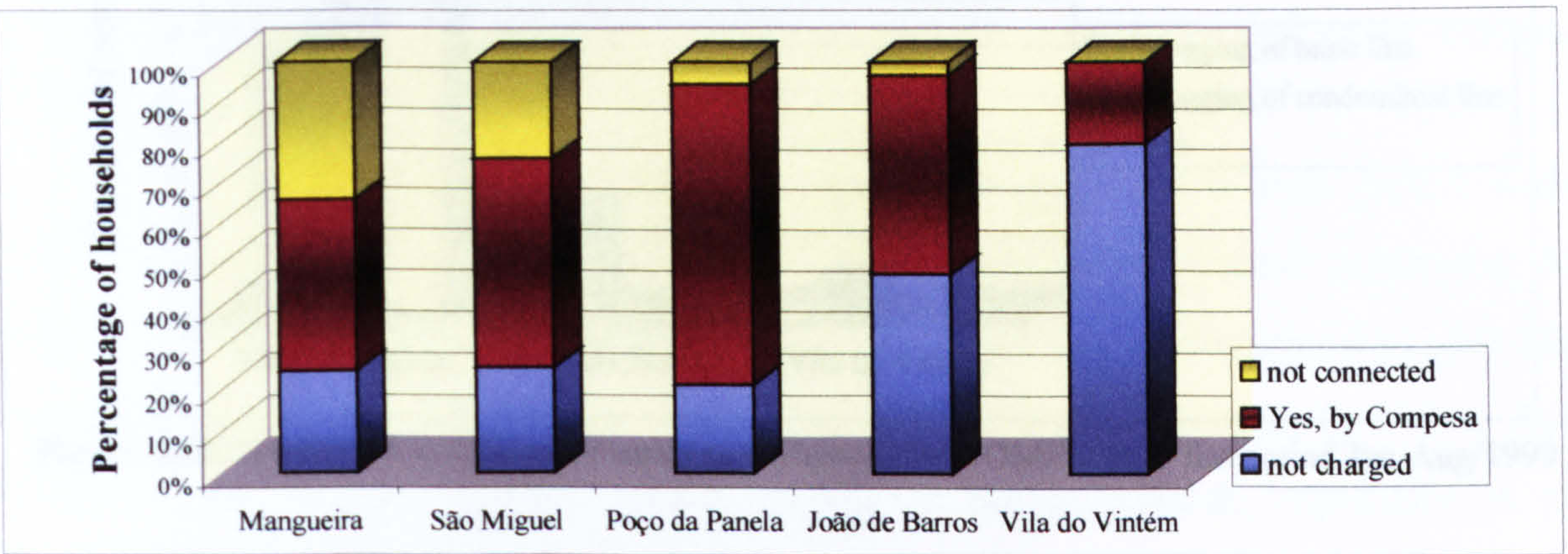


Figure 4.54. Users charged for the sanitation system

4.6.6. Model 1: Conventional condominial system

The three systems under this model are Vila São Miguel, Poço da Panela and Vila do Vintém. They have been in operation for over three years and, with the exception of Vila São Miguel (where the main sewer has still not been fully completed), the other two systems have a high level of house connections (94.7 and 100%).

None of these systems has a local treatment plant and their effluents are connected to conventional sewerage systems flowing to one of the two conventional treatment plants existent in the city. Furthermore, as these systems do not have pumping stations, O&M tasks are limited to the sewers: the condominial sewers (under residents' duties) and the main sewers (under COMPESA's responsibility).

COMPESA has officially taken over the three systems from URB, and is now the agency responsible for them. The tasks developed in these areas are basically corrective actions executed following complaints from the users. In this "conventional condominial" model, complaints are made to a central office that then sends a maintenance crew to execute the services. However, the delays in COMPESA attending to a call are a common disappointment among the residents.

As shown in Figure 4.55, COMPESA had also developed maintenance tasks in the condominial sewers of Vila São Miguel, where residents had not accepted their maintenance duties. This fact may be also adversely influencing the proper usage and acceptability of the system, contributing to a higher number of sewer blockages and illegal connections of wastewater to the drainage channels.

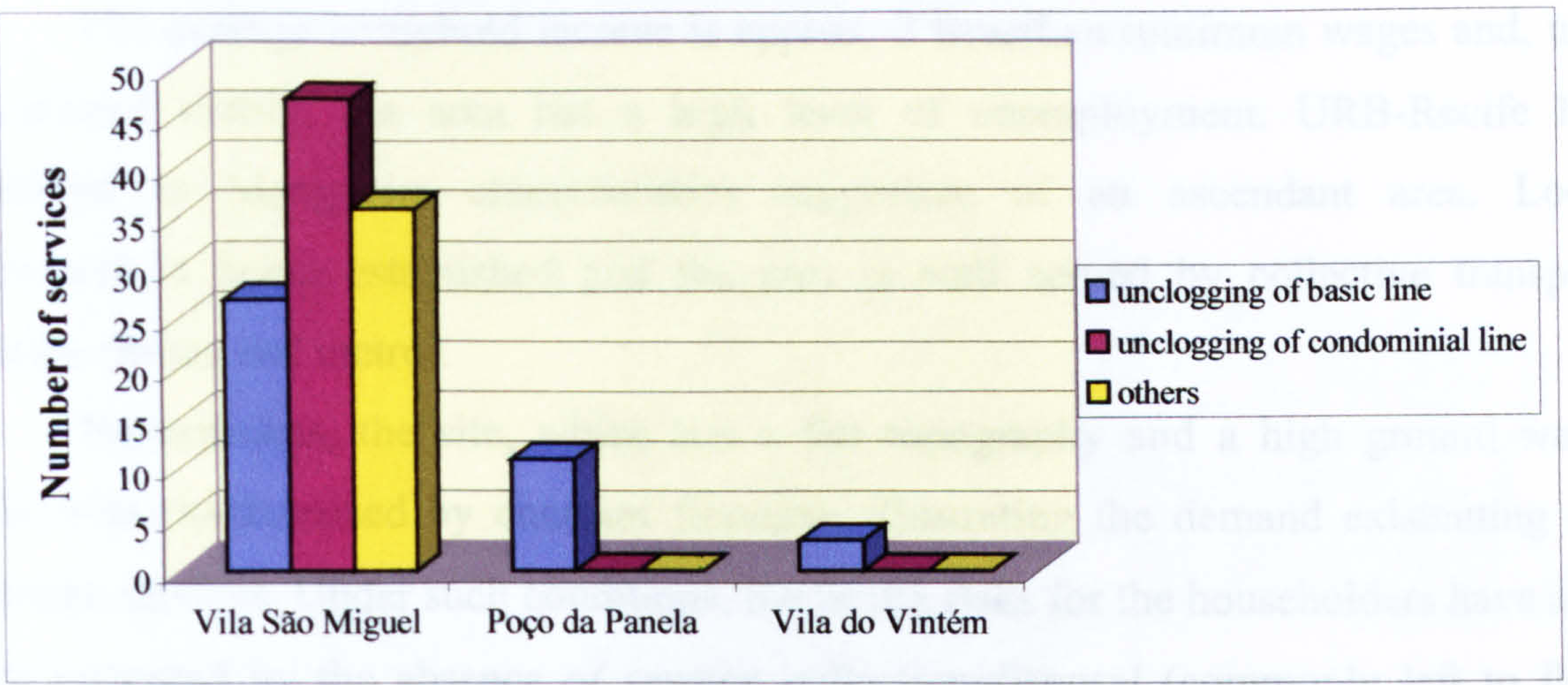


Figure 4.55. Number of maintenance services performed by COMPESA in the period Jan-Aug/1999

Vila do Vintém presented good participation of the residents towards the sanitation scheme. According to COMPESA, these residents have been satisfactorily maintening the condominial sewers, which is certainly contributing to the low number of interventions that have been required.

Finally, the charging system is also confused in these sites. COMPESA only starts to charge the users after they have made their house connections to the system. However, it has been hard (under the established circumstances) for COMPESA to control properly who has or who has not been connected. Therefore, among users of the same system, some are charged whilst others are not (as shown in Figure 4.54). This causes not only a reduction in the company's revenues (which is already affected by the high number of users that are charged and simply do not pay), but also causes an uncomfortable situation amongst those who pay.

4.6.7. Model 2: Decentralised condominial system

The Mangueira project is the system where a decentralised model was adopted for O&M. As mentioned, this system represents the main focus of this study, and therefore a more detailed investigation was carried out.

➢ **The Mangueira Area**

Mangueira is part of the district of Afogados located in the South of Recife. It covers an area of approx. 70 ha, with a population of 15,490 people living in 3,098 residences. Within the physical limits of the area, there are three "favelas" - Poço da Mangueira, Campo do Piolho and Sigismundo (Figure 4.56).

The average household income is approx. 2 Brazilian minimum wages and, true to national reality, the area has a high level of unemployment. URB-Recife has identified in Mangueira characteristics suggestive of an ascendant area. Local commerce is being established and the area is well served by collective transport systems (buses and metro).

Nevertheless, the site, which has a flat topography and a high ground water table, was characterised by constant flooding, illustrating the demand existenting for drainage services. Under such conditions, the health risks for the householders have also been increased by the absence of sewage collection/disposal (commonly left to flow openly at the streets), causing health hazards to the population, especially to the children. The diseases most frequently observed have been: filariasis, leptospirosis and diarrhoeas in general (Souza, 1997).

The Mangueira sanitation project started to be implemented in March 1993. The project was conceived as an isolated system, having its collected sewage locally treated. This treatment uses an UASB reactor followed by a polishing (nominally facultative) lagoon (Plate 4.49), and, the effluent discharges into a drainage channel flowing to the Jiquiá River.

Having community participation as the basis for implementation and development of the project, an agreement (known as "Parceria" - Portuguese for partnership) was established between URB and the residents of Mangueira. Different arrangements were applied for the definition of attributes in the "Parceria" leading to four distinguishable stages in the implementation of this programme.

The system's operation started in June 1998; however, the Sigismundo favela was still to be included in the programme. This delay was due to the option to relocate some families to a newly built housing area provided by URB (Plate 4.50). This housing area is approx. 700 m away from the original one and has 16 residential units. After relocation of the families, the conditions for urbanisation is expected to have improved making possible the inclusion of this favela in the Mangueira sanitation programme.

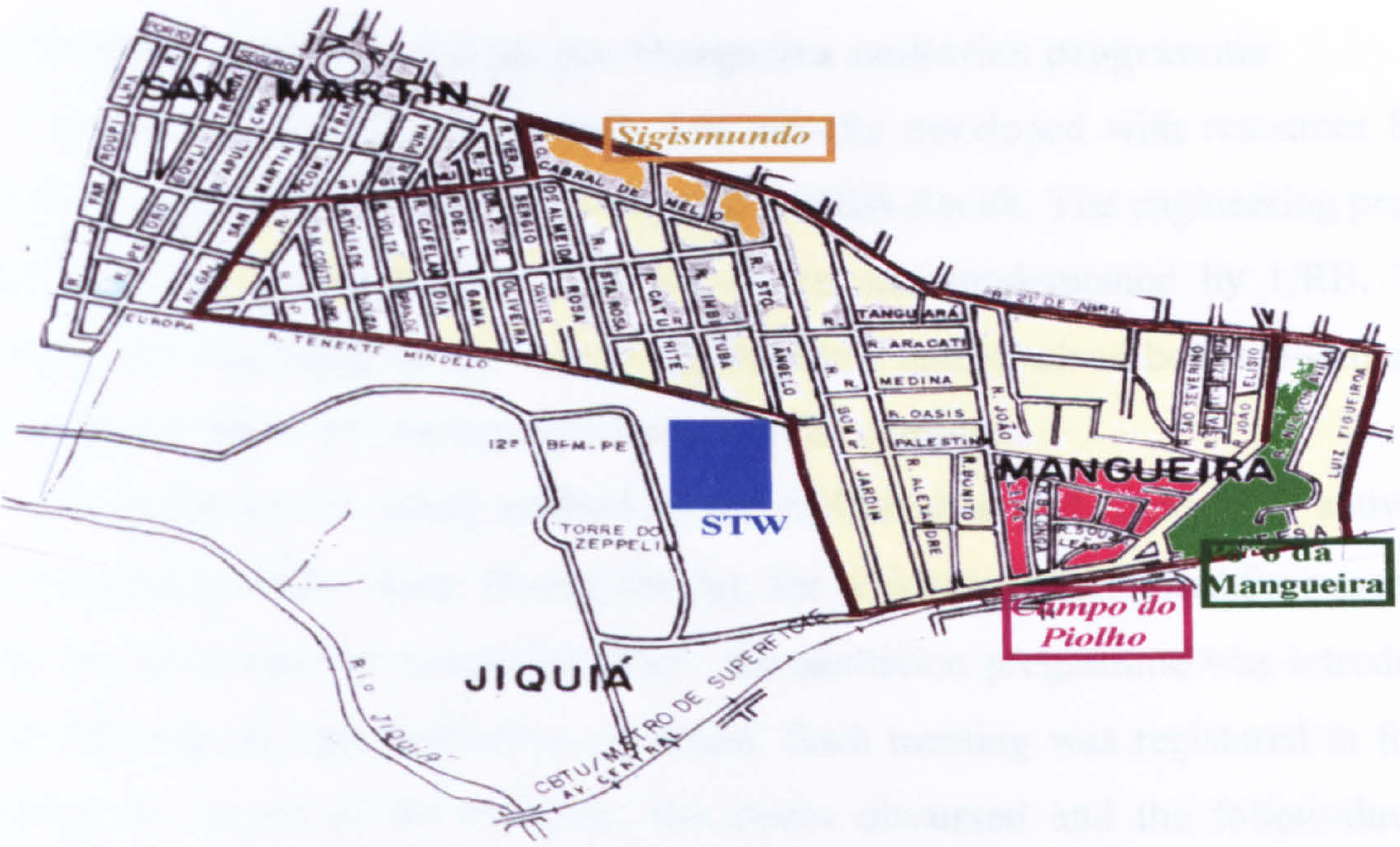


Figure 4.56. Map of the Mangueira ZEIS including the favelas (Sigismundo, Campo do Piolho and Poço da Mangueira) and the sewage treatment plant.

Plate 4.49. Mangueira Sewage Treatment Plant

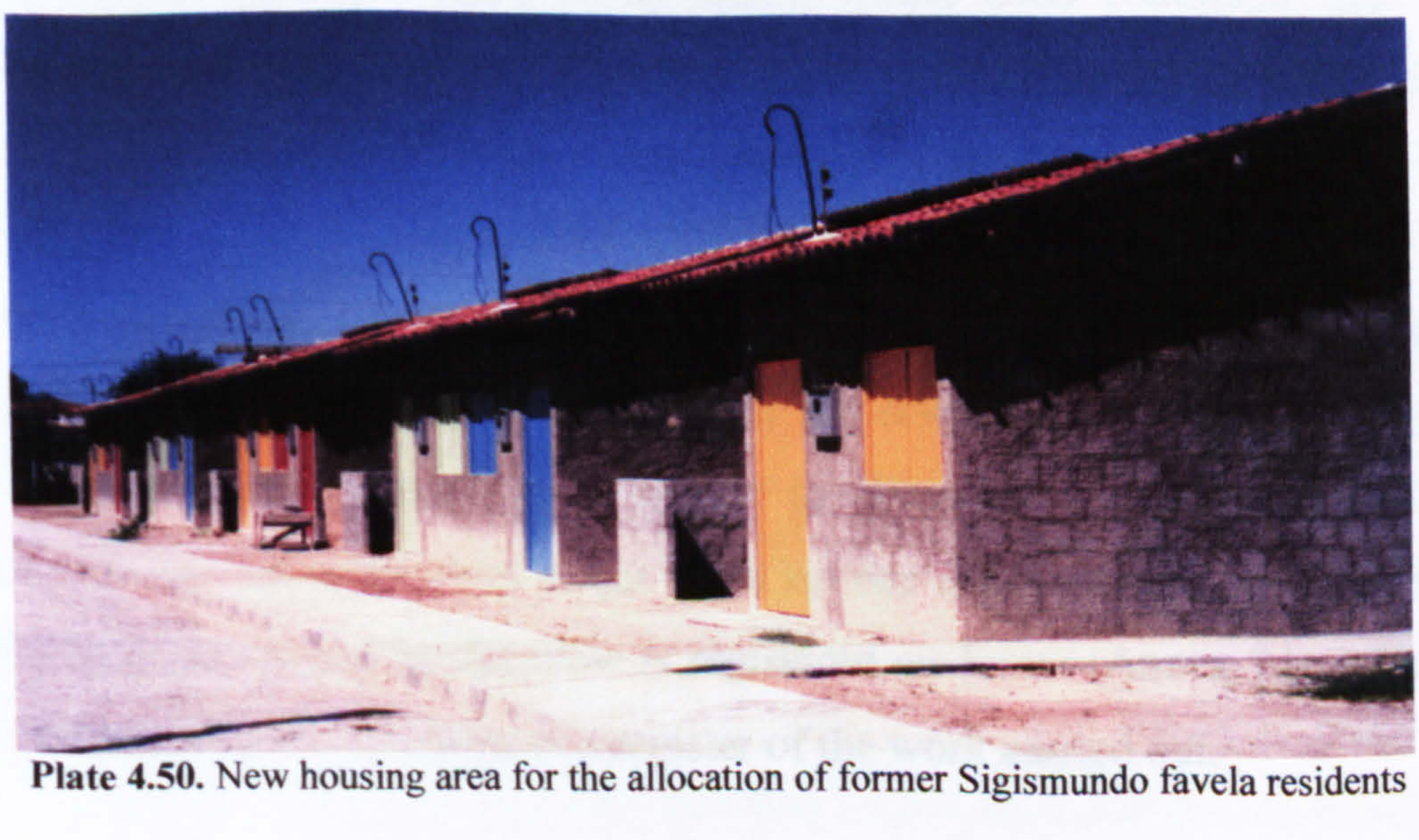


Plate 4.50. New housing area for the allocation of former Sigismundo favela residents

➢ **Institutional arrangements for the Mangueira sanitation programme**

The Mangueira sanitation project was initially developed with resources from the prefecture through its Urbanisation Company, URB-Recife. The engineering project was designed by a consulting engineering office and implemented by URB. This implementation was based on community participation and involved both the sanitation engineering and the social service departments of the company.

The social service group worked on the mobilisation and educational activities which occurred block by block. During the day, the residents were invited for a meeting (see the invitation card in Annex 7a) where the sanitation programme was introduced and the rules for its implementation explained. Each meeting was registered in forms containing the names of the residents, the issues discussed and the follow-through actions. Once the residents decided on the implementation of the project, the layout of the condominial sewer was defined and an agreement signed (Annex 7b). Educational material explaining the system and how to do any necessary maintenance was also distributed (Annex 7c).

EMLURB – a municipal company responsible for urban refuse collection – also participated in the programme. It added a selective solid waste collection programme, which was aimed to generate the financial resources necessary for the participation of poorest residents in the sanitation programme. Another agency that also took part in the programme was the municipal Secretariat of Health, which contributed with messages to improve hygienic habits among the residents.

In the last phase (when URB had stopped the programme due to lack of financial resources), COMPESA obtained credit and concluded the implementation. COMPESA carried out actions directly related to sanitation, whilst URB continued with other urbanisation interventions. Nevertheless, the sanitation system continued under URB's responsibility, and just after the system had gone into operation, it was transferred to COMPESA.

For maintenance, COMPESA contracted the service of a private company - SIRCAL, which develops maintenance tasks for the sewer network and the treatment plant. For this, a crew comprising six people (a chemistry technician, a sanitation technician and four labourers) was based in an on-site office (at the treatment works plant). The work developed by the crew is registered on forms (Annex 7d), which are given to COMPESA that uses them as a register of the work carried out.

➢ Community Organisation

◻ The Mangueira community representation

The Mangueira area has two community representative institutions: the Residents' Association and the Residents Council. They act in physically distinct parts of the community. In the PREZEIS Forum, both presidents (one from the Association and the other from the Council) represent the community. They have a conflicting relationship and their divergences seem to contribute to a political dispute in the area, resulting in difficulties for the acceptance and implementation of community-based programmes. Nevertheless, the area also has a third community leader who is well accepted by both sides and represents the whole community in the commission responsible for the urbanisation and legalisation of the ZEIS areas.

◻ The "Parceria"

URB-Recife has been investing in programmes based on community participation as a way to make projects viable. For the Mangueira's sanitation project, the "parceria" was adopted as the conceptual model for implementation. However, the conditions for this partnership agreement changed throughout the implementation, leading to four distinguishable stages (Souza, 1997):

▪ **Stage 1 – from February to December 1993:**

The first parceria agreement stated that the material and labour necessary to build the condominial sewers were of householders' responsibility and that URB was to be responsible for the implementation of the main sewer and for the construction of the treatment plant.

The residents demonstrated resistance to this agreement but, with the help of the local leader, the implementation of the project was initiated in a pilot area covering four streets. At this point, the construction of the treatment plant had not yet been initiated and the condominial sewers were being connected to a nearby conventional sewer.

After seven months, the development of the project was very slow and only three condominial sewers were constructed (a total of just 30 connections). In addition, the construction of many sewers was of poor quality and needed to be re-built. Based on this, URB redefined the "parceria" agreement and started to subsidise the costs for the poorest residences and to decrease (by up to 25%) the costs to be paid by the others.

The project continued with uncertainties from both sides: the community was still seeing the project with suspicion due to past experiences and URB had not yet been able to close contracts for the construction of the main sewer and the treatment works plant.

At the end of this stage, the results obtained were very discreet and confined to the original four streets.

- **Stage 2 – from January to June 94:**

URB took the responsibility for the construction of the condominial sewers and signed a contract for the construction of both the main and the condominial sewers. The Parceria agreement for this stage reduced, therefore, the residents' responsibilities, which now only had the responsibility for buying the pipes.

The fact that the main sewer was being constructed, increased the acceptability of the system, which now had the participation of approx. 900 families distributed in 30 blocks. By the agreement, the community was expected to organise themselves and purchase the number of pipes required for the condominial sewer in each block. However, the residents bought the pipes individually, so each family bought one pipe (6m length), which was not enough to complete the in-block line. To overcome this problem, a programme for solid waste collection was proposed, in which the community collected and sold recyclable solid waste, using the money so obtained to purchase the extra pipes, as well as the pipes for the poorest families. The Residents' Council was in charge of this programme.

The solid waste collection programme had the participation of 550 families and 8 collections occurred during this period (each collection was enough to buy 10 pipes). At the beginning, this programme was well accepted, but then the residents lost interest mainly due to: the absence of a criterion for the distribution of the pipes, lack of organisation, and political dispute between local leaders.

At this point, the community decided to terminate the "parceria". Nevertheless, they wanted the continuity of the construction of the sanitation system but now adopting a sidewalk layout and using only public resources. They also wanted to continue with the solid waste collection, but this time using the money for a food provision programme. URB did not accept this position and suspended the sanitation programme. Just after negotiations between the mayor and the community, the sanitation programme continued following the parceria model but also including actions on drainage (required by the community).

Due to all these conflicts, a discussion started involving URB, residents and consultants on the political importance of community participation not only on the sanitation programme, but also on the development of the community as a whole. As a consequence, a plan of actions for the community was elaborated, involving the residents, URB, EMLURB and the municipal Health Secretariat.

▪ **Stage 3 – from August 94 to August 96:**

The Plan for Actions in Mangueira determined that the sanitation programme would be continued based on the parceria model and on the development of educational programmes (including orientation on sanitation, health and selective solid waste collection). The creation of committees was promoted and the execution of educational activities was initiated. However, the committees for health and sanitation were not fully developed, and the selective solid waste collection committee only functioned up to January 1996, when the families (especially those that had already got their sewers) stopped the collection.

For the continuity of the sewers' construction, Mangueira was physically divided into three areas making possible a progressive implementation of the system. The work developed at this stage progressed faster than that carried out previously. This was attributed to the extensive acceptance and participation of the residents. The better income conditions of residents in the first area and their decision to use the sidewalk condominial layout also influenced the now smoother progress of the programme. The work continued through to the second area, but then, stopped due to lack of financial resources.

At the end of this stage, the construction of the main sewer had been finished as well as about 50% of the condominial sewers. The urbanisation of the three favelas (Campo do Piolho, Poço da Mangueira and Sigismundo) and the drainage interventions were still to be concluded.

Only the construction of the Treatment Plant, which obtained financial resources from the Caixa Econômica Federal - CEF, continued.

▪ **Stage 4 – from January/97 to June/98**

With the participation of COMPESA (who obtained financial resources from CEF to be applied in the sanitation project and to improve water supply in the area), the programme was re-initiated. The money was also applied on actions on the residents' sanitary installations, house connections and interventions on urbanisation and drainage. Therefore, URB and COMPESA agreed on the following distribution of responsibilities: URB executed the urbanisation of the favelas and the drainage actions, and COMPESA the interventions directly related to sanitation and water supply.

In this context, the parceria agreement was altered again and this time the residents agreed to pay for the costs of the condominial sewers, through the water and sanitation bills, after the implementation and after the system was fully functioning. The community leaders continued to follow the execution of the project, however, the integration between the Social Service Sector of URB and the sanitation system was terminated.

➢ **Costs**

The costs of the Mangueira sanitation system were as presented in table 4.13. (Pinheiro, 2001).

Table 4.13. – Costs of the Mangueira project

Intervention	Pop. (inh)	Costs (R$ per capita)	US$
Trunk + condominial sewers	19535	135.40	69.4
STW[1]	19535	73.90	37.9
Household connections (in 60% of the houses)	11721	20.48	10.5

[1](UASB + Facultative pond + Pumping Station + sludge drying bed)

➢ **Field Observation**

One year after the sanitation system had been in operation in Mangueira, the drainage and paving projects are still to be concluded. Only the main streets of the area had been paved and actions on drainage are still taking place (Plate 4.51).

As with the rest of Recife, the area is undergoing water rationing. The residents (that can afford it) are boring wells and, as illustrated in Plate 4.52, sharing the water with their neighbours.

In the favela areas, drainage services have been concluded. According to the residents the actions executed on drainage and sanitation have, in fact, improved their standard of living. Although none of these favelas has yet been paved, the streets are mostly dry, even during the rainy season (period of this study).

Sewage was not found flowing in the streets; however, this does not necessarily mean that all households have connected their sewage to the sewers. There is considerable evidence of irregular connections having been made to the drainage channels (see Plate 4.53). This is also illustrated by Plates 4.54 to 4.57.

Plate 4.51. Drainage construction taking place in the Mangueira area

Plate 4.52. The queue to collect water from a neighbour who had just drilled a well.

Plate 4.53. Household wastewater being discharged into drainage channels

Plate 4.54. Favela of Campo do Piolho – the arrows show the inspection chambers of condominal sewer.

Plate 4.55. Drainage channel in the favela of Poco da Mangueira.

Plate 4.56. Section of a drainage channel in the Sigismundo favela.

Plate 4.57. A resident that uses his older sanitation solution (where the children are playing), in spite of the presence of a condominial sewerage inspection chamber (left).

➢ **The survey questionnaire**

As to specific considerations that can be made from the results obtained by the questionnaire survey, it is noteworthy that one year after the system had been put into operation approx. 65% of the residences had provided house connections. The majority (93%) recognised that the system brought benefits and about 77% said that the maintenance of both the condominial and the main sewers was "good".

However, only 23% of the households confirmed that they are executing the maintenance tasks of the condominial sewer. This information is in accordance with the observation made that the maintenance crew (instead of the householders) were executing many of the maintenance activities on the condominal sewers. Asked about this, the technician in charge said that they were aware of the division of responsibilities, but that the residents were expecting them to solve the problems.

➢ Technical Inspections

Based on user complaints, which are made by phone or in person, the maintenance crew maintains the main sewer, the system appurtenances and the condominial sewers (in spite of the latter being the responsibility of the users).

As to the presence of this crew on the site, not all of the residents are aware of it. It seems that the residents of the favelas (where the crew has been developing the majority of their work) know the crew well and how to contact them, whilst in other parts of the site the residents appear to have never heard about the group.

Regarding the activities of the maintenance crew, four variables were measured through the analysis of the file of complaint attendances during the period of one year (since the beginning of the operation of the system – Jun/98). These variables were: the number of services executed per month, the response time, the type of maintenance service and the equipment used. Thus, a total of 1,270 service record cards (Annex 7d) were analysed.

Regarding the frequency of complaints per month, in the first month only 2 complaints were registered, but from there on, the number of complaints varied from 76 to 215, as shown in Figure 4.57.

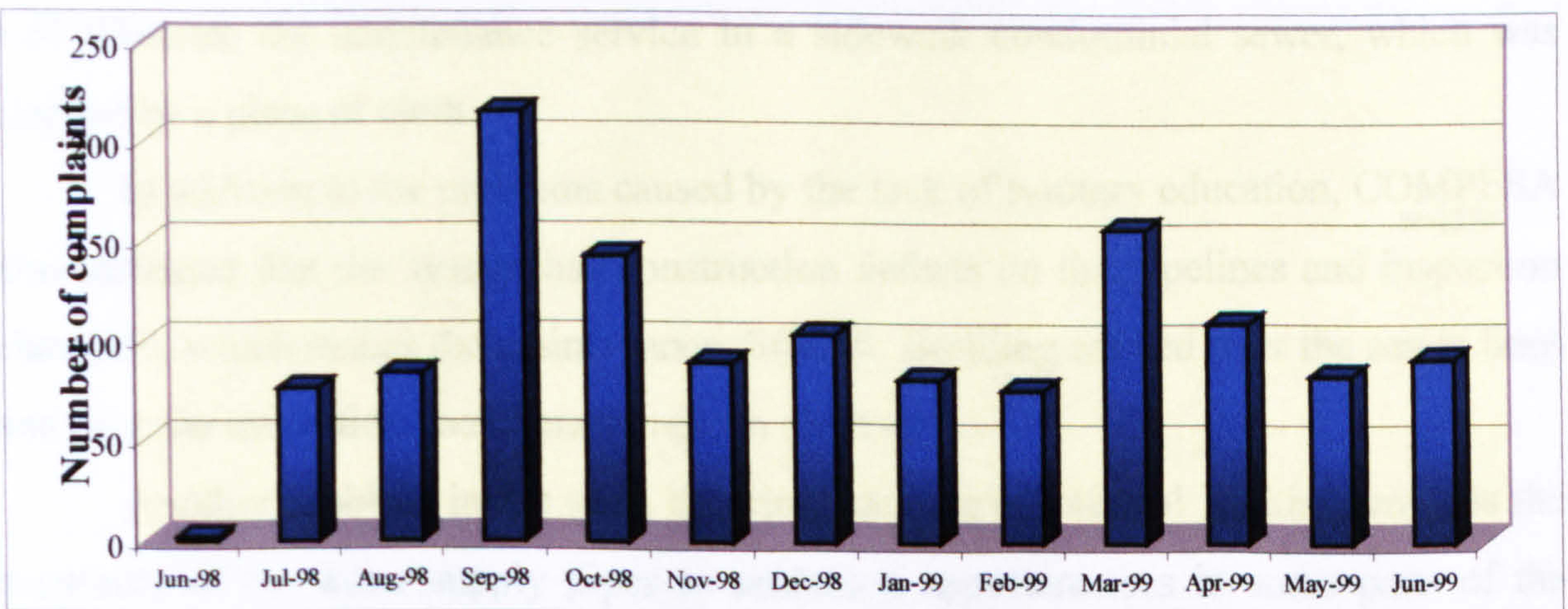


Figure 4.57. Frequency of complaints occurrence in one year period

94% of the complaints were attended to within 24 hours. This rapid response was also observed during the days spent on the site. The maintenance services were mostly for inspection chamber cleaning, followed by unclogging of the basic/condominial sewers, then by substitution of inspection chamber spare parts (rings and covers), by manhole cleaning, and finally by repairs to the condominial sewer, inspection chambers and manholes (Figure 4.58.).

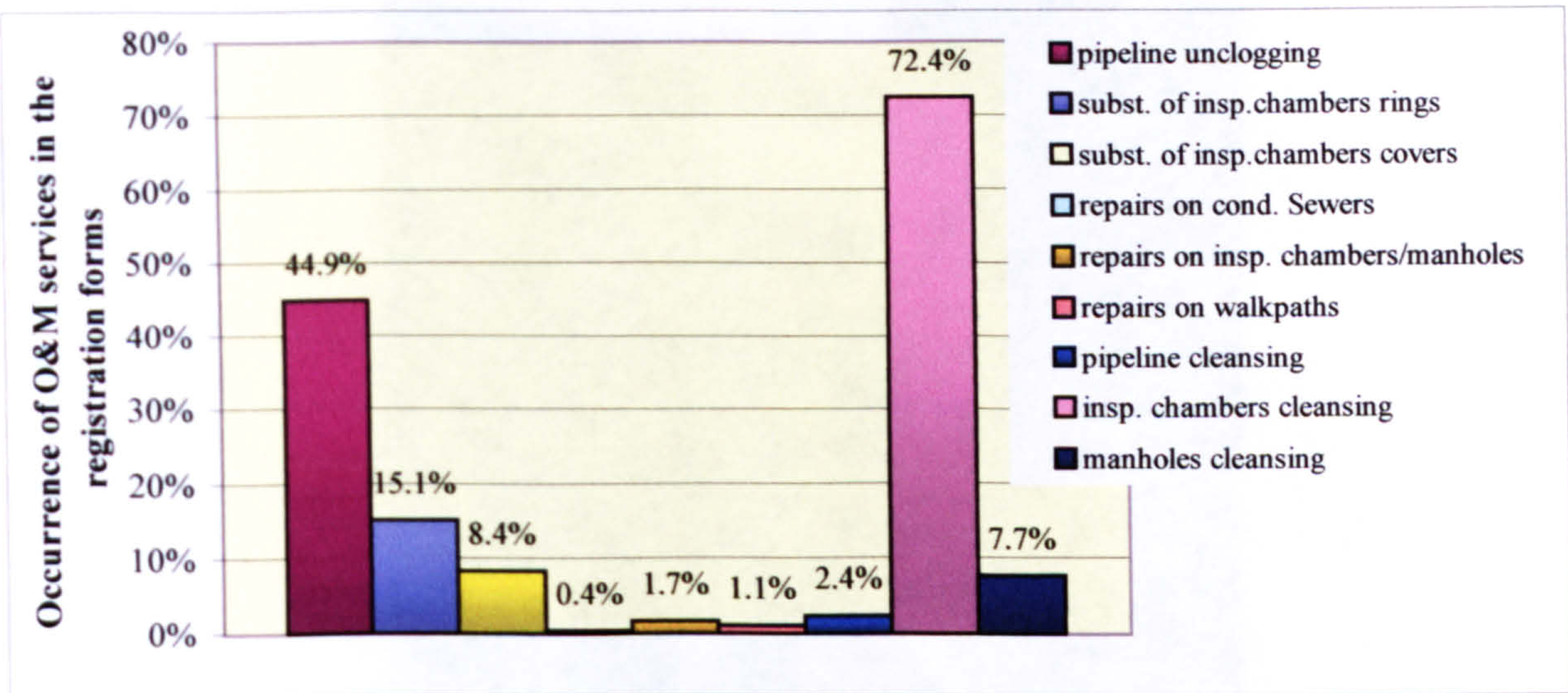


Figure 4.58. - Services registered in the O&M forms for the Mangueira project during the period of Jun/98-Jun/99 (note that more than one service could be registered per form).

The equipment used in the maintenance services was 97% based on "supportive equipment", 1% of "water jet" plus supporting equipment and 2% of the forms do not specify the equipment used. The equipment described as "supporting", shown in Plate 4.58, basically comprises a shovel, gloves, stick, hose, pickaxe and spatula. Plates 4.59-4.67 illustrate the maintenance service in a sidewalk condominial sewer, which was clogged by a piece of cloth.

In addition to the problems caused by the lack of sanitary education, COMPESA also indicated that the system has construction defects on the pipelines and inspection chambers, which makes the maintenance difficult. Building erected over the sewer lines and over the inspection chambers were also observed.

N=1270

Another problem in the area, this time causing a potential health hazard, is the proximity of the water supply pipes to sanitation appurtenances in some parts of the system. In one site, for example, the sewer line was laid in parallel with the water supply pipes at a separation of only 20-30 cm. Water pipes crossing inside of the inspection chambers were also identified. This situation is made worse when considering the water rationing situation and the possibility of contamination of the water supplied due to the lack of pressurised water flowing into the pipes or by the possibility of negative pressure in the water supply network.

