AN ASSESSMENT OF AN INSTITUTION'S SANITARY DISPOSAL SYSTEMS

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CERTIFICATION

This is to certify that this work was carried out by Mr. PETER, Adekunle Toba (CVE/97/9902) in the Department of Civil Engineering, Federal University of Technology, Akure, in partial fulfillment of the requirements for the award of the Degree of Master of Engineering in Civil Engineering (Water Resources and Environmental Engineering Option) of the Federal University of Technology Akure.

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ABSTRACT

This research project dealt primarily with the assessment of the sanitary disposal system of human wastes, for The Federal Polytechnic, Bida Campus, situated in Niger State of Nigeria, using socio-cultural, technical, institutional and economic factors, which impact on the potential of providing sustained services to all sectors of the campus. The criteria for evaluation of several existing systems were formulated using the factors determined through physical and attitude surveys conducted on the campus. The selection of appropriate systems were carried out to ensure acceptability and adequacy.

From the study, it was discovered that most of the existing sanitation facilities on the campus were not appropriate in terms of adequacy and acceptability. The systems, that were eventually selected and designed for different sectors of the campus, which satisfied the criteria for evaluation, in terms of adequacy and acceptability were: Ventilated Improved Pit (VIP) latrines, around the workshops and laboratories, due to socio-cultural factors; septic tank and soakaway pits for office buildings and residential quarters, where the topography of the terrain and the sparse population do not encourage a centralized facility; and sewerage and central sewage treatment system for the student hostels, where there is high population density and suitable topography for gravity flow.

Cost comparisons were carried out for these alternative sanitation systems, using the Total Annual Cost per Household (TACH) criterion. The cost implication would enable the users to decide on what service level they were willing to pay for, without sacrificing adequacy and acceptability.

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CHAPTER ONE

INTRODUCTION

1.1 General

Every normal human being passes out waste products from the body, in the form of excreta. The process itself is a healthy one, but if the waste products are not properly handled they may constitute problems and dangers to man. One of the major reasons why a good sanitation system for human wastes is indispensable is the need to safeguard human health. An effective system, therefore, must be able to collect, retain, and render excreta harmless and inoffensive to man.

Figures from the World Health Organization (WHO) for 1980 showed that only 53 percent of urban population, and 13 percent in the rural areas, of the developing countries had adequate facilities for excreta disposal. The figures, however, which were based on very modest definition of adequacy, do not mean that all facilities met the minimum public health requirements (Cairncross and Feachem, 1983).

It is bad enough that there are no adequate facilities for excreta disposal, but it is worse to discover that some of the existing facilities are not functioning effectively as one would desire. Even, some sophisticated facilities built in some communities have not recorded the expected high standard of performance on a continuous basis.

The case study is that of the Federal Polytechnic Bida, in Niger State, Nigeria. The sanitation facilities on the campus are the cistern flush toilets with septic tanks and soak-away pits. There are also a few pit latrines, strategically located. But, despite all these, one could still find people defecating in unapproved and inappropriate places on the campus, constituting poor excreta disposal practices, and serious health hazard to the community.

There are several alternative sanitation technologies for excreta disposal, ranging from simple techniques used by remote rural communities to the most specialized of recent innovations. It is, however, obvious that every sanitation system option cannot be appropriate for every community. Any right attempt at providing appropriate facility for a given community must be based on sound understanding of existing resources, limitations, and possibilities. With the benefit of hindsight, it should be possible to correct some of the short comings of past solutions as well as to develop a sequence of planned sanitation improvements, designed from the outset, to provide maximum health benefits while minimising costs.

Selection of alternative facilities has been largely based on quantitative indicators, which measure project success only in terms of fund spent (Eales, 1997). However, apart from the money spent (economic factor), there are other factors of influence to effective performance of sanitation systems. These include social, cultural, technical and institutional factors. Other things being equal, the selection of one design over another should be determined by a composite of these named factors.

1.2 The study area

The study area is The Federal Polytechnic, Bida, an institution established on March 1st, 1977 as Federal College of Technology, Kano, but was moved to Bida on July 27th, 1977, as Bida College of Technology. It became The Federal Polytechnic, Bida in 1979, through the enactment of Decree 33 of 1979. The institution is located in Bida town in Niger State of Nigeria, along Bida - Doko road. The site lies between latitude $9^0 00'$N and 9^0 15'N and longitudes 5^0 45'E and 6^0 15'E. (Fig 1.1)

The Institution is divided into three major zones: "LAGOS", "ABUJA", AND STAFF QUARTERS. The "Lagos" zone comprises the School of Business Administration and Management, School of Environmental Studies, School of Preliminary

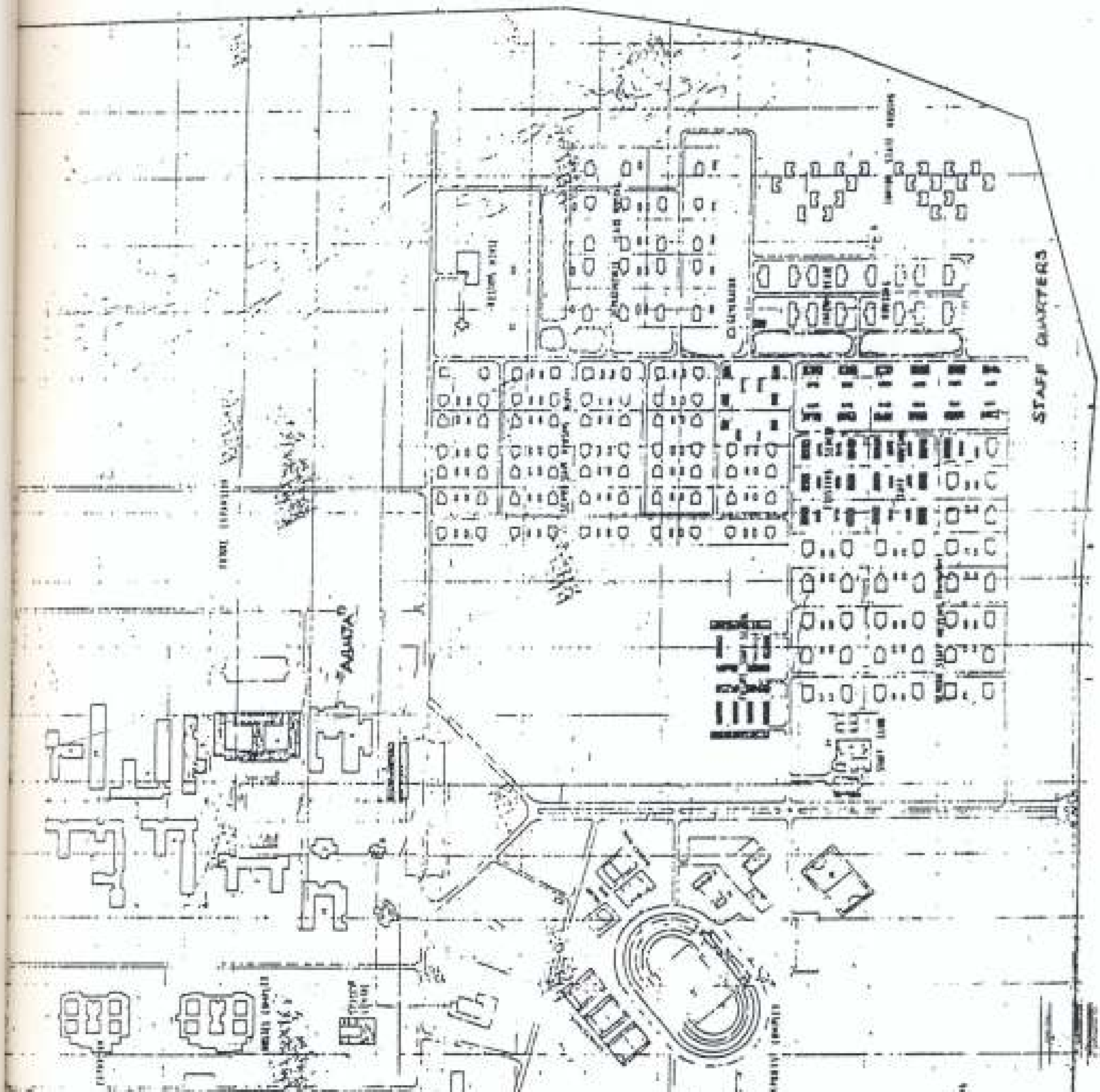

Fig 1.1: The layout of The Federal Polytechnic, Bida

Studies, the Polytechnic Library, Works and Services Department, and the Polytechnic Clinic. The "Abuja" zone comprises the School of Applied Arts and Sciences, School of Engineering Technology, the Administrative Complex, and the IBB Computer Centre.

The male hostels are located in the "Lagos" zone, while the female hostels and students çentre are located in-between the "Lagos" and "Abuja" zones. The laboratories, workshops, classrooms and offices are at both the "Lagos" and "Abuja" zones. The Polytechnic Staff School is situated on the way to the Staff Quarters.

As at January 31st 1999, the total staff strength of the Federal Polytechnic, Bida,was 940, made up of 418 senior staff and 522 junior staff. The total students' population for 1997/98 season was 12,053, with each school's figure as shown in Table 1.1.

Table I'.1 Student population distribution at the Federal Polytechnic Bida (1997/98 session)

Schools	Population
School of Business Administration and Management	5,201
School of Environmental Studies	933
School of Applied arts and Sciences	1,147
School of Engineering Technology	2,472
School of Preliminary studies	2,300
Total population	12,053

The staff quarters was capable of housing about 60 members of senior staff of the Polytechnic, while the official figures of bed spaces in the male and female hostels was about 1,136 and 784 respectively. The Polytechnic Staff School is made up of the Nursery and Primary School wing, and the Secondary School wing. Both run as day schools, with approximate populations of 1,320 and 270 respectively. The staff strength of the two wings was about 43. (1999 Figures).

1.3 Objectives of the project

The strategic sanitation approach, which has been defined as "an approach to the delivery of sanitation services which engages all the factors, social, technical, institutional and economic, which impact on the potential for sustained services provision to all sectors of the urban community", is an area that seemed to be receiving attention from many investigators in recent time (Darren, 1997 and Eales, 1997). The need to demonstrate this principle, using the Federal Polytechnic Bida as a case study, motivated this research project. The objectives of this work are therefore:

(a) To determine the type and extent of the existing excreta disposal facilities in the Federal Polytechnic, Bida campus, and to record their misuse, nuisance and health hazard potential;

(b) To study and document the social and cultural factors related to excreta disposal on the campus, and to determine the beneficiary system preference;

(c) To determine the technical and institutional factors relating to excreta disposal on the campus, if any;

(d) To evaluate alternative excreta disposal systems for the campus;

(e) To design an appropriate excreta disposal system for the campus.

CHAPTER TWO

LITERATURE REVIEW

2.1 General

The standard of providing one latrine and one water tap per family has received international recognition (Feachem et al, 1978). However, from available data, this is still a mirage as far as developing countries are concerned. Dangerfield (1983) has reported that 75 percent of all persons in developing countries live without any kind of sanitation facility. Bays (1992) also reported that about a quarter of the world population do not have adequate sanitation. Even though progress was made in water supply and sanitation during the drinking water supply and sanitation decade of the 1980s, when more than 1.3 billion people were newly supplied with adequate water and about 750 million with sanitation (Okun and Lauria, 1992), the present standard is still below expectation.

The significance of generalized data on the availability of adequate excreta disposal systems becomes much more evident when it can be compared with the detailed results of surveys from specific localities. One of such results is the one from a national survey carried out in Ghana by members of the Civil Engineering Department of the University of Science and Technology, Kumasi. The result showed that there was one communal latrine for every 389 rural persons on the average; and there were areas where 1,713 persons were served by one communal latrine (Wright et al, 1981).

It has been observed that enteric diseases spread by insanitary disposal of excreta and polluted water supply was a major cause of illness and death in developing countries, particularly among children (Carroll, 1983). The role of effective sanitation system is, therefore, to break this cycle of disease transmission.

Feachem et al (1978) have discovered that water supply alone cannot provide full health benefits. It was noted that, in some cases, owing to the lack of adequate facilities for excreta disposal, an increased water supply may even cause the spread of disease. In many ways, therefore, improvements in practices of disposing excreta are crucial to raising the level of public health in developing countries.

2.2 Technologies for excreta disposal

The generic classification of sanitation systems according to the 1982 works of Kalbermatten et al as reported by Edwards (1992), was in four broad categories (Fig 2.1):

(i) Those systems in which excreta are carried off-site by cartage or by water in sewers;

(ii) Those systems that treat and dispose of excreta on-site;

(iii)) Those systems that do not need water;

(iv) Those systems where water is mixed with excreta during flushing.