Plate 4.58. "Supportive" equipment used for maintenance

Plate 4.59. Three clogged inspection chambers

Plate 4.60. Close up of one of the inspection chambers

Plate 4.61. Workers using the hose to unclog the pipeline

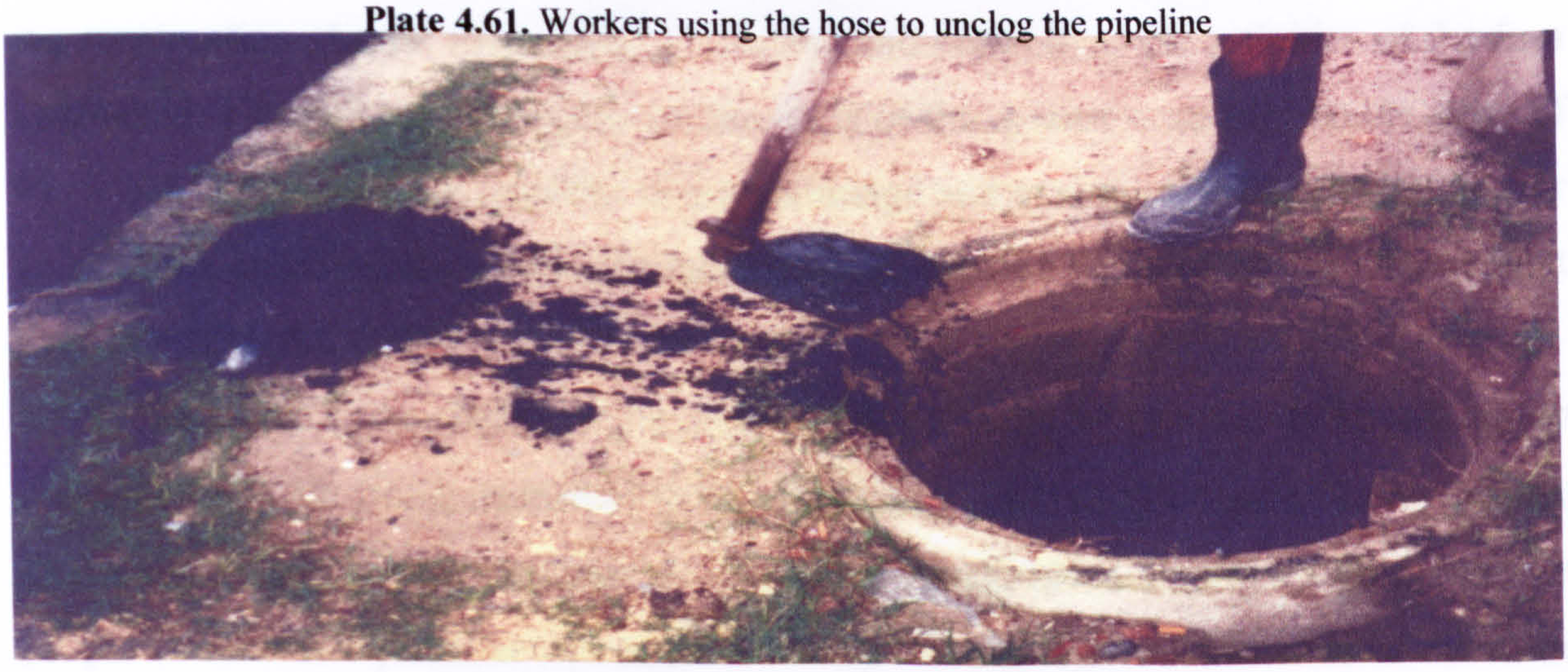


Plate 4.62. Removal of sand from the inspection chamber

Plate 4.63. Removal of sand

Plate 4.64. The cause of the blockage

4.6.8. Model 3: Participatory condominial system

The João de Barros ZEIS is a community of 208 households that has a distinct community organisation. The president of the Residents' Association has been in charge for over 7 years and has the approval of nearly 100% of the households. Under his administration the Association has improved the infrastructure conditions of the community and generated jobs through a co-operative society, which produces furniture and is now employing 83 people from the community.

Regarding the implementation of the sanitation programme (condominial/main sewers and pumping station), the community had a close participation. It managed all of the construction phases: inspecting, measuring and controlling the activities of the firm contracted. Through this management, the costs of the system were kept below those of the initial budget, making possible to start drainage and paving activities on the site (for an example on community self-management sanitation see a review on the Orangi Pilot Project – URL-32, 2001).

As to the maintenance of the condominial sewers, a "community based" group executes the tasks. Thus, instead of each householder operating and maintaining the part of the system located on his land, the Residents' Association employs a group of four people (a mason, a plumber and two labourers) for this. The maintenance of the main sewer is also carried out by this group and hence the services from COMPESA are requested only when the problem in the main sewer requires more specific equipment (such as the water jet) or for problems in the pumping station. This maintenance service scheme costs 610,00 reais per month (R$ 410,00 for the workers' payments and R$ 160,00 for materials) and is supported by the revenue obtained from the furniture co-operative society.

The community (or the Residents' Association) considers itself the owner of the system and their intensive participation may have influenced the growth of confidence in taking technical decisions regarding the sanitation system. An example of this is the decision made on the substitution of some lengths of both the condominial and the main sewers. This occurred a few months after the system had been in operation and was due to constant blockages of the pipelines. According to the president of the Residents' Association, "the diameter of the pipes selected by the project design (100 mm – the minimum diameter allowed by the code) was the main cause of the blockages". He also indicated the poor quality of the PVC pipes used as the cause of pipe breakdown.

Therefore, he decided for the substitution of these lengths of sewer for better quality PVC pipes of 150 mm diameter. For this, 1,810.00 reais were spent (money obtained from the furniture co-operative society).

Considering that the sewerage system is supposed to receive only household wastewater, the choice for 100 mm diameter pipelines follows the calculation parameters of this system design. Nevertheless, the residents seem very happy about their decision on the substitution of the pipes, saying that the blockage problems that occur now are localised and easily solved. However, through the technical inspections of the system, and based on the records from COMPESA, a large quantity of sand was found to be entering in the system. This sand comes into the sewers through connections of backyard drainage water to the inspection chambers, what certainly contributes to a rise in the volume of "wastewater" flowing in the pipelines. Moreover, the presence of solid waste deposited in the sewerage system is still high (in spite of intensive education of the residents by the maintenance group). In addition to contributing to blockages, solid waste also causes faults in the pumping station (which was initially constructed without a screen and recently installed by the Residents' Association).

Thus, the services executed by COMPESA in the Joao de Barros sanitation system are of main sewer unclogging, and cleansing out (sand removal) of the pumping station. The number of the services realised in the period of Jan – Aug/99 is:

Unclogging of the main sewer	Sand removal from the pumping station
3 times in 7 months	13 times (nearly twice a month)

The João de Barros sanitation system cost R$ 286 (US$ 146.6) per household, including the main sewers, the condominial sewers and a pumping station (Pinheiro, 2001).

The percentage of connections to the sanitation system was 97%. This high number of house connections was executed by the householders themselves under advice (or in some cases, pressure) of the Residents' Association. Based on the URB-questionnaire survey, 98% of the connected householders recognises that the sanitation programme promoted a better quality of life and 75% assess the quality of the maintenance service developed by the community group as "good".

4.6.9. Model 4: Transition Situation

The systems implemented in the ZEIS of Rua do Rio, Beirinha, Marrom Glacê and Mustardinha have now been in operation for about 10 months (since Jan/99, Jan/99, Dec/98 and Dec/98, respectively), and are in a transitory stage for their O&M. URB-Recife (the implementing agency) considers the systems finalised and has provided the documentation for their transfer to COMPESA, which is still analysing the projects.

According to COMPESA there is no deadline to take a position in relation to the systems (accept, ask for modifications or reject). Nevertheless, during this long period of transition the systems are in operation and, consequently, needing services. COMPESA are not yet officially responsible for the systems, which are still under URB's responsibility (that has no physical structure to undertake maintenance tasks). Therefore, the residents are being left without technical support to solve the problems and just in extreme cases COMPESA has been "unofficially" attending these areas.

The system implemented in Rua do Rio has, among the 13 systems, the lowest rate of house connection (38%). This system is interconnected with Beirinha through a "shared" treatment plant based on UASB technology. In both areas, householders recognise the benefits of the systems; however, they appear to be poorly informed about its availability and, also, about its utilisation.

On the other hand, the system implemented in Marrom Glace has a high rate of house connection (90%); however, the residents are not accepting their role in the maintenance of the condominial sewers and this has been even more aggravated by the non-operation of the system by COMPESA.

In Mustardinha, just over 40% of the houses are connected. During the implementation phase, URB decided to make the house connections in approx. 40% of the residences (which does not follow the original agreement). However, the whole community was expecting to have their connections provided by URB and, therefore, the householders do not consider the system completely implemented. They are still waiting for URB to connect the remaining 60% of the houses.

In fact, these are the most recent systems implemented by URB. Therefore, the connection rates are still expected to improve, and COMPESA should also soon be defining its position regarding O&M.

Nevertheless, after the implementation of ten other condominial systems it would have been expected that the main problems should have been solved, or at least minimised. Currently, factors such as: the long period of transition; institutions incoherence on the application of rules agreed; the lack of programmes stimulating house connections; and, the lack of information on the system functioning and usage are still compromising the operation of the systems.

4.6.10. Model 5: Undefined Situation

In the areas of Tamarineira, Água Fria and Córrego São José, a model for the O&M of the sanitation systems was not possible to be determined. The systems in Água Fria and Córrego São José have been in operation for three years; however, COMPESA has not yet officially "accepted" them. COMPESA has, instead, been performing some critical (not systematically) maintenance services requested by the communities, and this has led the communities to consider the company as the operator of the two systems. Nevertheless, under this situation, COMPESA cannot charge the users or be made responsible for the system. The operation of these systems has been verified as of poor quality, with high occurrence of blockages and breakage of sewers and inspection chambers. The rate of household connection was of 85% and 59%, and, even among householders that had their houses connected, there were users bypassing their inspection chambers to the surface water drainage channels.

In Tamarineira, the maintenance conditions of the sanitation system seem better than that of the two other systems discussed above. This system has been functioning for over five years, and, in spite of COMPESA also having not yet assumed the system, the community accepted their role in the maintenance of the condominial sewer and is developing this task satisfactorily. Therefore, the main operational problems in the Tamarineira system are related to the main sewer.

The case of this system illustrates well a problem that may be caused by bureaucracy. URB claims that it has been five years since it sent the documentation necessary for the transference of responsibility to COMPESA. In reply, COMPESA states that have had never received a request from URB. Regardless of which institution is providing the most accurate information, the fact is that has been 5 years that the system is functioning without an official operator.

4.6.11. Model 6: Rejection Situation

The sanitation system in the ZEIS of Coronel Fabriciano went into operation in 1993 (over seven years ago). This system was designed as an isolated system having a communal septic tank unit for the treatment of effluents. During the implementation phase, URB provided the house connections for 100% of the residences.

COMPESA had rejected the operation and maintenance of this system because of the location of the treatment unit. The system has its septic tank located within the playground of a local school. This position has led EMLURB to solve the main operational requirements of the system. However, this latter company has no experience in the maintenance of sanitation systems and the residents are dissatisfied, with approx. 54% of the householders classifying the maintenance of the main sewer as "bad".

In summary, the PREZEIS programme is a very important channel for community participation, allowing not only the communities to express their needs, but also to be involved in decisions and to participate in the execution of programmes. However, the effectiveness of this participation is not easily achieved and seems to depend largely on the charisma of community leaders.

The rules set out for condominial projects were not always followed either by the implementing agency (URB-Recife) or by the residents. For example, the residents seem to lose motivation to carry out maintenance of the condominial sewers. URB, on the other hand, is constantly changing its position on the execution of household connections. This undefined situation adversely affects the residents in a community, as well as those of other areas participating in similar programmes. Therefore, a revision of the rules for division of the responsibilities would be worth undertaken (changing the objectives that have not been accomplished and creating mechanisms to increase the effectiveness on the execution of the responsibilities).

Moreover, reports suggest that educational programmes only existed during the implementation phases of the system. However, to achieve behavioural changes, leading to a better utilisation of the programme, continued actions on the delivery of educational messages are clearly needed. Another aspect worth considering is the long period of transition, in which URB concludes the implementation and COMPESA does not starts the O&M, results in a gap in the continuity of the programme. This discontinuity, at the beginning of the operation phase, leads to a lack of both motivation and reliability on the functioning of the implemented technology.

4.7. Case Study 6: SISAR Programme (Ceará)

4.7.1. Introduction

The focus of this case study is on a sanitation programme, initiated in November 1992, aiming to deliver safe water and appropriate sanitation to rural villages in the Northern area of the State of Ceará - NE of Brazil (Figure 4.1).

Out of the regions of Brazil, the Northeast is the poorest one, presenting the highest rates of infant mortality, malnourishment and illiteracy in the country (Section 1.2.1.). The rural areas of the state of Ceará are representative of such a picture. The employment opportunities are limited and the main economic activities are usually crop plantations (basically domestic production), fishing and crafts (usually done by women and children).

The areas included in this programme usually have a health centre (with a "visiting" doctor on a weekly basis) and a primary school. The typical sanitation conditions prior to the implementation of the systems were of water collected from shallow wells (or nearest watercourse) and excreta buried or deposited in the backyards.

4.7.2. Background

➢ **Objectives**

This programme became known as the Rural Sanitation Programme of Ceará having as its main target the delivery of water and sanitation systems to rural communities through a "self-sustainable model". According to CAGECE (The Water and Sanitation Company of Ceará), the implementation of this sanitation programme had three main objectives:

- The recovery of citizenship;
- The reduction of water and excreta-related diseases; and,
- The improvement of the community's quality of life.

➢ **Adopted technologies**

The communities under this programme received both water supply and sanitation systems. The basic water supply systems were constituted by:

- Water source (90% wells with macro measurement);
- Minimum provision for water treatment (chlorination);
- Distribution reservoir; and,
- Household connections (100% measured).

The sanitation projects were based on two solutions: individual projects where the houses were located well apart or did not have a favourable topography (household level much below sewer level), and sewerage for areas with a higher population density.

The individual sanitation projects consisted of septic tanks followed by an anaerobic filter and the final infiltration of the effluent into the soil. The technology adopted for sewerage systems was the backyard condominial sewerage, and treatment was based on either waste stabilisation ponds or communal septic tanks.

Bathroom units were also provided for every residence. Its superstructure were made in precast concrete panels and located at the back of the plot.

➢ **Selection of the sites to be benefited**

The areas that received the programmes were geographically limited to the Northern part of the State (the region of Sobral). For their selection, a population size criterion was primarily used: the sites had to have between 250 and 3,000 inhabitants. The other requirements that the sites had to comply with were:

- Availability of water in sufficient quantity and adequate quality;
- Availability of electricity; and
- Existence of some level of community organisation.

By the end of this process, 45 districts were selected to take part in the programme.

➢ **Institutional arrangements**

The donors of the programme were: the Government of the State of Ceará (represented by CAGECE); KfW (a German Bank – Kreditanstalt für Wiederaufbau – as the financing agent); and the Federal Government (as the financial guarantee institution). Four main stakeholders were identified: CAGECE (as the responsible technical agency); the district prefectures (responsible for the payments of the electricity bill and the salary of the person operating the system); a German consulting firm (Kittelberger); and the residents' associations (indispensable for the development of community participation activities).

After 1996, SISAR (an institution to represent the community associations in the management of the sanitation programme) was created and became responsible for the management and O&M of the systems. Therefore, after the creation of SISAR, CAGECE assumed just a supportive role.

➢ **The implementation phase and community participation**

The implementation phase of the programme was launched between Nov 1992 and Jun 1997. The projects were designed by CAGECE and for construction a self-construction scheme was initially considered (using the labour of householders); however, having in mind that a day out of the householders from their usual activities might aggravate their already high level of poverty, CAGECE decided to hire a construction company to build the systems and encourage it to employ local workers as much as possible.

A consulting firm (AcquaPlan Consulting) was contracted to develop the activities related to community participation. The social activities were developed in parallel to the construction work and the aspects prioritised were:

- ***Community mobilisation:*** the community participation team started helping the areas without an established Residents Association to become organised, and then the planned activities were introduced; these were: presentation of the programme, explanation of the technology adopted, users' responsibilities and agreement on the rates to be charged for the service.

- ***Environmental and sanitation education:*** delivery of messages on the proper utilisation of the systems, hygiene habits and adequate storage of water.

- ***Training of personnel for the operation of the systems:*** The householders were invited to nominate three persons to attend a training course on the operation of the systems. The requirements for this were that the persons must: live in the community; be able to read and write; have good relationship and reliability; and be nominated by the community itself. The best qualified in the course was employed as the local operator receiving a salary of one Brazilian minimum wage to be paid by the local prefecture. The responsibilities of the operators were basically to keep the system units clean, operate the pumps, check the treatment units, solve blockage problems in the sewers and read the water meters.

Regarding the O&M of the systems, the operators performed the daily and simpler activities; however, until the beginning of 1996, CAGECE was the main organisation responsible for the system. The company provided the material necessary for its operation, spare parts and all technical assistance that the systems would require.

A charging policy for the system was considered a fundamental issue for the "sustainability" of the programme. Nevertheless, householders were expected to resist paying for these services due to the common vote-catching practice of local politicians ("vote for me for free water and sanitation"). Thus, the tariff value was negotiated and gradually introduced (Table 4.14.).

Table 4.14. – Tariff values for the SISAR programme

Date	No. of systems in operation	Value of the tariff (R$ per month)	Consumption limit (per month)
Jul 1994	15	0.70	unlimited consumption
Dec 1994	18	1.14	unlimited consumption
Dec 1995	37	2.15	*initially 5,000 l and then rise to 10,000 l

*Additional tariff charged for exceeding consumption.

➢ **The SISAR organisation**

Considering that the programme was designed to be self-sustainable, SISAR – a Portuguese acronym for Rural Integrated Sanitation System – was created to manage the systems. The essence of SISAR is to organise the districts – which have similar sanitation projects, as well as, social/economic characteristics – into an association that not only represents them, but is also managed by them. Providing, therefore, a stronger structure for the physical sustainability of these small sanitation systems.

Figure 4.59. – The SISAR flow diagram

As shown in Figure 4.59 (above), SISAR comprises:

a. The **General Council** is composed of 1 representative from each householders association;
b. The **Administrative and Financial Council** is composed of 12 members: 7 from the householders associations; 3 from the prefectures; 1 from CAGECE; and 1 from KfW (represented by the German consulting firm Luso Consult).
c. The **technical sector** is composed of 8 people: 1 coordinator; 1 engineer, 1 maintenance technician, 1 social technician, 1 financial technician (treasurer) and 3 field workers.

Excepting the coordinator of the technical crew, who is designated and paid for by KfW, the other members of the technical sector have their salary paid by SISAR through the money collected from the tariff for usage of the systems. After the establishment of SISAR (1996), the value of the tariffs has been defined annually by a general assembly. The systems have then been charged as follows:

- residence = R$ 3.50 (10 m^3/month)
- commerce (big premises) = R$ 4.70 (10 m^3/month)
- commerce (small premises) = R$ 1.20 (10 m^3/month)
- public = R$ 4.70 (10 m^3/month)

The users have their water meters read by the local operator, who tells them how much their bill will be and the treasurer collects the tariff at each locality. By the time of the field survey (Jan/2000), the tariff was based solely on the water consumption without any additional charge for sewerage; however, an update of the survey in December 2000, showed that the water bills were about to be increased (from 15/12/2000) and a sewerage tariff was being implemented. Therefore, the new charging system adopted for residences is now as follows (values per month):

Residences just served by the water system	Residences served by both water and sewerage systems	Residences just served by the sewerage system
R$ 4.00*	R$ 4.50*	R$ 1.50

* For residential water consumption up to 10 m^3 per month

The amount collected from the tariff is the only regular income received by SISAR. From this, a contribution to each residents' association is also made, as follows:

- Districts having up to 100 water connections = R$ 35.00
- Districts with more than 100 water connections = R$ 60.00

This contribution is to be used for small expenditures on the sanitation system, such as for telephone calls to the SISAR office, to buy cleansing material, small repairs (i.e. change light bulbs), etc. Some residents associations also add a charge of between R$ 0.50 and 1.00 per household per month to create a reserve fund for the association.

In order to empower SISAR and stimulate the districts (residents' associations) to join it, CAGECE stopped giving technical assistance to the systems. However, not all of the 45 districts that participated in the sanitation programme decided to join SISAR; 13 of them opted to manage their own systems independently and others decided to leave afterwards. Therefore, SISAR is now being composed by 27 districts (5,249 household connections).

A second phase of the programme (SISAR II) is currently being implemented. This time, however, the programme has the objective of attending areas located in the central part of the State, and, the SISAR I office is preparing a second maintenance crew to attend the 11 new districts of SISAR II.

4.7.3. The Areas Studied

Among the districts that received the sanitation programme, four were selected to participate in this study, they were:

- ***Serrota:*** This district is located at approx. 287 km Northwest of the city of Fortaleza – capital of the Ceará. The last 23 km is along an unpaved road and there is no regular public transport. Serrota has 203 houses with the majority of them concentrated in the highest (topographically) part of the area.
  The water supplied by the programme is collected from the dike Tucunduba, which is located about 300 m from the central point of the district (church square), this dike is also an important supplier of fish for the householders.
  Serrota has a residents' association that is being criticized by a dissident group; however, in the last election (Jan/2000) there was no opposition candidate and the group already in charge of the association was re-elected.
- ***Panacuí:*** The best access for the district of Panacuí is passing through the district of Serrota (above). However, the 10 km that separates the two districts is on a very badly maintained unpaved road, which is not possible to drive through during the rainy season. As in the case of Serrota, Panacuí is also located by the border of the dike Tucunduba (also the source of water for the water supply project). This district has 175 houses and the residents' association has been run by the same president for years without significant dissatisfaction among the householders.
- ***Parapuí:*** This district is located in the municipality of Santana do Acaraú, approx. 20 minutes by car from the city of Santana do Acaraú. In spite of the road giving access to the district being unpaved, Parapuí has a better-maintained and safer access than the two previous sites. The district has 220 households and the main economic activity is small-scale agriculture.
  The water used to supply the district is pumped from a deep well and the wastewater is treated in two waste stabilisation ponds. The residents' association has as its president a young woman who seems to be a strong

local leader. The main difference with this association is that it decided not to join SISAR and is managing its sanitation system independently.

- ***Juritianha:*** Located in the coastal area, this district has a much easier access than the areas described before, having a paved road crossing the site. It is part of the municipality of Acaraú and its population is approx. 1035 people. Fishing is one of the main economic activities of the district, which also has a better commerce than the other areas studied. Another important activity is making handmade lace, which is made by women and girls to supply the tourist market in the State capital.
  The water supplied is pumped from a deep well and the wastewater is being treated in a waste stabilisation pond or in a communal septic tank. The residents' association has just elected a new president, but the ex-president, who is now a local councillor, still has a strong participation.

4.7.4. Study Methodology

The data collected from the four areas studied (Panacuí, Parapuí, Serrota and Juritianha) were based on: **the project documents** (supplemented by informal interviews and visits to the projects units), and a **survey questionnaire.**

During the **study of the documentation,** information was collected on the institutional arrangements, on the project costs, the technical parameters applied and the social/educational activities developed. For the **survey,** the whole community was considered the target population and the questionnaires were applied in a sample of households selected systematically. The sample size for each area was: Serrota, 15%; Panacuí, 10%; Parapuí, 14% and Juritianha, 17.5% (N=30, 12, 31 and 36 respectively).

The questionnaire (Annex 8) comprised the following sections:

Section I - Identification / Social Economic Aspects
Section II - Participation of the community in the Programme
Section III - Technology Usage, Functioning and Satisfaction
Section IV - Health and Educational Programmes

4.7.5. Design of the Sanitation Units

➢ **The septic tanks**

The septic tanks, adopted for the houses that were located topographically out of the area attended by sewerage, followed the design presented in Figure 4.60.

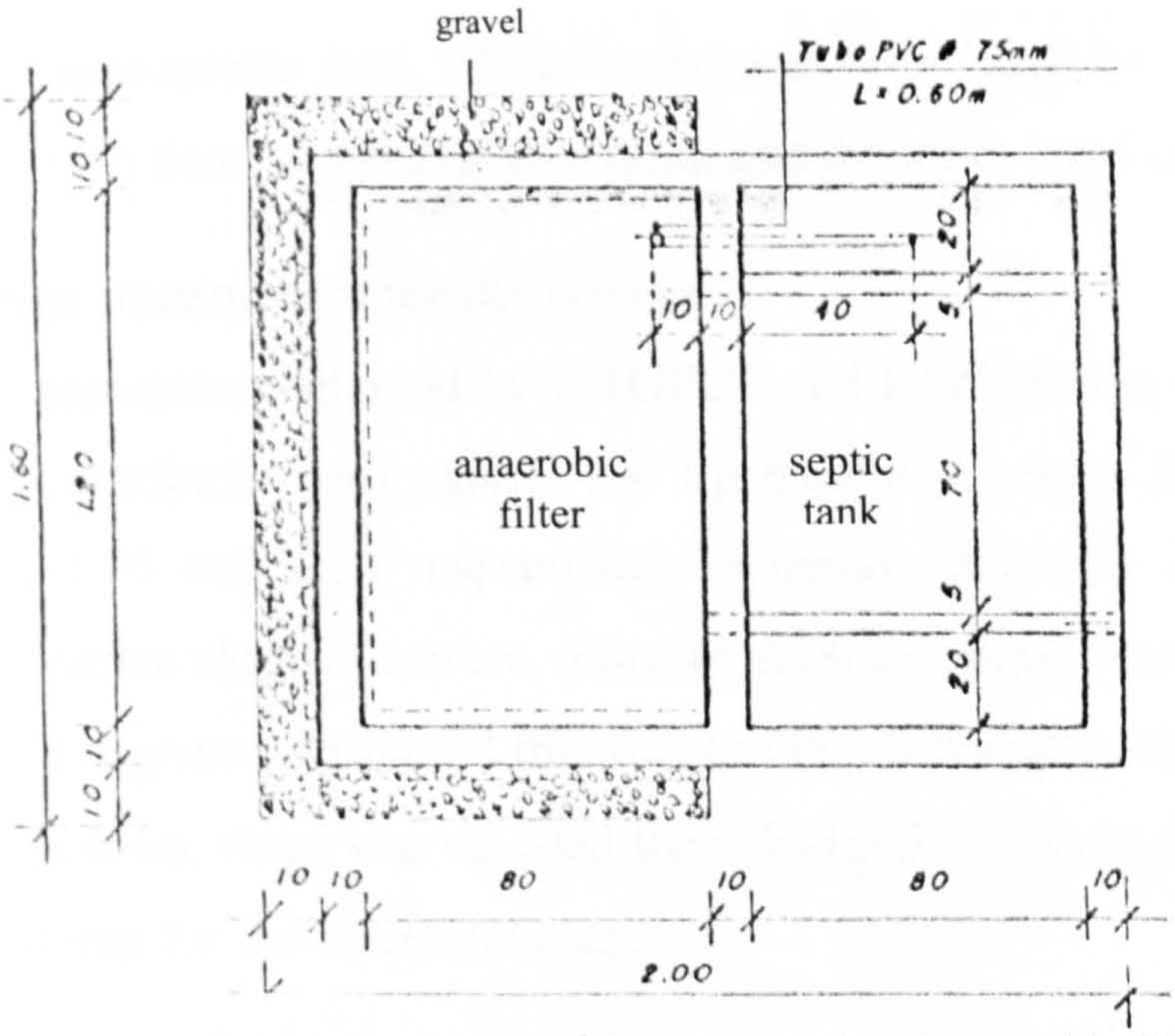


Figure 4.60. Dimensions of the septic tank and anaerobic filter (in cm).

➢ The condominial sewerage connections

The bathrooms constructed in the households in the area served by the condominial sewerage were connected to the network through inspection chambers, as illustrated in Figure 4.61.

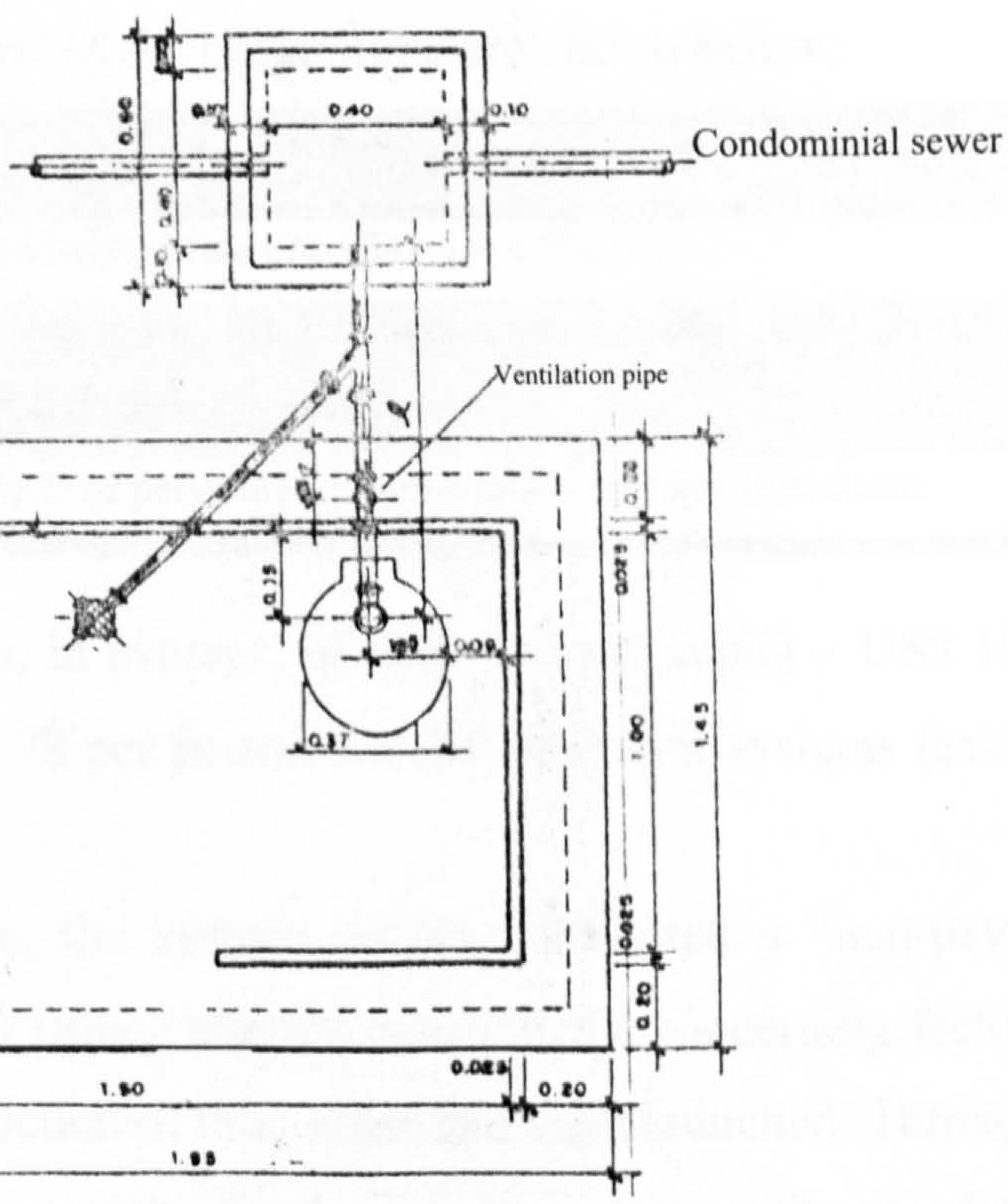


Figure 4.61. Bathroom connected to the condominial sewer through the inspection chamber

➢ The bathrooms

Independently of whether the sanitation option was an individual solution or sewerage, a bathroom was constructed for each residence that did not have the facility or had an inappropriate unit. These bathrooms were built in precast concrete panels having a wooden door, a water-sealed drain and the toilet bowl (see Plates 4.65 to 4.67).

➢ **The design parameters for the sewers**

The parameters adopted by CAGECE and KfW for the design of the sanitation units were: contribution per capita, 100 l/person*day; return factor, 80%; coefficients K_1 and K_2, 1.20 and 1.50 respectively; minimum diameter of condominial sewers, 100mm; minimum slope of sewers, 5‰ and minimum cover to soffit, 40 cm.

The designers considered that due to the small size of the communities (smaller than 2,000 people), there was no need for a detailed hydraulic design of the sewers and adopted 100 mm for the entire network.

➢ **The wastewater treatment plants**

The waste stabilisation ponds were designed as facultative ponds considering a BOD contribution 45 g/person*day, a surface loading of 350 kg/ha*day and a maximum depth of 1.50 m.

4.7.6. Project Costs

The financial resources applied in the programme are shown below:

Institution	Quantity	Restrictions
KfW (loan)	US$ 8.4 millions	5 years interest rate (90-95) – i = 4.5% p.a.
KfW (donation)	US$ 1.5 millions	Exclusively for the payment of a German Consultant Group, during the implementation stage.
Ceará State	US$ 2.5 millions	For costs of personnel, transportation and administration.

The cost of the systems was, in average, of US$ 183 per capita – US$ 105 for the water supply systems and US$ 78 per person for the sanitation systems (exchange values from January 1999-URL 21).

As to the charging scheme, the system initially presented a "non-payment" percentage of 55 to 60%. This high value certainly constitutes a concerning factor and, therefore, a programme for the reduction of this figure had been launched. Through this programme, the community that presents the lowest "non-payment" rate during a semester is awarded with R$ 250.00 (US$ 126) in materials to be used in the water and sanitation systems. It has also been organised events (a football competition) among the four districts with lower rate of non-payment (see a report in the SISAR informative paper – Annex 9).

Plare 4.65. A bathroom unit

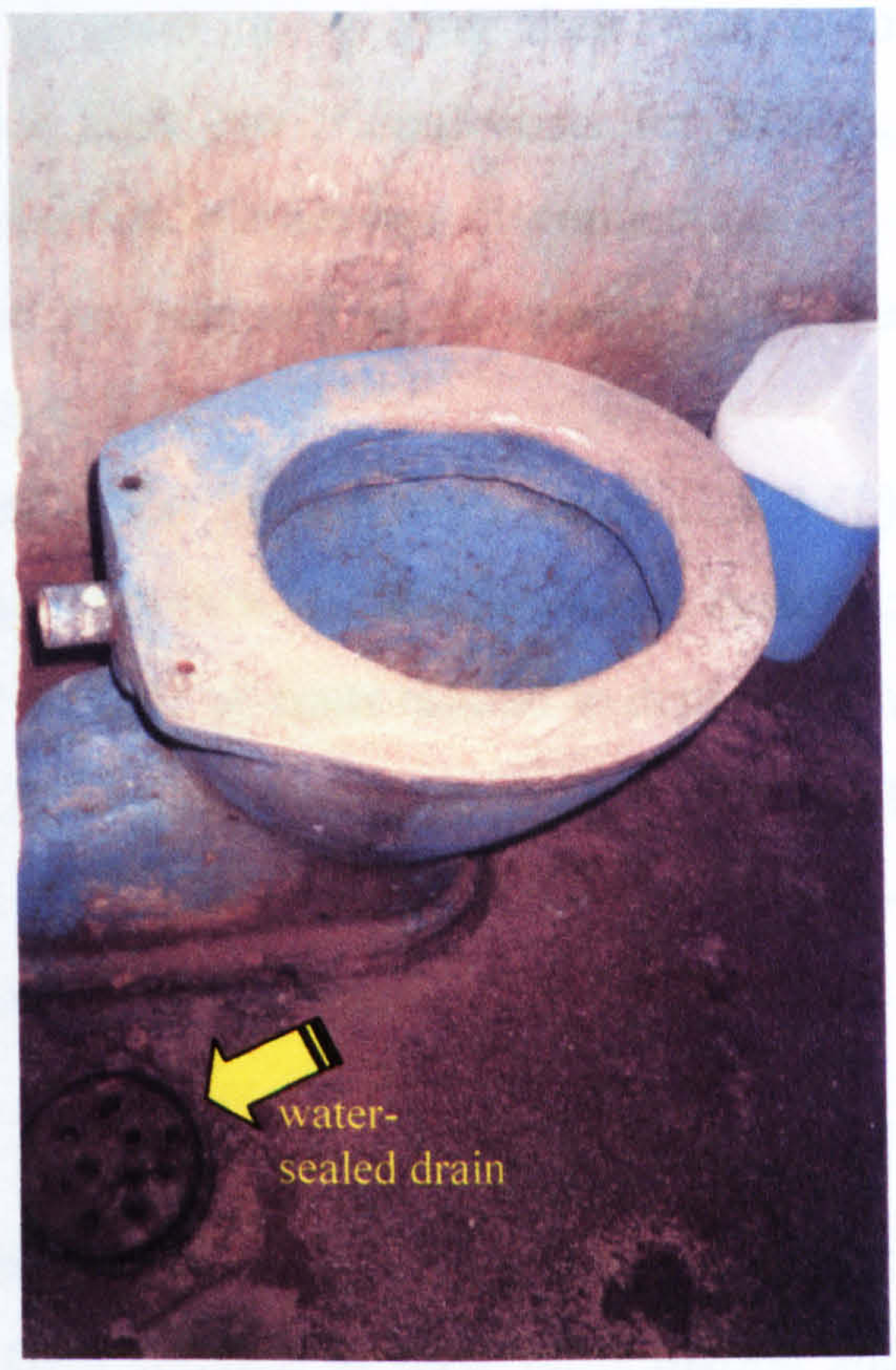


Plate 4.66. The toilet bowl and drain

Plate 4.67. A septic tank/bathroom unit

Another action to reduce the number of users not paying their bills is to disconnect the service. However, this represents high operational costs for SISAR, which has to provide personnel transportation and training in service disconnection.

The last figure obtained for non-payment rate was that in November 2000, the value reduced to 37% (average among all 27 districts).