Another investigator, Pacey (1981), subdivided the whole range of sanitation technologies as follows:

Cistern-flush latrines with conventional sewerage;

Specialized technologies (packing toilets, chemical latrines, e.t.c);

Aqua - privies and related systems;

Pit latrines and derivatives;

Composting latrines;

Bucket latrines or conservancy vaults with cartage of excreta off the site;

Simple techniques (trench latrines, open latrines funrowed defecation grounds e.t.c).

2.3 Description of human wastes disposal systems

(a) The trench latrine

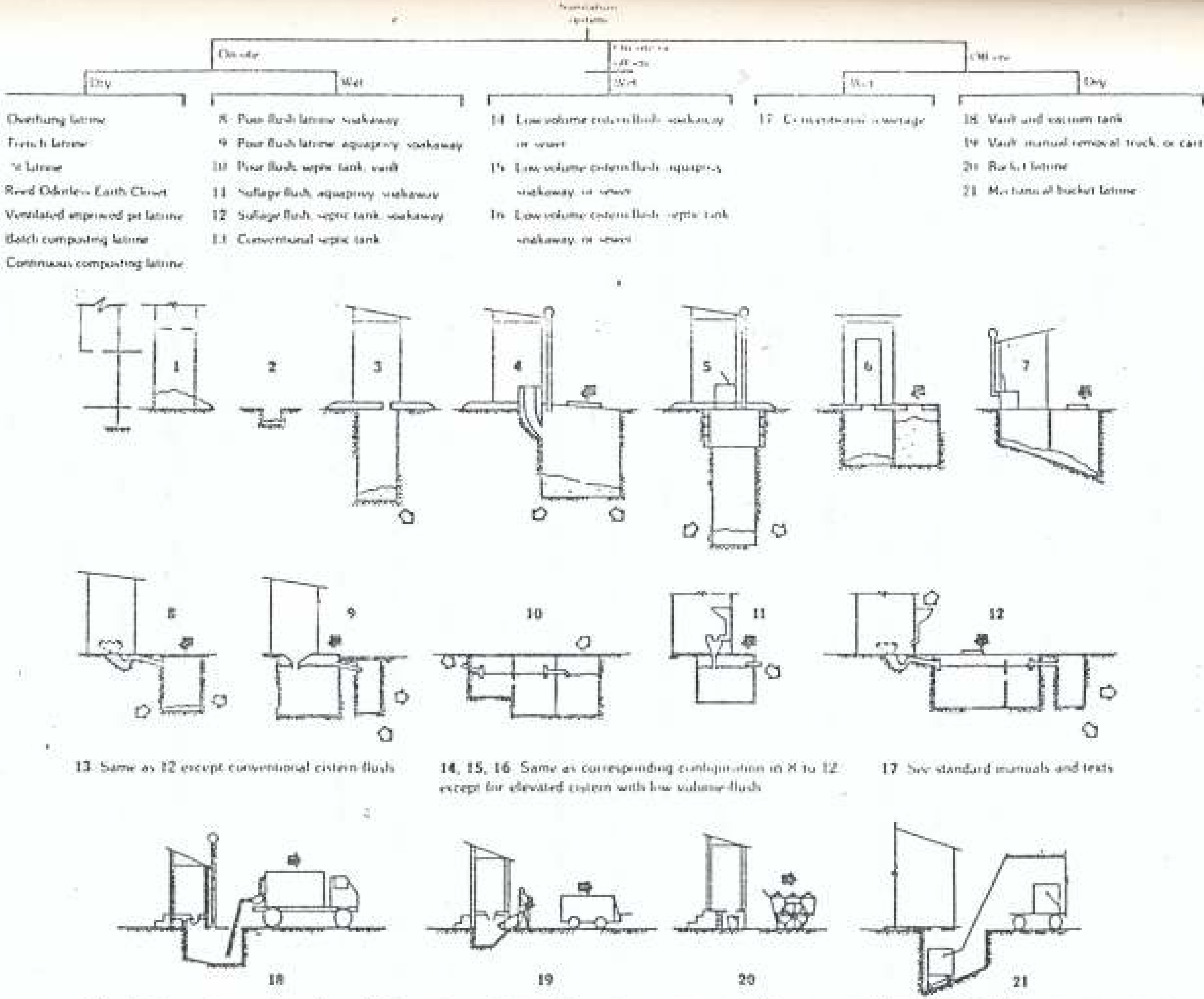

Fig 2.1 Generic classification of sanitation systems (Source: Edwards 1992)

This is a very crude method of excreta disposal. It consists of a small shallow pit dug in the ground for the purpose of defecation. This is only suitable for emergency and temporary situations, such as temporary military camp and building site (Edwards, 1992).

(b) Pit latrine

The essential components of the pit latrine are a superstructure, a squat slab, and a pit or hole into which excreta falls. Pit latrine has been reported as the most widely used technique for excreta disposal in developing countries, and the cheapest and simplest option to construct (Pacey, 1980). The pit receives and retains excreta which are biologically digested and eventually rendered harmless (Carroll, 1983).

(c) Bucket latrine

The bucket latrine consists of a superstructure, a squat slab and a bucket located in a small vault below the slab. The bucket is emptied into a larger collection bucket or the full bucket is replaced with an empty one, for transportation to a treatment depot. The operation of bucket latrine is normally insanitary (Merritt and Maxkurtz, 1986; Edward, 1992). The system may find good application in places where the re-use of excreta is customary (Pacey, 1981). Blackett (1994) reported that the British protectorate authorities presented bucket latrine system for urban sanitation in Lesotho in 1930, but this was eradicated in 1993 when people were persuaded to change to VIP latrines.

(d) The overhung latrine

This consists of superstructure and floor built on piles, above water, along the banks of rivers and in coastal areas. It has been reported that overhung latrines were common features on ponds in Asia, Southern China and Indonesia (Edwards, 1992).

(e) Composting latrine

This is a modified pit latrine, which deals with excreta in a dry state. Composting toilet, sometimes referred to as the moulding toilet, needs to be regularly fed with vegetable matter and sometimes with wood ashes (Pacey, 1980). Composting latrine was reported to have been successfully used in Vietnam since 1956 (Pacey, 1981).

(f) Pour-flush toilet

This is an improved pit latrine, with a water seal beneath the squat slab. This water seal entirely separates the pit and the latrine compartment, and prevents smells from getting from one into the other. From the investigation of Cairncross and Feachem (1983) it was discovered that, with pour-flush toilet, the very high water demand of the conventional cistern-flushed system could be avoided, so that the toilet is flushed by pouring water from a jug or bucket by hand, with about 1-3 litres per flush as opposed to 10 - 20 litres per flush for most cistern - flush toilets. This type of unit is believed to be best suited for public places like schools or community centres (Unrau, 1981).

(g) Vault latrine

This is a version of pit latrine where the removal of night soil or cartage is by buckets, carts or vacuum trucks. Edwards (1992) reported that this system was widely used in Europe and was still being practiced in Asia. In the Indian sub-continent, transport was often by bullock-drawncat, while mechanized transport system was employed for emptying the vaults in Japan, Korea and Taiwan (Pacey, 1981).

(h) Aqua - privies

This system consists of a water tight tank under the squat plate, and the inlet drop pipe in the floor slab. Excreta is deposited directly into the tank, rather than being flushed along pipe before reaching it. It was reported that aqua-privies were employed in Ibadan, Nigeria, at its comfort stations, to solve sanitation problems (Oluwande, 1981).

(i) Ventilated improved pit (vip) latrine

This is an improvement on the pit latrine, meant to reduce or eliminate odour and insect nuisance, by adding screened ventilation pipe to the chamber of a basic pit latrine. The advantages of ventilated improved pit latrine have been demonstrated in several countries, and a good many national and regional programmes have been started based on the technology. For instance, VIPs have been successfully developed and tested in Lesotho, Zimbabwe and Botswana (Blackett, 1994). The Blair latrine, a form of VIP latrine, has been developed in Zimbabwe, by the Ministry of health, as a means of improving the conventional pit latrine (Morgan, 1991).

(j) Reed odourless earth closet (roec)

This is an off-set dry pit latrine. It was originally developed in South Africa, but has been used in Botswana for over twenty years (Blackmore et al, 1981). ROEC operates with less nuisance because of the configuration of a chute which funnels excreta and urine into a chamber at the rear of the superstructure.

(k) Permanent improved pit (pip) latrine

This improved version of pit latrine consists of a double chambered, ventilated and emptiable pit. The system, which was a concept developed at the UK Building Research Establishment, has been installed in parts of Southern Africa, mainly in Botswana, where several thousands have been built and are called Revised Earth Closet (Carroll, 1983).

(l) Packing toilet

In this system, the fresh excreta is collected in a plastic tube, a short length of which is sealed off with excreta inside it every time the toilet is used. The used tube is collected in a sub-floor container, and the fresh excreta is not exposed any more, and is safe in handling. No decomposition takes place and the bags are taken elsewhere for treatment. This is a very recent development (Krisno, 1981).

(m) Chemical toilet

The essential characteristics of chemical toilet is the presence of chemical which prevents decomposition and odours, so that excreta can be stored until treatment can be arranged. This has found a wide application for remote areas and in transport systems. Chemical toilets have become quite acceptable in boats, buses, aeroplanes and holiday cottages (Krisno, 1981).

(n) Conventional sewerage system

This is a system where excreta is mixed with large volumes of water from a cistern-flush and are removed from house in a flow along pipes or sewers to a treatment plant. The first "modern" sewerage system was built in Hamburg, Germany, in 1842, by an innovative English engineer named Lindley (Howard et al, 1985). There can be no doubt that if funds are unlimited, conventional sewerage satisfies all the criteria for satisfactory excreta disposal (Pickford, 1981). The major advantages of conventional sewerage, in addition to safeguarding public health, are a high degree of user convenience (Edwards, 1992). There are, however, technical and financial constraints which often make sewerage systems less suitable option, in many situations, for developing countries (Mara, 1976).

From the findings of many investigators, the difference between the various types of system, so far as public health is concerned, is not much, as long as they are correctly built, maintained and used (Cairncross and Feachem, 1983; Dangerfield, 1983). However, septic tanks have limited use in municipal areas. Their effluents are odorous, high in chemical oxygen demand, and dangerous because of possible content of pathogenic organisms (Merritt and Maxkurtz, 1986). They are, however, in large scale use in urban areas of developing countries such as Nigeria.

Full sewerage, based on the technology of developed countries is very costly and requires expensive water resources. The development and application of alternative systems, using little or no water is therefore very important (Carroll, 1983). It is often assumed that developing countries would get used to mechanisation without much difficulty. But people ignored the fact that the importance of looking after machinery and equipment was learned by the industrial world only after centuries of involvement with industrialization (Dabha and Al-sabaqi, 1992).

Edwards (1992) reported that per capital cost for the installation of sewerage systems ranges from $150 to $600 (1979 data). This is too expensive for most developing countries.

2.4 Indicators for the need for sanitary improvement

Pacey (1980) reported that UNICEF has experimented with two checklists, in India, which could help locate areas where sanitary improvement is desired. Among other things, it becomes very obvious that sanitary improvement is desired when people defecate too close to, or at places where other people walk, or when the excreta is exposed to flies. Sanitary improvement is also desired when people defecate close to the source of drinking water or when the latrine systems are not kept clean.

Wherever there are problems of bad sanitation, with all the sicknesses and diseases that result, one may be tempted to assume that improved technology is the answer. But Pacey (1980) has discovered that technology by itself does not solve anything and that in rural areas of developing countries, it is often found that latrines, when built, are not fully used, and when used, do not always banish the diseases of bad sanitation. The essential point is that good sanitation depends primarily on people, and on how they organize hygiene-related activities.

2.5 The choice of appropriate sanitation technology

The choice of sanitation technology basically hangs on two factors: knowledge about each technology option, and criteria for comparing the technologies (Pacey, 1981). The process of choice can begin with an examination of an option. There will usually be some which can be excluded for technical or social reasons. Cairncross and Feachem (1983) pointed out that typical technical reasons for technology choice are water availability and soil conditions, particularly in areas of high population density; while an example of a social reason would be the unsuitability of Vietnamese composting latrines for people who use water for anal cleaning.

Once these exclusions have been made, cost comparison can be made for the remaining technologies, and some can be quickly excluded on grounds of excessive cost. Pacey (1980) has pointed out that the essence of the idea of appropriate technology is that equipment and techniques should be appropriate to local resources as well as to local needs. Careful appraisal of local resources and the options they represent is therefore the hallmark of any project that successfully creates an appropriate technology within a local community.

In considering what type of technology will be best, the need will usually be for equipment that is simple to assemble, does not depend on specialized imported components, and is low in cost. Also, the servicing and maintenance of the system should be relatively easy for local people to organize.

The criteria compiled for WHO by Wagner and Lanoix, and modified by Nimpuno, on the choice of appropriate sanitation technology, as reported by Pacey (1981), indicated, among other things, that: The surface soil, the ground water and surface water should not be contaminated. Fresh excreta should not be exposed to flies, and there should be freedom from odours. The system should be simple to operate and not too costly, and should require minimum water for operation. Also, from the report of Escritt (1972), the method of treatment to be adopted should depend on:

(i) The system which will involve the minimum of running costs, including loan repayment.

(ii) The extent to which nuisance due to flies or odour will matter.

(iii) The area of land available and the suitability of soil, or slope of land, for each of the methods of treatment.

(iv) The degree of treatment required.

Feachem et al (1978) believed that appropriate system must be cheap, not communal, use little or none of the potable water supply for the operation, work despite misuse, require little supervision, not use soakaways, dispose of all waste water, treat the waste water to a degree where it can be discharged with little subsequent danger to users, and require no mechanical equipment. Cairncross and Feachem (1983) also observed that, since the benefits of various sanitation systems cannot be quantified, the final step in identifying the most appropriate type must rest with the intended beneficiaries. Those alternatives which have survived technical, social and economic tests are best presented to the community with their attached price tags, so that users may decide what they are able and willing to pay for.

2.6 Influence of social factors on sanitation alternatives

Discussions of technology will only be for academic interest if people are unwilling or unable to put that technology to work. In the process of planning and development, the social factor is believed to be responsible for failure of technically sound projects (Cairncross and Feachem, 1983). Blackett (1994) has rightly observed that any sanitation project that tries to promote a technically adequate system but socially unacceptable is likely to fail.

Cairncross and Feachem (1983) have discovered that the likely effects of the various social factors on sanitation programme may be appraised, to some extent, by studying existing excreta disposal practices. According to Pacey (1981), the most important aspect of sanitation system is their acceptability by the communities concerned, and this can only be satisfactorily achieved by involving the users at all stages of programme planning and implementation. The assumptions that if the facilities were provided, people in the course of time would use them, could be erroneous.

Blackett (1994) pointed out that the locally used anal cleaning material usually dictates certain aspects of technical design. It is believed in some countries that sons-in-law and mothers-in-law must not use the same latrine. Another of such factor is the taboo in Muslim countries against defecating while facing Mecca (Cairncross and Feachem, 1983). Some of these factors can influence the technical design of the facilities, even though the factors are not scientific. For instance, for many of us, part of the proper order of things in that defecation be done in privacy.

Feachem et al (1978) reported that most low-cost high density housing areas in Africa were occupied by people who have moved from agricultural areas. Their behavioural pattern and habits are those of people living in a dispersed fashion where they are totally unaware of the dangers to health when living in close proximity. Consequently, they need, in general, very efficient systems, which will work despite their lack of understanding. Krisna has documented some findings on how some criteria can be applied to excreta disposal system, as reported by Pacey (1981), (Table 2.1).

Table 2.1: The suggested criteria applied to four types of excreta disposal system

Criteria	Conventional W.C. With Sewerage and Treatment plant	Aqua Privies	Pit Latrine	Composting Latrine
Health Criteria:				
No pathogen survival	xxx≠	ǂ	xxxǂ	xx≠
Full BOD digestion	xxx	xxx	xxx	xxx
No Pollution of soil	xxx	xx	x	xx
No ground water pollution	xx	-	x	xx
No surface water pollution	x	xx	xx	xx
No access by insects	xx	xx	x	xx
No handling of fresh excreta	xxx	xxx	xxx	xx
No odours	xxx	xx	-	-
Socio-Economic Criteria				
Simple toilet routine	xxx	xx	xxx	x
Cost lest than 10 percent house	-	xx	xxx	xx
Local material and technology	-	x	xxx	xx
Minimum use of water	-	-	xxx	xxx
Applicable in high density areas	x	x	xx	xx
Valuable by-product	-	-	x	xxx

xxx: Criterion fulfilled.

xx: Criterion fulfilled under certain conditions.

x: Criterion only fulfilled under most stringent controls.

ǂ: Weightings will differ according to circumstances.

Source: Pacey (1981).

2.7 Influence of cultural factors on sanitation alternatives

Very similar to social factor is the influence of cultural factor on sanitation alternatives. Many rural communities have distinctive ways of organising sanitation and hygiene, and it is part of the task of appraisal work to understand what this involves. Local hygiene culture may sometimes be a source of difficulty for a programme, but it may also present an opportunity. For example, Moslems and Hindus set a high value on cleanliness (Pacey, 1980). This is an opportunity for a good sanitation programme.

The cultural practices in some communities are to provide communal facilities. But, Feachem et al (1978) has observed that communal facilities are rarely, if ever, satisfactory, no matter what system is provided. This is because there is no individual responsibility. Once a latrine is fouled, by misuse or accident, the next user may have no choice but to foul it further. Organization becomes critical when toilets are to be used communally. In general, if facilities must be shared between households, someone must be appointed and rewarded to look after them. This method, however, has not been known to work. Cairncross and Feachem (1983) reported that, even in Ibadan, Nigeria, with strong ethnic and family ties, it has not proved possible to collect regular cash contributions for maintenance of communal urban latrines.

If new techniques are really to be part of a people's life style, then we need to think of them as being transformed from something that is imported and alien into something that truly belongs tothe local community. Another way is to start from what people are already used to and then upgrade the facilities gradually to the standard desired. A study of potential sanitation upgrading sequences carried out by Kalbermatten et al in 1982 was reported by Cairncross and Feachem (1983), as shown in Table 2.2.

Table 2.2 Potential sanitation upgrading sequences

	LEVEL OF WATER SUPPLY		
Toilet Type	Hand Carried	Yard Tap	In-house Connections.
VIP	•	•	x
Pour Flush	[•]	•	•
Sewered Pour Flush	x	•	•
Vault	x	•	•
Conventional sewerage or septic tank	x	x	✱

X Combination unlikely

[ ] Feasible only if sufficient pour-flush water is carried home.

✱ No upgrading required.

Source: *Cairncross and Feachem (1983)*

2.8 Influence of economic factors on sanitation alternatives

The single most useful figure for cost comparisons of technologies is the total annual cost per household (TACH), which included both investment and recurrent costs. A distinction between investment and recurrent costs is important for both technical and financial reasons. Edwards (1992) has found that a community with limited financial resources might find it impossible to raise the investment finance to construct a system with a large initial capital requirement, but could afford to build and maintain a system with the same TACH but with relatively high recurrent costs.

It is important to make correct comparisons among alternatives. For example, the cost of any water borne sanitation system must include the cost of flushing water, if it had to be compared with a system that does not use water. Similarly, the cost of VIP latrines must include the cost of separate sullage disposal system such as individual yard soakaways (Cairncross and Feachem, 1983).

Operating and maintenance cost can easily be recovered from the users, for public facilities. This can be done by charging for admission. This has been successfully tried in parts of India (Cairncross and Feachem, 1983). Some studies have been conducted on construction costs of aqua-privies and septic tanks, compared with other latrines (Pacey, 1981), as shown in Table 2.3.

Table 2.3 Construction costs of aqua-privies and septic tanks compared with other latrines

Latrine Type and Country	Approximate Construction Cost of latrine, plus Super Structure, US Dollars 1977 Prices.		
	Cost of materials only	Total cost of materials pluslabour	Cost of experimental models of Lobatse
Septic Tanks			
Nigeria	-	315+	-
Taiwan	-	160ǂ	-
Aqua-Privies			
Nigeria	90*	150+	-
Calcutt	-	220	-
Tanzania	-	300	-
Botswana	-	-	305
Pit Latrine			
Nigeria (slab only)	1.20	-	-
(All materials)	39.20*	69+	-
Zimbabwe	30-40*	-	-
India (off-set wet pit)	25-31	-	-
Botswana	13-24	-	340
Composting latrines			
(Multrum Type)			
Philippines	-	55ǂ	-
Tanzania	30-40*	-	-
Botswana	-	-	390

* Figures quoted during the conference from which this table originated.
\+ 1973 Cost.
ǂ Quoted costs may not cover whole installation.
Source: *Pacey (1981).*

2.9 Influence of public health and nuisance factors on sanitation alternatives

Feachem et al (1978) has observed that, in general, the lower the standard of health education the more necessary it becomes that the sanitation systems be self-operating and non-fouling. Since human excreta can be a source of infection from pathogenic bacteria, viruses and eggs of parasitic worms, which are spread through the deposition of excreta from infected persons (Carroll, 1983), the disposal facilities must prevent contaminations. Carroll (1983) has also noted that, a foul smelling latrine, infested by flies, is unlikely to be used if people can defecate in the open air or bush with less attendant risks to community health. Nuisance is subjective, and tolerance to nuisance of all kinds varies from person to person. However, in the context of social acceptance of the need to build and use latrine systems, odour and insect nuisance play a large part.

From the works of Carroll (1983), basic comparison can be made between different systems, incorporating health and nuisance factors, as shown in Table 2.4.

Table 2.4 Comparison of some basic systems

SANITATION SYSTEM	General Suitability Low density		High density	Cost		Technology	Skills	Water needs for flushing	Health hazard	Nuisance	Comments
	Rural	Urban	Urban	Initial	Original	Construct	Main-tain				
Night soil bucket and collection	Yes	Yes	Yes	Low	High	Very low	Low	None	High	High	Efficient Management essential
Overhung latrine	Yes	No	No	Low	Low	Low	Low	None	High	Medium to high	Environmentally polluting
Pit Latrine	Yes	No	No	Low	Low	Low	Low	None	Medium	Medium	Not permanent
Bore hole latrine	Yes	No	No	Low	Low	Low	Low	None	Medi	Medium	Medium Not permanent
Ventilated Improved Pit (VIP)	Yes	Yes	No	Low	Low	Low	Low	None	Low	Low	Not permanent
Bermanent Improved Pit (PIP)	Yes	Yes	No	Low	Low	Low	Low	None	Low	Low	Small double chambers emptiable
Compost Latrine	Yes	No	No	Low	Low	Low	Low	None	Medium	Medium	Extra user care required

Source: *Carroll (1983)*

2.10 Influence of soil conditions on sanitation alternatives

It is more difficult to excavate pits and pipe trenches in areas of rock or loose sand; and where there is a danger of ground water contamination this will influence the choice of sanitation system. Also, the feasibility of some systems for on-site disposal of excreta will be limited by insufficient infiltration capacity in local soils. For these reasons, Cairncross and Feachem (1983) warned that no large scale sanitation programme should be undertaken without soil survey.

The soil in the study area has been discovered to be of well graded sand, with little amount of silt. The soil is of intermediate plasticity (Yusuf, 1992). The results of percolation test conducted for the area gave an average infiltration rate of 200mm/hr (Ayanroh, 1986).

Carroll (1983) reported that, a pit latrine in dry soil above the water table has little spread of contaminants in a lateral direction, and penetration vertically is not likely to exceed three meters. But if the pit or disposal system has penetrated the water table, then the bacteria or chemical contamination may travel both downwards and laterally; transported by the ground water, the contaminants flow in the direction of flow of ground water. A study carried out by Pacey (1980) presented some criteria for the appropriateness of different types of latrine, where the effects of soil condition is reflected, as shown in Table 2.5.

Table 2.5 Some criteria for determining appropriateness of different types of latrine

Latrine	Cost to build	Depth of soil needed	Potential for better hygiene	Technical assistance	Best anal cleaning material	Fertilizer production
Simple pit latrine	Low	Deep soil not water logged	Medium	Simple mainly flush slab	Any	Can do
Pit latrine with vent pipe	Low	Deep soil not water logged	Good	Simple ;vent to be supplied	Any	Not easily
Soakage pit latrine, with water seal	High	Deep soil not water logged	Good	Skilled builder needed	Water	No
Agua-privy	High	Not water logged	Good	Skilled builder needed	Water	No
Composting latrine	Moderate	Any	Good	Skilled builder needed	Paper	Yes
Bucket latrine	Low	Any	Good	Simple	Any	Can do

Source: *Pacey (1980)*

CHAPTER THREE

MATERIALS AND METHODS

3.1 General

In order to achieve the objectives of this research project, the work was carried out in the following stages:

(i) An extensive literature review on various technologies for excreta disposal;

(ii) A physical survey of existing excreta disposal systems on the campus;

(iii) An attitude survey, by personal observations and standard questionnaire;

(iv) The formulation of criteria for evaluation of alternative excreta disposal systems;

(v) The actual evaluation of alternative excreta disposal systems for the campus, and the selection of appropriate option(s);

(vi) The design of the selected excreta disposal system option(s) for the campus, with their costs implications given.

3.2 Physical survey of existing excreta disposal facilities in the study area

The toilet facilities in the hostels were physically inspected to assess their conditions. Some of the porters of the respective hostels were also interviewed during the visit. Also inspected were the toilet facilities around the workshops, laboratories, classrooms and offices, the pit toilets built around the hostels and classrooms, and the toilet facilities at the staff school premises. It was not possible to gain entrance to some of the facilities located within the building in the staff quarters, for reasons of privacy. However, the conditions of the septic tanks and soakaway pits were assessed, and some members of staff living in the quarters were interviewed.