According to SISAR's technical consultant, the former tariff value (R$ 3.50) was "sufficient" to just cover the operational costs of both water and sanitation systems; however, it is still not "sustainable" in terms of coverage of costs related to depreciation and preventive maintenance. In fact, the average maintenance costs for the months of Jul-Aug/2000 (considered a typical period) was R$ 21,100.00 (an average of 4 reais – US$ 2.20 – per household) for both water and sanitation systems.

4.7.7. Institutional participation

A point of concern in the institutional arrangement of SISAR is the participation of the prefectures. They, in general, have not been reliable in their participation and fulfilment of their responsibilities towards the programme (see page 186).

In December 2000, just one prefecture (responsible for the district of Cruz) was fulfilling its agreement to pay the electricity bill for the system operation and the salary of the local operator. Another one (responsible for the district of Cruatá) was covering just the energy costs. For all the other districts SISAR was covering the costs of the salary of the local operator, and some of the districts were charging the users with R$ 0,70 in order to cover the energy costs and guarantee continuity of the service.

Moreover, some of the prefectures are among the "non-payers" users, i.e. not paying the water bill of public institutions such schools and health centres.

4.7.8. Field observation

➢ **General aspects of the areas**

The four areas studied present similar characteristics with respect to both physical layout and householder's habits. The presence of women and girls contributing to the domestic income through the production of handicrafts was very common.

➢ **The Serrota and Panacuí districts**

Serrota and Panacuí are districts located by the embankment of the dike Tucunduba, which is the source of water adopted by the programme for both districts

(Plate 4.68). The water treatment in each district is composed of slow sand filtration and chlorination (Plate 4.69). The treated water is stored in reservoirs and then distributed to the network. In Serrota, the water is also delivered to a public fountain that supplies a group of houses located away from the centre of the district.

The sanitation systems of both districts are based on condominial sewerage and septic tank units. In Serrota, the system was conceived as one basin that discharges into a waste stabilisation pond. This treatment unit has, in fact, been working as "an open tank" and the surface level has never reached the level of the outlet (Plate 4.70). The Panacuí sanitation system was conceived as three micro-systems, with each one having a waste stabilisation pond (Plate 4.71).

➢ **Parapuí**

The water source adopted for the Parapuí water supply system was a deep well. However, high levels of iron were identified in the water, requiring the incorporation of an aeration device. The treatment plant also has a slow sand filter and a chlorination unit (Plate 4.72). The sanitation system was topographically divided into two drainage basins with each network discharging into a waste stabilisation pond (Plate 4.73).

The Parapuí district manages its sanitation system independently from SISAR. This decision was taken through a householders' meeting in which the president of the association was one of the main proponents for the self-management of the system. The main contributor to this decision was the resistance of householders in transferring the financial resources collected from the tariffs. Thus, the residents' association manages the water supply and the sanitation systems without support from either SISAR or CAGECE. To be able to do that, the association charges the householders the same tariffs as SISAR and relies on the expertise of the local operator, who was trained together with all the others at the beginning of implementation of the programme. The association pays him the same salary that SISAR.

The Parapuí operator seems to be a confident professional and reported that there were no major problems in the O&M of the systems; and, when he needs advice he affirmed that can always contact other operators or the instructors from CAGECE or SISAR. In order to cover costs for spare parts for the system units, for services that cannot be carried out by the operator, or even for contracts for private technical assistance, the Parapuí association keeps a bank account into which is placed the money collected from the tariffs.


Plate 4.68. Dike Tucunduba, the water source for the districts of Serrota and Panacuí


Plate 4.69. The water treatment plant of Serrota (right) and Panacuí (left).

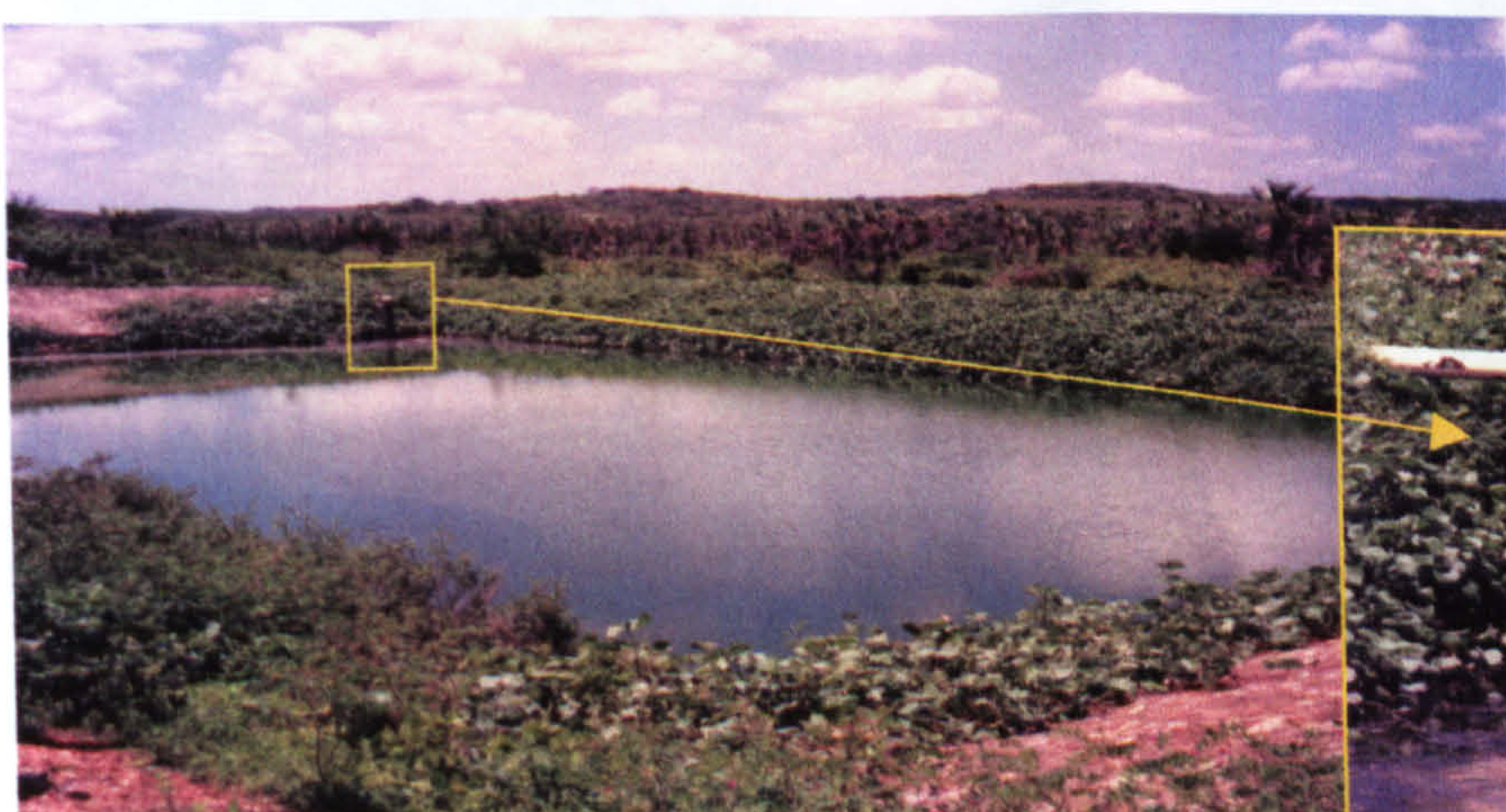
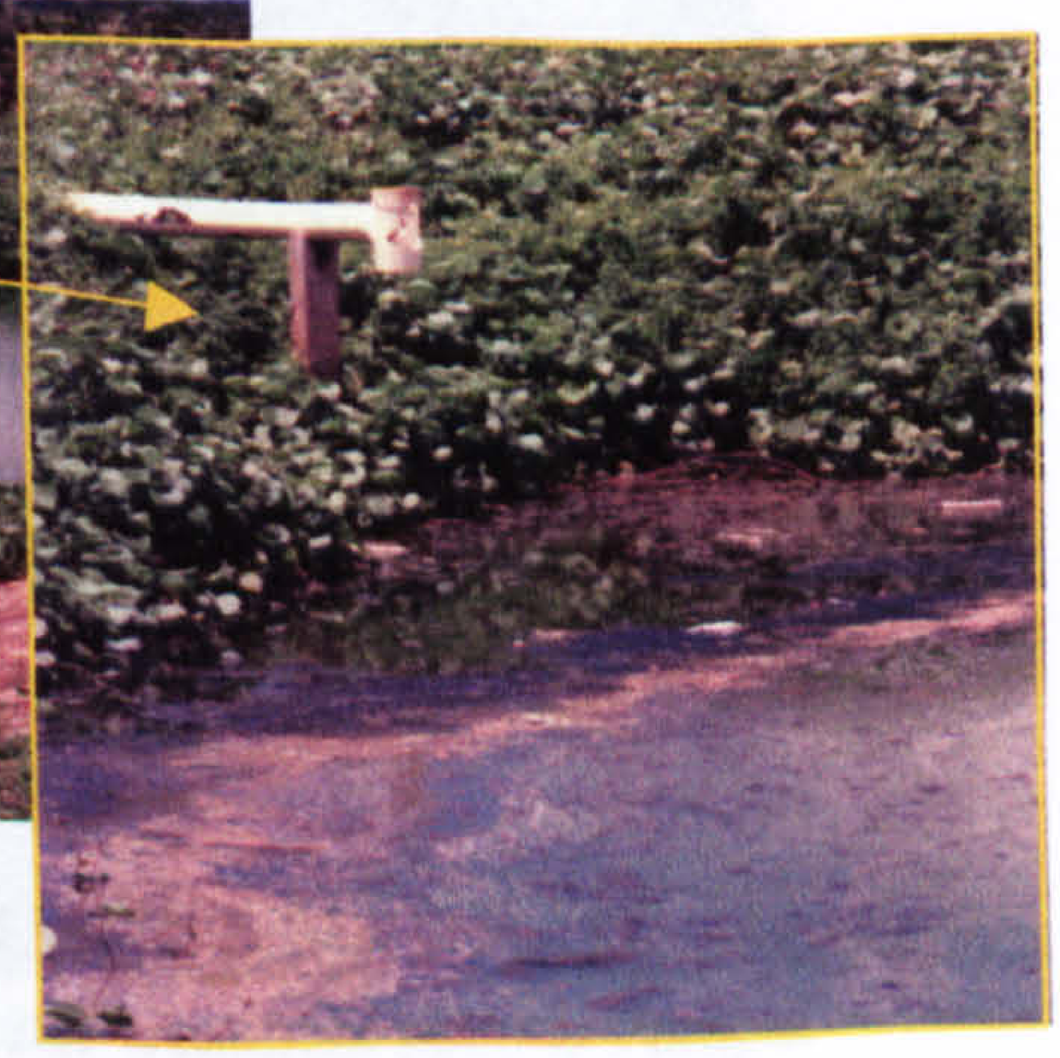



Plate 4.70. Waste stabilisation pond at Serrota, showing Outlet detail

Plate 4.71. The three waste stabilisation ponds at Panacuí.

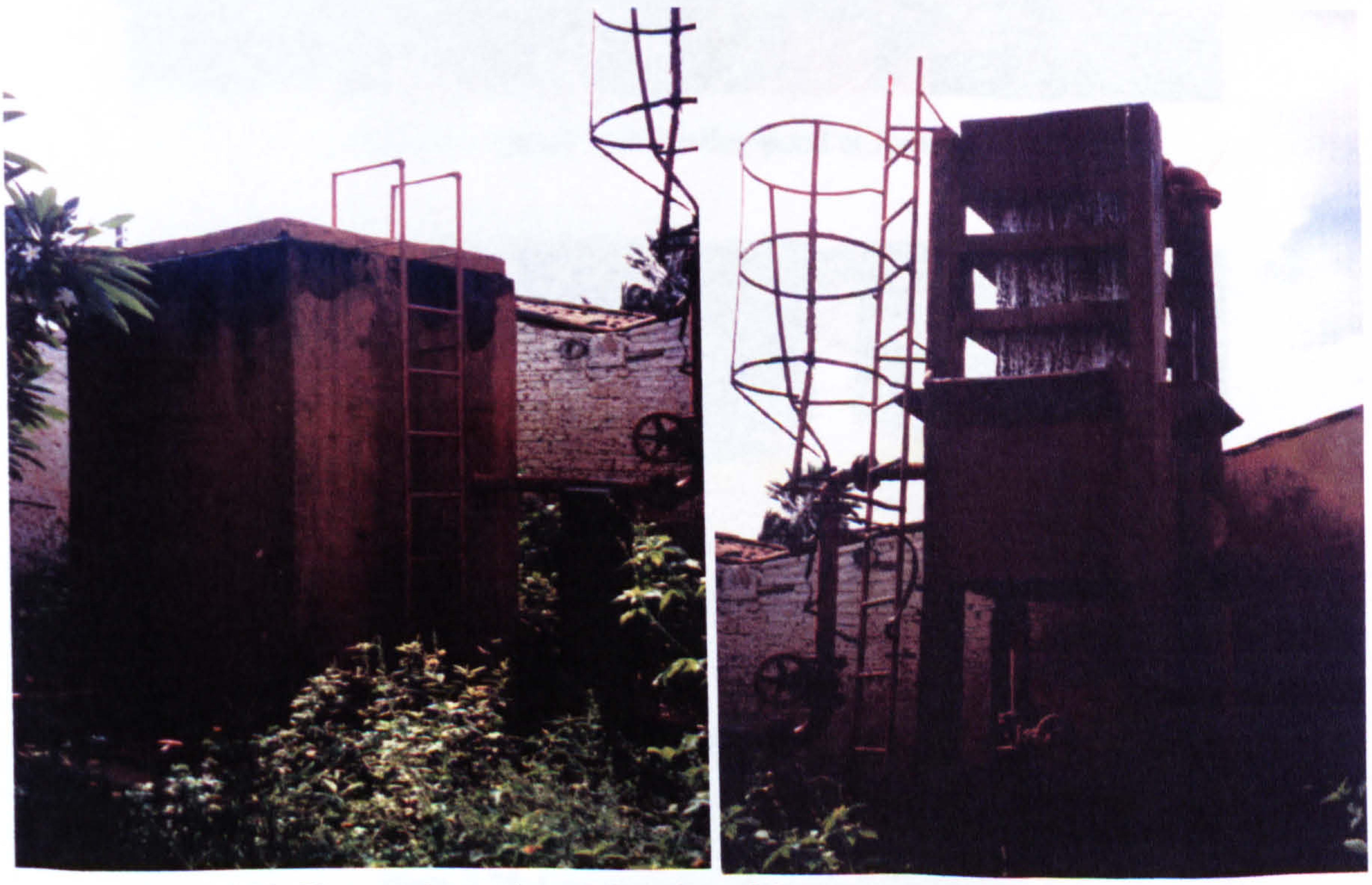


Plate 4.72. The aeration and sand filtration of the water treatment plant at Parapui

Plate 4.73. Waste stabilisation ponds at Parapuí

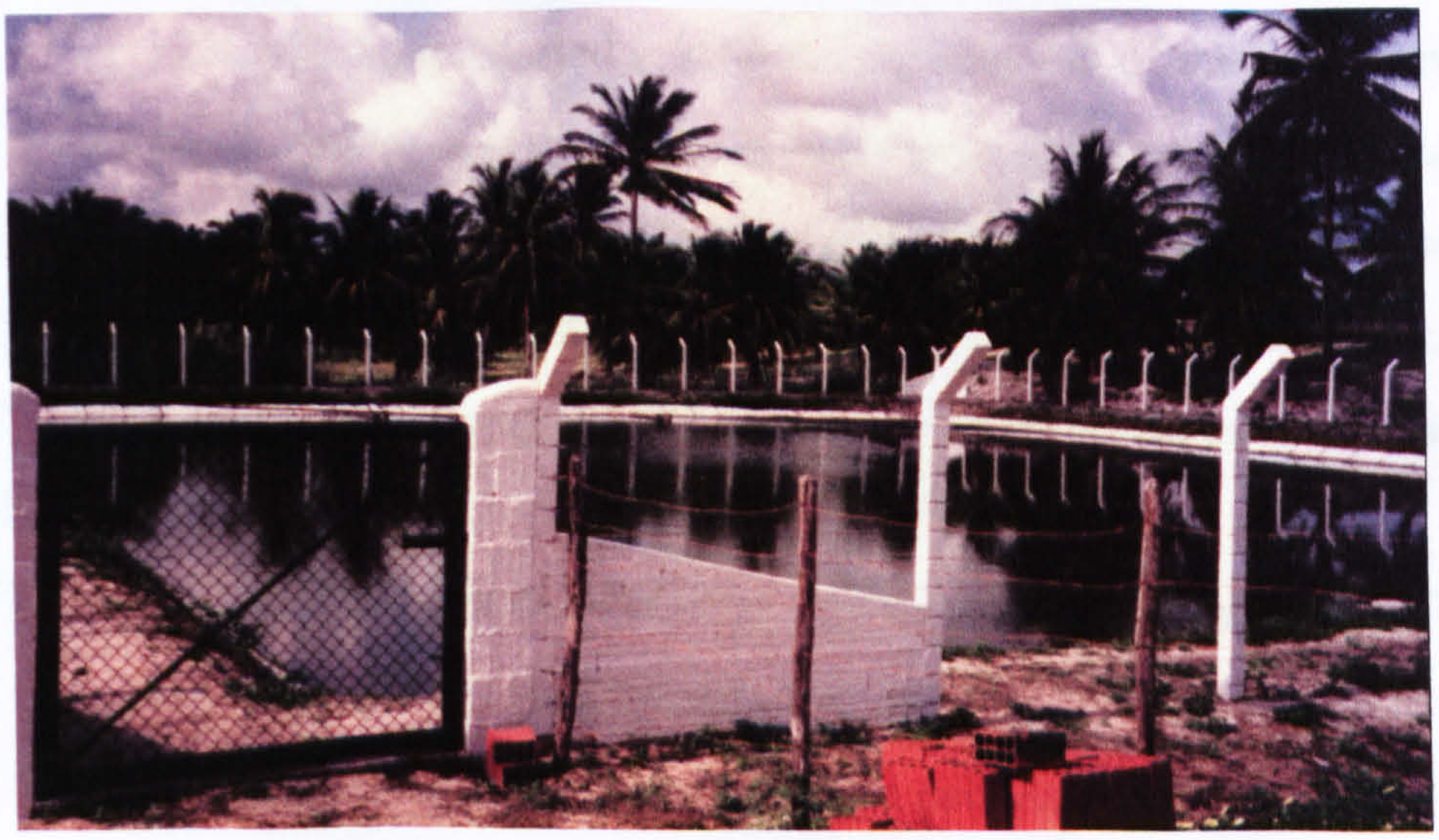


Plate 4.74. Waste stabilisation pond at Juritianha

Plate 4.75. Communal septic tank at Juritianha

➢ **Juritianha**

The district is associated to SISAR and its water supply project followed the basic scheme of the programme: water is collected from a deep well, chlorinated, pumped to a reservoir and then distributed by gravity throughout the district.

As a characteristic of this area, the majority of the households used to collect water from shallow wells through hand-pumps in their backyards. Therefore, for the majority of the community water was always available nearby. In spite of the public health risks of these wells (due to the proximity of latrines and vulnerability from domestic animals - including goats, chickens and horses), the householders reported a preference for the hand-pumped water, which, they say, is tastier than the water supplied by the programme (complaints about the chlorine). Thus, although nearly all the houses had initially received water connections, many continued to use their backyard water for some purpose and then when the water tariff started to rise (SISAR charging policy), householders started asking for the removal of their connections.

The sewerage system was designed as two micro-systems, one discharging into a waste stabilisation pond and the other into a communal septic tank (Plates 4.74 and 4.75). The effluent of the waste stabilisation pond discharges into a rock filter that, during this field study, was being rebuilt due to under-dimensioning (according to the field technician).

The septic tank was not in operation due to a blockage problem. The operator reported that, despite repairs that had already taken place, this unit had never functioned well. In fact, there seems to have a construction problem regarding the level of the tanks. To solve this, technicians were considering two alternatives: the reconstruction of the septic tank unit, or its abandonment (for the last alternative the option for the collected wastewater is to be pumped to the existing waste stabilisation pond).

4.7.9. Survey Questionnaire

➢ **Section I – Identification and Socio-economic Aspects**

The variables measured in this section were: occupation density, property ownership and the time that the families had been living in the area.

The four districts had household occupational densities varying from 4.2 (Serrota) to 5.7 (Panacuí), and the average for the four communities was 4.9 persons per household. The property ownership level revealed that more than 80% of the householders own their homes.

As shown in Figure 4.62, the majority of the families had been living in the houses for more than 7 years and had had, therefore, the chance to take part in the sanitation programme since its beginning.

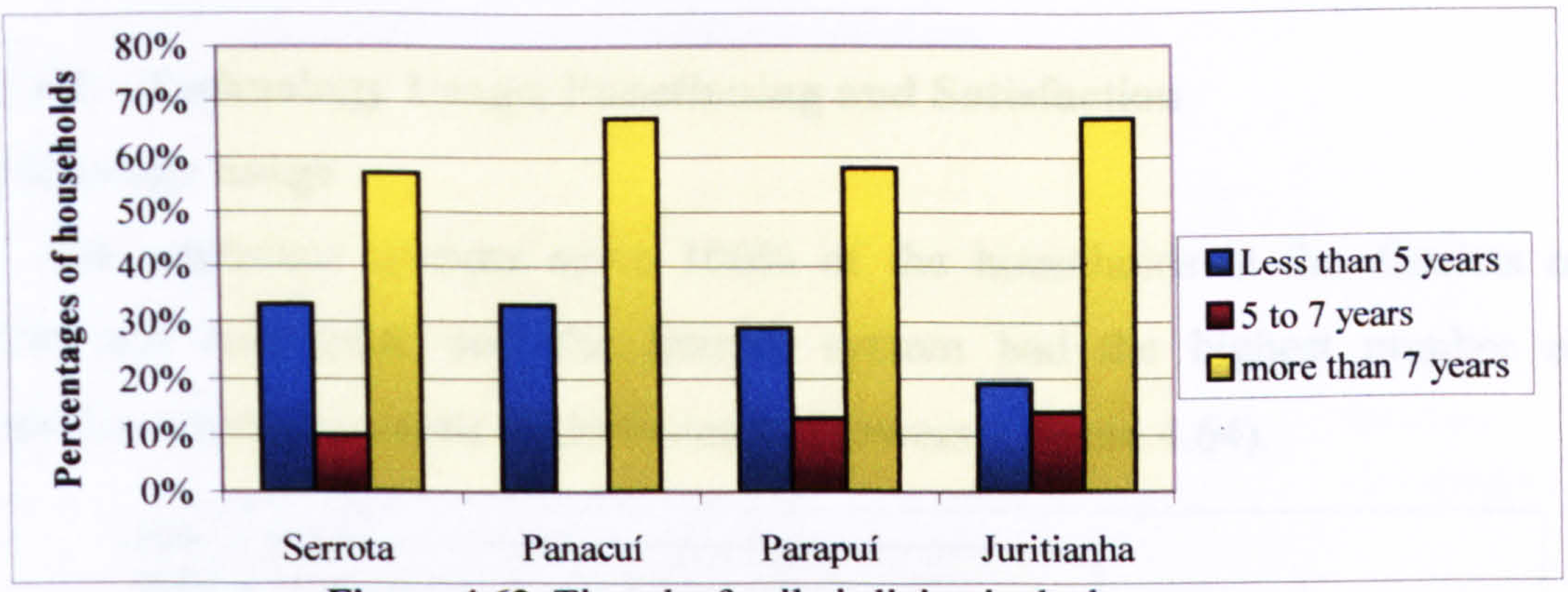


Figure 4.62. Time the family is living in the house

The monthly income for the households was not determined due to the characteristics of these rural villages (the great majority of families have no formal jobs and many of them live from domestic agriculture and fishing). This would have required a more detailed survey, which took into account not only cash incomes but also the cash equivalents of subsistence farming.

➢ Section II –Water Supply

In general, the water supply in the four districts was of a yard tap level and problems with the reliability of the systems were only associated with failures in the electricity supply.

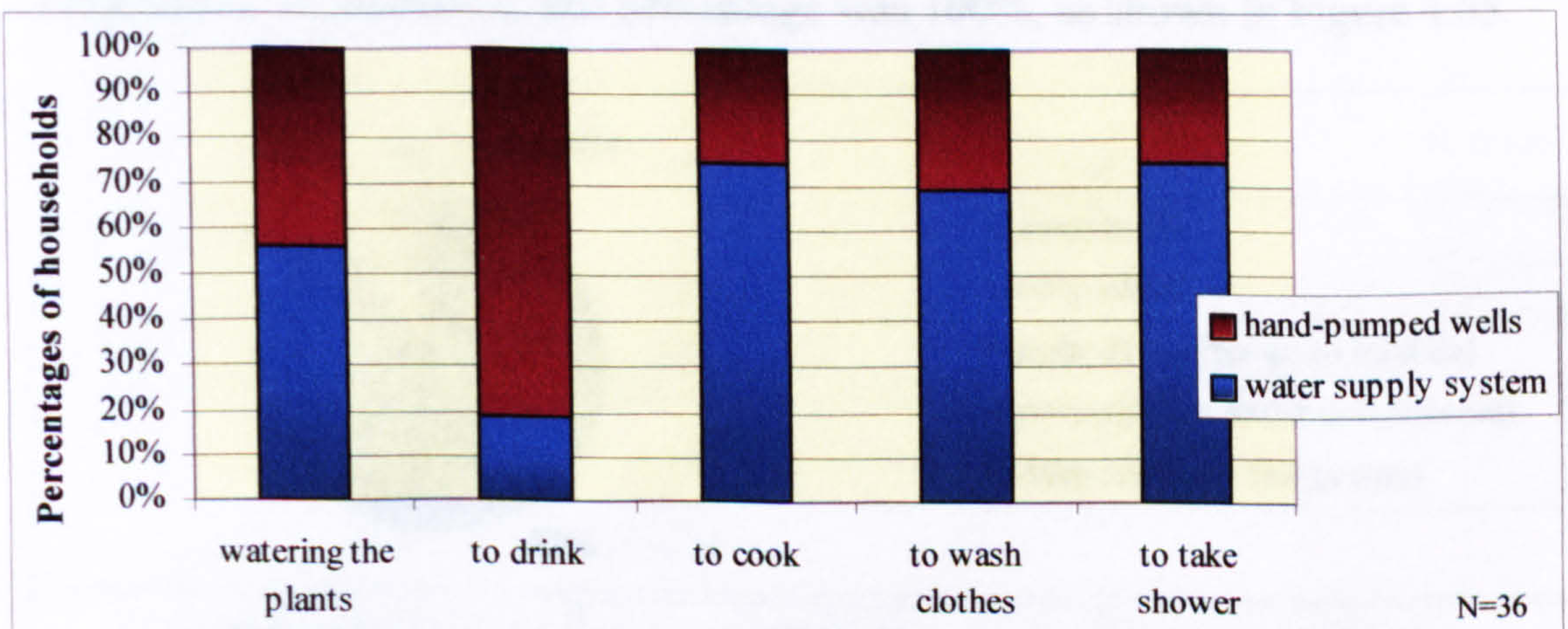


Figure 4.63. – Water usage among households using both sources of supply (shallow wells and treated water from the programme) in the district of Juritianha.

In the district of Juritianha (where householders also consumed hand-pumped water from shallow wells), 6% of the households were consuming water only from the wells, 42% were using solely the water supplied by the programme and 53% of the households were using both the water from the programme and water from the wells. As shown in Figure 4.63, the majority (81%) of the households that were consuming water from both sources preferred to drink the water from the wells and more than 56% used the treated water for watering their garden plants.

- **Section III – Technology Usage, Functioning and Satisfaction**

  - **Technology usage**

The sanitation systems serve 100% of the households in the districts of Serrota and Juritianha, and the Serrota system had the highest number of households served by septic tanks instead of sewers (Figure 4.64).

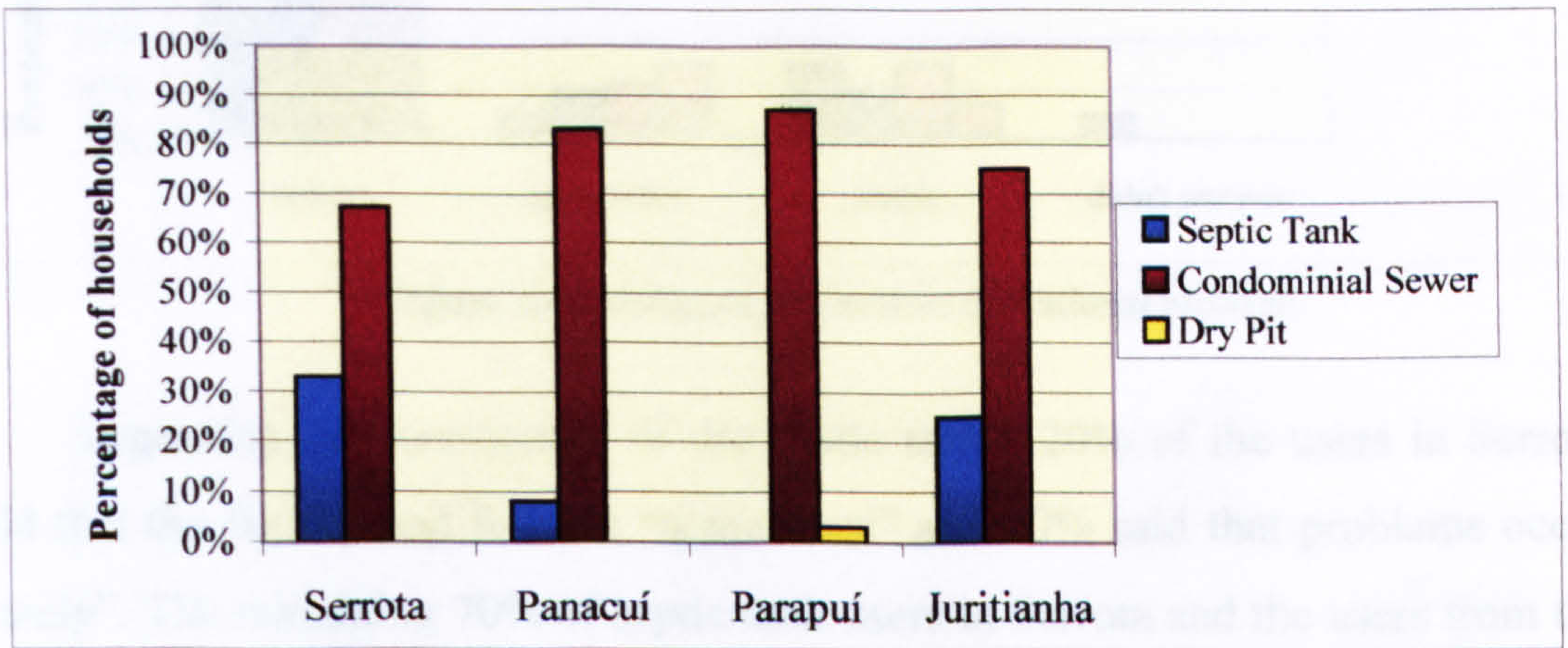


Figure 4.64 – Sanitation solutions used by householders

Regarding the utilisation of the facilities, more than 83% of the householders declared that the whole family uses the bathrooms built by the programme. In Juritianha, this percentage was 100%, as shown in Figure 4.65.

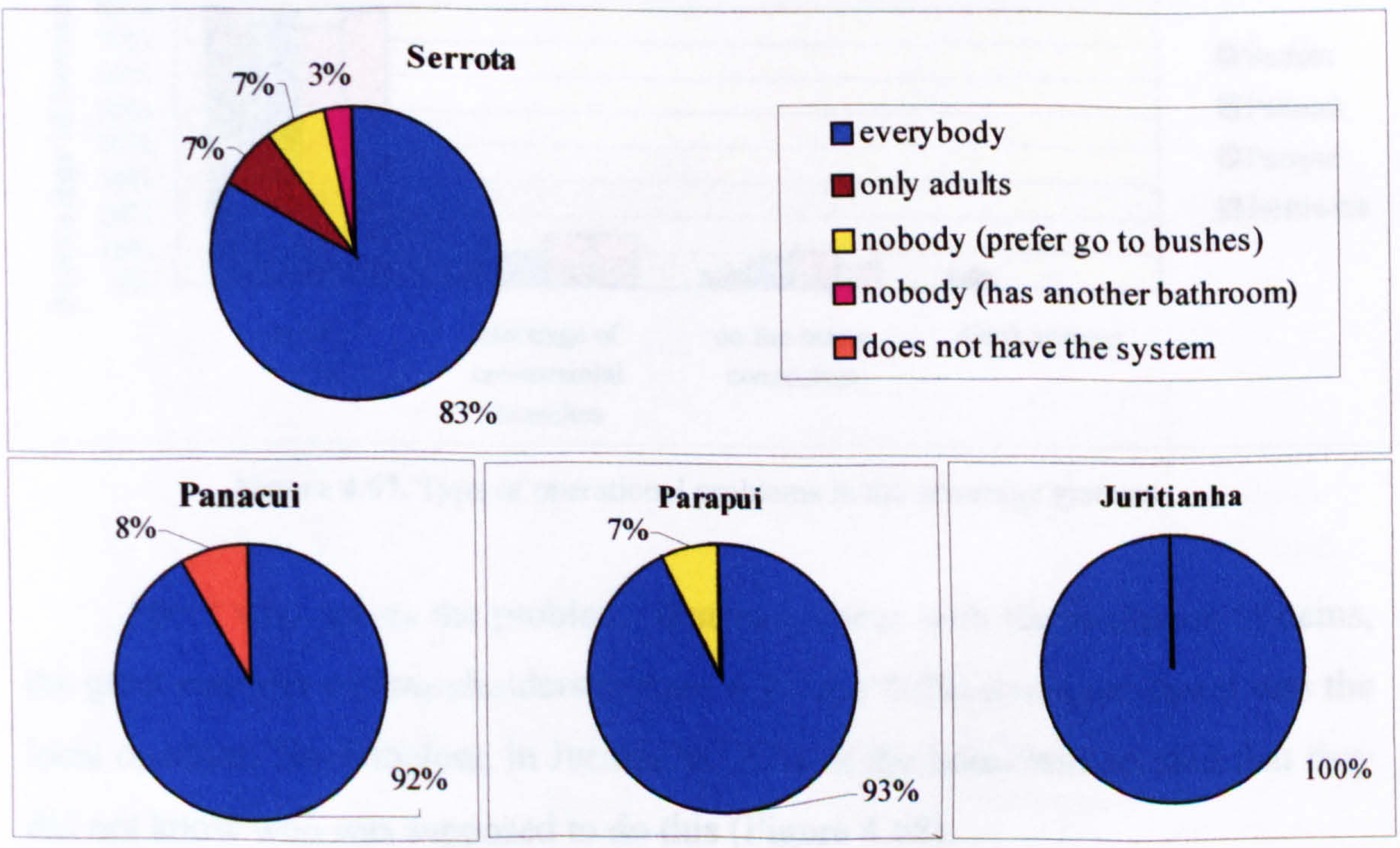


Figure 4.65. Usage of the sanitation facilities

- **Technology functioning**

According to the householders, the occurrence of failures in the condominial sewerage systems was not frequent. As shown in Figure 4.66, more than 70% of the users in the four districts never had any problem.

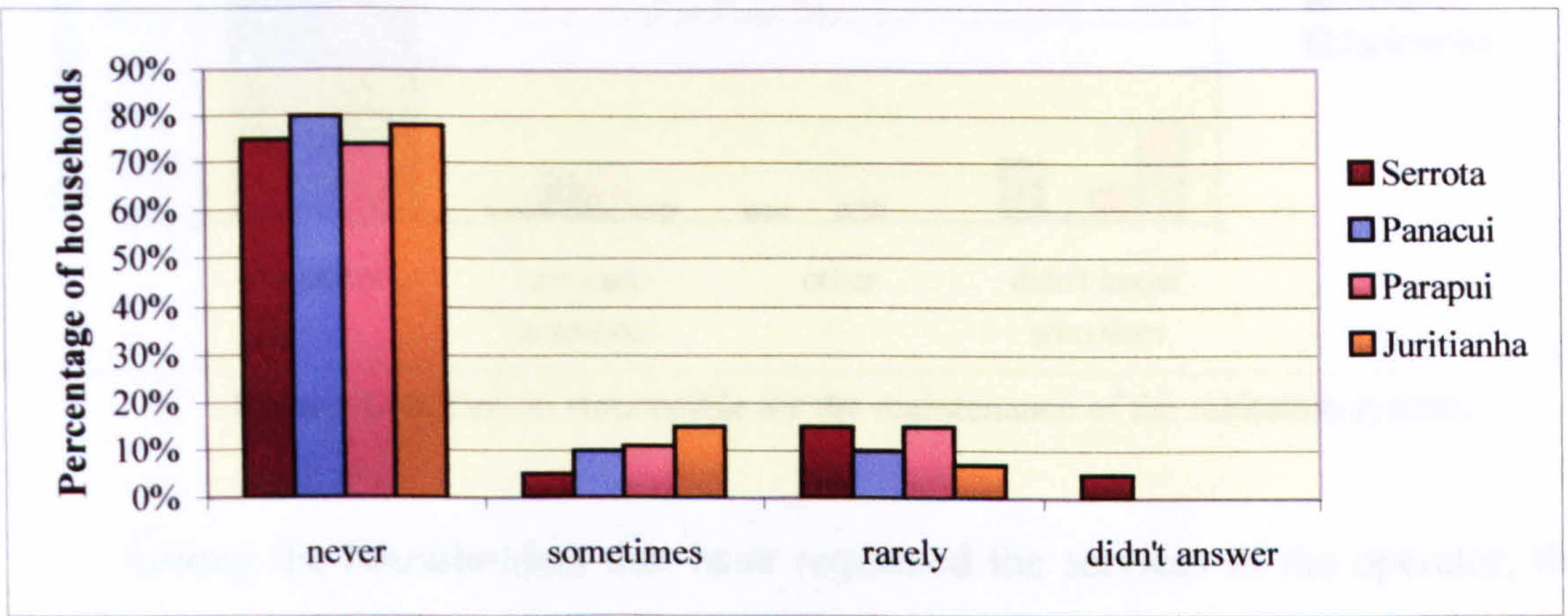


Figure 4.66. Frequency of sewers operational problem

Regarding the functioning of the septic tanks, 20% of the users in Serrota said that the facility had failures "sometimes" and 10% said that problems occur "rarely". The remaining 70% of septic tank users in Serrota and the users from the other districts said that problems "never" occurred.