The purpose of this survey was to determine the type and extent of the existing excreta disposal facilities in the study area, and to record their performance, misuse, nuisance and health hazard factors. The survey was carried out from early January 1999, when the students were on holidays, to March, 1999, when the students had fully resumed. Photographs of sample facilities were taken during the survey.

3.3 Attitude survey

Questionnaires were administered to both staff and students within the study area. The sampled population were drawn from students who had resided in the hostels for at least one year, and the senior staff members who had used the polytechnic sanitation facilities for at least one year. This was to ensure that those answering the questionnaires were familiar with the facilities in the study area. 400 staff members and 1420 students qualified for this survey, giving a target population of 1820.

Proportionate stratified random sampling technique was used in this study. In this technique, the population was first stratified in terms of the variables of interest, (i.e students and staff). Elements were then drawn randomly from each stratum in such a way that the relative proportioning of the strata in the resultant sample were the same as existed in the parent population. The relative contribution of each stratum in the population was exactly its relative contribution in the sample. There were two strata in the sample with the following allocations: 57 senior staff respondents representing 22% of the sample population, and 203 students respondents, representing 78% of the sample population.

Simultaneously with the administration of the questionnaires, personal observations were made on the sanitation attitude of the people, and interviews were also conducted across the rank and files of staff and students at random.

The attitude survey was carried out, essentially, to study the social and cultural factors related to excreta disposal in the study area. Some of the items that were investigated in the attitude survey included the favoured anal cleaning materials, the general background of the people's sanitation practices, reasons why people defecate on unapproved places, and how the practices could be stopped, and the social and hygienic acceptability of the existing facilities to the people.

Other factors studied in the attitude survey included the beneficiary system preference, adequacy (quantitatively and technically) of the existing systems, as well as the level of user's involvement in care and maintenance of the systems. Improvement on existing systems, desired by the people, were also investigated.

3.4 Technically related factors

Data related to sub-soil conditions were collected, for the study area, from past works. the composition of soil stratifications, of up to three metres deep, were obtained. Data relating to infiltration characteristics of the soil, within the study area was also obtained. A study of the mode of water supply, in the study area, was carried out. This was to determine the adequacies of water supply in there. Rainfall and temperature statistics were also collected for the study area.

3.5 Evaluation of alternative sanitation systems

The major factors considered in the evaluation of alternative sanitation systems were Acceptability, Adequacy and Affordability (AAA). Under acceptability, the influence of socio-cultural factors and beneficiary system preference were explored. For adequacy, technical, public health, and nuisance factors, as well as number of users to facilities, were considered. Affordability was measured on a sliding scale or relative costs of systems. The approach employed for the evaluation of alternative sanitation systems, was, therefore, the one that considered all the factors that impact on the potential for sustained services provision to all sectors of the study area.

The options were examined, in turn, in line with the criteria built up from socio-cultural, technical and institutional factors, to determine their acceptability and adequacy. The options that passed the tests of acceptability and adequacy were further subjected to cost comparison to determine their affordability.

3.5.1 Hypotheses

The following hypotheses were tested, each, at five per cent level of significance.

(i) The systems, in use now, do not significantly differ from the ones preferred.

(ii) The systems used outside the study area do not significantly differ from the ones preferred.

(iii) The anal cleaning materials, used outside the campus, do not significantly differ from the ones in use on the campus.

(iv) The use of the same facility for both urine and faeces is independent of socio-economic status.

(v) The social acceptability of the sanitation systems on the campus is independent of status.

(vi) The adequacy of sanitation facilities on campus is independent of status.

3.5.2 Method of data analysis

Frequency counts and percentages were used to answer the research questions. The hypotheses were tested using Chi square (X^2) distribution.

CHAPTER FOUR

PRESENTATION AND ANALYSIS OF DATA

This section of the study deals with the presentation and analysis of data collected from the physical and attitude surveys. The physical survey was carried out by personal observations and interviews, while the attitude survey was carried out by the administration of questionnaire, personal observation and interviews, as explained in chapter three

4.1 Data from the physical survey

4.1.1 Toilet facilities in the hostels

The two types of excreta disposal systems being used in the hostels were the cistern flush toilets and the pit latrines. The cistern flush toilets consisted of the cistern tank, the lavatory pan connected to the septic tanks which discharged to the soakaway pits. The pit toilets provided was the unimproved type, consisting of a pit dug below the squatting slab, and a superstructure made of sandcrete blocks and zinc roof.

The hostels were generally overpopulated, with an average of ten students per room, as opposed to the official allocation of four students per room. The general number of facilities versus approximate population of students in the male and female hostels are tabulated in Table 4.1 and 4.2 respectively.

Table 4.1 Facilities versus population at male's hostels

Hostels	Approximate Population	Cistern flush Toilets	Pit Toilets
A	340	6	
B	340	6	
C	270	6	
D	270	6	
E	270	6	(8)
F	270	6	
G*	270	6	
H*	270	6	
I*	270	6	
J*	270	6	
Total	2,840	60	8

*Facilities in hostels G,H,I and J were no longer usable.

Table 4.2 Facilities versus population at female's hostels

Hostels	Approximate Population	Cistern Flush Toilets	Pit Toilets
K	490	12	2
L	490	12	2
M	490	12	2
N	490	12	2
Total	1,960	48	8

The general misuse of excreta disposal facilities observed at the students hostels were:

(i) The toilets were not regularly flushed with water;

(ii) Students stand or squat on the lavatory pan instead of sitting on them, as a result of which many lavatory pans had been destroyed and some of the cistern tanks completely removed.

The plate 4.1 shows the extent of damage of the hostels excreta disposal facilities.

Plate 4.1 A typical hostel toilet, with lavatory pan destroyed and cistern tank removed.

The facilities in hostels G,H,I and J were no longer usable. The students in such hostels had to look for alternatives somewhere else. Also, it has been noticed that the disludging interval of the septic tanks in the hostels, especially the male hostels, had become too frequent over the years. The effluent from the septic tank was merely thrown on the ground surface around the tanks, constituting a bad practice, since the effluent, from a public health point of view, was as hazardous as raw sewage.

The pit toilets provided at the male's hostels were communal in nature (Plate 4.2). Two blocks were provided, each containing four pits. The pit toilets were the unimproved traditional type. Also, there was no light provided to illuminate the toilets, for users at night, and no water at the site for cleaning the slab.

Plate 4.2 A typical pit toilet around the male hostels.

Because of their crude design, the pit toilets produced foul smell, and constituted a breeding site for flies and mosquitoes. As most students would not use the pit toilets, for the reasons enumerated above, the surroundings of the pit toilets became defecating grounds, especially at night. A good number of students interviewed complained that the hot foul air coming out from the pit could be harmful to them if they squat directly on top of the hole.

4.1.2 Toilet facilities around the workshops, laboratories, classrooms and offices

Most of the toilet facilities around the workshops, laboratories, classrooms and offices were inspected. The facilities were mainly the cistern flush toilets with septic tanks and soakaway pits. However, at the "Lagos" zone, a communal block of four pit toilets, similar to the ones around the hostels, was built around the classrooms. Some of the cistern flush toilets were directly attached to the offices of some principal officers of the polytechnic, while some were directly attached to some academic departments. These groups of toilets attached to senior staff members were averagely well kept. However, the toilet facilities around the workshops and laboratories were generally in bad shape. Some of the facilities visited were filled up with heaps of faeces (Plate 4.3). Many of them have also been badly damaged.

Plate 4.3. A Typical toilet around the laboratories and workshops

The people interviewed about the status of the facilities around the laboratories and workshops claimed that, the reason for such a degree of misuse was the high rate of use by the students, from classrooms to laboratories and workshops, both day and night. It was difficult to regulate the use of the facilities, which were purely communal without any degree of user care. It was also reported that the flow of water in that area were very erratic. Many junior staff members attached to the laboratories and workshops claimed to be using the open field or bush for defecating.

The sites of the toilet facilities around the classrooms stank badly. Most students interviewed claimed to be using the open fields behind the classrooms for defecating at night, while studying there. It should be noted that a large majority of the students' population studied at night in the classrooms at the "Lagos" zone.

4.1.3 Toilet facilities at the polytechnic staff school and staff quarters

The toilet facilities at the Polytechnic Staff School premises, housing the Nursery and Primary Schools and the Secondary School, were also inspected. The toilet facilities were the cistern flush type. They were all averagely well kept with no visible sign of health hazard. It was not possible to gain entrance to most of the facilities located within the buildings in the staff quarters, for reasons of privacy. However, from the few facilities inspected, and the interview conducted with some of the staff members, it was very clear that a good user maintenance culture was effectively practiced. However, most of the septic tanks and soakaway pits were no longer structurally sound. The dilapidated condition allowed reptiles and rodents to crawl into the chambers, and permitted the extrusion of odour into the environment.

4.2 Technically related data

4.2.1 Sub-soil

The study area was entirely underlain by sedimentary formations called Nupe Sand Stones. Nupe sand stones consist of shales, limestones, and sandstones accumulated during cretaceous period (ADS, 1993). Soils formed by this underlying or parent rocks after weathering are predominantly sand and clays which covers the sedimentary rocks. The results of percolation tests conducted for the study area gave an average infiltration rate of 200mm/hr.

4.2.2 Water supply

The water supply source, up till the end of 1998, was a surface storage tank of capacity 378.61m^3 that receives water from the Niger State Water Board, Bida, and a borehole that supplied water to an elevated storage tank of capacity 70m^3. Both the surface tank and the elevated tank with its borehole were located in the same area at "Lagos" zone in a relatively depressed elevation (fig 4.1). The mode of distribution was by pumping for four hours daily, two hours in the morning and two hours in the evening. This practice made the level of water supply unstable and inadequate, especially at the students' hostels area. However, a project has just been completed in 1999, consisting of a surface water storage tank of capacity 800m^3, which receives water from the Niger State Water Board network, and an elevated tank of capacity 70m^3 located at an elevation where water could flow by gravity to the students hostels

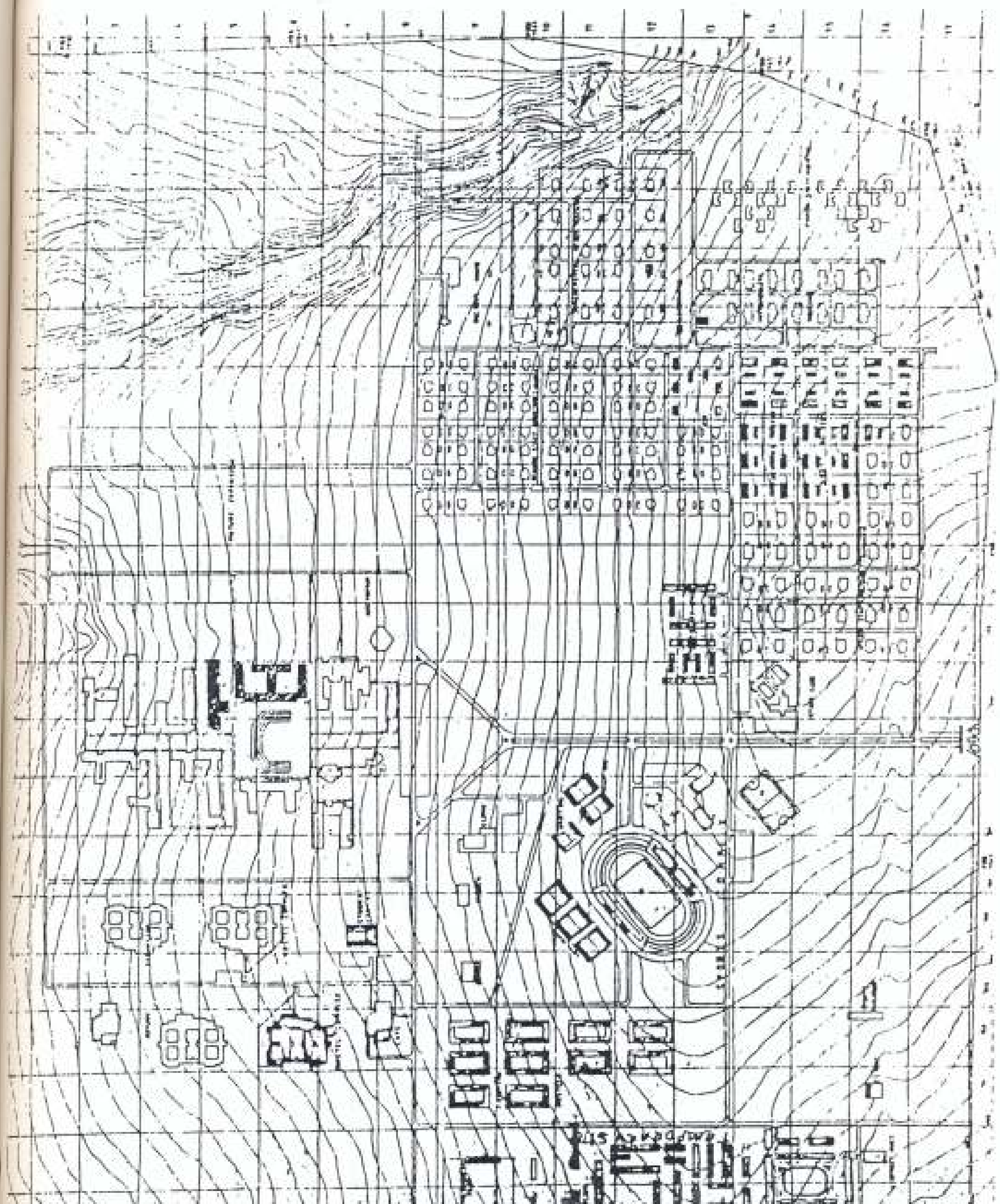

Fig 4.1 The topography of the study area

Table 4.3 Temperature and rainfall data for Bida (1981- 1990)