In the sewerage systems, the type of problems reported was of blockage in the condominial sewers and in the household connections (Figure 4.67).

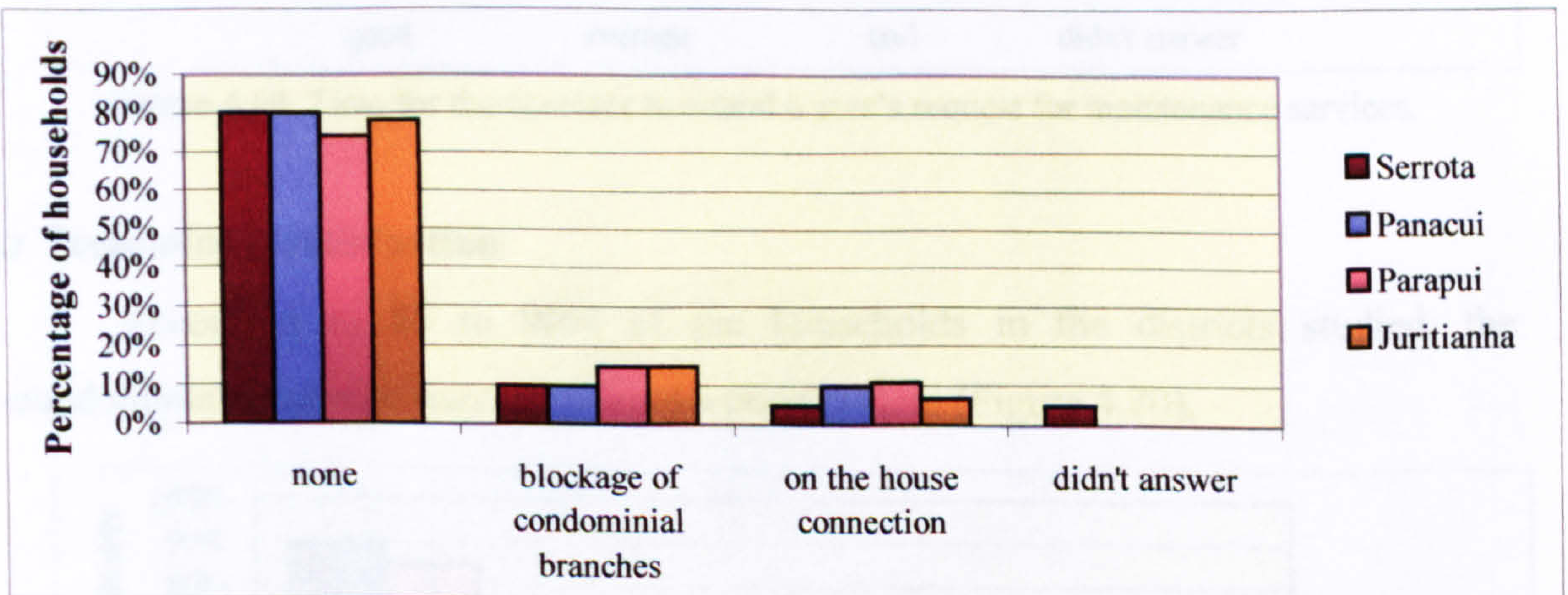


Figure 4.67. Type of operational problems in the sewerage systems

About who solves the problems that may occur with the sanitation systems, the great majority of householders (between 73 and 80%) answered that it was the local operator. Nevertheless, in Juritianha, 20% of the householders said that they did not know who was supposed to do this (Figure 4.68).

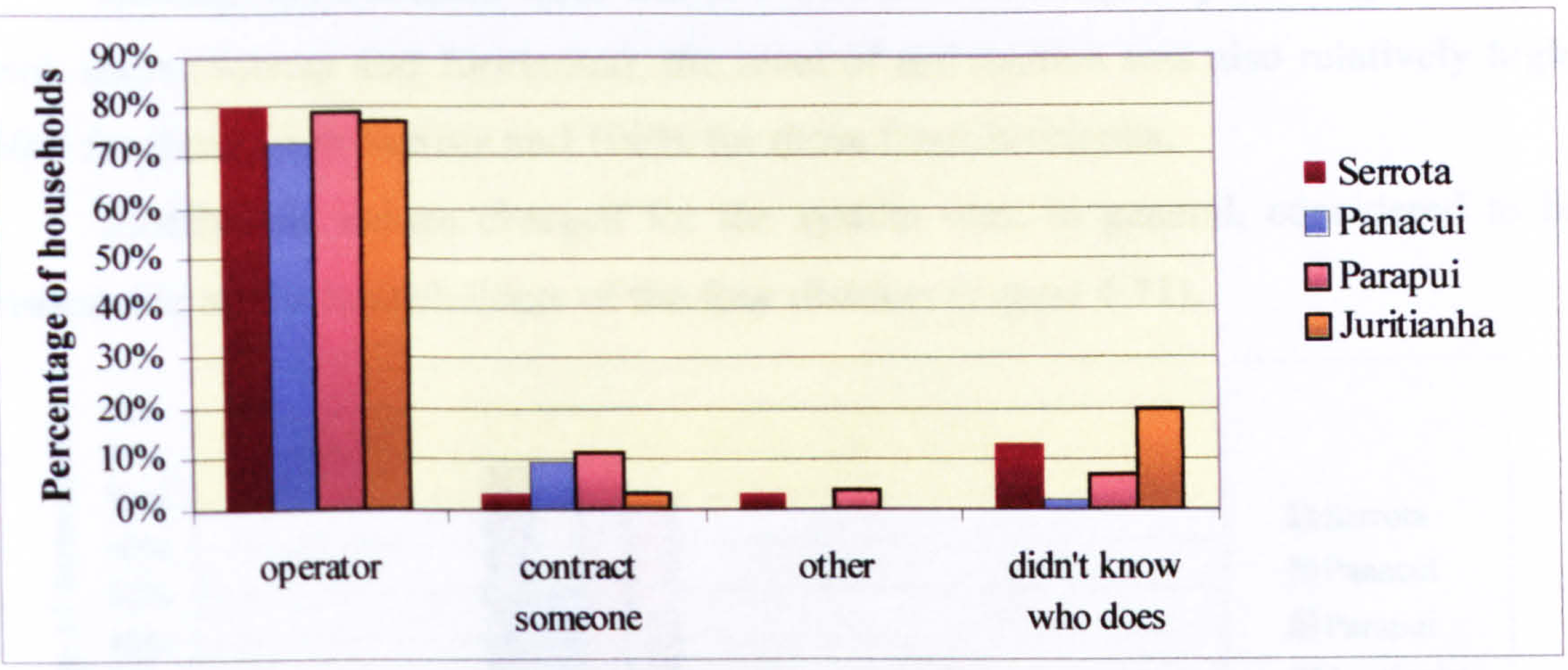


Figure 4.68. Person responsible for the maintenance of the sanitation system.

Among the householders that have requested the services of the operator, the great majority reported an attendance in less than 24 hours (Figure 4.69).

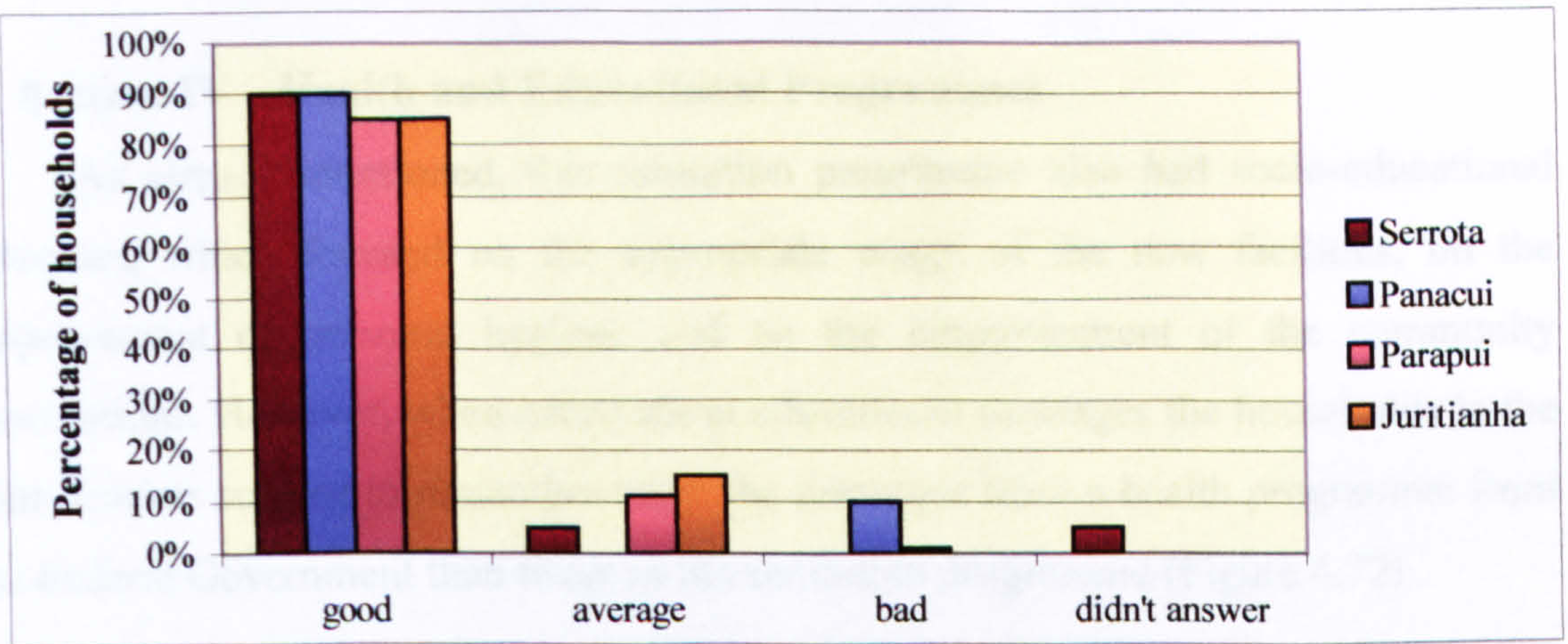


Figure 4.69. Time for the operator to attend a user's request for maintenance services.

❑ Technology Satisfaction

According to 85 to 90% of the households in the districts studied, the condominial sewerage was considered a good system (Figure 4.70).

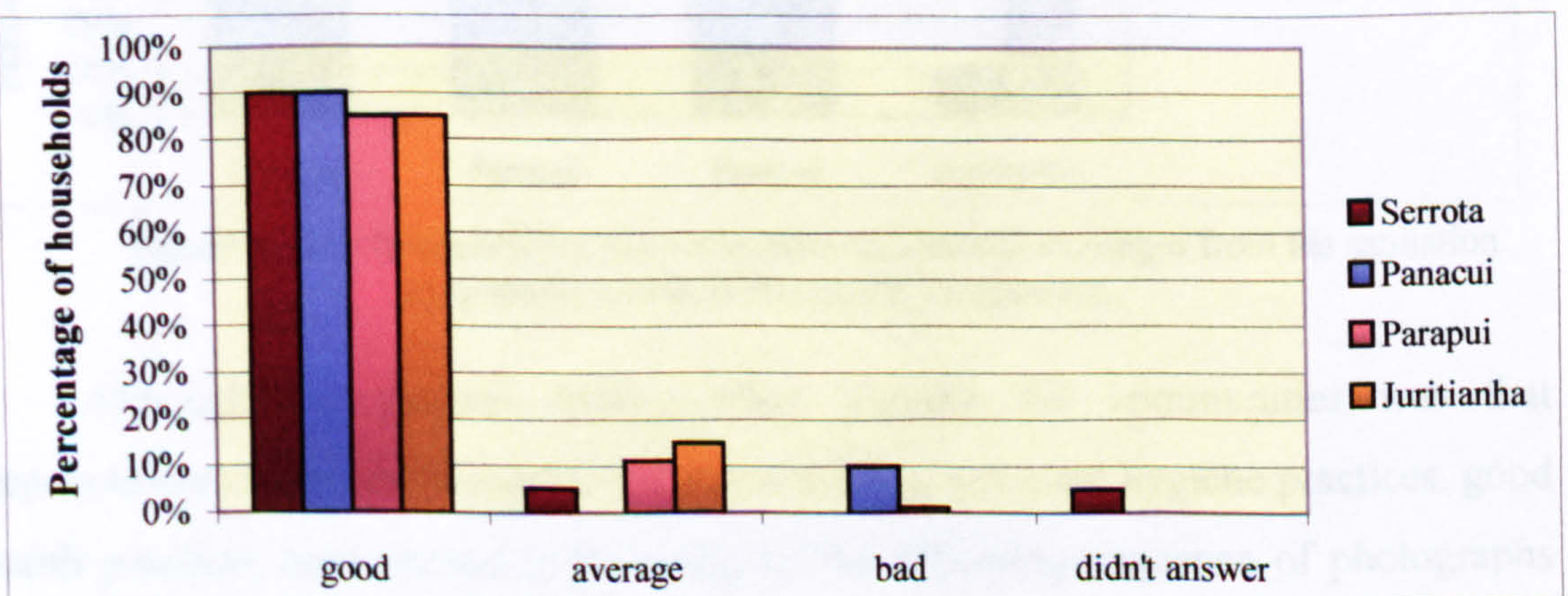


Figure 4.70. – Level of user satisfaction with the condominial sewerage system.

Among householders from the two districts with higher percentage of septic tank users (Serrota and Juritianha), the level of satisfaction was also relatively high: 60% for those from Serrota and 100% for those from Juritianha.

Finally, the values charged for the system was, in general, considered to be reasonable by the householders of the four districts (Figure 4.71).

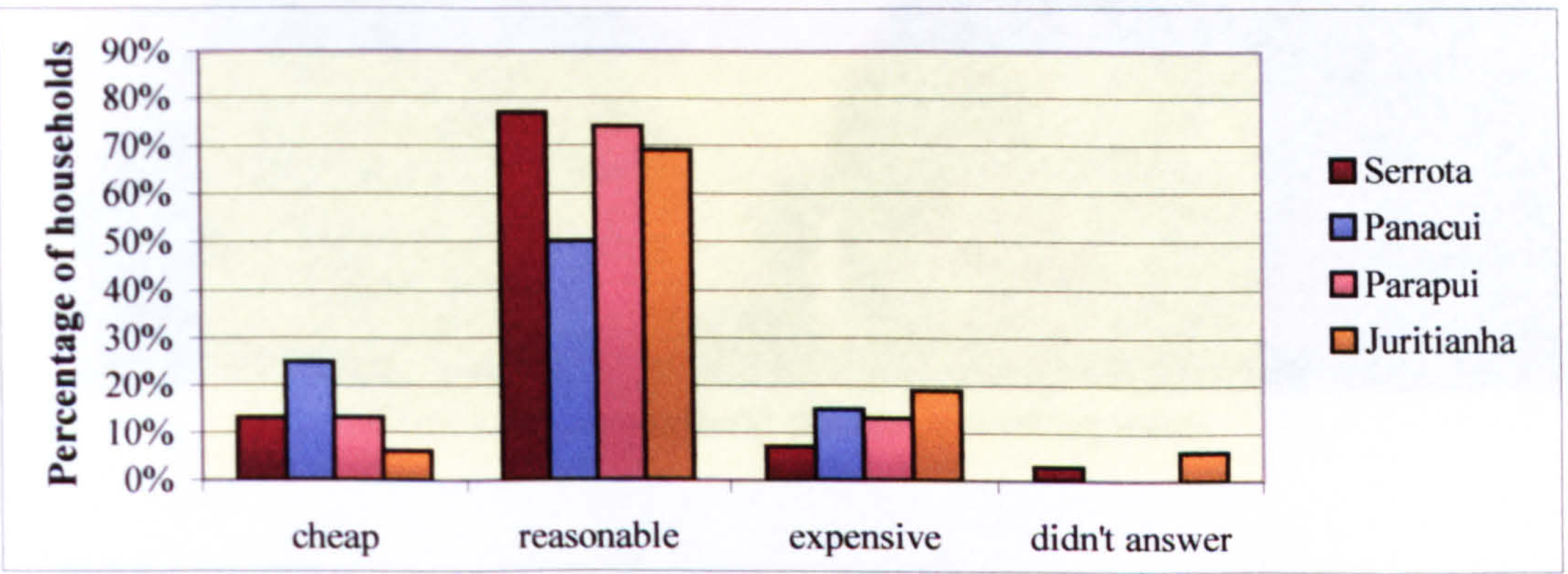


Figure 4.71. – Amount of money paid by the users.

❑ Section IV – Health and Educational Programmes

As already mentioned, this sanitation programme also had socio-educational activities, which focused on the appropriate usage of the new facilities, on the improvement of personal hygiene and on the empowerment of the community associations. However, when asked about educational messages the households in the four districts seemed to remember more the messages from a health programme from the Federal Government than those of the sanitation programme (Figure 4.72).

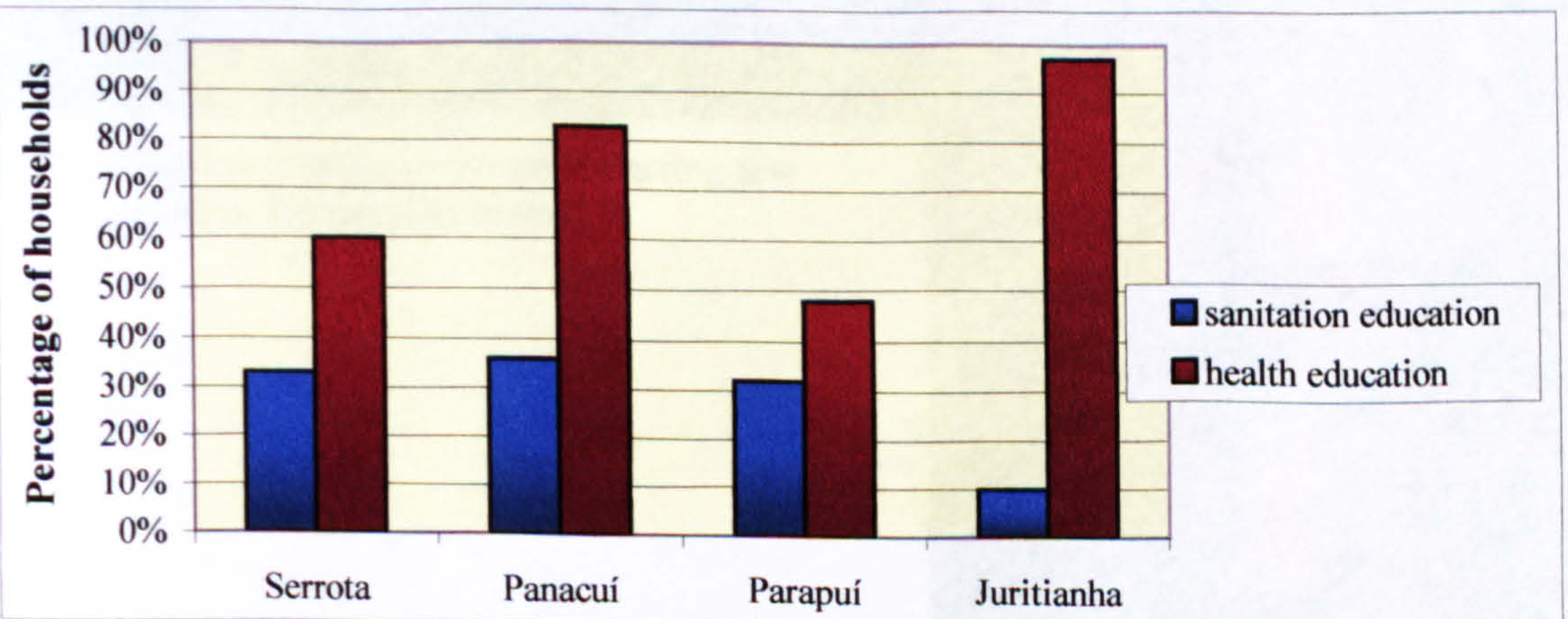


Figure 4.72. – Householders that remember educational messages from the sanitation programme and from the health programme.

Although the general feeling when visiting the communities was that improvements were still needed to the householders' personal hygiene practices, good health practices have started to be noticed. The following sequence of photographs exemplifies this (Plates 4.76-4.78).

Plate 4.76. – Household storage of drinking water.

Plate 4.77. – Children playing in the street (having few clothes, but wearing shoes).

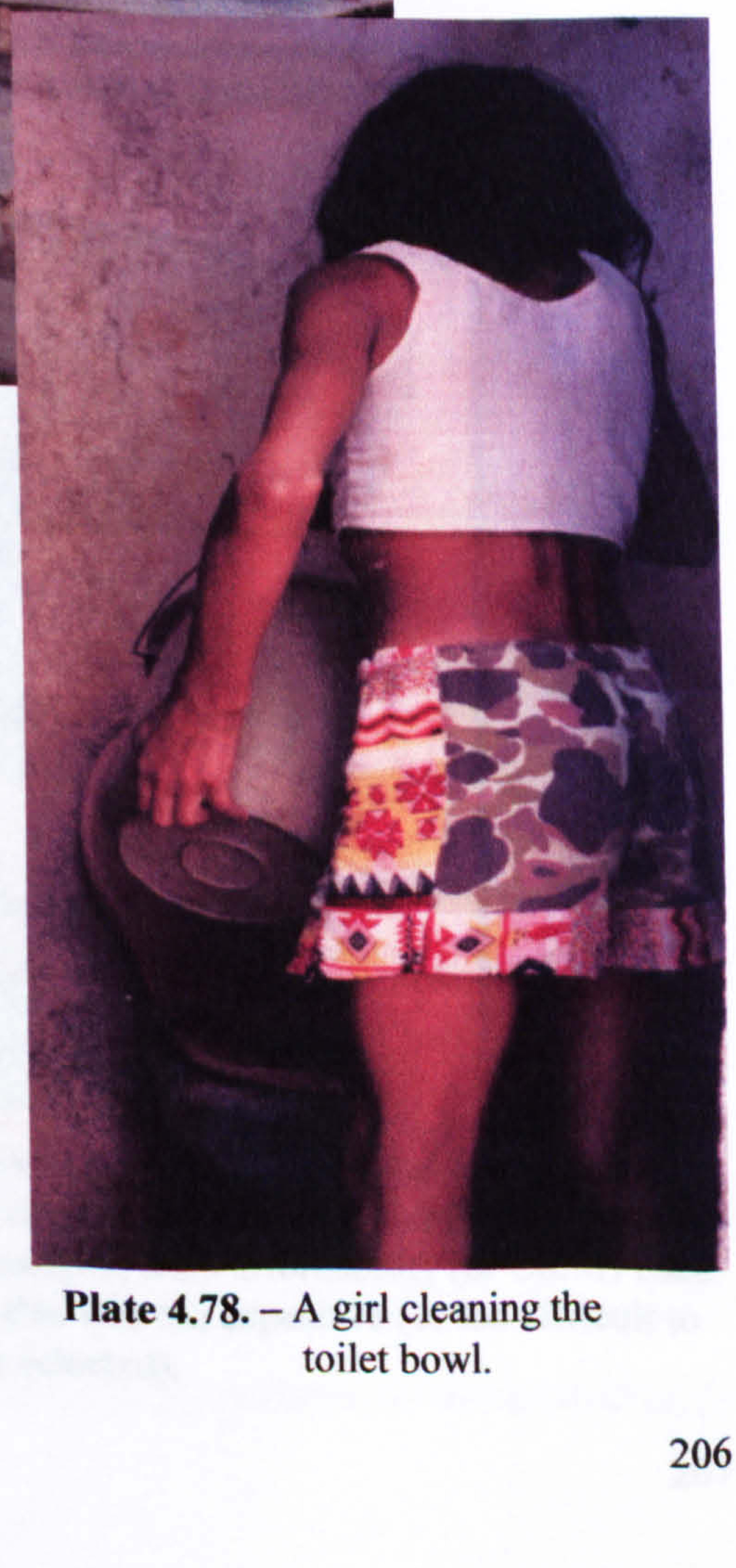


Plate 4.78. – A girl cleaning the toilet bowl.

Chapter 5: Discussion

5.1. Introduction

Instead of focusing on the individual outcomes of each case study presented in Chapter 4, this chapter is concerned with the aspects that are most likely to influence the sustainability of the low-cost sanitation programmes.

The ***institutional framework*** in which the programmes are developed is seen here as the primary factor for the achievement of programme's objectives. A clear definition of institutions and their responsibilities towards the programmes – based on a consistent and realistic assessment of capability – is therefore believed to directly influence the aspects leading for sustainable sanitation programmes.

Those aspects identified for discussion here were: the social and managerial parameters for ***technology selection***; the technical parameters for the ***design*** of the systems; the approaches adopted for ***implementation*** of the programmes; the ***O&M*** arrangements; user ***acceptability*** and ***satisfaction***; and financial aspects, i.e. the systems' ***affordability***.

In addition, long-term ***social and health improvements*** should follow as a direct consequence of sustainable sanitation programmes. This is illustrated in Figure 5.1.

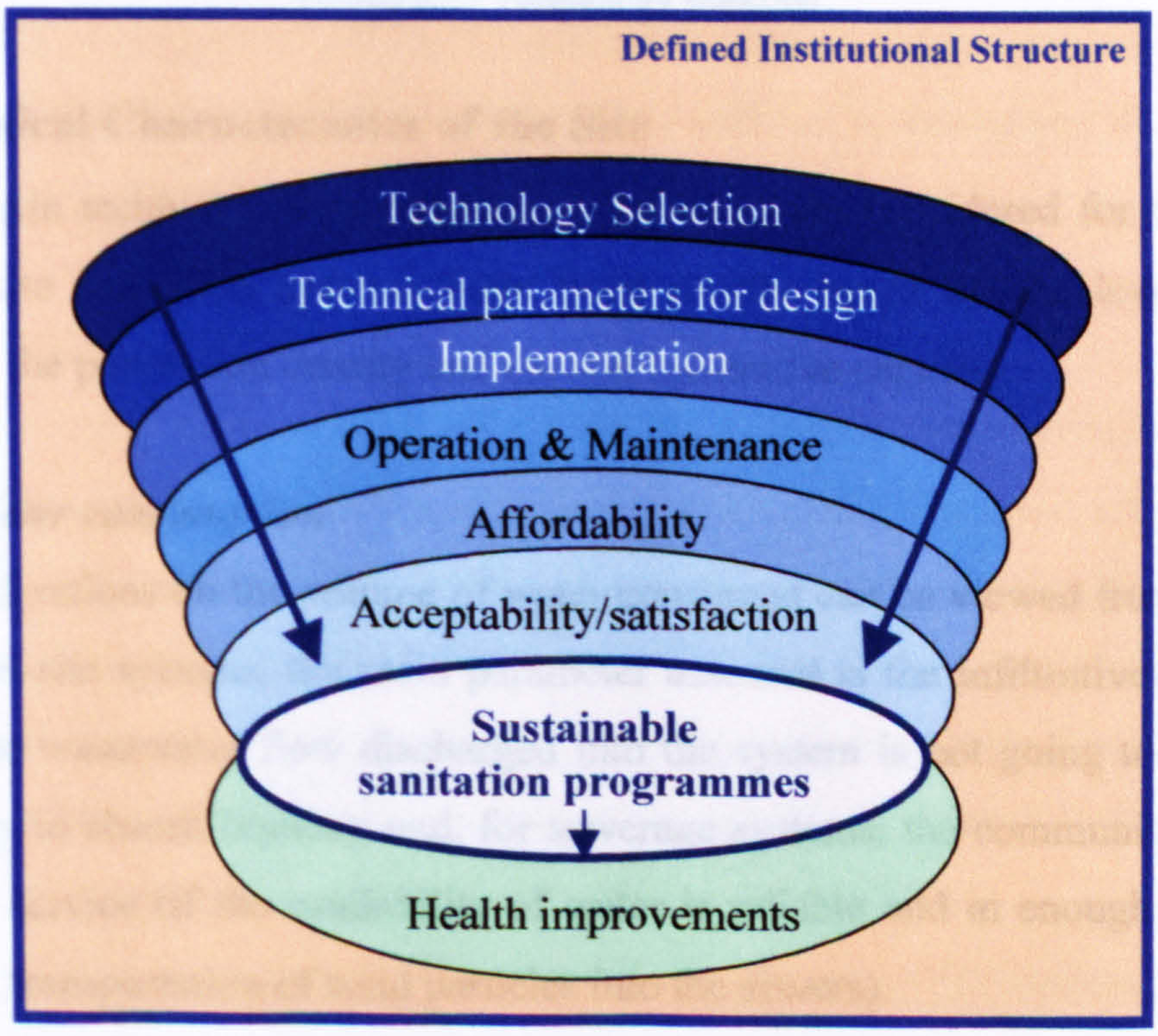


Figure 5.1.- The main aspects influencing the sustainability of sanitation programmes (there may, of course, be feedback loops within this diagram – such as, for example, from affordability (or O&M) back to technology selection; this would occur when a technology that was too expensive (or too difficult to operate and maintain had been selected).

5.2. Technology selection: Social and Managerial Parameters

That sanitation technologies must be appropriate is a general consensus. However, as according to Kalbermatten *et al.* (1982), the concept of technological appropriateness is *"a relative one, which can only be applied within a particular context"*.

Whilst general guidance is available for the first stage of technology selection (such as algorithms and decision support systems – Franceys *et al.*, 1992; Loetscher, T. URL-20, 2000), the final decision must be based on locally supported, site-specific data.

Based on the case studies, the main aspects considered for appropriate technology selection would lie among technical, social and managerial parameters (Figure 5.2.).

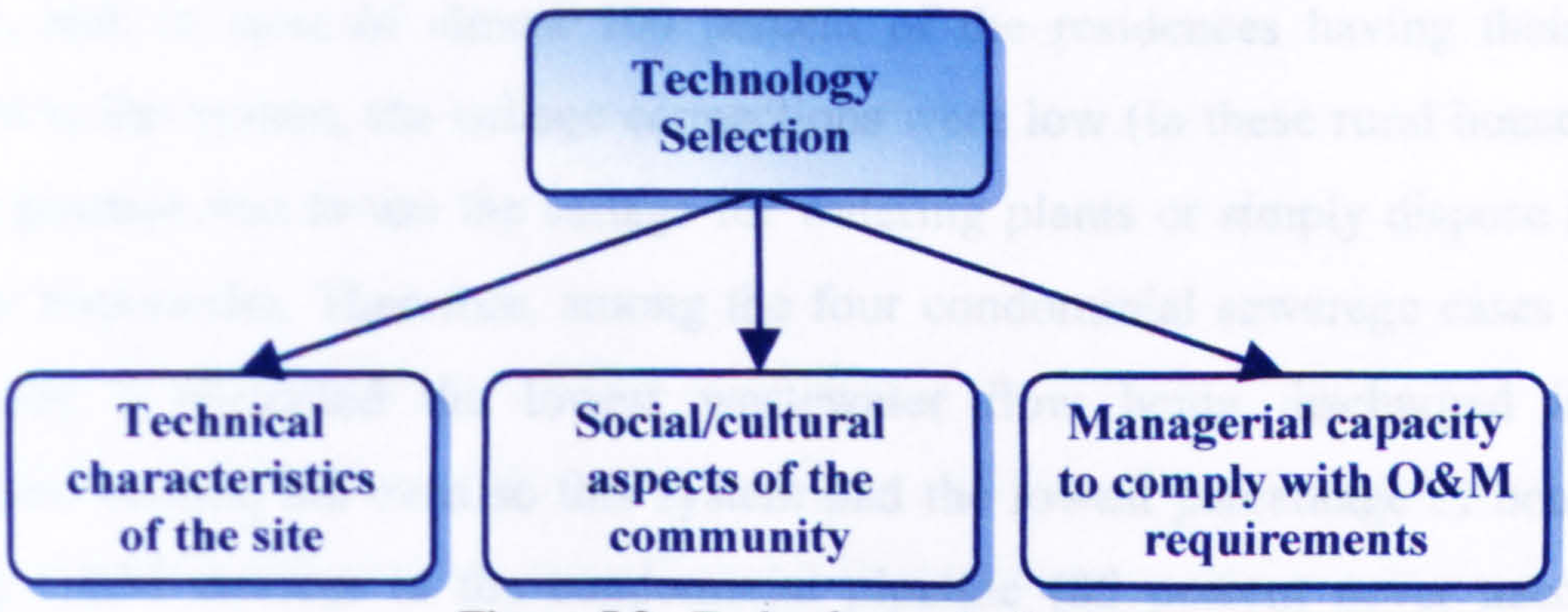


Figure 5.2.- Technology selection

5.2.1. Technical Characteristics of the Site

The main technical characteristics of the localities considered for selection of on- and off-site sanitation systems have been mostly based on the level of water consumption, the population density and the soil infiltrative capacity.

➢ ***Level of water consumption***

Considerations on the volume of water consumed can be viewed from two main angles. For on-site systems, the main parameter assessed is the infiltrative capacity of the soil (if the wastewater flow discharged into the system is not going to exceed the soil's capacity to absorb liquids); and, for sewerage systems, the community's level of water supply service (if the availability of water is reliable and in enough quantity to guarantee the transportation of solid particles into the sewers).

In Case Study 2, the on-site system of Aero Rancho had a projected wastewater flow of 96 litres/capita/day (80 percent of the per capita water consumption adopted for the site's water supply system). During this study, approx. 53 percent of the households discharged all wastewaters (excreta and sullage) into their leach pits, thus, just over half of the pits were receiving a theoretical wastewater flow higher than the values traditionally indicated for the adoption of on-site systems (50 lcd in Kalbermatten, 1982). Nevertheless, 82% of the leach pits surveyed had not yet required maintenance (mainly emptying) services even after 6 years of system operation (designed for 5 years design life).

For the SISAR programme (Case Study 6), the selection of a condominial sewerage system was supported, as far as water consumption was concerned, by the provision of an in-house service level of water supply, with at least one tap located inside each house. Nevertheless, the great majority of the households did not have cistern-flush toilets (10 litre capacity buckets were mostly used to discharge water for flushing), and, in spite of almost 100 percent of the residences having their toilets connected to the system, the sullage connections were low (in these rural households a common practice was to use the sullage for watering plants or simply dispose it off in the sandy backyards). Therefore, among the four condominial sewerage cases studies, Case Study 6 presented the lowest wastewater flow being discharged into the condominial sewers, but even so this system had the lowest percentage of households requiring O&M services in the condominial pipeline (85 percent never needed any service and 12 percent rarely had O&M services required). Suggesting, therefore, that condominial systems would be able to work well with minimum discharges of wastewater.

➢ ***Population density***

The influences of population density on the selection of sanitation technologies are closely linked to the availability of physical space and to the cost viability of the programmes. Poor periurban housing areas such as the ones presented in Case Studies 1 (Olinda), 3 (Natal) and 5 (Recife) are typical of Brazilian favelas (population densities of 385, 345 and 279 people per hectare, respectively). In such high-density areas, the provision for sullage disposal is also a very desirable requirement and on-site systems are usually not recommended.

Nevertheless, in the specific situation of Case Study 1 (VIP latrines plus micro-drainage systems for sullage collection) the high population density could not be identified as a factor contributing to the failure of the programme. The few latrines built were in fact located among the poorest households, where problems related to space availability were most evident. Also, as the system had been planned to be mechanically emptied, there would be no need for space to build another pit or to bury the sludge (the lack of relation between small size plots and their inadequacy to on-plot sanitation has also be indicated in a study in Mozambique and Ghana – see Cotton & Saywell, URL-33, 1998).

Low-cost off-site systems (mainly condominial sewerage, because settled sewerage system also requires space for interceptor tanks) usually do not have problems related to the availability of space. Even in higher density areas, at least one of the alternative layout (backyard, front yard or sidewalk) can be physically well integrated to the household characteristics, as observed in all four case studies based on this technology. Moreover, the costs of condominial sewerage have been reported to decrease as the population density increases, becoming – in the case of Natal (Case Study 3) – cheaper than on-site systems at population densities above 150 persons per hectare (Sinnatamby, 1983).

➢ ***Soil infiltrative capacity/groundwater table level***

These aspects, which affect mainly on-site systems, did not represent a high risk for the two on-site sanitation programmes reported. Although, in Case Study 1, the VIP latrines were built in an area with high groundwater table level, the risks from health hazards were diminished by the fact that the community was supplied with water from the city network, not using groundwater for consumption.

For the pour-flush toilet system, Case Study 2, the site presented a groundwater table level 4 m below surface and a good soil infiltrative capacity (40 to 60 l/m^2/day). This certainly contributed to the fact that 83 percent of the pits had still not required emptying even after 6 years of operation.

5.2.2. Sociocultural Aspects of the Community

The involvement of the community in the process of technology choice has been presented as a fundamental issue for the selection of the most appropriate sanitation alternative (Andrade Neto, 1999). The importance of this integration is strongly supported by the theory that allowing residents to make their own decisions reduces the chances of implementing a system that may be destined to fail due to specific habits of the local people. Moreover, the sense of ownership of the system by the residents is also believed to increase when they are given the choice of the technology, contributing to their greater interest in preserving the system's component parts.

Despite wide acceptance of the above aspects, the application of methodologies allowing people to choose their sanitation systems still presents practical problems. Questions remain on where to draw boundaries defining the limits between decisions taken by technical experts and those by the communities. For this, suggestions have varied from having the community as a consultant giving them the last say, to having the communities as partners, with professionals and users working together from the beginning. In practice, however, the specific dynamic of each community (city or region) brings up sociocultural factors that can make methodologies successfully applied in one area be ineffective in another.

In all case studies, intensive activities to promote social development of the communities and their mobilisation towards the sanitation programmes were reported. Nevertheless, regarding the choice of technologies, users participation was more in a sense of acceptance of the option offered than in properly making choices.

In Case Study 1, the VIP latrine system was mainly selected by the technical team and based on the cost limitations of the programme. Considerations regarding the sociocultural aspects of the community were expressed by the adoption of toilet bowls, as the squatter position usually adopted for latrines was not locally accepted. However, the direct deposition of excreta (absence of water-sealed toilets) meant the system was perceived by the community as a "primitive" system, contributing to the limited interest of potential users (only 40 VIP latrines were built out of 240 households).

Another noteworthy aspect was the adoption, by law, of the condominial sewerage as the only sanitation option to be implemented in Recife (Case Study 5) and in Brasília (Case Study 4). In these areas, the choice given to the users refers to the layout of the system (backyard, front yard or sidewalk), rather than to which sanitation technology they would prefer.

Without disregarding the obvious criticisms on the existence of a law limiting the engineering provision of technological alternatives, the fact is that for residents of the majority of poor periurban areas in Brazil, a sewerage system is socioculturally well accepted as it may represent a step towards a "quality of life" approaching that of the medium and upper income areas of the cities.

Moreover, in Brasília, having such technology as a standard option strengthened the sanitation company, which adapted its structure (from the planning to the O&M

sectors) to work with condominial sewerage. The company also gained in confidence and experience enough to starting implement this "poor community" technology in the very rich areas of the Federal District of Brazil. CAESB is currently held in high regard in relation to its successful implementation of condominial sewerage.

5.2.3. Managerial Capacity to Comply with O&M Requirements

The conditions necessary to comply with O&M requirements must be assessed during the process of selection of the sanitation technology. This may sound obvious but factors connected to political interests and poor communication among institutions may overshadow definitions of responsibilities for the post-implementation requirements of the programmes.

In Case Study 1, the political momentum of the city of Olinda motivated the implementation of the sanitation programme. However, the arrangements designed for the O&M of the single pit latrines were shown to be unreliable. In fact, the prefecture had not provided services for the mechanical emptying of the latrines and most householders were unable to afford the costs of emptying services from private companies. Thus, resulting in the manual emptying of 23 percent of the latrines (53 percent were never emptied and 12 percent did not answer the question).

As mentioned previously, CAESB (in Case Study 4) reorganised its structure to provide all the conditions necessary to comply with the requirements of condominial systems. The company installed local maintenance offices for the bigger systems in the satellite towns around Brasilia and kept the other systems attended by a central office.

On the other hand, in Recife (Case Study 5) the systems did not present a well defined institutional relationship. Considering that the implementing agency (URB-Recife) had no structure to provide O&M services for condominial systems, an agreement was made for the state water and sanitation company (COMPESA) to be the institution responsible for O&M. Nevertheless, out of the 13 systems, 8 were not being officially serviced by COMPESA due to bureaucracy or design problems.

5.3. Technical Parameters for Design of Sanitation Systems

One of the main advantages of low-cost sewerage is that it allows the design of systems considering specific characteristics of the site. This may have a positive impact on the construction phase (favouring the local capacity for provision of materials and labour) and also on the adoption of design parameters that most accurately reflect the specific requirements of the users. Based on the Case Studies, the main aspects regarding the design of the systems are now considered.

5.3.1. Design of Superstructures for Toilet Units

The two on-site (Case Studies 1 and 2) and the rural sewerage (Case Study 6) case studies included sanitary kits as part of the sanitation programme. These kits were, generally, composed of a toilet bowl and materials for construction of a pre-designed superstructure.

Regardless of the technology adopted for the systems, the superstructures had, as expected, a compact design. Although these designs were most appropriate for units constructed outside the house, some householders had opted for in-house construction or for the incorporation of the toilet unit into the house after it had been extended.

The privacy offered by the superstructures also stimulated the householders to use the toilet units as a shower area even in units that did not have a space so designated (in which case, householders would adapt the superstructures by opening holes to allow the sullage to drain from the units - Plate 5.1). Therefore, water containers, plastic showers or adapted shower-pipes could easily be identified inside the units (Plate 5.3).

Problems with the doors of the toilet were identified as being of two causes: quality and size. Regarding *quality*, a large number of units, by the time of the fieldwork, no longer had their original doors, with low-quality being a common complaint among householders in all three case studies (Plates 5.4). As for *size*, inconveniences caused to users by the small size of the doors - 50 cm wide - designed for the Aero Rancho programme (Case Study 2) constituted an adverse factor that militated against the acceptance and usage of the system.

Other problems identified in the superstructure were: the removal of ventilation openings and the vent-pipes in the VIP latrine system in Olinda (which is an educational, rather than a design, problem); and, dangerously cracked walls in a few units in the Ceará programme (a problem that deserves further investigation, but as was seen in a relatively few cases it was probably related to either construction or soil (or both) rather than design - Plate 5.2).

Plate 5.1. – Opening to allow sullage to drain from the units

Plate 5.2. – Cracked superstructure walls

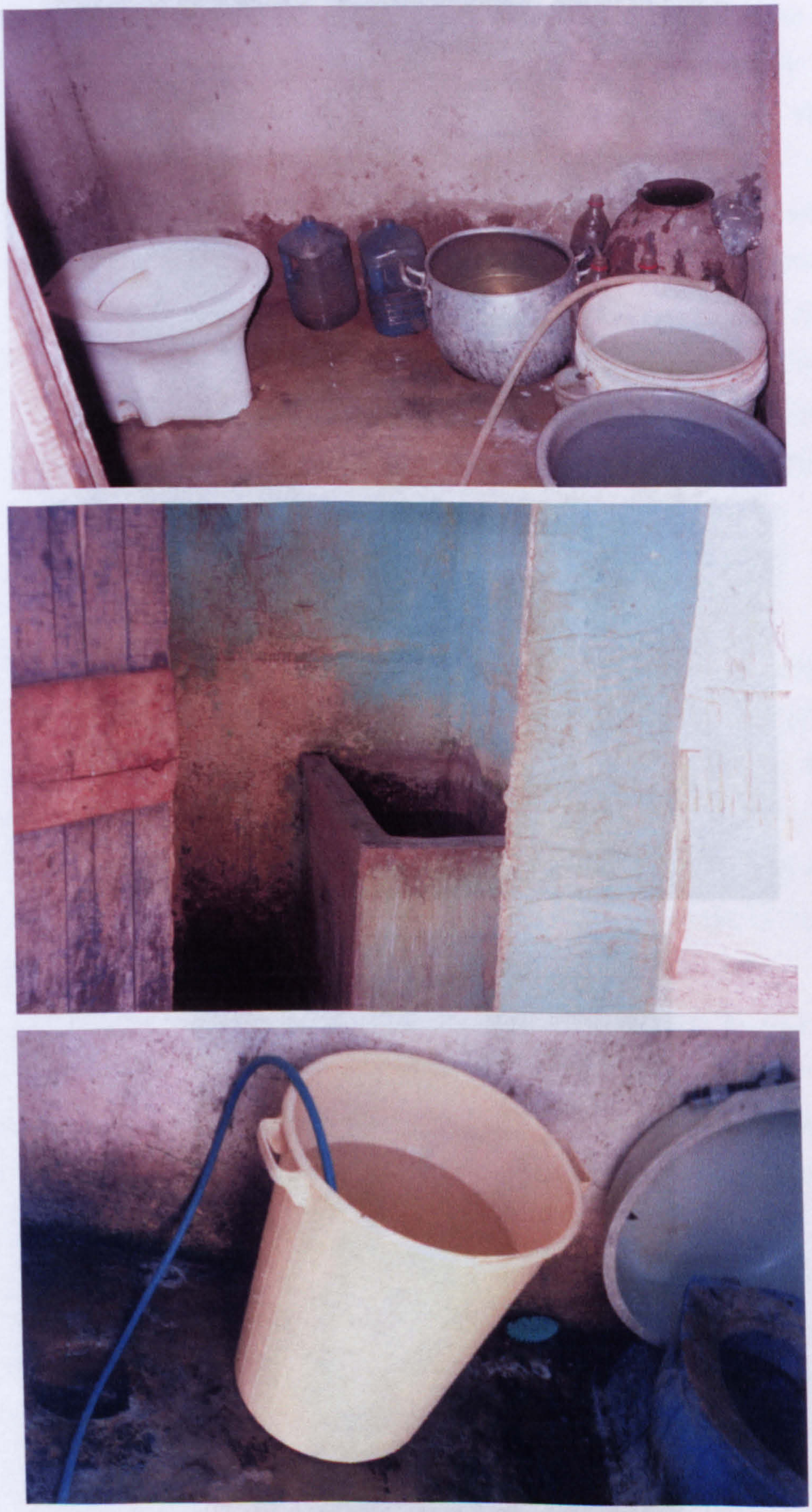


Plate 5.3. - Water containers inside the superstructure.

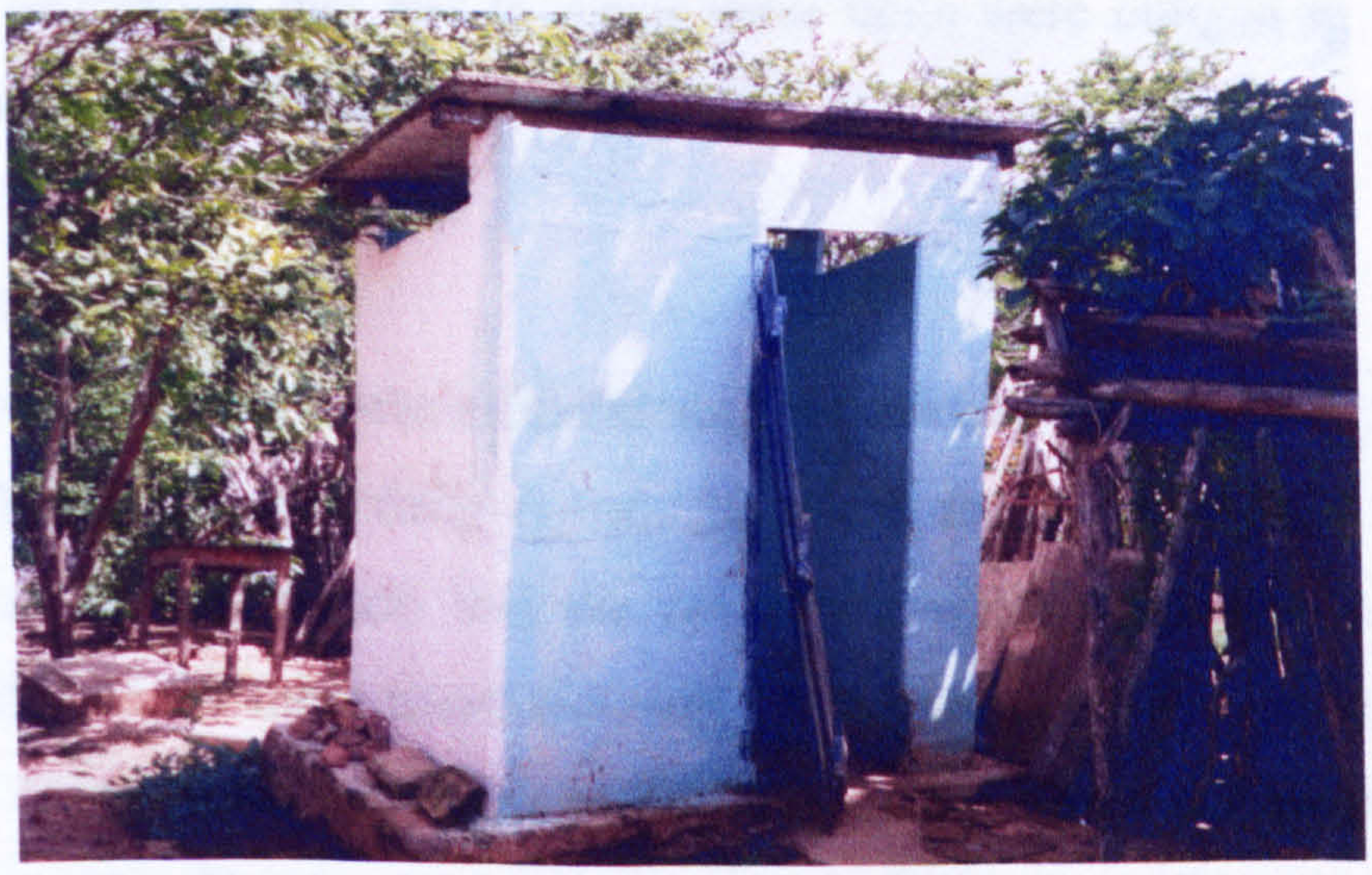


Plate 5.4. - Superstructure doors

For the experience reported in Case Study 6 (rural Ceará), the condominial sewerage systems were designed based on the typical values of 80 percent return factor and water consumption of 100 l/person*day, which the present study suggests that are too high for the conditions found in the field (see Section 5.2.1.). Although this does not have a great impact on the design and functioning of the sewers (due to the small size of the villages, the 100 mm was the only pipe diameter required), the much lower volume of wastewater actually returning to the sewer was problematic for the wastewater stabilisation ponds (some of the ponds were functioning with no effluent being discharged – see Plate 4.73).

Other contributing factors for the determination of wastewater flow are the stormwater and the groundwater infiltration (the latter was not investigated in this study, but is generally assumed as a given rate per unit length of sewer – Kolsky, 1998).

Regarding stormwater, Brazilian sewerage systems are designed as separate systems, not receiving stormwater, which is the case for all four condominial sewerage systems studied (Case Studies 3 to 6). In practice, however, the two case studies in which this variable was investigated showed a considerable percentage of stormwater connections to the sewers (although the sanitation companies responsible for the systems had officially banned the practice). Thus, in Case Studies 3 (in Natal) and 4 (in Brasilia), 24 and 26 percent, respectively, of the surveyed households were discharging stormwater into the sewers (usually via pipes, drains or holes on the inspection chambers).

As asserted by Mara *et al.* (2001), in practice, these systems actually work as partially combined systems. These authors also stress that such a practice should not be permitted (partially combined sewerage would require much higher values for K_1), but demonstrate that for the design practice of condominial sewers currently adopted in Brazil (min. peak flow of 1.5 l/s), there is an "inherent [safety] allowance for at least some stormwater". Additionally, stormwater is also likely to increase the requirements for O&M due to the amount of soil particles carried together into the sewer.

These facts make the study of the drainage characteristics of the area (i.e. presence of microdrainage systems, existing household stormwater connections) and the general aspects of the household yards (i.e. paved yards, discharges of roof water) factors also to be surveyed and considered for the definition of design parameters in condominial sewerage systems.

5.4. Implementation Approaches

More than just the introduction of new technological options, low-cost sanitation programmes also bring innovative processes for systems implementation and for the relationship among stakeholders. Some of these innovations are based on the new roles that users play for the establishment of successful infrastructure developments, especially, for the low-cost sanitation programmes.

5.4.1. Community Mobilisation

In the demand-responsive approach, the self-mobilised community should express its needs for the competent institution to act in response to such demand, i.e. with the provision of sanitation systems. In practice (at least for all six case studies), an external agent capable of inducing this process is frequently necessary to increase awareness and to assist the community in getting organised.

Having an external agent actively inducing the community mobilisation process does not sound like a genuine community-driven action. Amongst the main criticisms against such a strategy is the tendency to use "community participation" as a label to carry on programmes that are in fact delivering decisions already taken through an up-down managerial structure. Therefore, the balance for inducing the process of mobilisation without manipulating the participation of the community is the point that sanitation promotion institutions should aim for in the provision of sustainable services.

According to Andrade Neto (1999), the level of participation of a community in a sanitation programme depends on the degree to which the householders have been mobilised towards the programme. A range of social techniques is available for working "with" communities (DFID, 1998), but the choice must be based on the communities' particular characteristics.

Case Study 6 (Ceará) provides an example of rural villages that had to become organised in order to be included in the sanitation programme. Thus, the main action initially developed by the mobilisation team was to strengthen the community as an associative institution. This was also the case in Case Study 2 (in Favela Aero Rancho), where the dispersed peri-urban community had its mobilisation programme based on development techniques addressing issues such as citizenship, women's associations and alternative medicine.

Although this broad approach to strengthen community associations has produced good results for the small rural villages programme of Case Study 6, the community of Favela Aero Rancho (Case Study 2) does not appear to have assimilated well either the importance of residents' associations or the messages specifically directed to the sanitation system. Among the main factors for this would be: incomplete establishment of the community in the area, socio-economical factors influencing the settlement of the families in the community (as stated in Section 4.3.7, the economic condition of the families in March 2000 was worse than in 1996) and the lack of continuity of the educational programmes to reinforce the main aspects of the system.

In the programmes where community organisation existed (at least to some degree) prior to the implementation and where the mobilisation process could be more concentrated on the sanitation programme itself, the preferred approach was the mobilisation block-by-block. This had been proven to be an effective strategy for the programmes implemented in large communities, i.e. Case Studies 3 (Rocas/Santos Reis), 4 (Vila Planalto) and 5 (for the Mangueira ZEIS), where the results in having closer contact with smaller groups produced better results than approaching the whole community at once. Table 5.1. summarises the approach adopted in the Case Studies programmes.

Table 5.1. – Strategy adopted for community mobilisation

Case Study	Community Size (Households)	Mobilisation strategy
1	240	Whole community.
2	510	In groups of 50 households.
3	3,100	Pilot experience in a single block, then expanded block-by-block.
4	790	Block-by-block.
5*	3,098	Block-by-block.
6	50 to 600	Whole community.

* Based on the Mangueira projects

5.4.2. Implementation Approaches

Having the community mobilised towards the sanitation programme was the first step adopted in all six case studies for systems implementation. After this, one of the following three approaches was applied: complete implementation of the system in one step; progressive implementation dividing the community in sub-areas; or, implementation based on a pilot project.

The main lessons from these experiences were that to completely implement the system in a single step two main aspects are required: a high level of acceptability of the selected technology attained during the community mobilisation process and sufficient financial resources to avoid interruptions during implementation and so leave the system only partially built and not in operation (damaging users' confidence toward the programme). When financial resources are not completely guaranteed, a progressive implementation of the system is more advisable. In this case, the system should be designed such that one phase is in operation while the next phase is under construction or awaiting additional resources. This second approach can also increase the acceptability of the technology amongst users living in the area where the system will subsequently be implemented.

The third approach would be appropriate when the user acceptability and/or the suitability of the technology are still not assured; therefore, the use of pilot projects seems to the most appropriate approach.

Nevertheless, a fundamental factor which influences the appropriateness of any approach adopted is the capacity of the implementing institution in providing the necessary requirements to reach the final stage for the complete implementation of the programme.

5.5. Operation and Maintenance

A *well-defined* and *reliable* institutional and community structure to manage the O&M of low-cost sanitation programmes represents an important step for the adequate operation of the systems, as well as for preserving/improving users' satisfaction.

5.5.1. Operation

Based on the fieldwork, the main factors interfering in the adequate operation of the low-cost systems studied were the quality of the construction, the coverage of the systems and how the users had received and accepted the educational messages.

➢ ***Construction***

The low-cost on-site technologies studied (Case Studies 1 and 2) are of easy construction, only requiring basic skills for their execution. Pre-cast materials such as that for the superstructure (walls, roof and cover slab) and/or for pit lining were applied in both case studies. The utilisation of these materials can facilitate the construction and also support local production capacity, as was the case in the Case Study 1 (in Olinda).

The characteristics of the soil also deserve attention in order to avoid subsidence problems (that would result in cracks or even in the collapse of the superstructure), and to provide the lining necessary to secure the pit walls during excavation.

Condominial sewerage systems, on the other hand, require trained workers able to lay the sewers at the designed gradients. The minimum gradient adopted in the design of condominial sewerage is 1 in 200 for a 100 mm diameter pipe, which is a value much lower than that used in conventional sewerage (1 in 40 according to McGuire's rule (Marriott, 1994)). This emphasises the importance for training the workers in appropriate construction techniques able to ensure the right design requirements.

In Case Study 5 (ZEIS programme in Recife), the residents were initially responsible for the construction of the condominial branches. However, the quality of the construction was, in fact, sufficiently bad to encourage URB-Recife (company responsible for the implementation of the system) to change this initial agreement. Therefore, URB hired a private company to continue the construction and repair the pipeline sections presenting problems.

Nevertheless, another example (this one from the condominial system of Panacuí, Ceará – Case Study 6) shows that, in spite of having a company hired to execute the job, the system still presented major construction problems, thus demonstrating the need to select adequate personnel for the job.

In Brasília (Case Study 4), in spite of CAESB had had no major problems with the sewers under its responsibility, the company technicians had identified construction problems in the "household connections" of high-income areas. The houses in this neighbourhoods usually have long backyards, frequently requiring a long length of pipeline. As house connections are of the householders responsibility, they usually hire workers in the city (there are not many with experience in condominial systems) for such a "simple" task, which later results in the need for corrective interventions.

Thus, these examples emphasise the need for experienced workers and training in construction techniques to ensure the quality of sewers' construction in flat gradients conditions.

➢ ***Coverage of the Systems***

The concept of coverage has been defined in this study as the ratio between the number of households using the system and the number of households existing in the project design area. Therefore, Table 5.2. summarises the coverage rates obtained during the fieldwork.

As the household adoption of the sanitation facilities provided by the programmes were not compulsory for 5 out of the 6 case studies, the increase of usage was more dependent on the success of community mobilisation programmes and on the level of acceptance of the technologies by the residents.

Table 5.2. – Coverage rate of the sanitation programmes studied

	Case Studies	Data when the systems started functioning	Date of the fieldwork	Systems' Coverage Rate	Users that never had Functioning Problems
	1. Peixinhos Triangle – Olinda	1984	1999	17%	59%
	2. Aero Rancho – Campo Grande	1994	2000	70%	83%
Condominial Systems	3. Rocas/Santos Reis – Natal	1980	1999	83%	40%
	4. Vila Planalto – Brasília [1]	1993	2000	99%	50%
	5. ZEIS Programme – Recife	-	1999	-	-
	Vila Sao Miguel	1996		76%	
	Vila do Vintem	1994		100%	
	Poco da Panela	1996		95%	
	Mangueira	Jun/1998		66%	
	Joao de Barros	Dec/1995		97%	
	Beirinha/Rua do Rio	Jan/1999		71/30%	
	Mustardinha	Dec/1998		49%	
	Marrom Glace	Dec/1998		90%	
	Tamarineira	Ago/1994		90%	
	Agua Fria	1996		85%	
	Corrego Sao Jose	1996		59%	
	Coronel Fabriciano	1993		100%	
	6. SISAR Programme – Ceará	1993	2000	100%	77%

[1] – In Brasilia, households' connection to the sanitation system is compulsory.

With exception of Case Study 1, where problems with the acceptability of the technology where identified (17 percent coverage), the Recife ZEIS programme (Case Study 5) presented the lowest connection rate (Table 5.1), varying from 31 to 100 percent. Although the sanitation systems in some of the areas were "new" and residents were still expected to provide their connections, such variation in coverage rates was also influenced by the implementing company's changes of policy (providing household connections for some areas and not for others). Therefore, by the time of the update of this study, in January 2001, the company was then providing connections for the areas that were still presenting low connection rates (see Section 4.6.3).

Another usage aspect to be considered is the connection of household appliances to the systems. In Case Study 2, 26 percent of the residents did not connect their sullage (mainly the wastewater from kitchen sink and from laundry) to the pour-flush toilet system. The main reason for that was the misinformation that the pits would get full too easily. Therefore, householders constructed a second pit just to receive sullage and in spite of having the two pits, they were being used at the same time (not following the double pit scheme as the technology was designed for).

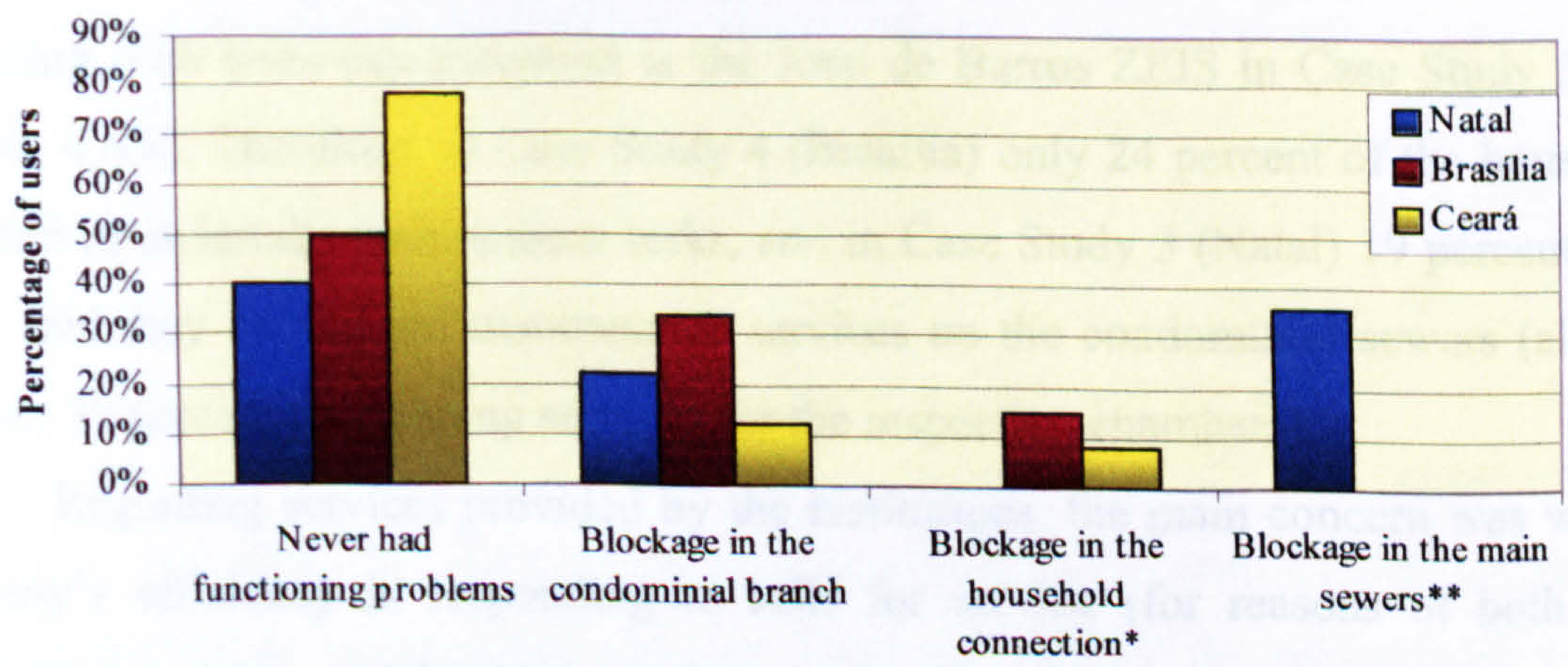
In Recife, Case Study 5, another case of household resistance in connecting sullage to the sanitation system was observed. Among the users that had already invested in their house connections, over 20 percent had just connected one of the two household wastewaters (sullage or excreta – see Figure 4.47). On the other hand, in Case Studies 3 (in Natal) and 4 (in Brasilia) nearly 100 percent of all household appliances were connected to the condominial sewers.

Cases of poor connection rates such as those reported above were actually highly influenced by poor understanding of the educational messages or disbelief of the users in the functioning and reliability of the systems.

➢ ***Problems related to systems' operation***

The most frequent problems reported for the VIP latrines in Case Study 1 were related to foul smell and presence of insects. However, 71 percent of the latrines were without a door and only 65 percent of the units still had a vent-pipe (of which 36 percent did not have a flyscreen). For the other on-site system (pour-flush toilets – Case Study 2), 83 percent of the users never had functioning problems. The "problems" reported by the other 17 percent concerned the pit getting full. In fact, among these, just 10 percent followed the programme's orientation in terms of constructing a second pit.

Among Case Studies 3, 4 and 6 on the condominial sewerage systems of Natal, Brasilia and Ceará, respectively, the most common operational problems were of blockage in the sewers (condominial and main line) and in household connections as illustrated in Figure 5.3.



* Data from Natal not available ** Data from Brasilia and Ceará not available

Figure 5.3. – Occurrence of main operational problems on the condominial sewerage case studies

Although some of this functioning problems were caused by poor construction (as already discussed), the majority was due to poor usage of the system, mainly, the presence of solid waste and soil (sand, silt) into the pipelines.

➢ *Importance of educational messages*

Many of the functioning problems occurring in the systems are actually problems related to poor understanding (or no understanding at all) of messages explaining the functioning demand of the technology (i.e. emptying intervals, importance of ventilation tubes, how double pit schemes work, why stormwater should not be connected to the sewerage, etc).

Although all the sanitation programmes included here had reported extensive educational activities, some of them did not adequately concentrate on explanations regarding the demands of the systems' functioning and on how the users should proceed in cases of repair or substitution of spare parts.

5.5.2. Maintenance Performance

Cotton (2000) suggests 8 key areas that should be covered by performance indicators (PI) for the evaluation of O&M of water and sanitation systems. These areas are: User's opinion and satisfaction, Community management, Financial, Level of Service, Materials, Personnel, Equipment and Work Control.

Some of these aspects have been covered in this discussion; however, "Level of Service" is an aspect that is still to be taken into account. Thus, two levels are to be considered: services realised by users and services provided by the companies.

Although users were responsible for the backyard condominial branches in all condominial sewerage case studies, much less than half of the households were actually executing such tasks (an exception is the Joao de Barros ZEIS in Case Study 5 – see Section 4.6.8). Therefore, in Case Study 4 (Brasilia) only 24 percent of the households reported to undertake maintenance tasks, and in Case Study 3 (Natal) 19 percent of the users said they carried out maintenance services on the condominial sewers (although another 39 percent do cleaning services for the inspection chambers).

Regarding services provided by the institutions, the main concern was with the company's efficiency in responding to calls for service (for reasons of both user's satisfaction and lowered health hazards). As to this efficiency, Figure 5.4 shows that users reported satisfactory levels of service in Case Studies 3, 4 and 6, with the companies responding to the majority of calls in less than 24 hours. For Case Study 4 (ZEIS Mangueira), data were gathered from forms which recorded O&M services and showed that 94 percent of the calls for services were attended within 24 hours.

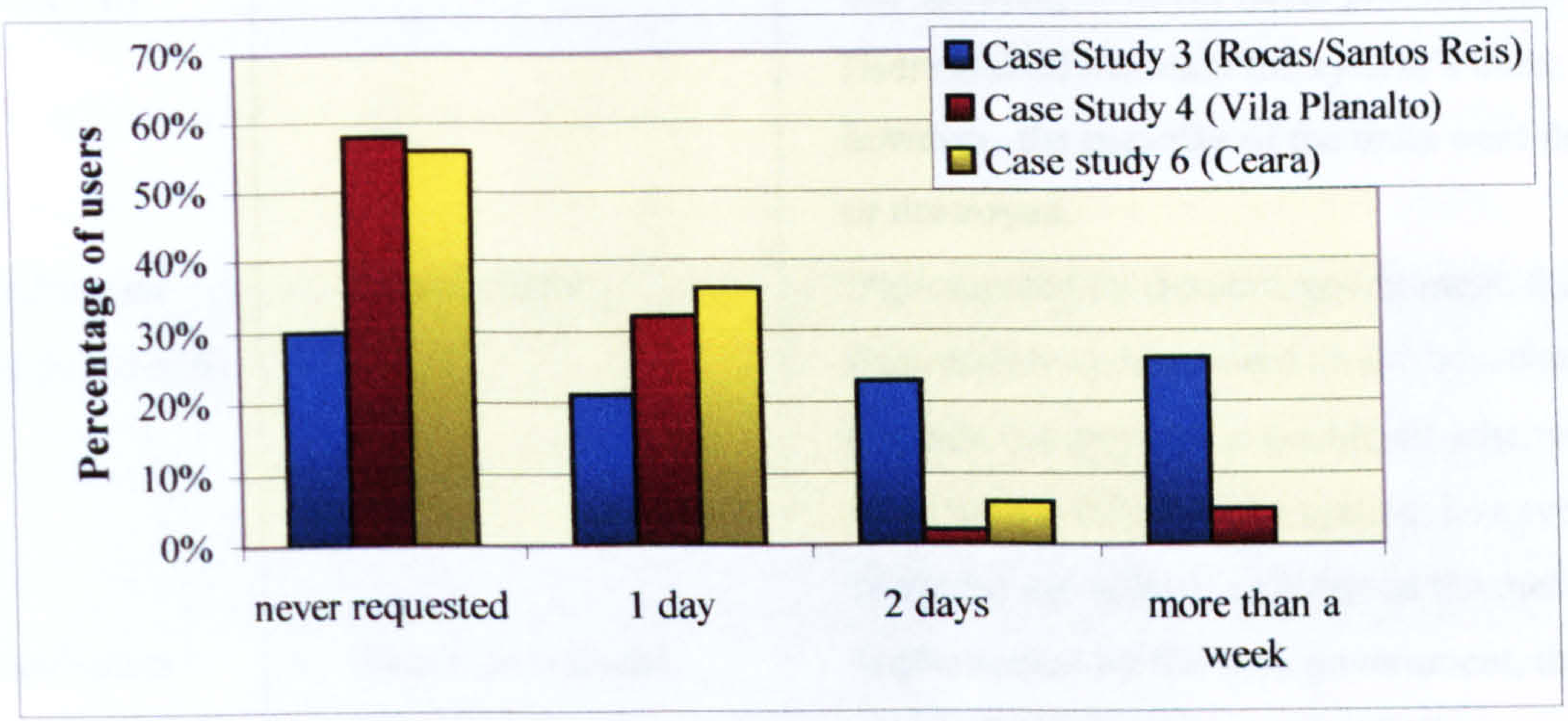


Figure 5.4. – Time for companies to respond a call from users to execute O&M services

5.5.3. Institutional Arrangements

As discussed in Section 5.2.3., O&M is a requirement that should be planned at the beginning of the selection process; that is, adopting technologies that can have their O&M services provided by an institution which is, in fact, physically and managerially capable of doing so.

A wide set of institutional arrangements was observed for the case studies, as shown in Table 5.3. The main aspect in common among these arrangements is the inclusion of users as active participants with defined responsibilities on the systems' O&M.

There were large differences in the level of requirement for O&M between the on-site and the off-site systems. The on-site technologies have the advantage of allowing a programme be designed not relying too much (or not at all) on governmental or private institutions for the provision of the necessary O&M services. Despite this low requirement, the two on-site case studies were, in different ways, adversely affected by the institutions' non-provision of O&M activities. For Case Study 1, the only O&M aspect under the responsibility of the local institution was the provision of emptying services for the VIP latrine's pits at 5 yearly intervals; however, the emptying service was never provided. The other on-site system, Case Study 2, had its O&M designed to be independent of institutional services; however, neither the educational messages regarding users actions for the system's O&M was effectively disseminated, nor was a programme to reinforce such messages developed.