Month	Jan	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean Max (^{o}C)	34.60	36.97	37.67	36.50	33.11	31.69	30.30	29.94	30.60	32.61	35.64	34.74
Mean Min (^{o}C)	20.82	24.19	25.79	25.97	24.27	23.39	22.79	22.70	22.29	22.43	20.91	21.24
Mean (^{o}C)	27.71	30.58	31.73	31.23	28.69	27.54	26.54	26.32	26.44	27.52	28.28	27.99
Mean Rainfall (mm)	6.9	13.7	20.2	120.9	121.9	138.0	251.6	216.2	187.4	64.2	0.8	0.0

4.3 Data from attitude survey

This section of the study deals with the analysis of data collected from questionnaire administered to the students and staff in the study area (Appendix A.). The analysis was arranged according to the research questions.

1. Status of the sample population

A total of 260 people respondent to the questionnaire administered, out of which 203(78%) were students and 57(22%) were staff.

2. Rate of defecation

The response to the question on defecating times per day was analysed as shown in table 4.4.

Table 4.4 Defecating times per day

Times per day	1	2	3	4
Students	133	61	9	-
Staff	35	14	5	3
Total	168	75	14	3
Percentage	64.6	28.8	5.4	1.2
Pooled Mean	=1.43			

3. Use of the same facility for both urine and faeces

Out of the 260 respondents, 84 students and 38 staff were using the same facility for both urine and faeces, while 119 students and 19 staff do not use the same facility for both.

4. Sanitation system types, used outside the campus

The response to the type of sanitation facilities used to outside the campus was analysed as shown in Table 4.5.

Table 4.5 Type of sanitation facilities used to outside the campus

Sanitation facilities	Students	Staff	Total	Percentage
Bucket Latrine	6	3	9	3.5
Pit Latrine	49	15	64	24.6
Water Systems	137	39	176	67.7
Open field or bush	11	-	11	4.2
Total	203	57	260	100

5. Type of sanitation systems used on campus

The response to the type of sanitation facilities used on campus was analysed as shown in Table 4.6.

Table 4.6 Type of sanitation facilities used on campus

Sanitation Facilities	Students	Staff	Total	Percentage
Bucket Latrine	-	-	-	0
Pit Latrine	41	-	41	15.8
Water Systems	125	49	174	66.9
Open field or bush	37	8	45	17.3
Total	203	57	260	100

6. Social acceptability of sanitation systems

The response to social acceptability of sanitation systems on campus was analysed as shown in Table 4.7

Table 4.7 Social acceptability of existing systems

Social acceptability	Students	Staff	Total	Percentage
Very acceptable	-	2	2	0.8
Acceptable	42	10	52	20
Fairly acceptable	74	28	102	39.2
Not acceptable	87	17	104	40
Total	203	57	260	100

7. The need for improvement on existing systems

Table 4.8a The need for improvement on existing systems

Need	Students	Staff	Total
Yes	166	47	213
No	37	10	47

Table 4.8b Types of improvement desired on existing systems

Improvement desired	Students	Staff	Total	Percentage
Adequate provision of water	89	21	110	51.6
Replacement of damaged systèms	12	12	24	11.3
Adequate maintenance and cleaning	60	8	68	31.9
Provision of systems that will use less water	5	6	11	5.3
Total	166	47	213	100

8. Preferred systems

The response to the type of sanitation facilities preferred was analysed as shown in Table 4.9.

Table 4.9 Preferred sanitation facilities

Preferred facilities	Students	Staff	Total	Percentage
Bucket latrine	-	-	-	0
Pit latrine	21	6	27	10.4
Water systems	174	51	225	86.5
Open field or bush	8	-	8	3.1
Total	203	57	260	100

9. Anal cleaning materials used outside the campus

The response to the type of anal cleaning materials used outside the campus was analysed as shown in Table 4.10.

Table 4.10 Anal cleaning materials used outside the campus

Anal cleaning materials	Students	Staff	Total	Percentage
Water	108	40	148	56.9
Toilet roll	76	7	83	31.9
Hard paper	18	6	24	9.2
Leaves	-	4	4	1.5
Maize cob	1	-	1	0.5
Total	203	57	260	100

10. Anal cleaning materials used on campus

The response to the type of anal cleaning materials used on campus was analysed as shown in Table 4.11.

Table 4.11 Anal cleaning materials used on campus

Anal materials	Students	Staff	Total	Percentage
Water	85	36	121	46.6
Toilet roll	8	15	95	36.5
Hard paper	38	6	44	16.9
Leaves	-	-	-	0
Maize cob	-	-	-	0
Total	203	57	260	100

11. The hygiene state of the existing systems

Out of the 260 respondents, 63 students and 34 staff believed that the existing systems were hygienic enough for them; while 140 students and 23 staff felt that the systems were not hygienic enough for them. The reasons given by those who felt the systems were not hygienic enough were analyzed as shown in Table 4.12.

Table 4.12 Reasons for unhygienic sanitation systems on campus

Reason	Students	Staff	Total	Percentage
Inadequate water supply	44	17	61	37.4
Bad habit of uses	57	2	59	36.2
Cleaners not doing their job	39	4	43	26.4
Total	140	23	163	100

12. Use of distant facilities

Out of 260 respondents, 117 students and 27 staff frequently had to use facilities not closest to them. The reasons given for using distant facilities were analysed as shown in Table 4.13.

Table 4.13 Reasons for using distant sanitation facilities

Reasons	Students	Staff	Total	Percentage
The closest facilities not good	65	8	73	50.7
The closest facilities not accessible.	27	5	32	22.2
Lack of water to operate facilities	25	14	39	27.1
Total	117	27	114	100

13. Adequacy of existing facilities on campus

The response to the question on adequacy of existing sanitation facilities on campus was analysed as shown in Table 4.14.

Table 4.14 Adequacy of existing sanitation facilities on campus

Adequacy	Students	Staff	Total	Percentage
Very adequate	-	-	-	0
Adequate	9	7	16	6.2
Fairly adequate	40	13	53	20.4
Not adequate	139	29	168	64.6
Grossly inadequate	15	8	23	8.8
Total	203	57	260	100

14. Reasons for defecating on unapproved places

The response to the question on why people defecate on unapproved places on the campus was analysed as shown in table 4.15.

Table 4.15 Reasons for defecating on unapproved places

Reasons	Students	Staff	Total	Percentage
Inadequate no of facilities	65	34	99	38.1
Bad facilities	100	8	108	41.5
Bad sanitation attitude	22	8	30	13.9
Lack of water for the system	10	7	17	6.5
Total	203	57	260	100

15. How to stop defecating in the bush

The response to the question on how defecating in the bush around the campus could be stopped, was analysed as shown in Table 4.16.

Table 4.16 How to stop defecating in the bush around the campus

What to do	Students	Staff	Total	Percentage
Provision of more facilities	81	30	111	42.7
Repair of systems, provision of water and good maintenance	90	16	106	40.8
Clearing of the surrounding bush and installation of light	14	5	19	7.3
Education of the people	18	6	24	9.2
Total	203	57	260	100

16. Level of water supply

The response to the question on the general level of water supply on the campus was analysed as shown in Table 4.17.

Table 4.17 The general level of water supply on the campus

Level of water supply	Students	Staff	Total	Percentage
Very adequate	-	-	-	0
Adequate	7	-	7	2.7
Fairly adequate	60	22	82	31.5
Not adequate	117	31	148	56.9
Grossly inadequate	19	4	23	8.9
Total	203	57	260	100

17. Effect of the level of water supply on the sanitation systems

Out of the 260 respondents, 24 students believed that the level of water supply had a positive effect on the sanitation systems on the campus, and 163 students and 55 staff believed that the level of water supply on the campus had adversely affected the sanitation systems; while the remaining 16 students and 28 staff were undecided.

18. The impact of the existing pit latrines

Out of the 260 respondents, 80 students and 16 staff believed that the existing pit latrines had made positive impact, and 93 students and 35 staff believed that the latrines made no impact at all, while 30 students and 6 staff believed that the latrines had made negative impact.

4.4 Testing of hypotheses

The statistical tool used for the inference analysis was the Chi square (X^2) test. On a general note,

$$x^2 = \sum_{i}^{k} \frac{(0 - E)^2}{E} \qquad (4.1)$$

Where 0 = Observed Frequency

E = Expected frequency (4.2)

k = Number of categories, groupings or possible outcomes.

$$E = \frac{F_R x F_C}{N}$$

Where E = As defined above

F_R = Total row frequency

Fc = Total column frequency

N = Total frequency

Also, the degree of freedom in a contingency table was given by:

d_f = (R - 1) (C - 1) (4.3)

Where d_f = Degree of freedom

R = Number of rows

C = number of columns

The hypotheses were tested, each, using the X^2 distributions, by calculating the X^2 value and compared it with the critical value of X^2 for the appropriate sampling distribution, as determined by the degree of freedom and level of significance.

4.4.1 Hypothesis (I)

The systems in use now do not significantly differ from the ones preferred. Table 4.18 provides the data used in the analysis of this hypothesis.

Table 4.18a Systems Preferred versus Systems In Use, and contingency table

System preferred

	Bucket latrine	Pit latrine	Water systems	Open field or bush
Bucket latrine	-	-	-	-
Pit latrine	-	7	34	-
Water systems	-	9	160	5
Open field or bush	-	11	31	3

Table 4.18b

(Contingency table)

0	E	0	E	
7	6	34	35	41
14	23	160	151	174
14	6	31	39	45
35		225		260

$\chi^2_{cal} = 16.57$

but $\chi^2_{cri}(2, 0.05) = 5.991$

Since $\chi^2_{cal} > \chi^2_{cri}$, the null hypothesis was rejected at 5% level of significance. That is, the systems in use significantly differed from the ones preferred.

4.4.2 Hypothesis (II)

The systems used outside the campus do not significantly differ from the ones preferred.

Table 4.19 provides the data used in the analysis of this hypothesis.

Table 4.19a Systems preferred versus systems used outside the campus, and contingency table

(Systems preferred)

		Bucket latrine	Pit latrine	Water systems	Open field or bush
(Systems Used outside the Campus)	Bucket latrine	-	3	4	2
	Pit latrine	-	8	35	1
	Water system	-	14	159	3
	Open field or bush	-	2	7	2

Table 4.19b

tingency table)

0	E	0	E	
18	11	66	73	84
17	24	159	152	176
35		225		260

$$\chi^2_{cal} = 7.48$$

but

$$x^2_{crit}(1, 0.05) = 3.841$$

Since $\chi^2_{cal} > \chi^2_{crit}$, the null hypothesis was rejected at 5% level of significance. Thus, the systems used outside the campus significantly deferred from the ones preferred.

4.4.3 Hypothesis (III)

The anal cleaning materials, used outside the campus do not significantly differ from the ones in use on the campus. Table 4.20 provides the data used in the analysis of this hypothesis.

Table 4.20a Anal cleaning materials in use versus the ones used outside the campus, and contingency table

(Anal cleaning materials in use)

	Water	Toilet roll	Hard paper	Leaves	Maize cob
Water	98	35	15	-	-
Toilet roll	13	54	16	-	-
Hard paper	8	5	11	-	-
Leaves	2	1	1	--	-
Maize cob	-	-	-	-	-

Table 4.20b

(Contingency

	0	E	0	E	0	E	
	98	69	35	54	15	25	148
	13	39	54	30	16	14	83
	10	13	6	11	13	5	29
	121		95		44		260

$$\chi^2_{cal} = 75.46$$

But $\chi^2_{cru}(4,0.05) = 9.488$

Since $\chi^2_{cal} > \chi^2_{cru}$, the null hypothesis was rejected at 5% level of significance. Thus, the anal cleaning materials used outside the campus significantly differed from the ones in use on the campus.