Table 5.3.- Institutional arrangements for the case study programmes

Case Study	Institutional Arrangement for O&M	Observations
1. Peixinhos Triangle (Olinda-PE)	- Local government - Householders	- Implemented by the local government, this institution was responsible for the emptying of the VIP latrines; however never provided the service. Users should maintain the system's units; however, the majority of the units were damaged or destroyed.
2. Aero Rancho (Campo Gd-MS)	- Householders	Implemented by the state government, this pour-flush toilets system relied on the households to upgrade the systems to double pit scheme and carry on the O&M of the system; however, users appeared not to have understood the message.
3. Rocas/Santos Reis (Natal-RN)	- State Government - Community	- Implemented by the state government, this system is also O&M by the same institution. The community is responsible for the maintenance of the condominial sewers; however, workers from the state company were also observed to be developing maintenance services for the condominial sewers and household connections.
4. Vila Planalto (Brasilia-DF)	- Federal District Government - Community	- Implemented by the Federal District government, this system is also O&M by the same institution. The community is responsible for the maintenance of the backyard condominial sewers; however, users can request this service from the company by paying a fee for this.
5. ZEIS Programme (Recife-PE)	- State Government - Communities	- 13 systems implemented by the local govern. O&M transferred to the state government company, which had three different models of service provision (decentralised, centralised and participatory) and had 8 systems under transitory, undefined or rejection situations. The community participation varied from a system to the other, having since a community fully in charge of the O&M of the sewers (participatory model) to systems relying on the company to maintain even the condominial sewers.
6. SISAR Programme (Ceará)	- Joint Community-based Organisation	40 systems implemented by the state government and O&M by a joint community organisation created under support of the state government and the donor agency to manage the systems.

On the other hand, sewerage systems rely on water companies to safely remove sewage from households and adequately return the treated wastewater to the environment. In low-cost systems, however, O&M may be arranged with the users participating in the maintenance of the sewers located on their plots, as proposed by the initial "philosophy" of the condominial sewerage (i.e. CAERN - Andrade Neto, 1999). This user participation for sewers' maintenance leads to lower O&M costs, which is reflected in the users' water bills and can represent up to a 60% reduction on the charges related to wastewater services.

Nevertheless, such arrangements are not easily accomplished. People have a natural resistance in dealing with sewerage-related tasks. For example, in Brasilia users generally opt for the sidewalk layout of condominial sewerage, in which the tariff is higher than the backyard layout but the responsibility for O&M tasks is of the water and sanitation company instead of the householders (Luduvice, 2001).

Furthermore, users seem more likely to carry out the maintenance activities just when they are really attracted by the reduction in charges, and when the educational messages and the purpose of the task have been definitely understood and accepted by the community (usually with the help of strong residents' associations).

5.6. Affordability

According to DFID (1998), *financial sustainability* of water and sanitation systems refers to the ability of these systems in meeting their capital, operating and maintenance costs. Therefore, sustainable sanitation programmes must be designed under the perspective of affordability, which certainly includes the selection of a *technology* that users are *willing-to-pay* for (taking into account price, necessity and convenience), and a *charging policy* that is realistic to the financial demand of the system, as well as to the income limitations of the community.

5.6.1. Technology Costs

The costs for the implementation of condominial sewerage varied greatly between the case studies investigated. Nevertheless, all case studies presented capital costs significantly lower than those normally accepted for conventional sewerage in Brazil (as illustrated in Table 5.4).

Table 5.4 – Capital costs of conventional and condominial sewerage

	Capital costs per household (US$)	Date of the values
Conventional Sewerage in Brazil	1,500	
Case Study 3 - Natal	325	1983
Case Study 4 - Brasilia	110-170	2000
Case Study 5 - Recife (Mangueira)	346	Nov/2000
Case Study 5 - Recife (Mustardinha)	190*	Nov/2000
Case Study 5 – Recife (João de Barros)	147*	Nov/2000
Case Study 6 - rural Ceará	390**	Jan/1999

* values include costs of one pumping station
** value includes costs of treatment

In the case of Natal, the costs would reflect the pioneering characteristic of the system (in 1983) but, in general, the cost variations shown above may be a result of the different organisational structures of the implementing institutions towards the technology adopted.

In Recife (Case Study 5), the same institution implemented all the systems; however, the three values presented above still varied considerably. As the population densities of these areas were similar, the factor most probably influencing such variation is the different system management adopted during the implementation phase. For example, while the João de Barros system was smoothly implemented with strong community participation, the Mangueira system had a long period of implementation with interruptions due to both the lack of financial resources and an uneasy relation between the community and the implementing company (see Section 4.6.7).

5.6.2. Charging Policy

The capital and O&M costs in a sustainable scheme are usually targeted to be fully covered. Nevertheless, whereas the running costs of the systems must be covered independently of financial resources external to the community, the *partial* return of capital costs from the users would be an acceptable strategy when: social/health interests justify it, more affordable technological solutions are not appropriate, and a clear financing scheme to complement the coverage of the costs is adopted.

Table 5.5 summarises the arrangements for the recovery of costs in the case studies investigated.

Table 5.5 – Arrangements for cost recovery

	Return of capital costs	O&M costs
Case Study 1 – in Olinda	Only 37% of users remembered paying for the VIP latrines (payment being of 3 to 5 cement bags).	No community level service for O&M. Individually, 35% of users arranged for emptying their wet pits (only 12% did it mechanically).
Case Study 2 – in Campo Grande	Users prepared to be charged in the first months after implementation. However, decision was made to not carry on with the charging plans.	Programme designed with no need for community level O&M; however, orientation for the construction of the second pit was generally not followed.
Case Study 3 – in Natal	Costs designed to be recovered over a 30 year period by surcharging the monthly water bill.	Users charged monthly.
Case Study 4 – in Brasilia	Users charged for capital costs during the first months after implementation.	Users charged monthly.
Case Study 5 – in Recife	No capital costs were recovered from users.	Just 5 out of 13 systems were charging users.
Case Study 6 – in rural Ceará	No capital costs were recovered from users.	Users charged monthly. "Non-payers" were 37% in Nov/2000.

Although the on-site programme of Case Study 2 was designed to recover capital costs from the users in the first few months after implementation (and the users had agreed to this), the implementing company decided not carry on with the charges claiming that the costs to produce the bills and collect the payments would be higher than the amount to be paid by the users. The users were not informed of this decision and during this fieldwork a common worry among them was the possibility of being charged now, approx. 7 years after implementation.

Regarding the condominial sewerage systems, a policy to recover capital costs was implemented in only two out of the four programmes studied. Different approaches were adopted by the two programmes for charging the users: in Natal, costs were collected monthly over a 30 year period, whereas in Brasília the charges were made during the first few months after implementation, allowing reinvestment of the revenue in other areas.

The tariff system to cover O&M costs of the condominial sewerage programmes is mainly based on a surcharge on the water bills with values set according to the level of participation of householders in the maintenance services. Among the case studies, the only exception to this was the SISAR programme (Case Study 6), which was initially just charging users for the water supply system and only in Dec/2000 was about to start the charging of a fixed value for the sanitation systems (see Section 4.7.2.).

5.6.3. Willingness-to-pay

The general rule of considering users willingness-to-pay towards water and sanitation services to be 3 to 5 percent of their income has for long been considered inconsistent (DFID, 1998). Willingness-to-pay is considered to be a function of convenience/reliability provided by the service, socio-economic characteristics of the community as well as of the charging policy adopted, and therefore, is very site specific.

In Case Study 3 (Natal), 46 percent of the users perceived the prices they were paying for the sanitation system as reasonable (Figure 5.5a shows the variation of users' opinions according to their income stratum); however, 28 percent (overall average) of the users expressed that the system should be available free of charge (Figure 5.5b). In fact, 29 percent of users demonstrated ability to pay for the service up to 2 reais and 14 percent up to 4 reais, which represent, respectively, up to 1.3 and 2.7 percent of their minimum income.

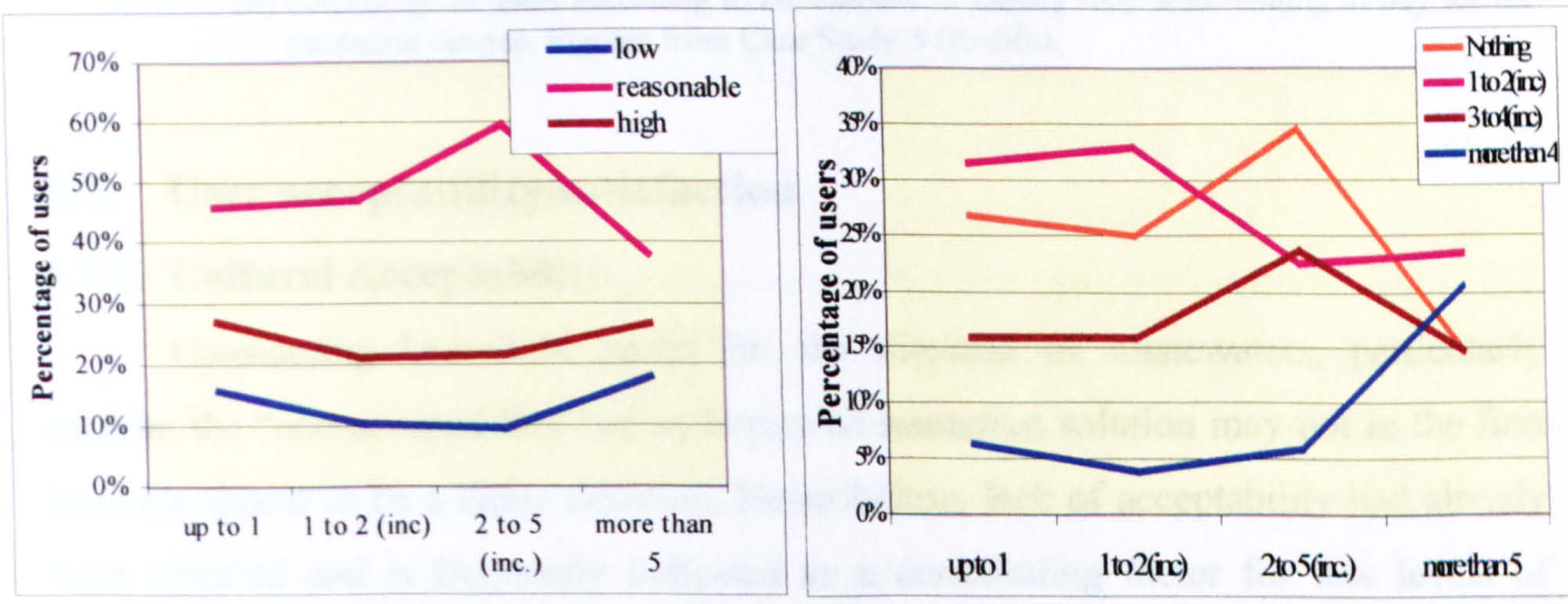


Figure 5.5. – (a) Percentage of users according to their perception of the value of sanitation services varying with the income stratum; and,
(b) Percentage of users according to the amount of money they were willing to pay for the sanitation service. Figures from Case Study 3 (in Natal).

Case Study 5 (ZEIS programmes in Recife) the results showed that the income level of the users was in general dropping linearly (Figure 5.6a). Nevertheless, their willingness-to-pay for the service declined considerably from the first to the second category (Figure 5.6b), with the overwhelming majority of the householders willing to commit only about 2 percent of their minimum income.

Although in general, the condominial sewerage programmes presented high usage rates (see Table 5.1.), a threat for their financial sustainability is the non-payment of the bills. For example, during the first year of the SISAR programme "non-payment" rates were of approx. 55 to 60 percent. To reduce such values (as described in Section

4.7.6), the management team introduced a financial reward for the community with the lowest "non-payment" rate in one full semester and also promote a football championship among the four with the lowest "non-payment" values. As a result in Nov/2000, the non-payment rate fell to 37 percent (average among the 27 communities).

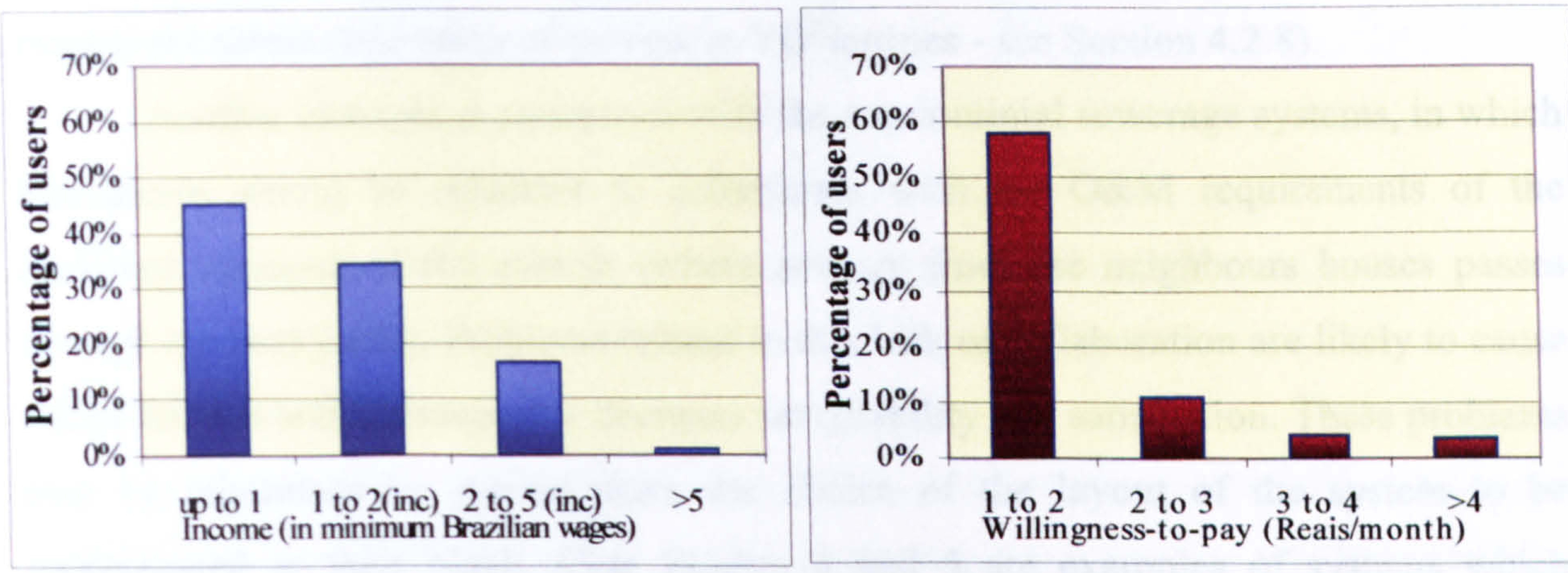


Figure 5.6. – (a) Percentage of users distributed according to their income; and,
(b) Percentage of users according to the amount of money they were willing to pay for the sanitation service. Figures from Case Study 5 (Recife).

5.7. User acceptability/satisfaction

5.7.1. Cultural Acceptability

Considering household needs for the disposal of wastewaters, particularly excreta, the "non-acceptability" of an improved sanitation solution may not in the first instance appear to be a likely situation. Nevertheless, lack of acceptability had already been reported and is frequently indicated as a contributing factor for low levels of utilisation of sanitation facilities. Cultural aspects (i.e. religious beliefs, requirement for privacy, position for defecation, material used for anal cleaning, and user behaviour regarding children/women/men sharing the same facilities) are usually the main factors to be considered prior to decisions influencing in the acceptability of the systems. Nevertheless, two other aspects that should be assessed are: community politics and the technological characteristics of the systems.

Communities with more than one leader (or influential resident) should have their internal organisation well understood in order to do not leave any groups out of the implementation process, and therefore risking that the programme runs into an internal political dispute. This kind of problem is more likely to occur in large communities, such as, for example, the Mangueira ZEIS (Case Study 4) where the mobilisation team was, however, able to identify the community leaders and minimise the political dispute generated about the sanitation programme (see Section 4.6.7).

Technological aspects of the systems may also interfere with acceptability. On-site technologies more usually adopted for rural communities may not be well accepted in poor urban (peri-urban) areas, as in Case Study 1 for example (where the community refused the direct deposition of excreta in VIP latrines - see Section 4.2.8).

Another example is concerned with the condominial sewerage systems, in which households would be reluctant to collaborate with the O&M requirements of the backyard variation of the system (where sewage from the neighbours houses passes through the backyards). Problems related to this lack of collaboration are likely to cause O&M failures and consequently decrease acceptability and satisfaction. These problems may be minimised by giving users the choice of the layout of the system to be implemented in their block. Case Studies 4 and 5 are examples of systems which householders could choose the layout they prefer (being, therefore, previously informed and having accepted the O&M duties as well as the respective charges of each layout option).

5.7.2. Level of Satisfaction

The measurement of satisfaction among users of a sanitation system can be used as a "thermometer" for the sustainability of the systems. The importance of this parameter is associated with the response from the community in relation to the utilisation of the technology, providing inputs to increase awareness about problematic operational aspects and to improve managerial capacity.

Considering the on-site case studies, two opposite responses were obtained in regard to the level of satisfaction. While the peri-urban community of Case Study 1 (VIP latrine) had a low acceptability of the technology, with 78 percent of the householders suggesting actions for better disposal of the sullage as a way to improve the sanitation of the area (29 percent suggested to clean the drainage channels; 20 percent to cover the channels; and, 29 percent to have a sewerage system), 77 percent of the community of case study 2 (pour flush toilet) were satisfied with the system.

In the condominial sewerage case studies, the householders were asked to classify their level of satisfaction with the sanitation programme as high, reasonable or low. Figure 5.7 shows that, on average, 73 percent of the users reported a high level of satisfaction towards the sanitation programme, compared with only 10 percent that expressed a low level of satisfaction.

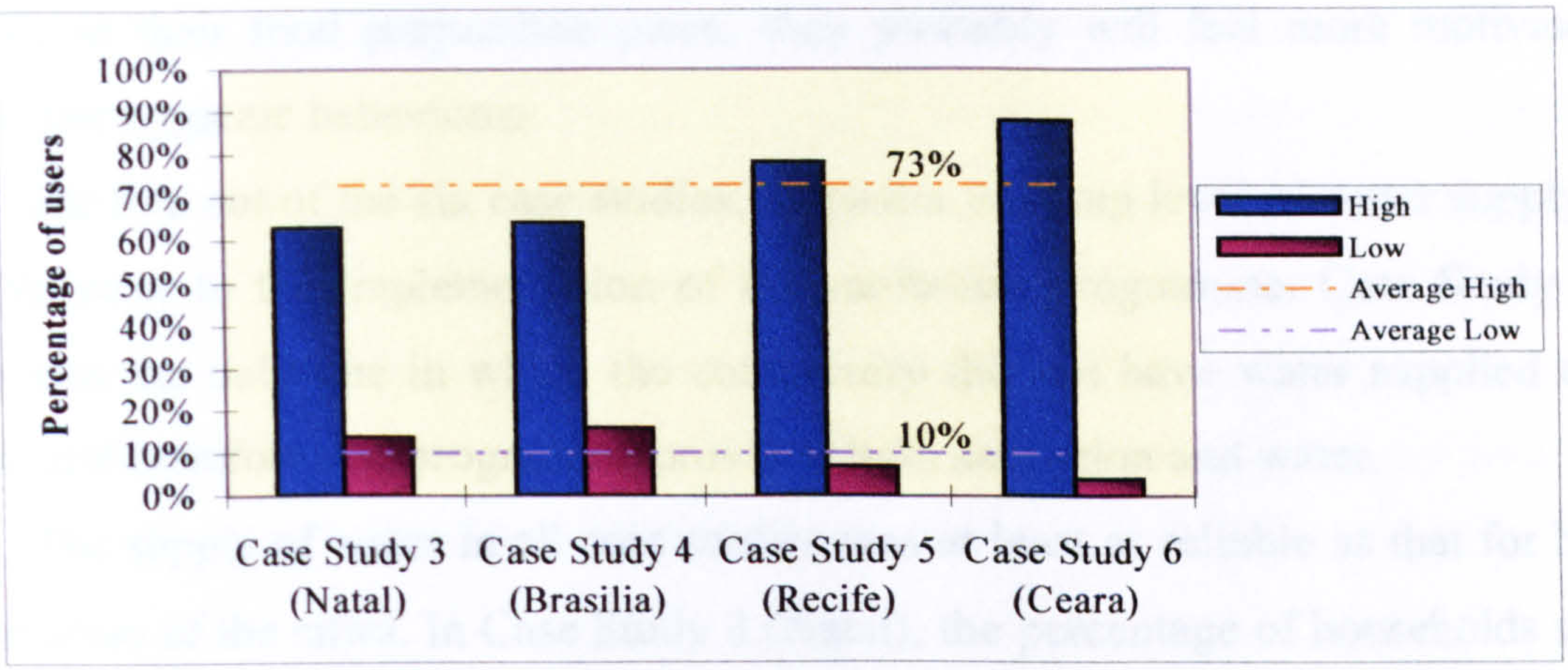


Figure 5.7. – Level of satisfaction among users of condominial sewerage

5.8. Health improvements

The methods available for epidemiological studies associating sanitation interventions with health impacts are highly susceptible to biases and have inherent difficulties in controlling confounding variables (see Section 2.7).

Bearing in mind such problems, and without the intention of performing an epidemiological investigation, this study collected data on aspects brought by the implementation of the sanitation systems that were considered likely to contribute to improvements on health, such as hygiene behaviour and educational programmes.

5.8.1. Behaviour and Health Indicators

Behavioural changes towards better hygiene practices are already accepted as a major factor in achieving higher health standards especially, when complementing water and sanitation interventions. Considering that diarrhoea-related diseases and helminthic infections are the two main diseases targeted by water, sanitation & hygiene programmes, this study obtained information on handwashing & availability of water, diarrhoea & helminthic infections, and familiarity with oral rehydration therapy.

➢ ***Handwashing of and availability of water***

Although water availability is not the only parameter to be considered in hygiene promotion, the proximity of the water source to households is likely to influence better hygienic practices (Curtis *et. al.*, 1995). Users are more likely to remember washing their hands after defecation if they have water and soap close to their latrines or toilets. The same analogy can be made for food preparation. When the individuals responsible for meal preparation (most commonly housewives or daughters) have enough water available in their food preparation place, they probably will feel more motivated to adopt better hygienic behaviours.

For five out of the six case studies, at least a yard tap level of water supply was available prior to the implementation of the sanitation programme. Case Study 6 (in Ceará) was the only one in which the community did not have water supplied to the houses, and therefore, the programme provided both sanitation and water.

The supply of water in all case studies was at least as reliable as that for higher income areas of the cities. In Case Study 3 (Natal), the percentage of households served by a yard tap decreased from 73 percent (prior to the implementation of the sanitation system – Sinnatamby (1983)) to 12 percent during this study (88 percent of the households had in-house connections).

In Case Study 1 (Olinda), 67 percent of the households that were still using the VIP latrines had a yard tap level of water supply, and in 76 percent of them there was no facilities for handwashing near the latrines (as shown in Table 5.6).

Table 5.6.- Level of water supply and presence of handwashing facilities in Case Study 1

Case Study 1 - Olinda	Level of Water Supply			Handwash Facilities	
	Yard Tap	In-house	Other	Yes	No
Group 1 (VIP latrine users – data on the VIP latrines)	67 %	33 %	0 %	24 %	76 %
Group 2 (ex-VIP latrine users – data on the solution adopted by the family)	11 %	78 %	11 %	67 %	33 %
Group 3 (never used VIP latrine–data on the solution adopted by the family)	14 %	78 %	8 %	58 %	36 %

➢ ***Occurrence of diarrhoea and helminthic infections***

Diarrhoea is considered the second main cause of mortality especially among children under 5 (see Section 2.3.2). Based on data collected during the household survey (where mothers were asked about the occurrence of diarrhoea among children under 5 in the previous 15 days), diarrhoea occurred at a rate varying from approx. 1 in 4 to 1 in 6 children per fortnight. The results are presented in Table 5.7.

Table 5.7.- Occurrence of diarrhoea among under 5's

	Occurrence of diarrhoea among Under 5's in the previous 15 days			
	Yes	No	Didn't answer	Rate
Case Study 2 – Favela Aero Rancho, in Campo Grande	23 %	77 %	0 %	1 in 4.3
Case Study 3 – Rocas/Santos Reis, in Natal	17 %	71 %	12 %	1 in 5.8
Case Study 6 – SISAR programme, in rural Ceará	15 %	85 %	0 %	1 in 6.5

Regarding helminthic infections, in Case Study 3 (Natal) children's faeces were said to have had been tested for helminths in the previous 12 months in 59 percent of the households which had at least one child under 15 years of age. According to the mothers interviewed, 31 percent of the tests had positive results with roundworm and giardia being the main parasites identified (see Figure 4.32) – according to a study presented in Wheeler *et al.* (1999), a developed country such as England showed an annual occurrence of infectious intestinal diseases of 1 in 5.

➢ ***Knowledge on oral rehydration solution (ORS)***

Oral rehydration is a life-saving therapy of fundamental importance in the fight against deaths due to diarrhoea-related diseases, which should therefore be implemented as a complementary action for more sustainable solutions such as improved water supply and sanitation systems (see Section 2.3.2).

In Brazil the spread of knowledge on the ORS has, therefore, been the focus of many educational campaigns in the media and also in the public health services. Among the three case studies surveyed for this variable, householders (mostly the female head of household) were familiar with the ORS at a percentage which varied from 88 to 97. When probed about how they prepared the solution, the values corresponding to proper preparation were in the range of 79 to 92 percent, as illustrated in Table 5.8.

Table 5.8.- Knowledge about ORS among female heads of household

	Have heard about ORS ? Where ?					Knowledge on preparation	
	No	**Yes, in the media**	**Yes, trough the health service**	**Yes, other**	**Total of Yes**	**Yes**	**No**
Case Study 2 – in Campo Grande	12 %	0 %	63 %	25 %	**88 %**	83 %	17 %
Case Study 3 – in Natal	12 %	27 %	57 %	1 %	**88 %**	92 %	8 %
Case Study 6 – in rural Ceará	3 %	0 %	91 %	6 %	**97 %**	79 %	21 %

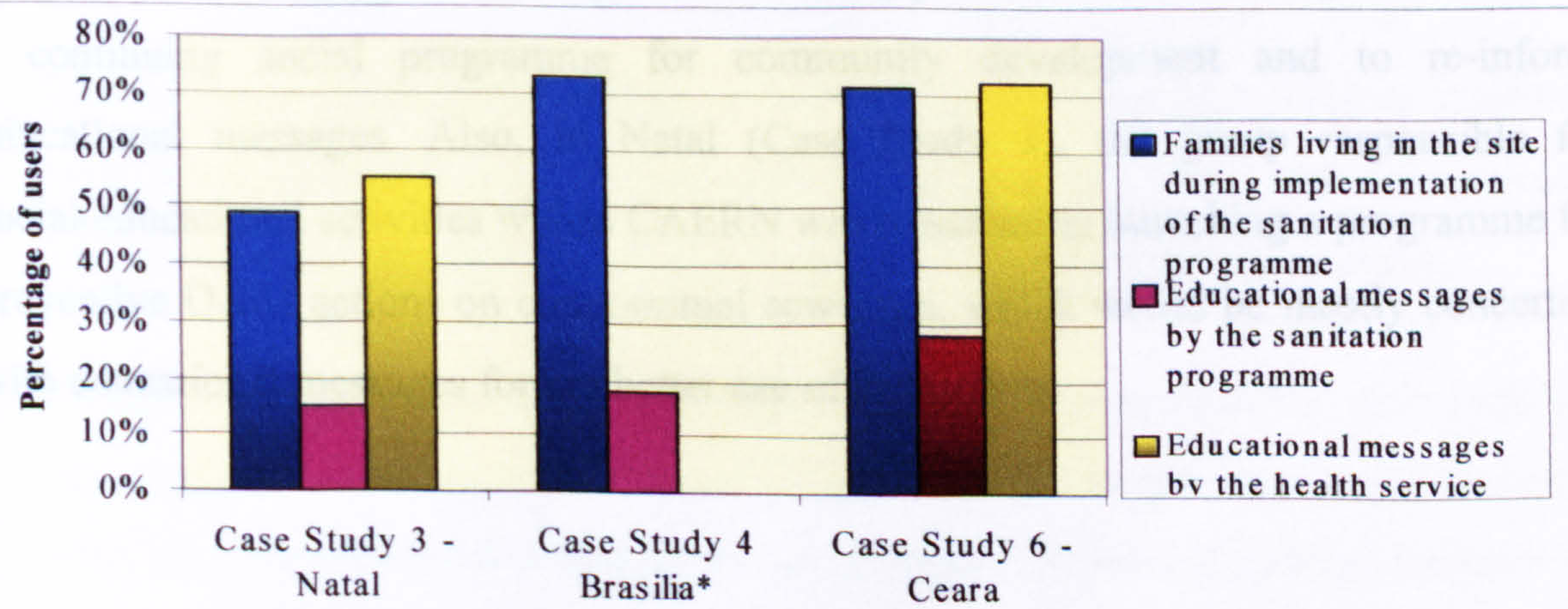
Although no formal data were collected during the fieldwork, the availability of a "measuring spoon" for preparation of ORS was common in the houses. A ready-made mixture (distributed by the public health service) was also available in some houses.

5.8.2. Educational Programmes

Educational programmes were mentioned as part of the sanitation programmes in all of the case studies. However, the programmes presented low commitment with evaluation and continuity of educational actions after the implementation phase.

As already discussed (Section 5.5.1.), the operational arrangements of low-cost sanitation systems involve the participation of users. Therefore, households should be familiar with the proper operation of the system, as well as with the procedures necessary for maintaining the components under their responsibility. For that, effectively educational programmes are fundamental for the appropriate utilisation of the sanitation installations, avoiding not only technical problems, but also, the consequent health hazards.

Comparing the percentages of families that were already living in the communities by the time of implementation of the systems and families that said they still remembered the educational messages delivered during the implementation phase, differences varying from 34 to 55 percent could be identified (Figure 5.8). However, considerations should be made for the time difference between the implementation of each programme and the collection of data during the fieldwork of this study (nearly 20 years for Case Studies 1 and 2). Nevertheless, in the more recent programmes (Case Studies 4 and 6 were 8 and 7 years old, respectively), the differences between residents that received the messages and those remembering them are still high (or even higher).



* Data from Brasilia on messages by the health service not available

Figure 5.8. – Families remembering educational messages

➤ ***Health assistants***

Two main health programmes were identified in the case study communities. These, which were primarily sponsored by the Brazilian Federal Government, were the programme to combat the dengue mosquito (*Aedes aegypti*) and the programme "Family health". Both programmes are based on health assistants that work in a pre-defined area making periodical visits to households (weekly or monthly according to residents).

The dengue programme is based on: the delivery of messages regarding the proper storage of clean water (avoiding adequate breeding conditions for the mosquitoes), the inspection of possible breeding places and the application of pesticides. The "Family health" programme, on the other hand, delivers messages about personal and household hygiene, on women's health and follows children's growth.

These two health programmes had been implemented in the majority of the case studies communities. However, no connections were found linking the educational programme of the sanitation systems to these health programmes. Figure 5.8. above, also shows the percentage of households that remember having received messages from these health programmes.

➢ ***Follow-up educational programmes***

None of the case studies monitored or evaluated the educational programmes executed during the implementation phase of the sanitation systems. Programmes targeted to reinforce or continue the educational messages were also not executed in the majority of the case studies.

Therefore, only Case Study 6 (rural Ceará) presented, in its managerial structure, a continuing social programme for community development and to re-inforce educational messages. Also, in Natal (Case Study 3), the group responsible for social/educational activities within CAERN was considering launching a programme for preventive O&M actions on condominial sewerage, which would be mostly concerned with educational messages for the better use of the system.

Chapter 6: Conclusions and Recommendations for Further studies

6.1. Conclusions

Physical sustainability of infrastructure projects has increased in importance and awareness. It can be understood as a way of effectively applying resources to achieve a worldwide healthier quality of live, decreasing inequalities and improving the interaction between human beings and the environment.

Previous reports suggest that efforts have been made towards the improvement of parameters for the identification, application and measurement of sustainable strategies. The study presented in this thesis investigated aspects considered relevant for the sustainability of low-cost sanitation programmes and, based on the data obtained, the following conclusions may be drawn:

1. Low-cost sanitation programmes must be designed taking into account specific characteristics of the sites and of the communities, and, this has to be done at all stages of the project: selection, designing, implementation and maintenance. A number of guidelines are available to drive the technology selection process. Nevertheless, the specific characteristics of a given community make the application of generalised "recipes" not always the best strategy.

2. The capacity of institutions (e.g. a water and sewerage company, a resident's association, or even a household) to undertake successfully the O&M of the selected system should be strongly assessed during the technology selection process.

3. Condominial sewerage is in fact a system designed to overcome the main problems regarding the provision of sanitation in high-density urban areas. It can work well with minimum wastewater flows and can be physically well adapted to the crowded conditions of urban slums. As a sewerage option, the condominial system is culturally very well accepted among urban residents; and it can be cheaper than on-site systems in such high-density conditions. Nevertheless, the two main vulnerabilities for its sustainability are related to user awareness (and behavioural changes) towards the adequate utilisation of the system, and the reliability of the adopted O&M strategy.

4. Including the household connections in the timetable of the implementation of the programmes would be a better strategy than leaving it to the responsibility of the householders (unless the community is easy to manage and guarantees are taken for the connections). Particularly in programmes based on the condominial sewerage technology, a strategy where the connections of a block are provided during the system's execution phase, and under the supervision of trained personnel may improve the chances for both the appropriate quality of the construction and the provision of the connection itself.

5. Regardless of the institutional administrative level (community, local or estate), commitment and accomplishment of responsibilities are certainly two key factors for the institutions involved in the O&M of low-cost sanitation systems.

6. Community participation in O&M is a strong factor in the management of low-cost sanitation programmes. Nevertheless, realistic assumptions should be considered and financially sustainable mechanisms created to overcome eventual deficiencies.

7. Educational programmes need to be evaluated, monitored and continued. Therefore, they should also be carefully balanced without introducing more messages than the community can absorb at once.

8. Educational messages delivered for the post-implementation phase of the sanitation programmes must reach all households with clear messages to reinforce the main aspects of the O&M of the systems, as well as to stress the importance of behavioural changes focusing on health improvement.

9. As has been advocated, the provision of safe water and sanitation is an urgent need that has to be accomplished. Nevertheless, the solutions cannot be delivered in response to conditions of emergency or political transience. Therefore, the urgent need for sanitation (service delivery) must be solved, but in a way that the future requirements of the systems (for examples, reliable O&M arrangements and upgrading possibilities) are also addressed.

6.2. Recommendations for Further Studies

The present study investigated aspects influencing the sustainability of low-cost sanitation programmes; however, further knowledge is still necessary in order to improve the reliability of the systems, as well as acceptance among both funding agencies and users. Therefore, further studies are suggested to be undertaken, as follows:

- Detailed comparison of the different O&M strategies adopted in the various case studies reported herein, to establish which one or ones might be advantageously used more widely (perhaps as standard solution for different periurban or rural environments).

- Better information on the full costs of the low-cost sanitation programmes (including costs of the technical system and social interventions) in order to provide (or update) cost comparisons between the different technological options and data on the influence of community densities.

- To assess the operation of condominial sewerage in areas where the water supply is unreliable or intermittent.

- To address more closely the use of condominial sewers to receive, and their capacity to accept, stormwater flows.