4.4.4 Hypothesis (IV)

The use of the same facility for both urine and faeces is independent of socio-economic status. Table 4.21 provides the data used in the analysis of this hypothesis.

Table 4.21a The use of the same facility for both urine and faeces, and contingency table

	Students	Staff
Yes	84	38
No	119	19

Table 4.21b

(Contingency table)

	O	E	O	E	
	84	95	38	27	122
	119	108	19	30	138
	203		57		260

$$\chi^2_{cal} = 10.90$$

But $\chi^2_{cri}(1, 0.05) = 3.841$

Since $\chi^2_{cal} > \chi^2_{cri}$, the null hypothesis was rejected at 5% level of significance. Thus, the use of the same facility for both urine and faeces was dependent on socio-economic status.

4.4.5 Hypothesis (V)

The social acceptability of the sanitation systems on the campus are independent of status. Table 4.22 provides the data used in the analysis of this hypothesis.

Table 4.22a Social acceptability of the sanitation systems on the campus, and contingency table

	Students	Staff
Very acceptable	-	2
Acceptable	42	10
Fairly acceptable	74	28
Not acceptable	87	17

Table 4.22b

	0	E	0	E	
Contingency table	42	42	12	12	54
	74	80	28	22	102
	87	81	17	23	104
	203		57		260

$\chi^2_{cal} = 3.7,$

But $\chi^2_{crit}(2, 0.05) = 5.991$

Since $\chi^2_{cal} < \chi^2_{crit}$, the null hypothesis was not rejected at 5% level of significance. Thus, the social acceptability of the sanitation systems on the campus were independent of status.

4.4.6 Hypothesis (VI)

The adequacy of sanitation facilities on campus is independent of status. Table 4.23 provides the data used in the analysis of this hypothesis.

Table 4.23a Adequacy of sanitation facilities on campus, and contingency table

	Students	Staff
Very adequate	-	-
Adequate	9	7
Fairly adequate	40	13
Not adequate	139	27
Grossly inadequate	15	8

Table 4.23b

	0	E	0	E	
Contingency table	49	54	20	15	69
	139	131	29	37	168
	15	18	8	5	23
	203		57		260

$\chi^2_{cal} = 6.41$

But $\chi^2_{cru}(2,0.05) = 5.991$

Since $\chi^2_{cal} > \chi^2_{cru}$, the null hypothesis was rejected at 5% level of significance. Thus, the adequacy of sanitation facilities on campus was dependent on status.

CHAPTER FIVE

EVALUATION OF ALTERNATIVE SANITATION SYSTEMS FOR THE STUDY AREA

The evaluation of alternative systems was carried out by employing the factors that impact on the potential for sustained services provision to all sectors of the study area. The feasible options were examined along the line of socio-cultural and technical factors, built up from both physical and attitude surveys, to determine their acceptability and adequacy. The acceptable and adequate options were further subjected to cost comparisons for affordability, and to determine how each could be singly used or all used in combination.

5.1 Criteria for evaluation

The following criteria were built up, for the selection of appropriate sanitation systems for the study area, based on the data collected and analysed in both the physical and attitude surveys.

(i) The areas that were having major sanitation problems were the students' hostels, classrooms, workshops and laboratories areas at 'Lagos' zone;

(ii) Majority of the people (73%) believed that the number of systems were not adequate, especially on the students side;

(iii) With 30 people per facility for residential areas, and 50 people per facility in non-residential area, more facilities would be needed at the hostels and 'Lagos' zone;

(iv) The most acceptable sanitation system, to the users, was the water system; and 87% of the total population preferred it. There is very little preference for pit toilet.

(v) 63% of the population believed that the existing pit latrines had either made negative impacts or made no impact at all on the sanitation of the study area, because of the problem of odour and fly nuisance;

(vi) The type of pit toilet that the people (users) wanted was one that will not produce foul smell and fly nuisance;

(vii) The frequency of disludging the existing septic tanks at the students' hostels were too high;

(viii) The topography and the general layout at the students' hostels were conducive for sewerage systems. However, water supply must be adequate, and treatment site could be acquired adjacent to the polytechnic's boundary;

(ix) The level of water supply on the campus was not adequate (before 1999); however, with the storage tanks just put in place (January, 1999), the present level of water supply needed to be assessed for adequacy;

(x) The students in the hostels preferred to squat than to sit on the lavatory pan;

(xi) The popular anal cleaning materials on the campus were water and toilet roll (47% and 36% respectively);

(xii) The soil on the study area has a very good infiltration capacity, being 200mm/hr on the average;

(xiii) 55.4% of the population used any available good facility, anywhere on the campus, and not necessarily the ones closest to them;

(xiv) Many people (53.1%), mostly students, would need separate urinals, in addition to the general toilets.

These criteria were used in evaluating alternative sanitation facilities.

5.2 *Assessment of adequacy of capacities of the existing sanitation facilities*

Because of the high frequency of disludging the existing septic tanks at the students' hostels, there was the need to assess the adequacy of the capacities of both the septic tanks and soakaway pits, in terms of population served. Also, apart from the fact that the existing pit toilets had problems of odour and fly nuisance, which must be rectified in the new design, it was necessary to assess the capacity of the pits in terms of the number of users per facility, for one year usage before pit emptying. Using appropriate relations, details of the existing sanitation facilities and their respective capacities are presented in table 5.1 below.

Table 5.1 Details of the existing sanitation facilities at the hostels.

Parameters	Septic tanks	Soakaway pits	Pit latrines
Length	2.60m	3.0m	1.0m
Width	1.20m	3.0m	1.0m
Depth	1.80m	2.0m	1.5m
Volume	5.62m^3	18.0m^3	1.5m^3
Capacity per day	23 People	15 People	18 People

5.3 Design of the proposed septic tanks, soakaway pits and pit latrines

Considering the capacities of the sanitation facilities presented in Table 5.1, the existing capacities were inadequate. There was, therefore, the need to design new facilities that would be adequate, by the criteria built up from the surveys. The details of the designed facilities (Appendix B.), which had capacities of 30 students per septic tank and soakaway pit, and 50 students per pit latrine, were presented in Table 5.2.

Table 5.2 Details of the proposed septic tanks, soakaway pits and pit latrines at the hostels

Parameters	Septic tanks	Soakaway pits	Pit latrines
Length	2.80m	3.0m(2 units)	2.20m
Width	1.50m	3.0m(2 units)	1.20m
Depth	1.80m	2.0m (2 units)	1.54m
Volume	7.56m^3	18m^3 (2 units)	4.07m^3
Capacity/day	30 People	30 People	50 People

5.4 *Assessment of adequacy of the level of water supply on the campus*

The total volume of water that could be stored per day, based on the present (1999) storage tanks' capacities in the Polytechnic, was about $1388.61m^3$. The water demands for various components of the Polytechnic have been computed (Appendix D.). Approximately 993m3 of water would be needed per day, showing that one day storage still leaves a surplus of $395m^3$ per day. The level of water supply (as at 1999) was therefore, considered adequate. Also, since the level of water supply at the residential area was above the minimum of 75 lpcd, required for water-borne sewerage systems (Cairncross and Feachem, 1983), it was possible to provide the sewerage system for the students' hostels, where the conditions were favourable for it.

5.5 *Design of sewerage and sewage treatment plant for the students' hostels*

The sewerage systems essentially consisted of:

(a) The sanitary sewers, responsible for the collection and transmission of waste waters from the points of generation to the point of discharge or treatment.

(b) Treatment systems, for the treatment of the sewage before its disposal, to destroy pathogenic agents present generally improve the quality of the effluent, and to ensure re-use possibilities.

5.5.1 Design of sanitary sewers

(i) Design criteria:

Per capita sewage flows (G), which is about 80% of per capita water consumption = 80 lpcd.

Manning's coefficient for concrete pipe = 0.013

Peak or maximum flow Q = 3DWF

Sewage flow velocity: Minimum allowable = 0.61mls

Maximum allowable = 2.44mls

Minimum pipe diameter allowable = 100mm

Infiltration rate = 0.01l/s

(ii) Design Formulas:

Q = Av (5.1)

Q = 3DWF (5.2)

$$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} \quad (5.3)$$

$$V = \frac{1}{n}\left(\frac{D}{4}\right)^{\frac{2}{3}} S^{\frac{1}{2}} \quad (5.4)$$

DWF = N x G + I (5.5)

$$D = \left(\frac{4^{\frac{5}{3}} nQ}{\Pi\, S^{\frac{1}{2}}}\right)^{\frac{3}{8}} \quad (5.6)$$

where,

Q = Peak flow,

V = Velocity of flow,

A = Cross sectional area of pipe,

D = Diameter of pipe,

DWF = Dry weather flow,

R = Hydraulic radius,

S = Slope of sewers,

n = Manning's coefficient,

N = Population,

G = Per capita sewerage flow

I = Infiltration from ground to sewer.

(III) Computer analysis of sewer network systems

Many application packages are available for Civil engineering design, especially in the field of water and waste water engineering. Among such packages is the 'SEWER' which uses heuristic programming and the Manning's formula for the optimal design of gravity sanitary sewer systems. The package ('SEWER') was used for the analysis of sewer network systems in this study. Alternative network layouts were prepared, and designated as schemes. The optimal design of each scheme was carried out; and scheme three ("Peter Sewer 3") shown in Appendix E, with the least optimal cost, was selected.

5.5.2 Design of waste stabilization pond system

(i) Design criteria:

Population = 10,680,

Per capita waste water contribution = 80 lpcd,

Per capita BODs contribution = 40gpcd,

Total infiltration to sewers = 106.8 m^3/d,

Influent bacterial concentration = 5×10^7 Fc/100 ml,

Mean minimum monthly temperature = 21^0C,

Effluent standard required for } < 25mg/lBODs,

Unrestricted irrigation } < 100 Fc/100ml.

(ii) Design calculations

Sewage flow = 10680 x 80 l/d = 854.4m^3/d

Infiltration = <u>106.8m^3/d</u>

Total flow rate (Q) = 961.2m^3/d

Total organic load = 10,680 x 40g/cd = 427.2kg/d.

Influent BODs concentration = 427.2/961.2= 444.4mg/l.

(a) Anaerobic ponds

At 21°C, anaerobic ponds were designed using volumetric loading λ_v = 0.25kg BODs/m³/d.

Volume of pond = 427.2/0.25 = 1708.8m³

Check detention time (t*) = 1708.8/961.2 = 1.78 days

Use 2-day detention time (t* = 2).

Volume required (V = Qt*) = 1922.4m³ (1930m³).

Use 2 anaerobic units, each 965m³, for flexibility of operation, plus one reserve pond 965m³ volume. With operation depth of 4m, mid depth area of each pond = 242m². Total (mid depth) area of anaerobic pond = 726m².

(b) Facultative ponds

$$\lambda_s = 20T - 60 \qquad (5.7)$$

Where λ_s = Areal loading rate (kg BODs/ha/day)

T = Temperature (°C).

With T = 210C, λ_s = (20 x 21) - 60 = 360 kg BODs/ha/day.

With BODs removal of anaerobic ponds at 60%, influent BODs to facultative pond = 0.4 x 444.4 = 177.8 mg/l. But,

$$A = \frac{10 \times L_i \times Q}{\lambda_s} \qquad (5.8)$$

Where A = Facultative pond area (m²)

L_i = Influent BODs concentration (mg/l),

Q = Influent flow rate (m³/d)

Thus, A = (10 x 177.8 x 961.2)/360 = 4747.26m²(4748m²)

With depth of 1.75m, volume = 8309m³.

Detention time of facultative pond (t^*) = V/Q (5.9)

Where V = Volume of pond

Thus, t^* = 8309/961.2 = 8.6 days.

With 70% BODs removal in facultative pond. Commulative removal = 88%.

(c) Maturation ponds

The maturation ponds were designed to achieve an effluent FC concentration of 100 Fc/100 ml.

$$B_e = \frac{B_i}{1+K_{b(T)}t^*} \quad (5.10)$$

Where, B_i = Influent bacteria count (per 100 ml)

B_e = Effluent bacteria count (per 100 ml)

K_b = First order bacteria removal rate at T^oC in day $^{-1}$

t^* = Detention time

$K_b(20)$ = 2.6 day^{-1} for coliforms,

But $K_b(T)$ = $K_b(20).(1.19)^{(T-20)}$ 5.11

Thus, $K_b(T)$ = $2.6\,(1.19)^{(T-20)}$

The total fecal coliform removal in ponds in series is given by:

$$B_e = \frac{B_i}{(1+K_{b(T)}t^*_{an})(1+K_{b(T)}t^*_{fac})(1+K_{b(T)}t^*_{mat})^n} \quad 5.12$$

Where t^*_{an}, t^*_{fac}, and t^*_{mat} are the detention times of the anaerobic, facultative and maturation ponds respectively; and n is the number of maturation units in series.