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ANNEX 1: Translated questionnaire applied in Case Study 1

Form N º _______

Questionnaire control:

	In field in ______		Returned form field in_____		Checked in __________

SECTION I - Identification

1. **Position of the interviewee within the family:**_______________________________
2. **For how long is the family living in the house?** _____________anos______________meses

SECTION II – Socio-economic Aspects

3. **How many people is living in the house?**__________
4. **How many people living in the household is employed ?** _________
5. **The ownership situation of the house is:**

	Own		Rented		Borrowed		Other:_____		D'Know/ D'Answer

6. **Do you have TV at home?**

	Yes		No

7. **Do you have TV at home?**

	Yes		No

8. **Do make part in the residents association activities?**

	Yes		No

SECTION III – Water Supply and Solid Waste

9. **What is the source of the water used by the family ?**

	COMPESA – in-house		COMPESA – yard tap		Well
	Collect from neighbour		Other:___________		D'Know/D' Answer

10. **What is the frequency of water shortage?**

	Rare		Monthly		Weekly		Other:_____		D'Know/ D'Answer

11. **What is the home treatment for drinking water?**

	None		Boil		Filter		Buy mineral water
	Use Chlorine		Other:___________		D'Know/D' Answer		

12. **Where is the solid waste deposited ?**

	Collected by the prefecture		on the main road		In the former compost. unit		Other:_____		D'Know/ D'Answer

SECTION IV – Community Participation on the Sanitation Programme (Groups 1 and 2)

13. **How did you (your family) become aware about the sanitation programme ?**

	Residents Association		Local Church		Neighbors
	Prefecture staff		Other:		D' Know/D' Answer

14. **When did you (your family) start to take part in the sanitation programme?**

	Already connected when moved in *(GO TO V)*		When the construction started		After see the system functioning		
	In the discussions phase		When moved in		Other:_________		Don't Know/ Don't Answer

SECTION IV – Community Participation on the Sanitation Programme *Contin.*

15. What were the main reasons that led your family to accept the system ?

____

16. How much did your family paid for the construction of the VIP latrines (in money or materials?____

17. Which construction material did your family buy ? ____________________

18. Which construction material did the prefecture provide ? ____________________

SECTION V – Technology adopted for the System *(Group 1)*

19. Who uses the sanitation facilities in the house ?

[ ] Everybody	[ ] Only adults	[ ] Other:________	[ ] D't K/ D't A

20. What is the solution adopeted for the faces of the person that does not use the facility ?

____

21. What sort of operational problem (s) occurr (ed)?

[ ] Foul smell	[ ] Presence of insects	[ ] Drainage chan. overflow
[ ] None	[ ] Other:________	[ ] D' Know/ D' Answer

22. With which frequency does the system requires maintenance services?

[ ] Never	[ ] Rarely	[ ] Sometimes
[ ] Every week	[ ] Other:__________	[ ] D' Know/ D' Answer

23. Who does the maintenance of the system?

[ ] Members of the Family	[ ] Hired person	[ ] Friends
[ ] Prefecture	[ ] Other:__________	[ ] D' Know/D' Answer

24. Which maintenance tasks are realized?

[ ] Manual emptying	[ ] Mechanical emptying	[ ] Superstructure repairs
[ ] Vent pipe repairs	[ ] Other:__________	[ ] D' Know/D' Answer

25. What is the destination of the sludge from the pit emptying?____________________

26. Have you (your family) received educational messages regarding the VIP latrine system?

[ ] No. FINISH	[ ] Yes

27. When was the last time? ____________________

28. What was it about ? ____________________

SECTION V – Technology adopted in Substitution to the VIP latrines *(Groups 2 and 3)*

29. Which sanitation solution did your family adopted for excreta disposal?

____

30. Which sanitation solution did your family adopted for sullage disposal?

____

31. Are you satisfied with the sanitation solution provided be the family ?

[ ] Yes	More ore less . Why:____________________
[ ] D' Know/ D' Answer	No. Why?____________________

32. How can the system be improved ?

____

INSPECTION: SEÇÃO I – The VIP Latrines *(Groups 1 and 2)*

1. Type of Latrine: ( ) inside single pit ( ) outside single pit ( ) double pit
2. In relation to the cover slab:
   a. Which material was used? ______________________
   b. Presenting cracks ? ( ) yes ( ) no
   c. Observation:____
3. In relation to the sanitary bowl:
   a. Which type was used? ______________________
   b. Presenting cracks ? ( ) yes ( ) no
   c. Was the toilet bowl with a cover ? ( ) yes ( ) no
   d. Observation:____
4. In relation to the superstructure:
   a. Which material was used? ______________________
   b. Presenting cracks ? ( ) yes ( ) no
   c. Has a door? ( ) yes ( ) no
   d. Does the door has any arrangement to be kept closed ? ( ) yes ( ) no
   e. Observation:____
5. In relation to the roof:
   a. Which material was used? ______________________
   b. Observation:____
6. In relation to ventilation:
   a. Which material was used for the vent pipe? ______________________
   b. Is the vent pipe installed ? ( ) yes ( ) no
   c. What is diameter of the vent pipe? ____________
   d. In how many centimetres does the vent pipe is higher than the roof? __________
   e. Does the vent pipe has a flyscreen ? ( ) yes ( ) no
   f. There is any opening for ventilation between the superstructure and the roof? ( ) yes ( ) no
   g. Observation:____
7. Hygiene conditions? ( ) good ( ) acceptable ( ) bad ( ) very bad
8. Presence of facilities for handwhashing ? ( ) yes ( ) no
9. Observations about the VIP Latrines:____________________________________

____

____

INSPECTION: SEÇÃO II– Sullage Collection *(Groups 1 and 2)*

10. Which sullage are connected to the channels? ( ) kitchen ( ) shower ( ) laundry
( ) sink ( ) none ( ) other

11. Precense of sullage around the house? ( ) No ( ) Yes. Where?___________

12. In relation to the sullage channel conditions ?

a. Glogged ? ( ) yes ( ) no

b. with household solid waste?( ) yes ( ) no

c. Presenting cracks ? ( ) yes ( ) no

d. General conditions? ( ) good ( ) acceptable ( ) bad ( ) very bad

13. Observations about the VIP Latrines:____

____

____

INSPECTION: SEÇÃO III– Facility Adopted by the Family *(Groups 2 and 3)*

14. Which sanitation solution has been used ?_________________________________

15. Hygiene conditions? ( ) good ( ) acceptable ( ) bad ( ) very bad

16. Presence of facilities for handwhashing ? ( ) yes ( ) no

17. Observations about the VIP Latrines:____

____

____

Date:____/____/____ Interviewer:____

Form processed in:______/______/_______

ANNEX 2: Translated questionnaire applied in Case Study 2

POUR-FLUSH TOILETS – CAMPO GRANDE: Aero Rancho Project

Form N º ______

SECTION I – Identification/ Socio-economic Aspects and Level of Water Supply Service

1. **Position of the interviewee within the family:**______________________________

2. **For how long is the family living in the house?** ____________anos____________meses

3. **How many people is living in the house?**__________

4. **How much does the family earn per month (in Brazilian minimum wages) ?**

	Until 1		1 to 2 (inc.)		2 to 5 (inc.)		More than 5	D'Know/ D'Answer

5. **What is the source of the water used by the family ?**

	SANESUL – in-house		SANESUL – yard tap		Well
	Buy in the doorstep		Other:___________		D'Know/D' Answer

SECTION II – Technology Usage, Functioning and Satisfaction

6. **Is the household excreta (faeces and urine) connected to the pour-flush toilet system?**

	Yes. *Go to 9*		No		D'Know/D' Answer

7. **Why is not connected to the system?**

	Lack of knowledge on the system		Lack of financial resources		Break and has not been mended

	Waiting for SANESUL		Don't think is important		Other:_________		Don't Know/ Don't Answer

8. **What is the excreta destination?**______________________________

9. **When did you (your family) start to take part in the sanitation programme?**

	Already connected when moved in		When the construction started		After see the system functioning

	In the discussions phase		When moved in		Other:_________		Don't Know/ Don't Answer

10. **What is the destination of sullage ?**

a. Shower	( ) system's pit	( ) yard	( ) street	( ) drainage	( ) other
b. Basinwash	( ) system's pit	( ) yard	( ) street	( ) drainage	( ) other
c. Kitchen sink	( ) system's pit	( ) yard	( ) street	( ) drainage	( ) other
d. Laundry	( ) system's pit	( ) yard	( ) street	( ) drainage	( ) other

11. **Had the pit ever be emptied ?**

	Yes. How many time?		No. *Go to 9*		D'Know/D' Answer

12. **Who emptied the pit?**

	The family		Hired person/company		Friends
	SANESUL		Other:___________		D'Know/D' Answer

13. **The emptying process was:**

	manually		mechanically		D'Know/D' Answer

14. **What was done to the sludge ?**

	Taken to another site		Buried		Other:_________		Dn't K/ Dn't A

SECTION II – Technology Usage, Functioning and Satisfaction (continuation)

15. How long does it take to CAERN attend to a maintenance request?

	Never requested		1 day		2 days		A week
	15 days		Other:________		D' Know/ D' Answer		

16. What is your opinion about the condominial system?

	Good		Reasonable		Bad
	Other:________		D' Know/ D' Answer		

SEÇÃO III – Public Health and Educational Programmes

17. Can you smell foul odour from the sanitation system?

	Yes		No		D'Know/D' Answer

18. There is mosquitoes in the household ?

	Yes		No		D'Know/D' Answer

19. How many children between 0 and 5 years old are there in the household ?

	Zero. *Go to 23*		1 to 2		3 to 5
	5 plus		D' Know/ D' Answer		

20. How many children between 0 and 5 years old had diarrhoea in the past 15 days ?

	Zero. *Go to 23*		1 to 2		3 to 5
	5 plus		D' Know/ D' Answer		

21. Have you heard about the oral rehydration solution (soro caseiro) ?

	No. *Go to 23*		Yes. By the TV/radio		Yes. By the resid. Ass.
	Yes. By the health service		Other:________		D' Know/ D' Answer

22. How do you prepare the solution ? ( ) OK ( ) don't know

23. Have you (your family) received educational messages regarding the condominial sewerage?

	No. FINISH		Yes

24. When was the last time? ______________________________

25. What was it about ? ______________________________

INSPECTION

a. Location of the unit ( ) inside ( ) outside	e. Type of pit ( ) single ( ) double
b. Presence of flushing device ( ) Yes ( ) No	f. Presence of grease trap ( ) Yes ( ) No
c. Presence of a Vent pipe ( ) Yes ( ) No	g. Rainwater connection ( ) Yes ( ) No
d. Pit cover sealed ( ) Yes ( ) No	h. Open flow of sullage ( ) Yes ( ) No

Questionnaire control:

	In field in ______		Returned form field in_____		Checked in ________

Date:____/____/____ Interviewer:______________________________

Form processed in:______/_____/________

ANNEX 3: Translated questionnaire applied in Case Study 3

CONDOMINIAL SYSTEM – NATAL: Rocas/Santos Reis Project

Block No.______ **Form N º** ______

Questionnaire control:

	In field in ______		Returned form field in______		Checked in ______

SECTION I - Identification/Socio-economic Aspects

3. **Address:**______________________________ **No.** ______

4. **Position of the interviewee within the family:**____________________

5. **For how long is the family living in the house?** __________anos__________meses

4. **How many people is living in the house?**__________

5. **How much does the family earn per month (in Brazilian minimum wages) ?**

	Until 1		1 to 2 (inc.)		2 to 5 (inc.)		More than 5	D'Know/ D'Answer

6. **The ownership situation of the house is:**

	Own		Rented		Borrowed		Other:____	D'Know/ D'Answer

SECTION II – Water Supply

7. **What is the source of the water used by the family ?**

	CAERN – in-house		CAERN – yard tap		Well
	Buy in the doorstep		Other:________		D'Know/D' Answer

8. **What is the frequency of water shortage?**

	Rare		Monthly		Weekly		Other:_____	D'Know/ D'Answer

SECTION III – Participation of the Community in the Sanitation Programme

9. **Is the household wastewater connected to the condominial system?**

	Yes. *Go to 12*		No		D'Know/D' Answer

10. **Why is not connected to the condominial system?**

	Lack of knowledge on the system		Lack of financial resources		Break and has not been mended

	Waiting for CAERN		Don't think is important		Other:________		Don't Know/ Don't Answer

11. **What is the wastewater destination?**

	Drainage.*Go to28*		Sep.Tank *Go to28*		Other:________ *Go to28*		D' Know/ D' Answer *Go to 28*

12. **How did you (your family) become aware about the sanitation programme ?**

	Residents Association		Local Church		Neighbors
	CAERN staff		Other:		D' Know/D' Answer

13. **When did you (your family) start to take part in the sanitation programme?**

	Already connected when moved in		When the construction started		After see the system functioning

	In the discussions phase		When moved in		Other:________		Don't Know/ Don't Answer

SECTION IV – Technology Usage, Functioning and Satisfaction

14. Who uses the sanitaty facilities in the house ?

Everybody	Only adults	Kids older than 5	Kids older than 10
	Other:________	Dn't K/ Dn't A	

15. Which sanitary appliances are connected to the system?

a. Toilet ( ) H.C ( ) H.NC ( ) D.H	d. kitchen sink ( ) H.C ( ) H.NC ( ) D.H
b. Shower ( ) H.C ( ) H.NC ( ) D.H	e. laundry tank ( ) H.C. ( ) H.NC. ( ) D.H
c. Sink ( ) H.C. ( ) H.NC. ( ) D.H	f. washing machine( ) H.C ( ) H.NC ( ) D.H

16. Who does the maintenance of the system?

Members of the family	Hired person	Friends
CAERN	Other:___________	D' Know/D' Answer

17. With which frequency does the system requires maintenance services?

Never	Rarely	Sometimes
Every week	Other:___________	D' Know/ D' Answer

18. What sort of functioning problem (s) occur (ed)?

Blockage on the househ. connection	Blockage on the sewer condominial	Broken inspection chamber	
Broken sewer	None	Other:_________	Don't Know/ Don't Answer

19. What maintenance tasks does your family realize?

Cleaning of cond. Sew.	Cleaning of insp.cham.	None
	Other:________	Dn't K/ Dn't A

20. What do you do when you (or your family) can not solve a maintenance service?

Call a neighbour	Call CAERN	Call the Resid. Assoc.
Call a professional	Other:___________	D' Know/ D' Answer

21. How long does it take to CAERN attend to a maintenance request?

1 day	2 days	A week
15 days	Other:___________	D' Know/ D' Answer

23. What is your opinion about the condominial system?

Good	Reasonable	Bad
Other:___________	D' Know/ D' Answer	

SECTION V - Tariff

24. How do you see the price payed for the sewerage system?

Low	Reasonable	High
Other:___________	D' Know/ D' Answer	

25. How much do you think the service worth (in Reais)?

1 to 2	3 to 4	4 plus
Nothing	D' Know/ D' Answer	

26. How much are you willing-to-pay for the service (in Reais)?

1 to 2	3 to 4	4 plus
Nothing	D' Know/ D' Answer	

SEÇÃO VI – Public Health and Educational Programmes

27. How many children between 0 and 5 years old are there in the household ?

	Zero. *Go to 31*		1 to 2		3 to 5
	5 plus		D' Know/ D' Answer		

28. How many children between 0 and 5 years old had diarrhoea in the past 15 days ?

	Zero. *Go to 31*		1 to 2		3 to 5
	5 plus		D' Know/ D' Answer		

29. Have you heard about the oral rehydration solution (soro caseiro) ?

	No. *Go to 31*		Yes. By the TV/radio		Yes. By the resid. Ass.
	Yes. By the health service		Other:___________		D' Know/ D' Answer

30. How do you prepare the solution ? ( ) OK ( ) don't know

31. How many children between 0 and 15 years old are there in the household ?

__________ *(answer = 0 ➔ Go to 35)*

32. How many of them had their faeces tested in the period of 1 year? ____ *(answer = 0 ➔ Go to 35)*

33. How many had positive results?_________________

34. Which helminths were identified?

	hookworm		ascaris		giardia
	amoeba		Other:___________		D' Know/ D' Answer

35. Have you (your family) received educational messages regarding the condominial sewerage?

	No. *Go to 38*		Yes

36. When was the last time? ______________________________

37. What was it about ? ____

38. Have you (your family) received educational messages regarding health?

	No. FINISH		Yes

39. When was the last time? ______________________________

40. What was it about ? ____

INSPECTION

a. Presence of grease trap	( ) Yes ( ) No	d. Rainwater connection	( ) Yes ( ) No
b. Inspection chamber locked	( ) Yes ( ) No	e. Open flow of sullage	( ) Yes ( ) No
c. Broken inspection chamber	( ) Yes ( ) No		

Date:____/____/____ Interviewer:____

Form processed in:______/______/________

Key: [H.C] has the appliance and it is connected; [H.NC] has the appliance but it is not connected
[D.H] does not have the appliance

ANNEX 4: Translated questionnaire applied in Case Study 4

CONDOMINIAL SYSTEM – VILA PLANALTO

Date:____/____/____ Interviewer:____

Form processed in:______/_____/________

Key: [H.C] has the appliance and it is connected; [H.NC] has the appliance but it is not connected
[D.H] does not have the appliance

Form N º ________

Questionnaire control:

[ ] In field in ______	[ ] Returned form field in_____	[ ] Checked in __________

SECTION I - Identification

1. **Address:**____**No.** ______
2. **Position of the interviewee within the family:**______________________
3. **For how long is the family living in the house?** ____________anos____________meses
4. **How many people is living in the house?**__________

SECTION II – Water Supply

5. **What is the source of the water used by the family ?**

[ ] CAESB – in-house	[ ] CAESB – yard tap	[ ] Well
[ ] Buy in the doorstep	[ ] Other:	[ ] D'Know/D' Answer

SECTION III – Participation of the Community in the Sanitation Programme

6. **Is the household wastewater connected to the condominial system?**

[ ] Yes. ***Go to 9***	[ ] No	[ ] D'Know/D' Answer

7. **Why is not connected to the condominial system?**

[ ] Lack of knowledge on the system	[ ] Lack of financial resources	[ ] Break and has not been mended	
[ ] Waiting for CAESB	[ ] Don't think is important	[ ] Other:________	[ ] Don't Know/ Don't Answer

8. **What is the wastewater destination?**

[ ] Drainage.***Go to20***	[ ] Sep.Tank ***Go to20***	[ ] Other:________ ***Go to20***	[ ] D' Know/ D' Answer ***Go to 20***

9. **How did you (your family) become aware about the sanitation programme ?**

[ ] Residents Association	[ ] Local Church	[ ] Neighbors
[ ] CAESB staff	[ ] Other:	[ ] D' Know/D' Answer

10. **When did you (your family) start to take part in the sanitation programme?**

[ ] Already connected when moved in	[ ] When the construction started	[ ] After see the system functioning	
[ ] In the discussions phase	[ ] When moved in	[ ] Other:________	[ ] Don't Know/ Don't Answer

SECTION IV – Technology adopted for the System

11. Who uses the sanitaty facilities in the house ?

	Everybody		Only adults		Other:________		Dn't K/ Dn't A

12. Which sanitary appliances are connected to the system?

a. Toilet ( ) H.C ( ) H.NC ( ) D.H	d. kitchen sink ( ) H.C ( ) H.NC ( ) D.H
b. Shower ( ) H.C ( ) H.NC ( ) D.H	e. laundry tank ( ) H.C. ( ) H.NC. ( ) D.H
c. Sink ( ) H.C. ( ) H.NC. ( ) D.H	f. washing machine( ) H.C ( ) H.NC ( ) D.H

13. Who does the maintenance of the system?

	Members of the family		Hired person		Friends
	CAESB		Other:____________		D' Know/D' Answer

14. With which frequency does the system requires maintenance services?

	Never		Rarely		Sometimes
	Every week		Other:		D' Know/ D' Answer

15. What sort of functioning problem (s) occurr (ed)?

	Blockage on the househ. connection		Blockage on the sewer condominial		Broken inspection chamber

	Broken sewer		None		Other:_________		Don't Know/ Don't Answer

16. How long does it take to CAESB attend to a maintenance request?

	Never requested		1 day		2 days

	A week		15 days		Other:		Dn't K/ Dn't A

17. What is your opinion about the condominial system?

	Good		Reasonable		Bad

	Other:____________		D' Know/ D' Answer

18. How do you see the price payed for the sewerage system?

	Low		Reasonable		High

	Other:____________		D' Know/ D' Answer

SEÇÃO V – Educational Programmes

19. Have you (your family) received educational messages regarding the condominial sewerage?

	No. FINISH		Yes

20. When was the last time? ______________________________

21. Was it about what ? ____

INSPECTION

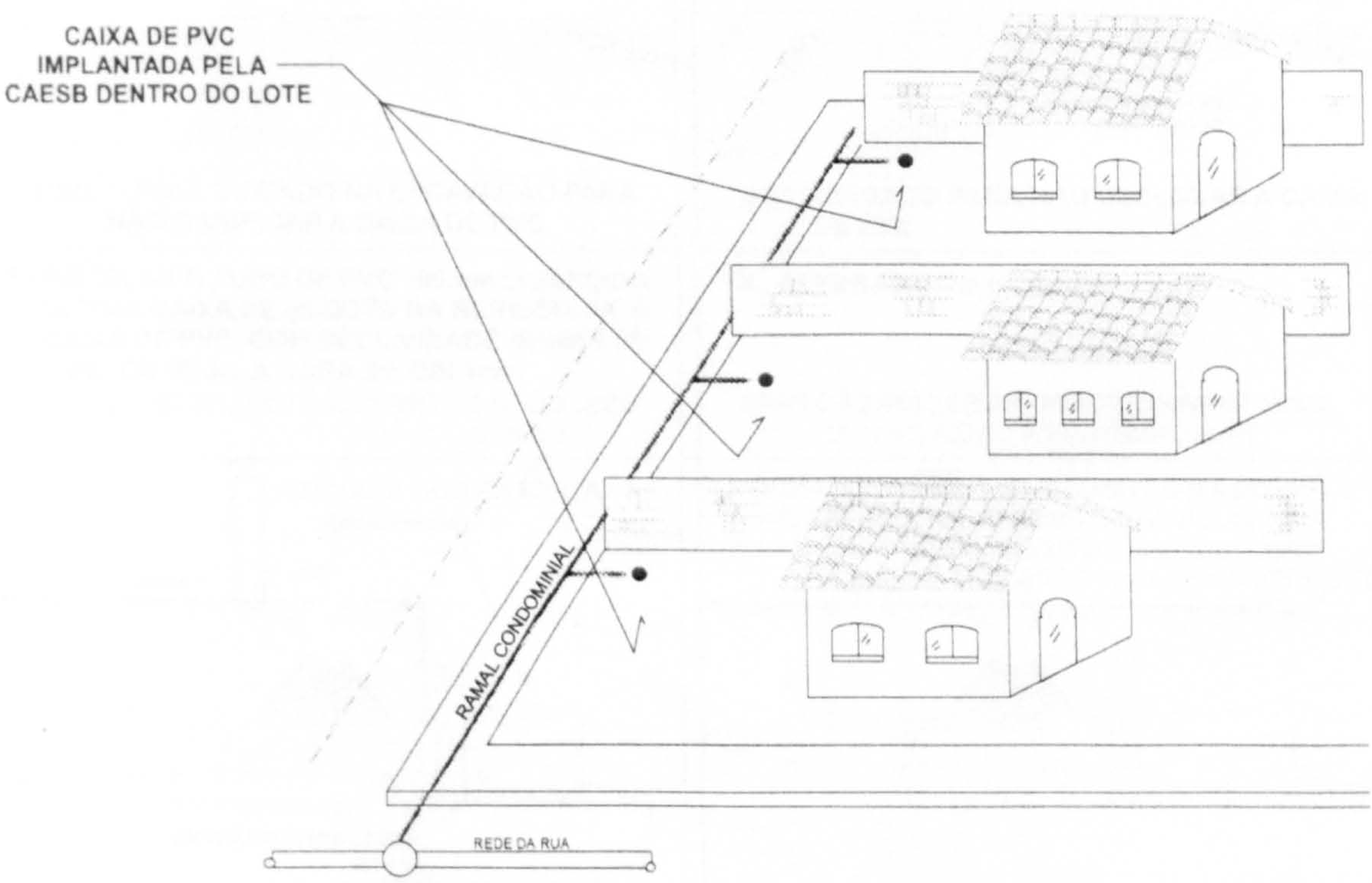
a. Presence of grease trap ( ) Yes ( ) No	d. Rainwater connection ( ) Yes ( ) No
b. Inspection chamber locked ( ) Yes ( ) No	e. Open flow of sullage ( ) Yes ( ) No
c. Broken inspection chamber ( ) Yes ( ) No	

ANNEX 5: Instruction for connection on the 100% plastic systems

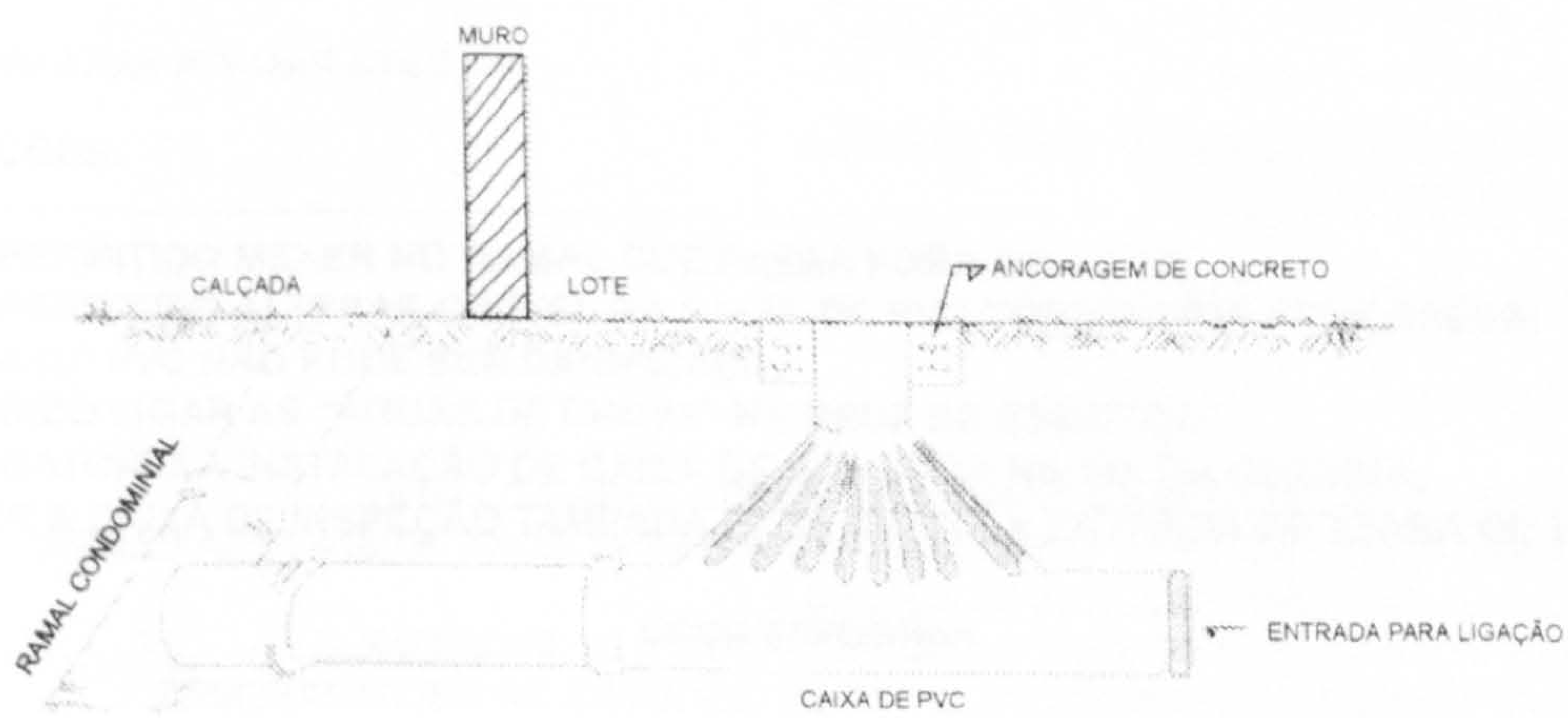
ORIENTAÇÕES PARA SISTEMAS DE ESGOTO CONSTRUÍDOS COM CAIXA DE INSPEÇÃO DE PVC

caesb

A CAESB IMPLANTOU A REDE DE ESGOTO EM SEU CONJUNTO E CONSTRUIU UMA CAIXA DE ESGOTO DENTRO DE CADA LOTE ONDE DEVERÁ SER LIGADO O ESGOTO DA SUA RESIDÊNCIA

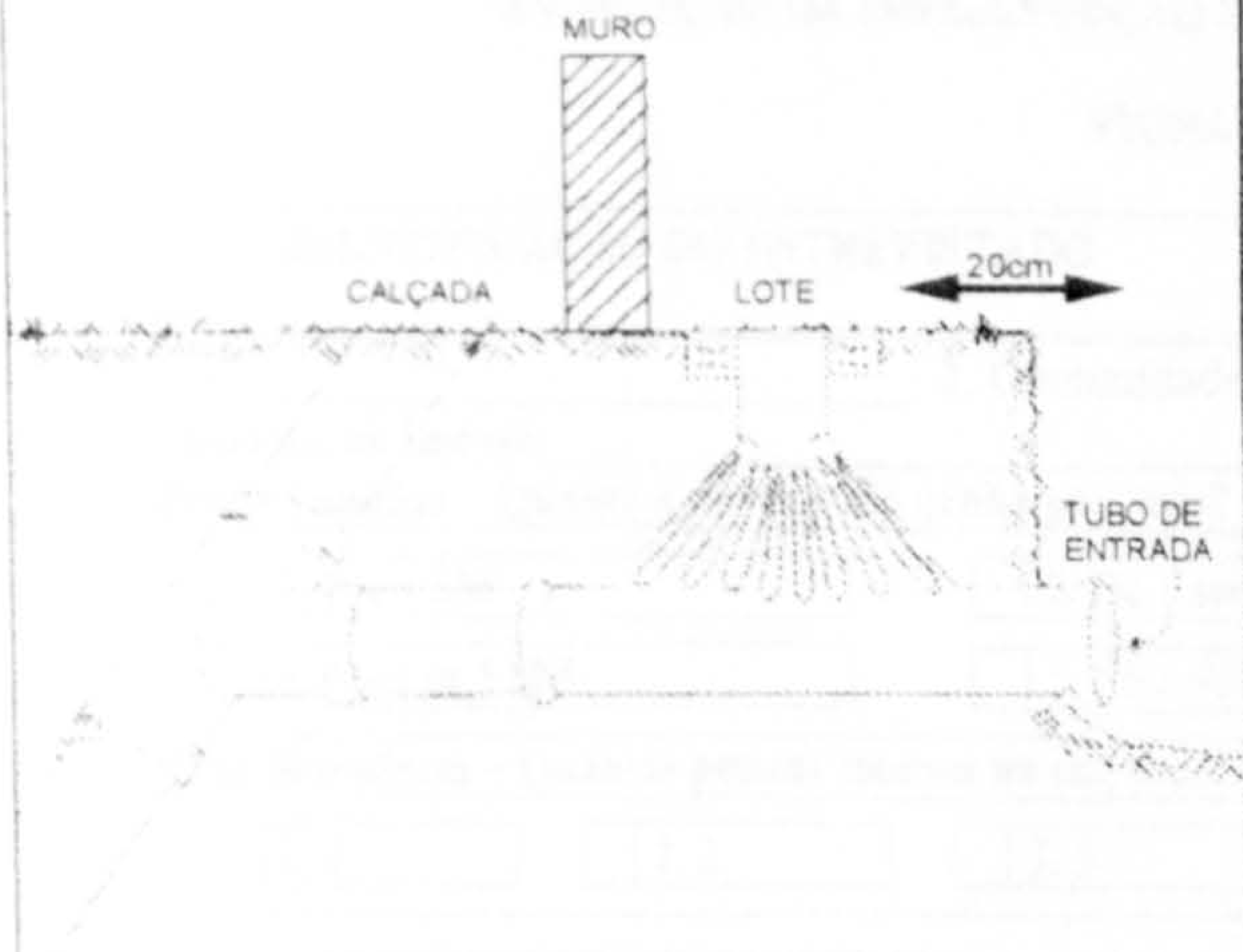


A NOVA CAIXA DE INSPEÇÃO DE PVC



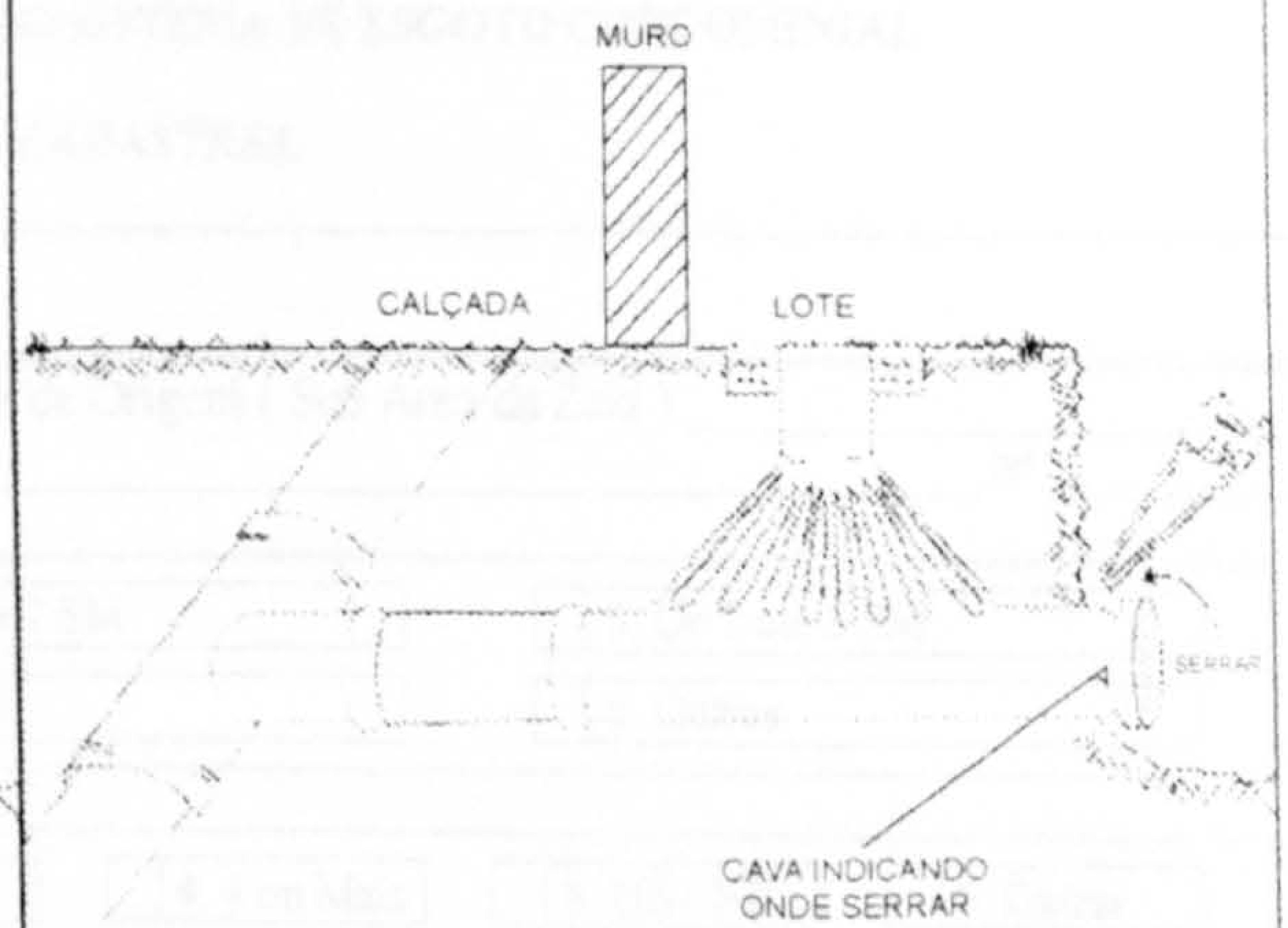
COMO FAZER A LIGAÇÃO?