Three maturation ponds, with five day detention time were used in series.

T = 21^0C

$K_b(T)$ = $2.6\,(1.19)^{(21-20)}$ = 3.1

$$B = \frac{5x10^7}{(1+2x3.1)(1+8.6x3.1)(1+5x3.1)^3} = 55.9 Fc/100ml$$

Therefore, the bacteria effluent standard was satisfied.

The Cummulative BODs removal = 95%

Effluent BODs = 0.05 x 444.4 = 22.22mg/l.

This also satisfied BODs effluent standard.

Using V = t*Q, maturation pond volumes were 4,806m^3 each.

With depth = 1.5m, the mid-depth area of each maturation pond = 3204m^2

(iii) Summary

Anaerobic ponds: 3 units, 242m^2 x 4m,

Facultative ponds: 4748m^2 x 1.75m,

Maturation ponds: 3 units, 3204m^2 x 1.5m.

Total mid-depth area of pond system = 15,086m^2

Approximate surface area = 18,000m^2

Approximate area required for the system = 2 hectare.

Total sewage flow rate = 961.2m^3/day

Influent BODs concentration = 444.4mg/l

Effluent BODs concentration = 25mg/l.

Influent bacteria concentration = 5 x 10^7Fc/100ml

Effluent bacteria concentration = 100Fc/100ml.

5.5.3 Design of activated sludge treatment plant

(i) Design criteria

Population = 10,680,

Per capita waste contribution = 80lpcd

Per capita BODs contribution = 40gpcd.,

Total infiltration to sewers = 106.8m^3/d., Sludge concentration in aeration basin (C_{BA}) = 2,500mg/l of MLVSS,

Recycled sludge concentration (C_R) = 12,000 mg/l of MLVSS

BOD5 removal efficiency = 90%

Mean minimum monthly temperature = 21^{0}C

(ii) Design calculations

Sewage flow = 10680 x 80 l/d = 854.4m^3/d

Infiltration = 106.8m^3/d

Total flow rate (Q) = 961.2m^3/d.

Total organic load = 10,680 x 40 g/cd = 427.2kg/d.

Influent BOD5 concentration (L_o) = 427.2/961.2 = 444.4mg/l

Effluent BOD5 at discharge (L_e) = 0.1 x 444.4 mg/l = 44.4mg/l

(a) Aeration tank design

Using conventional treatment:

Retention time (t) = 10 hrs.

Recycle ration of MLVSS ® $= \dfrac{C_{BA}}{C_R - C_{BA}}$ (5.13)

2500/(12,000-2500) = 0.26

Tank capacity $V_{BA} = Q(1 + r)t$ (5.14)

961.2 (1 + 0.26) x 10/24 = 504.63m^3

Provide 16m x 8m x 4m tank (512m^3).

(b) Oxygen requirement

Influent BOD5 = 444.4 mg/l.

Final effluent BOD5 = 44.4 mg/l.

BOD5 removal = 444.4 - 44.4 = 400 mg/l

$= \quad 400 \times 961.2 \times 10^{-3} = 384.48\text{kgBOD/day}$

With 2.0kg 0_2/kg BODs removed,

Oxygen required $= \quad 384.48 \times 2 = 768.96$ kg 0_2/day

If the transfer efficiency is about 6%,

Oxygen required $= \quad \frac{768.96}{0.96} = 12816$ kg 0_2/day

(c) Final settling tank

Overflow rate (V_0) $=$ 30 m^3/m^2d

Retention time (t) $=$ 2 hrs.

$$Vo = \frac{Q}{L.B} \quad (5.15)$$

Where, L = Length of tank, and B = width of tank

Surface area (L x B) $= \frac{961.2}{30} = 32.04m^2$

Capacity of tank $= Q \times t = \frac{961.2 \times 2}{24} = 80.1m^3$

Depth of tank $= \frac{80.1}{32.04} = 2.5m$

With a circular settling basin,

Diameter (d) $= \left(\frac{4 \times 32.04}{\pi}\right)^{½} = 6.4m$

Provide final settling tank of diameter 7m and depth 2.5m ($96.2m^3$), and surface area $38.5m^2$.

(d) Activated sludge return pump

$$\text{Volume of return sludge } (V_R) = \frac{Q \times C_{BA}}{C_R} \quad (5.16)$$

$$= \frac{961.2 \times 2500}{12000} = 200.25 m^3/day$$
$$= 2.32\ l/s.$$

Pump capacity (allowing for a factor of 2.5 to overcome sludge resistance)

= 2.32 x 2.5 = 5.8 l/s.

Provide a pump of capacity 6 l/s.

(v) Effluent disposal

Overflow $(Q_{ET}) = Q \frac{C_s - C_M}{C_s - L_s}$ (5.17)

961.2 x (12000 - 2500)/(12000 - 44.4) = 763.8m^3/day

(f) Sludge drying bed

The under flow, or sludge flow (Q_u) = $Q - Q_{ET}$ (5.18)

= 961.2 - 763.8

= 197.4 m^3/day

With 600mm depth, the surface area = $\frac{197.4}{0.6}$ = 329m^2

Provide 20m x 17m (329m^2) bed, 2.00m deep.

(iii)Summary

Aeration tank: 16m x 8m x 4m (512m^3).

Oxygen requirement: 12816 kg O_2/day

Final settling tank: Diameter 7m, depth 2.5m (96.2m^3).

Activated sludge return pump: a pump of capacity 6 l/s.

Overflow rate: 763.8m^3/day

Sludge drying bed: 20m x 17m and 2.00m deep.

Total sewage flow rate = 961.2 m3/day

Influent BODs concentration = 444.4 mg/l

Effluent BODs concentration = 44.4mg/l.

5.6 Cost analysis of alternative sanitation systems

At the heart of analysis of alternative sanitation technologies lies comparative costing. However, there are unquantifiable costs associated with alternative sanitation technologies, such as convenience and environmental consequences of installing a particular system. The analysis carried out here were, therefore, basically that of the monetary investments on the alternative sanitation systems considered.

The approximate quantities and cost estimates of alternative sanitation systems, considered in this study, were carried out as shown in Appendix F. Preliminaries and installation costs of ten per cent of the estimated costs were added to arrive at the investment costs; while recurrent percentages of 5%, 21%, 21% and 33%, of the Total Annual Cost per Household (TACH), were used for the pit toilets, septic tank, stabilization ponds, and activated sludge systems respectively (Kalbermatten et al, 1980). The summary of the cost analysis, for alternative sanitation systems considered, is shown in table 5.3.

The maximum number of users per household, used in both the design and cost analysis, were: 50 for VIP and VIDP; 30 for septic tank with soakaway pit; and 30 for the sewage treatment systems.

Table 5.3 Summary of annual costs per household for alternative sanitation systems considered

Alternative sanitation systems	Ventilated improved pit latrine (VIP)	Ventilated improved double pit latrine (VID)	Septic tank with soakaway pit	Sewerage systems	
				Stabilization ponds	Activated sludge system
Annual investment cost per house hold (AISH) (₦)	3000.94	2746.56	5204.43	10736.01	11286.22
Annual recurrent cost per household (ARCH) (₦)	157.94	144.56	1383.46	2853.88	5558.88
Total annual cost per household (TACH) (₦)	3158.88	2891.12	6587.89	13589.89	16845.10

CHAPTER SIX

DISCUSSION OF RESULTS

The discussion in this section was carried out on the basis of the physical survey, the attitude survey and hypotheses tested, as well as the systems assessment, systems design and cost analysis and comparison carried out.

6.1 Discussion of the results of the field survey

Considering the number of users per effective facility in the study area, the figures for 'Lagos' zone and male hostels (77 and 65 respectively) were relatively high, especially when it was noted that user's care was almost nil in those places. The majority of the studied population (73%) believed that the number of facilities were not adequate. However, the adequacy of the sanitation facilities on the campus was dependent on status, with the staff more favoured than the students.

Before January 1999, the general level of water supply in the study area was inadequate. Majority of the studied population (84%) believed that the level of water supply had adversely affected the sanitation systems on the campus. The level of water supply, then, had been between that of 'hand carried' and 'yard tap' (about 29 lpcd). However, with the concluded projects on water distribution storage tanks (early 1999), the storage capacity of $1388.61m^3/day$ was assessed and found adequate for the proper operation of the facilities in the study area.

Many lavatory pans (W.C.) and cistern tanks had been destroyed at the hostels, as a result of students standing on the pans and holding on to the tanks for stability, instead of sitting on the pans. There was also odour and fly nuisance associated with the existing pit toilets on the campus as a result of lack of ventilation pipes.

About 53% of the surveyed population were not using the same facilities for both urine and faeces, and since there were no urinals these groups of people must have been using unapproved places. However, the use of the same facility for both urine and faeces was dependent on socio-status, with more staff using the same facility, for both urine and faeces, than students.

About 57% of the studied population were already used to water for anal cleaning, outside the campus. The popular anal cleaning material in use on the campus was also water. However, the anal cleaning materials used outside the campus significantly differed from the ones used on the campus, with less percentage of people using water on the campus than outside the campus. This might be as a result of inadequacy of water on campus before January 1999.

More than half of the studied population (55%) frequently use other facilities apart from the ones closest to them, majorly, because the closest systems were not in good condition. The effect of this practice was the overloading of the few good systems, and the consequent break down of the overloaded systems.

A good percentage of the studied population (63%) believed that the existing systems were not hygienic enough as a result of inadequate water supply, bad habit of users and the failure of the cleaners in doing their job. However, only about 40% of the population believed that the systems were not socially acceptable. The social acceptability of the facilities were also dependent on status, with the facilities for staff more socially acceptable than that of the students. The general opinion was that there was urgent need for improvement on the existing systems to eliminate the earlier mentioned problems.

The most popular and most acceptable system both outside and on the campus was water system. Majority of the studied population (87%) preferred water system for their sanitation, while there were some few (about 10%) that would prefer pit toilets, if given a chance to make their choice. The systems preferred significantly differed from both the ones used to outside the campus and the ones in use on the campus, showing that the people were only using what they were using because they could not get what they wanted. It was therefore, believed that if appropriate facilities were provided, defecating on unapproved places in the campus would stop.

The soil in the study area, was of a very good infiltration capacity (200mm/hr). This was considered very good for on-site disposal systems, since there were no dangers of ground water pollution. The topography of the study area did not present a one directional gradient for the entire area. As a result of this it would be very costly to employ conventional sewerage systems for the entire study area, since a lot of pumping would be required. However, the gradient around the students' hostels area was favourable for gravity flow in sewer; and if treatment site could be acquired close to the polytechnic boundary, sewerage systems leading to a central sewage treatment plant would be ideal for that segment of the study area, in view of its density.

6.2 Discussion of the evaluation of alternative sanitation systems

From the people's perceptions of the existing situation and interest in or susceptibility to change, which were determined through the surveys, the criteria formulated were used to evaluate and select the appropriate sanitation alternatives for different locations of the campus. For instance, though the overall level of water supply, was sufficient, it varied from yard connection to in-house connection rates, for different locations of the campus. This informed the mixture of water carriage system and improved pit latrines on the campus. Also, for the water carriage systems, the topography, soil condition, and population density were used to determine the suitability of on-site and off-site methods, for different locations of the campus.

The level of hygiene practices, the form of anal cleaning materials, and attitude towards re-use of wastes, as well as the level of users' care, easily precluded many alternative sanitation systems for the campus. The alternatives that were finally selected, based on acceptability and adequacy, for the different locations of the campus, and in various mixtures, were: The Ventilated Improved Pit latrines, Septic Tanks with Soakaway pits, and the Sewerage and central sewage treatment plant. The assessments carried out on the existing facilities revealed that the capacities were no longer adequate. This was in addition to the problems created by the pit toilets which were neither ventilated nor lighted, and the lavatory pans of the water systems in the students hostels that needed to be changed from the sitting type to the squatting type.

6.3 Discussion of the design and costing of alternative sanitation systems

The pit latrines were designed for fifty users per facility per day, while the water carriage systems were designed for thirty users per facility per day. The pit toilets designed were the Ventilated Improved types, while the sitting type lavatory pans of the water systems were changed to the squatting type. For the water carriage system, three alternatives were designed:

(i) The septic tanks with soakaway pits;

(ii) Sewerage system and stabilization ponds; and

(iii) Sewerage system and activated sludge treatment plant.

The cost comparison were carried out for the alternative sanitation systems, using the Total annual Cost per Household (TACH), which consisted of Annual Investment Cost per Household (AICH), and annual Recurrent cost per Household (ARCH). The VIDP had the lowest TACH of ₦2891.12, followed by VIP with TACH of ₦3158.88. The three alternative water carriage systems: (i), (ii), and (iii) above had TACH of ₦6587.89, ₦13589.89 and ₦168945.10 respectively.