1 - CAVAR AO LADO DA CAIXA PARA ENCONTRAR O TUBO DE ENTRADA



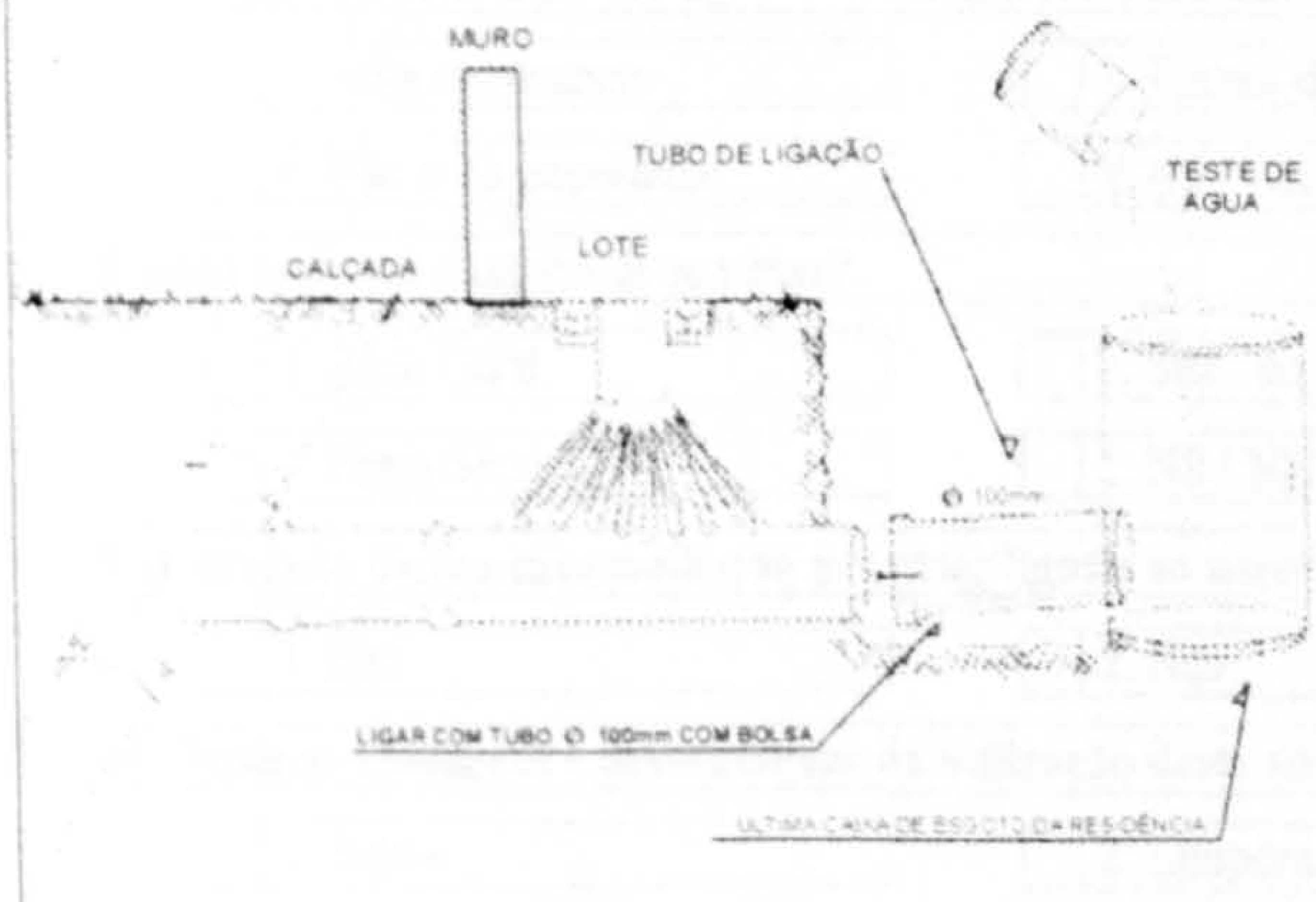
OBS: TOMAR CUIDADO NA ESCAVAÇÃO PARA NÃO DANIFICAR A CAIXA DE PVC

2 - SERRAR O TUBO DE ENTRADA DA CAIXA DE ESGOTO NA "CAVA" EXISTENTE



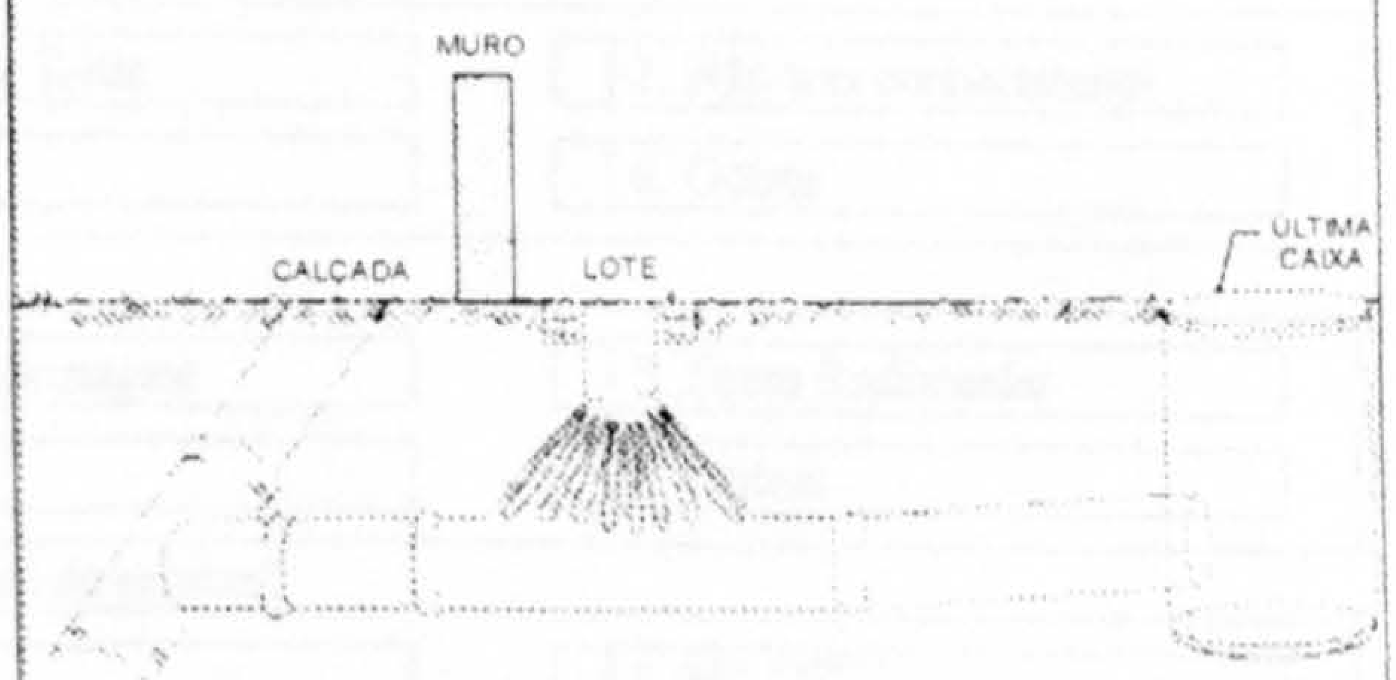
OBS: CUIDADO PARA NÃO DESLOCAR A CAIXA DE PVC

3 - INSTALAR O TUBO DE PVC 100mm LIGANDO A ÚLTIMA CAIXA DE ESGOTO DA RESIDÊNCIA À CAIXA DE PVC, COM DECLIVIDADE MÍNIMA DE 0,5%, OU SEJA, A CADA 2m CAI 1cm.



OBS: FAZER TESTE COM ÁGUA PARA VERIFICAR ESCOAMENTO

4 - ATERRAR COM CUIDADO



ESTÁ PRONTA PARA USO

OBSERVAÇÕES:

1 - NÃO É PERMITIDO MEXER NO RAMAL QUE PASSA FORA DO LOTE;
2 - NÃO É PERMITIDO ALTERAR O NÍVEL DA CAIXA DE PVC CONSTRUÍDA PELA CAESB;
3 - A CAIXA DE PVC NÃO PODE SER DANIFICADA;
4 - É PROIBIDO LIGAR AS "ÁGUAS DE CHUVA" NA REDE DE ESGOTOS;
5 - É OBRIGATÓRIO A INSTALAÇÃO DE CAIXA DE GORDURA NA PIA DA COZINHA;
6 - MANTER A CAIXA DE INSPEÇÃO TAMPADA PARA EVITAR A ENTRADA DE TERRA OU LIXO.

COCQ/SPPE/DRSE

ANNEX 6: Questionnaire applied in Case Study 5

EMPRESA DE URBANIZAÇÃO DO RECIFE - URB
DIRETORIA DE INTEGRAÇÃO URBANÍSTICA - DIUR
DIVISÃO DE PESQUISA E ACOMPANHAMENTO - DPA

Ficha Nº ______

AVALIAÇÃO DA IMPLANTAÇÃO DO SISTEMA DE ESGOTO CONDOMINIAL

FICHA CADASTRAL

I. IDENTIFICAÇÃO DO ENTREVISTADO

Nome:

1. ZEIS: ______ 2. Comunidade de Origem (Sub Area da Zeis) ______

3. Endereço do Imóvel: ______ Nº ______

4. Renda Familiar - Quanto a sua família ganha por mês?

1. Até 1 SM	2. De 1 até 2 SM	3. De 2 até 5 SM
4. Mais de 5 SM	5. NS / NR	6. Outros

5. Nº de Moradores - Quantas pessoas moram na sua casa?

1. 1	2. 2	3. 3	4. 4 ou Mais	5. NS / NR	6. Outros

II. SITUAÇÃO DA CASA/FAMÍLIA

6. Quais os cômodos da sua casa estão ligados ao sistema de esgoto condominial?

1. Nenhum	2. Banheiro (s)	3. Cozinha
4. Área de serviço	5. NS / NR	6. Outros

7. Por que sua casa não está ligada ao sistema condominial?

1. Falta de recursos	2. Receio de Taxas	3. Não tem conhecimento
4. Não acha importante	5. NS / NR	6. Outros

8. Para onde vai o esgoto de sua casa?

1. Rede Geral	2. Sist. de Drenagem	3. Fossa Rudimentar
4. Fossa Séptica	5. NS / NR	6. Outros

9. A situação da sua casa melhorou por estar ligada ao sistema de esgotos?

1. Sim	2. Não	3. NS / NR

10. Quais as vantagens e desvantagens da utilização deste sistema para sua casa/família?

1. Saúde	2. Limpeza	3. Mau Cheiro
4. NS	5. NR	6. Outros

III. SITUAÇÃO DO SISTEMA DE ESGOTOS EM RELAÇÃO À ZEIS

11. Como está funcionando a rede geral de esgoto da Area?

1. Não Está Funcionando	2. Bom	3. Razoável
4. Ruim	5. NS / NR	6. Outros

12. Você conhece o sistema condominial de esgoto?

1. Sim	2. Não	3. NS / NR

13. Como está funcionando o sistema de esgoto que serve a sua casa?

1. Não Está	2. Bem	3. Razoável
4. Ruim	5. NS / NR	6. Outros

14. Quais os principais problemas do sistema de esgoto que serve a sua casa?

1. Não Há	2. Mau Funcionamento	3. Falta de Manutenção
4. Má Utilização	5. NS / NR	6. Outros

IV SERVIÇO / MANUTENÇÃO

15. Quem faz a manutenção do sistema de esgoto que serve à sua casa?

- [ ] 1. Ninguém
- [ ] 2. COMPESA
- [ ] 3. EMLURB
- [ ] 4. comunidade
- [ ] 5. Moradores
- [ ] 6. Outros

16. Como você avalia a manutenção do sistema de esgoto que serve à sua casa?

- [ ] 1. Boa / Satisfatória
- [ ] 2. Razoável
- [ ] 3. Ruim
- [ ] 4. NS / NR
- [ ] 5. Outros

17. Como esta manutenção poderia melhorar?

- [ ] 1. Não pode melhorar
- [ ] 2. Melhor serv. prestado
- [ ] 3. Fiscalização da Pop.
- [ ] 4. Participação da Pop.
- [ ] 5. NS / NR
- [ ] 6. Outros

V. SERVIÇO DA COMUNIDADE

18. Há algum grupo comunitário que trabalha na manutenção do sistema de esgoto em sua ZEIS?

- [ ] 1. Sim
- [ ] 2. Não
- [ ] 3. NS / NR

19. Como você avalia este serviço?

- [ ] 1. Bom / Satisfatório
- [ ] 2. Razoável
- [ ] 3. Ruim
- [ ] 5. NS / NR
- [ ] 6. Outros

20. Quais as dificuldades para o desenvolvimento deste tipo de trabalho?

- [ ] 1. Não Existe
- [ ] 2. Falta Qualificação
- [ ] 3. Falta Assessoria
- [ ] 4. Falta Participação
- [ ] 5. NS / NR
- [ ] 6. Outros

VI. TARIFAS / CUSTOS

21. A quem são pagas as tarifas do serviço de esgoto?

- [ ] 1. Não Paga
- [ ] 2. COMPESA
- [ ] 3. EMLURB
- [ ] 4. Comunidade
- [ ] 5. NS / NR
- [ ] 6. Outros

22. O que você acha do valor pago pelo serviço de esgoto?

- [ ] 1. Baixo
- [ ] 2. Alto
- [ ] 3. Razoável
- [ ] 5. NS / NR
- [ ] 6. Outros

23. Quanto você acha que vale o serviço de esgoto (valor em R$)?

- [ ] 1. De 1 a 2
- [ ] 2. De 2 a 3
- [ ] 3. De 3 a 4
- [ ] 4. 4 ou Mais
- [ ] 5. NS / NR
- [ ] 6. Outros

24. Quanto você estaria disposto a pagar?

- [ ] 1. De 1 a 2
- [ ] 2. De 2 a 3
- [ ] 3. De 3 a 4
- [ ] 4. 4 ou Mais
- [ ] 5. NS / NR
- [ ] 6. Outros

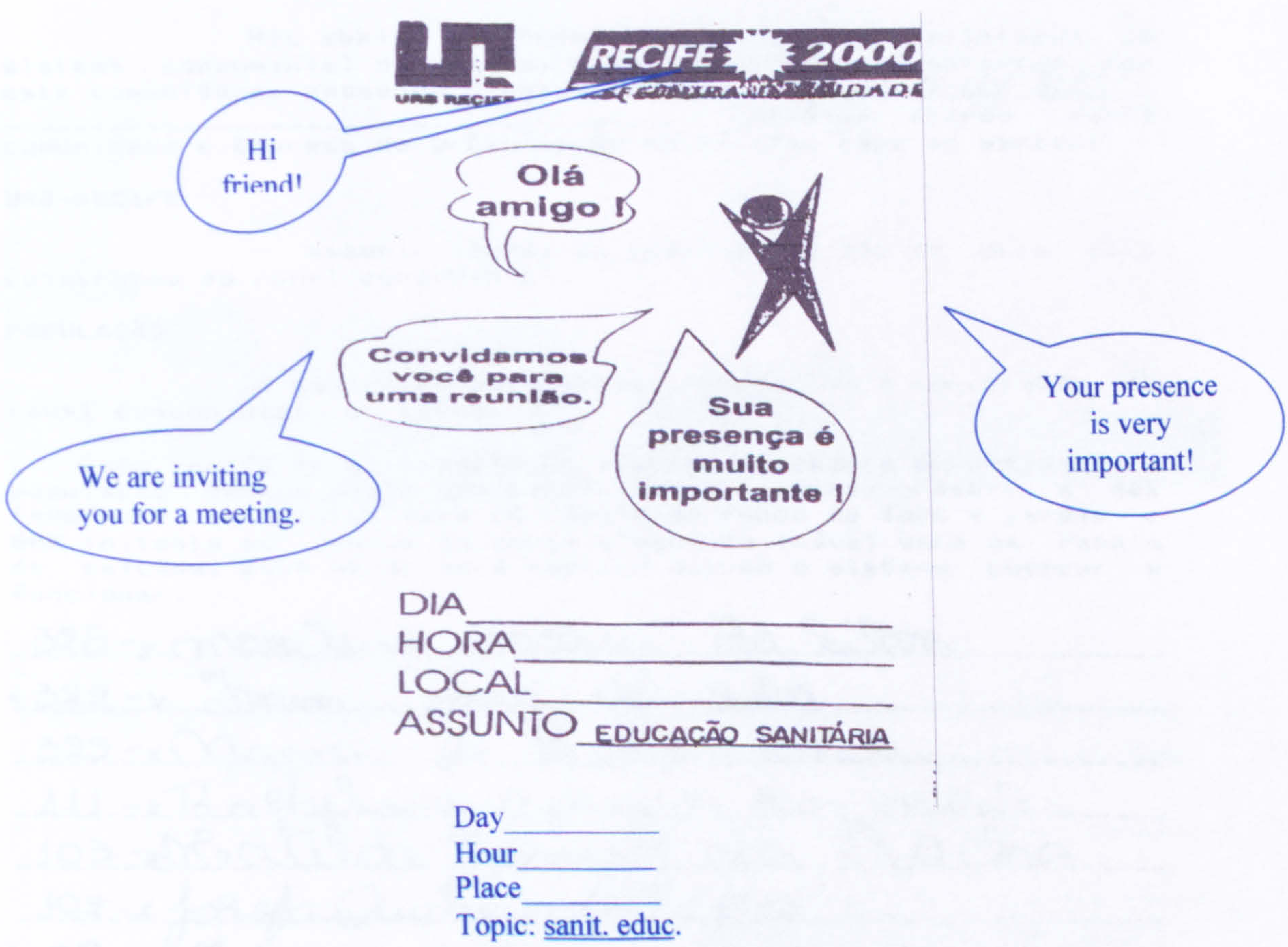
Esta Pesquisa foi solicitada pelo Fórum do PREZEIS (Câmara de Urbanização),
Comissão de Saneamento: Secretaria de Infra - Estrutura /COMPESA,
FASE,
ETAPAS,
URB/RECIFE

Data: ____________________ Pesquisador: ______________________________

ANNEX 7: Materials used in the Mangueira Sanitation Programme

ANNEX 7a: Invitation Card

This card was used to invite residents of a housing block to the meetings regarding the different aspects involved in the implementation of the condominial systems on the respective blocks.



ANNEX 7b: Agreement

Agreement between URB-Recife and the residents of a block (block 96; condominial branch number 2) for the implementation of the condominial system.

"We require the implementation of the condominial sewerage system, to be constructed in partnership with this community, having the condominial branch located on the backyard. As agreed by the community and by URB, they have the following responsibilities:
URB-RECIFE: be responsible for all labouring costs for the construction of the branch.
COMMUNITY: buy the necessary material for the construction of the branch.
1 – As for the charge for the utilisation of the condominial system, the community must pay a monthly bill, correspondent to 40% of the water bill in the cases of back and front yard branches and 80% of the water bill for sidewalk branches. This charge will just start to be applied when the system start functioning."

TERMO DE ADESÃO

Quadra 96
ramal 2

A URB-RECIFE

Nós abaixo assinados, solicitamos a implantação do sistema condominial de esgoto, a ser construído em parceria com esta comunidade, passando o ramal pelo (a) fundo de lote conforme acordo entre comunidade e Empresa de Urbanização do Recife, cabe as partes:

URB-RECIFE

– Assumir todas as despesas de mão de obra para construção do ramal condominial.

POPULAÇÃO

– Aquisição do material necessário a construção do ramal condominial, os tubos.

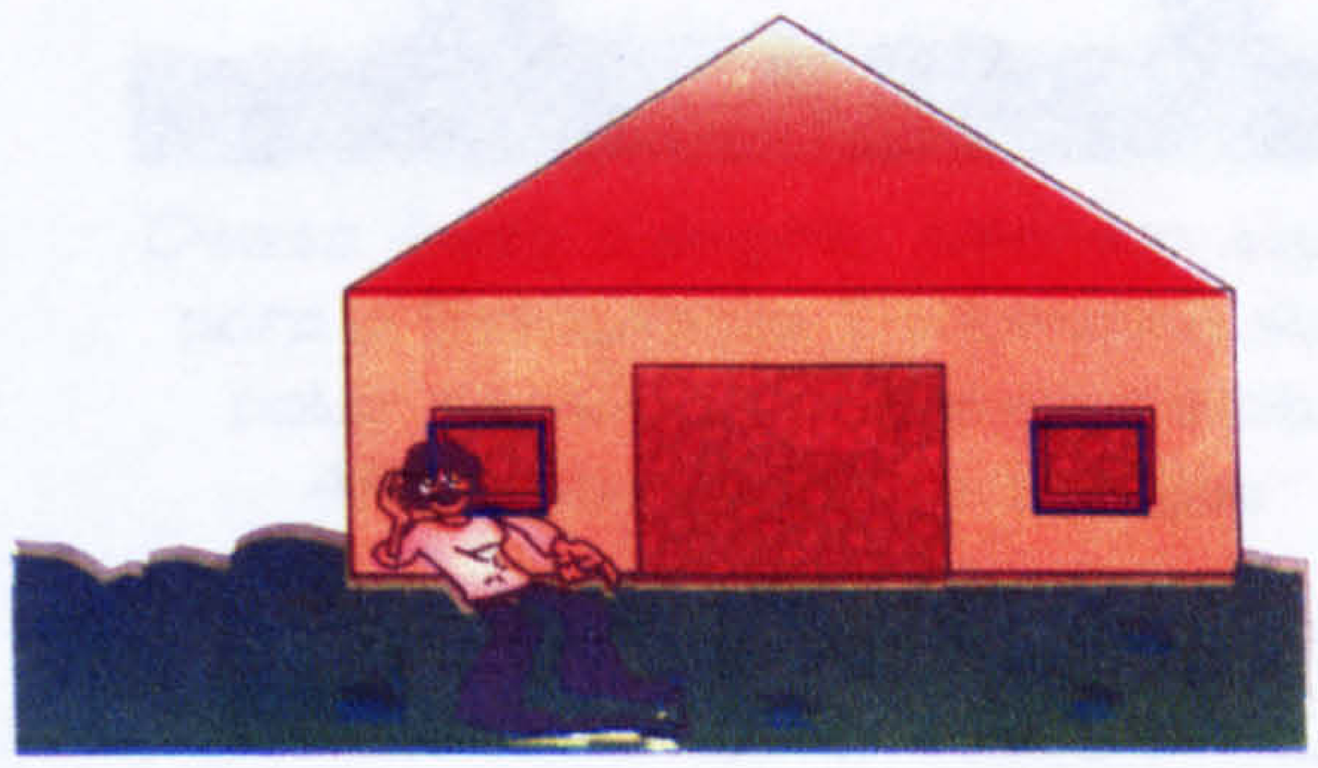
1 – Como tarifa de utilização do sistema de esgoto condominial, a população deverá pagar uma tarifa mensal, correspondente a 40% (quarenta por cento) para os ramais de fundo de lote e jardim e 80% (oitenta por cento) da conta d'agua do imóvel para os ramais de calçada. Este valor será cobrado quando o sistema começar a funcionar.

328-x marlene maria da Silva
x322-x Ivana soares da silva
325-x Marlei de Paula Silva
111-x Rachelane Pereira dos Montes
103- Matilde Gomes da Rocha
102-x Josefa Quiteria da Silva
• 88-x MANOEL JERÔNIMO DA SILVA FILHO
x323 x Jacira celestina da Silva (obs: Falta tampa)
1 x323 A x Edilene Souza de Brito
Debora Josi Barreto
*
94x Josefa Torquelina dos Santos

ANNEX 7c: Educational material

O Recife tem mais de um milhão de pessoas sem Sistema de Esgotos nas suas casas

Por esta razão, a população está sujeita a todo tipo de doenças: CÓLERA, TIFO, FILARIOSE, DENGUE E MUITAS OUTRAS.



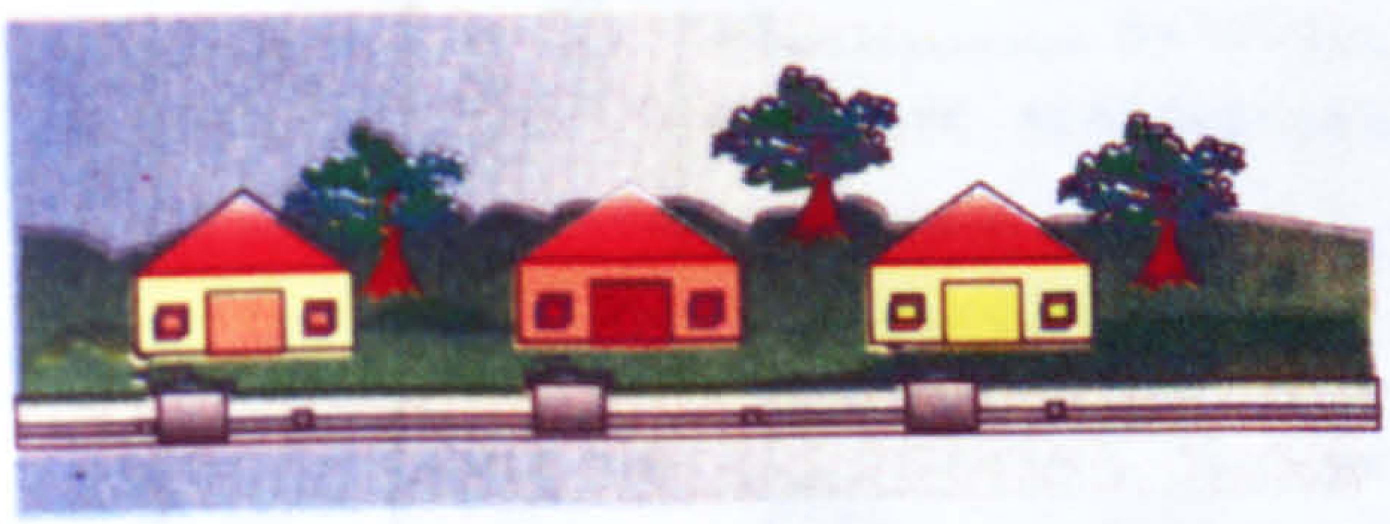
Putting the sewerage into the pipes

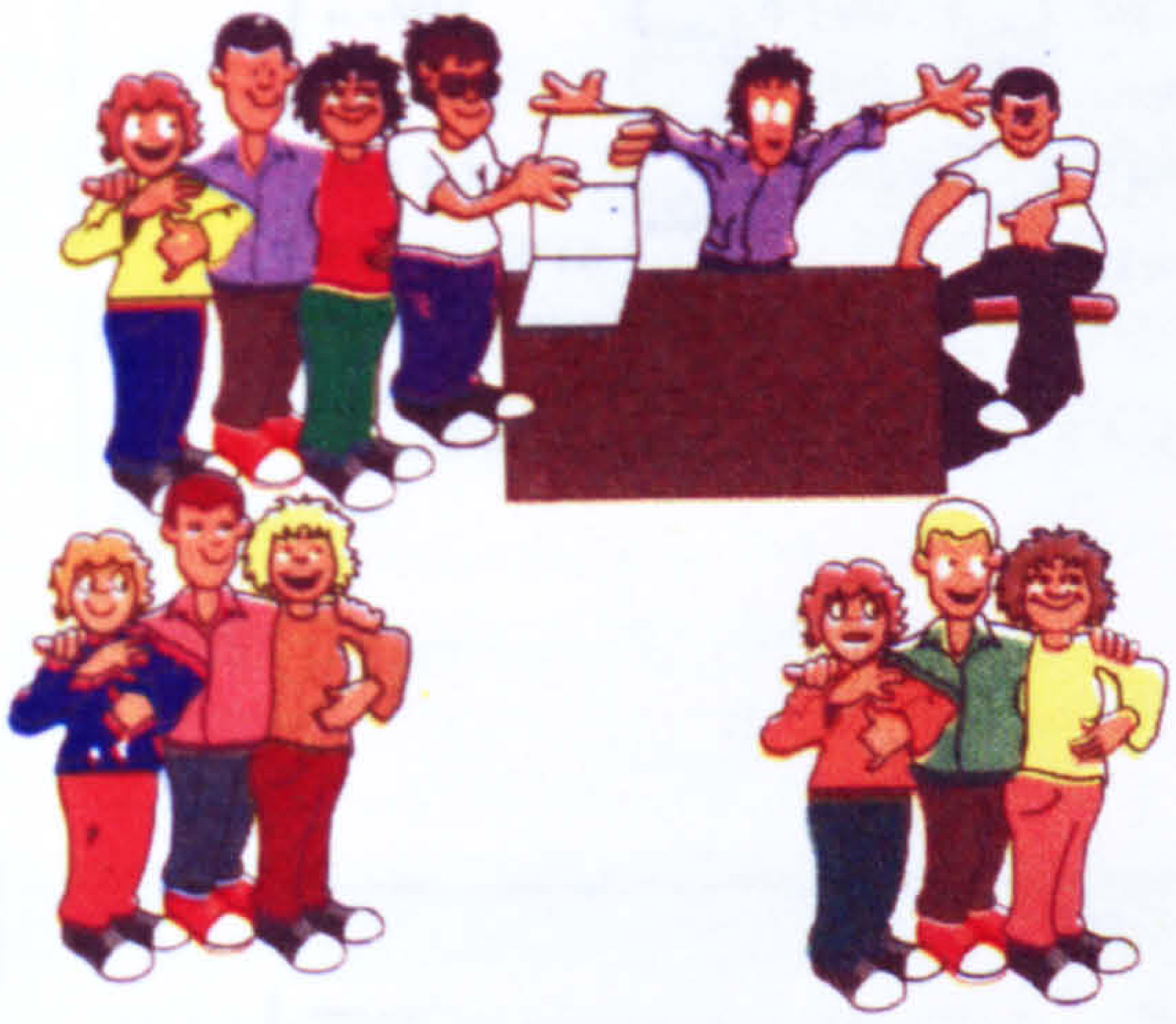
Recife has more one million people without sewerage systems for their houses.

For this reason, the population is exposed for all kinds of diseases: COLERA, THYFO, FILARIOSIS, DENGUE AND MANY OTHERS.

ESTA SITUAÇÃO PODE MUDAR!

O Sistema de Esgotos Condominiais
pode beneficiar um maior
número de pessoas.





Mas tem um detalhe:
Ele só funciona com a
participação de todos.

TUDO COMEÇA COM A ORGANIZAÇÃO

1 - Zelar e fazer a manutenção do Sistema construído dentro dos lotes.

2 - Pagar a tarifa mensal.
3 - Seguir a orientação repassada pelo Serviço Público.
4 - Cobrar do Serviço Público eficiência na manutenção do Sistema implantado em Área Públicas.

Desse modo o esgoto coletado segue para a Estação de Tratamento sem poluir os rios, canais e canaletas. Afastando assim as doenças do bairro.

THIS SITUATION HAS TO IMPROVE!

The condominial sewerage system can benefit a higher number of people.

EVERYTHING STARTS WITH ORGANISATION

1 – Take care and maintain the system built inside the plots.

2 – Pay the monthly bill.
3 – Follow the instruction given by the Public sector.
4 – Require efficiency of the Public Sector in the maintenance of the system implemented in Public Areas.

But there is a detail:
It just work with the
Participation of everybody

In this way, the sewage collected goes to a treatment plant without polluting the rivers, channels and soakaways.
Taking the diseases away from the boroughs.

ANNEX 7d: Field forms for the Registration of Maintenance Activities

Compesa | SOLICITAÇÃO/RECLAMAÇÃO DE ESGOTO | Nº

DADOS DO USUÁRIO

NOME:

RUA, AV, ETC:

Nº ______ BAIRRO: ______ CIDADE: ______

PONTO DE REFERENCIA:

DATA: ___/___/___

EXPECIFICAÇÃO DOS SERVIÇO's						EQUIPAMENTO's P/O'S SERVIÇO's	
COLETOR	☐	CAIXA	☐	SERVIÇO INTERNO	☐	JATO	☐
RAMAL	☐	PLUG	☐	NÃO HÁ REDE	☐	VACUO	☐
RADIAL	☐	POÇO	☐	END. INCOMPLETO	☐	MINI JATO	☐
DRENO	☐	FOSSA	☐	NÃO HÁ OBSTRUÇÃO	☐	EQUIP./APOIO	☐
EMISSÁRIO	☐			SERVIÇO DE GALERIA	☐		

___/___/___ data ______ Ass: do Vistoriante | ______ Ass: do usuário

SERVIÇO (s) EXECUTADO (s)

☐ DESOBSTRUÇÃO
COLETOR:
RAMAL:
PLUG:
DRENO:

☐ SUBSTITUIÇÃO
RAMAL:
BASE:
DISCO:
T. DE CAIXA:

☐ CONSERTO
COLETOR:
RAMAL:
PLUG:
RADIAL:
CAIXA:
POÇO:
EMISSÁRIO:
FOSSA:
CALÇADA:
DRENO:

☐ LIMPEZA
COLETOR:
CAIXA:
POÇO:
FOSSA:

☐ CONSTRUÇÃO
CAIXA:
LIGAÇÃO:
POÇO:

INÍCIO: ___/___/___ ÀS ______ HORAS | TÉRMINO ___/___/___ ÀS ______ HORAS

OBS:

___/___/___ data ______ Ass: Supervisor | ___/___/___ data ______ Ass: Chefia

ANNEX 8: Translated questionnaire applied in Case Study 6

CONDOMINIAL SYSTEM – SISAR Programme/Ceará

Form N º ________

Questionnaire control:

	In field in ______		Returned form field in______		Checked in ___________

SECTION I – Identification/ Socio-economic Aspects and Water Supply

1. **Position of the interviewee within the family:**_______________________________
2. **For how long is the family living in the house?** ____________anos____________meses
3. **How many people is living in the house?**_________
4. **The ownership situation of the house is:**

	Own		Rented		Borrowed		Other:_____		D'Know/ D'Answer

5. **What is the source of the water used by the family ?**

	SISAR – in-house		SISAR – yard tap		Well
	Collected		Other:__________		D'Know/D' Answer

6. **What is the frequency of water shortage?**

	Rare		Monthly		Weekly		Other:_____		D'Know/ D'Answer

SECTION II – Participation of the Community in the Sanitation Programme

7. **Is the household wastewater connected to the condominial system?**

	Yes. Sewerage		Yes. Septic tank		No

8. **Why is not connected to the condominial system?**

	Lack of knowledge on the system		Lack of financial resources		Break and has not been mended

	Waiting for CAGECE		Don't think is important		Other:_________		Don't Know/ Don't Answer

9. **How did you (your family) become aware about the sanitation programme ?**

	Residents Association		Local Church		Neighbors
	CAGECE staff		Other:		D' Know/D' Answer

SECTION III – Technology Usage, Functioning and Satisfaction

10. **Who uses the sanitary facilities in the house ?**

	Everybody		Only adults		Kids older than 5		Kids older than 10
			Other:________		Dn't K/ Dn't A		

11. **With which frequency does the system requires maintenance services?**

	Never		Rarely		Sometimes
	Every week		Other:__________		D' Know/ D' Answer

12. **What sort of functioning problem (s) occurr (ed)?**

	Blockage on the main sewer		Blockage on the sewer condominial		Broken inspection chamber

	Broken sewer		None		Other:_________		Don't Know/ Don't Answer

SECTION III – Technology Usage, Functioning and Satisfaction (cont.)

13. What do you do when you (or your family) can not solve a maintenance service?

	Call a neighbour		Call the system operator		Call the Resid. Assoc.
	Hire a professional		Other:__________		D' Know/ D' Answer

14. How long does it take to the system operator to attend a maintenance request?

	1 day		2 days		A week
	15 days		Other:__________		D' Know/ D' Answer

15. What is your opinion about the condominial system?

	Good		Reasonable		Bad
	Other:__________		D' Know/ D' Answer		

16. How do you see the price payed for the sewerage system?

	Low		Reasonable		High
	Other:__________		D' Know/ D' Answer		

SEÇÃO IV – Public Health and Educational Programmes

17. How many children between 0 and 5 years old are there in the household ?

	Zero. *Go to 21*		1 to 2		3 to 5
	5 plus		D' Know/ D' Answer		

18. How many children between 0 and 5 years old had diarrhoea in the past 15 days ?

	Zero. *Go to 11*		1 to 2		3 to 5
	5 plus		D' Know/ D' Answer		

19. Have you heard about the oral rehydration solution (soro caseiro) ?

	No. *Go to 21*		Yes. By the TV/radio		Yes. By the resid. Ass.
	Yes. By the health service		Other:__________		D' Know/ D' Answer

20. How do you prepare the solution ? ( ) OK ( ) don't know

21. How many children between 0 and 15 years old are there in the household ?

__________ *(answer = 0 ➔ Go to 25)*

22. How many of them had their faeces tested in the period of 1 year? ____ *(answer = 0 ➔ Go to 25)*

23. How many had positive results?_______________

24. Which helminths were identified?

	hookworm		ascaris		giardia
	amoeba		Other:__________		D' Know/ D' Answer

25. Have you (your family) received educational messages regarding the condominial sewerage?

	No. *Go to 28*		Yes

26. When was the last time? ______________________________

27. What was it about ? ____

28. Have you (your family) received educational messages regarding the condominial sewerage?

	No. FINISH		Yes

29. When was the last time? ______________________________

30. What was it about ? ____

Date:____/____/____ Interviewer:____

Form processed in:______/_____/________

ANNEX 9: Informative SISAR

SISAR
Sistema Integrado de Saneamento Rural

SISAR REALIZA TORNEIO DE FUTEBOL

No dia 20 de agosto de 2000, o SISAR esteve presente na localidade de Barra do Sotero (Croatá), para entregar o prêmio a essa comunidade , por apresentar o ***menor índice de inadimplência no 1º Semestre de 2000.*** O prêmio, no valor de R$ 250,00 (duzentos e cinqüenta reais), foi dado em materiais e entregue a Presidente da Associação a Sr.ª Márcia.

Como meio de aumentar a integração SISAR/Comunidades, foi organizado um torneio de futebol com a participação das quatro comunidades que apresentaram os menores índices de inadimplência: Barra do Sotero; Camilos; Sapó e Betânia.

Também estiveram presentes participando da festa o Sr. Marnilo representante de Almas (Cariré), onde atuou como juiz e o Sr. Adalto Alves (Gerente Adm. Fin. do SISAR).

PRESIDENTE DO SISAR ENTREGA TROFÉU PARA A COMUNIDADE DE BARRA DO SOTERO

A equipe de manutenção do SISAR não pára de trabalhar! Nossos técnicos durante o mês de novembro visitaram as comunidades de Caiçara, Juritianha, Araquém, Sapó, Panacuí, Juá, Triângulo do Marco, Aranaú, Preá, Castelhano, Barra do Sotero, Betânia, Lagoa dos Carneiros e São Gonçalo.

Os serviços realizados pela equipe foram de limpeza e desinfeção de poço tubular, limpeza e desinfeção de poço amazonas, pintura do letreiro do SISAR, substituição de bomba submersa, manutenção em quadro de comando e proteção, visita técnica para avaliação dos sistemas filiados, substituição de ventosas em adutoras e recuperação de registros.

O Sr. Evandro (Gerente Técnico do SISAR), em entrevista exclusiva nos disse: " *Estamos fazendo um serviço que nunca antes tinha sido feito no SISAR : coleta sistemática de água para análise laboratorial. Nossa preocupação é garantir a boa qualidade da água nos sistemas mantidos pelo SISAR.* "

O Sr. Adalto (Ger. Adm. Fin.) informa as demonstrações financeiras do SISAR. Veja o quadro abaixo e acompanhe a conta : As **receitas** (dinheiro que entra no caixa do SISAR) menos a **taxa de operação** (dinheiro que fica para as associações) é igual ao **total arrecadado.** O **total arrecadado** menos os **custos** e as **despesas** é igual ao **resultado.** O resultado pode ser positivo (sobra dinheiro) ou negativo (falta dinheiro). No mês de outubro o resultado foi negativo (vermelho). É muito importante que você acompanhe bem de perto as contas do SISAR e da sua Associação. Participe ! Você só tem a ganhar.

Demonstrativo Financeiro do SISAR
Outubro de 2000 / Valores em Real

RECEITAS	24.899,50
TAXA DE OPERAÇÃO	(6.064,07)
TOTAL ARRECADADO	18.835,43
CUSTOS	(18.716,42)
DESPESAS	(6.966,55)
RESULTADO	6.847,54

INFORMATIVO SISAR ANO V ; Nº 01 DEZEMBRO / 2000
SISAR - Av. John Sanford , 1994 – Sobral – CE Fone/fax : (88) 614.1869