CHAPTER SEVEN

CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

The evaluation of alternative sanitary disposal systems of human wastes, carried out in this study, based on the criteria for acceptability and adequacy, revealed that the existing sanitation systems, in some sectors of the campus, were not appropriate. The existing pit latrines, all over the campus, were found not acceptable, while the sitting type lavatory pan was found not adequate for the students sector.

The capacities of the existing systems, in the students hostels, were not adequate to serve the existing population, which resulted in overloading of the systems and general poor sanitation practices, in the sectors affected. There was also poor distribution of sanitation facilities across the campus; from four people per facility to seventy seven people per facility.

The systems designed, based on the evaluation criteria built up from this study, were VIP, VIDP, Septic tanks and Soakaway pits, and sewerage and central sewage treatment facility. These systems were both acceptable and adequate for the different sectors of the campus. The cost implications of each system was presented, so that the users could decide on what service level they were willing to pay for.

7.2 Recommendations

Based on the results of this study, the following recommendations were made

(i) The damaged sanitation systems on the campus should be repaired, and the lavatory pans in the hostels changed from the sitting to the squatting types.

(ii) If the option of septic tank and soakaway system is desired for the students hostels, the tanks and pits should be enlarged according to the design provided in this study. If the sewerage and central sewage treatment system is preferred, the waste stabilization ponds, with lower total annual cost per household, is recommended, and the one designed in this study should be implemented.

(iii) Irrespective of the option chosen in the (ii) above, some VIDPs should be built; 14 at the male hostels, 5 at the female hostels and 33 at the "Lagos" zone. The existing pit toilets should be converted to VIP by introducing ventilation pipes.

(iv) Lighting systems should be provided around the toilets, and water storage tanks should be installed at the sites of the VIDPs, to provide water for anal cleaning and the regular cleaning of the squatting plates.

(v) Specific facilities in the hostels should be allocated to specific rooms, to encourage decent usage and high level of user's care.

(vi) Cleaners should be attached to specific facilities, for daily cleaning and maintenance, with basic disinfectants provided.

(vii) Sanitation education should be organized to educate the people on good sanitation practices.

7.3 Suggestion for further research

Similar research should be encouraged in a more heterogeneous society settings, where there are diversities of socio-cultural backgrounds, with a view to identifying more of the factors that influence sanitation appropriateness.

Also, researche should be encouraged in the area of production of software that could be used as a guide, by the policy makers, on choosing appropriate sanitation for different communities with different socio-cultural backgrounds.

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APPENDIX A.

QUESTIONNAIRE

This questionnaire is part of an on-going research work, titled: *AN ASSESSMENT OF AN INSTITUTION'S SANITARY DISPOSAL SYSTEMS* The work is for an M.Eng. Degree at the Federal University of Technology, Akure; with The Federal Polytechnic Bida campus as case study.

You are, please, requested to complete this questionnaire, to the best of your knowledge. Every information given shall be for the purpose of the research work only, and treated confidentially.

Thanks.

PETER, A. TOBA

1. Status: Student... staff...

2. On the average, how many times do you defecate per day?..

3. Do you normally use the same facility for both urine and faeces?...................................

4. Which of the sanitation systems were you used to, back at home, outside the campus?

   (i) Bucket latrine................................... (ii) Pit latrine...

   (iii) Water systems.................................. (iv) Others, Please specify).....................

5. Which sanitation system are you using now, on campus?..

6. How socially acceptable is the present sanitation system to you?......................................

   ....

7. Do you think the present system you are using, needs some improvements?....................

   If yes, what type of improvements?...

Which type of sanitation system would you prefer, if allowed to make your

   choice?......... ....

9. What type of anal cleaning materials were you used to, back at home, outside the campus?..

10. What type of anal cleaning materials are you using now, on campus?..............................

11. Is the present sanitation system you are using hygienic enough for your liking (Yes/No)?

....

If no, what do you think is the cause?...

....

Do you, frequently, have to use other facilities, on the campus, apart from the one closest to your room/office/residence (Yes/No)?..

If yes, why?..

....

13. On a general note, how adequate, do you think, is the sanitation facilities on the campus?...

14. What do you think is responsible for people defecating on unapproved places on the campus?...

15. How do you think defecating in the bush, around the campus, can be stopped?...............

....

16. What can you say about the general level of water supply on the campus?.......................

....

17. What do you think is the effect of water supply on the sanitation systems on the campus?..

18. What impact do you think the strategically located pit latrines have made on the general sanitation of the campus?...

19. Any other observations and comments?...

APPENDIX B

DESIGN OF SEPTIC TANK AND SOAKAWAY PIT, FOR THE STUDENT' HOSTELS

(a) Septic tank

Generally $V = Qnt,$

Where V= Volume of septic tank (m3),

Q = Waste flow (m^3/hd),

N = Population,

tr = Detention time (usually 3 days).

For a limiting ratio of 30 people per facility, and with 80% of water used as waste,

$V = 0.08 \times 30 \times 3 = 7.2m^3$

Provide $2.8 \times 1.5 \times 1.8 = 7.56m^3$

This gives: length = 2.8m, width = 1.5m, depth = 1.8m.

(b) Soak away pit

Generally $A = \frac{NQ}{I}$

Where A = Infiltration area (m^2)

N = Population,

Q = Waste flow (l/hd),

I = Infiltration rate (l/m^2d),

For a limiting ratio of 30 students per facility, and infiltration rate of 50 l/m^2d),

$A = \frac{30 \times 80}{50} = 45m^2$

Use two units of $3_m \times 3_m \times 2_m$ ($24m^3$)

This gives two units of: Length = 3.0m, width = 3.0m, depth = 2.0m.

APPENDIX C.

DESIGN OF PIT LATRINE

(a) Pit design

Generally $V = CPN$;

Where P = Population per pit,

V = Volume of the pit (m^3)

C = Pit design capacity (m^3/person/year)

N = Number of years the pit is to be used before emptying.

C = $0.06m^3$/person/year

For a 75% usable volume, $V = 1.35$ CPN

For 50 people and 1 year before pit emptying:

$V = 1.35 \times 0.06 \times 50 \times 1 = 4.05m^3$

Provide $V = 1.2 \times 2.2 \times 1.54 = 4.07m^3$

The top area of the pit $= 1.2 \times 2.2m^2$, while the depth $= 1.85m$.

(b) Top slab design

To withstand two 100kg men standing at the centre, with $M = PL/4$,

Where M = Mid-span moment (Nm)

P = Design load (N)

L = Span (m)

$M = 2 \times 100 \times 9.8 \times 1.425/4 = 698.25Nm$

Using the limit state method (BS 8110), $As = 216mm^2$

Provide eight numbers of 6mm diameter reinforcement ($As = 226mm^2$)

Nominal reinforcement of four numbers, 6mm diameter, should also be provided for the ground beam.

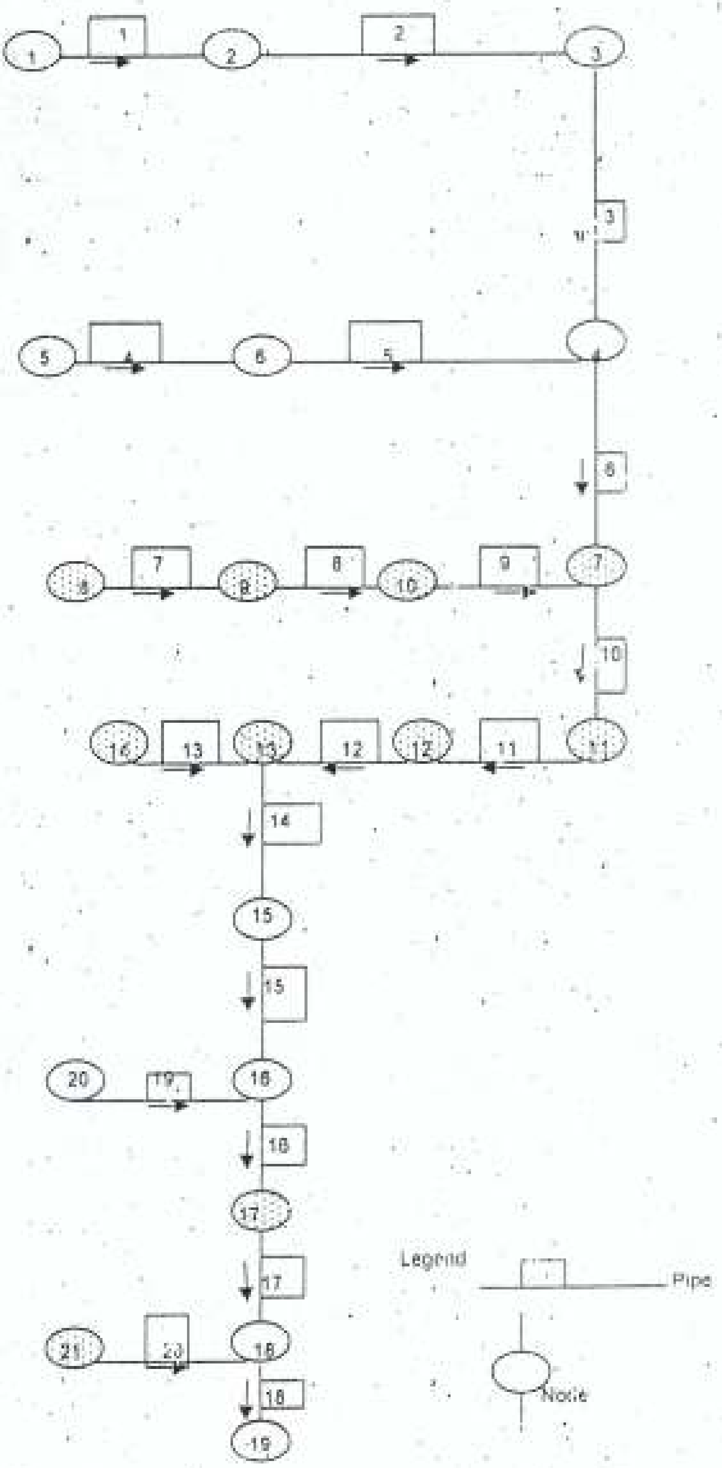
APPENDIX D.

Table D.1 Approximate water demand for the Federal Polytechnic, Bida

Components	Rate of water demand (**)	Population	Total water demand (m^3)
Students' hostels	100 lpcd	4,800	480
Staff quarters	115 lpcd	600	69
Offices	30 lpcd	940	28.2
Laboratories	300 l/h.seat	40 x 6 = 240	72
Restaurant	65 l/h. seat	100	65
Guest house	152 lpcd	6	0.912
Clinic	220 l/h.bed	2	0440
Staff school	20 lpcd	1633	32.660
Fire storage	1 lpcd	15,226	15.226
Losses	30% of water Supplied		229.031
Gross total			992.469

** Santosh (1986) and Hofkes (1992).

COMPUTER ANALYSIS OF SEWER NETWORK SYSTEMS



T I T L E	:	PETER SEWER 3
NO. OF PIPES	:	20
NO. OF NODES	:	21
PEAK FACTOR	:	3
MIN SCOUR VELOCITY (mps)	:	.61
MAX VELOCITY (mps)	:	2.44
MAX COVER DEPTH (m)	:	4.5
SEWER OUTFALL NODE	:	19
CROWN ELEV. OF OUTFALL NODE (m)	:	126
TOT SYSTEM LENGTH (m)	:	2936
AVE WEIGHTED DIAMETER (mm)	:	172.5221
AVE WEIGHTED EXC. DEPTH (m)	:	2.339641
AVE WEIGHTED EXC. AREA (sq.m)	:	.4139052

LINK NO.	FROM Node	TO Node	PEAK FLOW (L/S)	LENGTH (M)	DIA (MM)	WATER DEPTH (MM)	VEL (MPS)	PIPE SLOPE %	MIN SLOPE %	MAX SLOPE %	GROUND SLOPE %
1	1	2	0.96	75	100	25.44	0.61	1.72	1.72	88.45	0.93
2	2	3	1.92	100	100	42.17	0.61	1.00	1.00	48.87	1.30
3	3	4	1.92	100	100	34.51	0.80	2.11	1.00	48.87	2.40
4	5	6	0.75	75	100	21.37	0.61	2.10	2.10	109.52	0.67
5	6	4	1.50	100	100	35.10	0.61	1.21	1.21	60.26	1.10
6	4	7	3.42	100	125	45.13	0.86	1.72	0.68	32.49	2.90
7	8	9	0.75	55	100	21.37	0.61	2.10	2.10	109.52	1.45
8	9	10	1.50	55	100	35.10	0.61	1.21	1.21	60.26	0.36
9	10	7	2.25	50	100	47.61	0.61	0.90	0.90	42.75	1.00
10	7	11	5.67	100	150	51.66	1.05	2.13	0.48	22.65	2.90
11	11	12	5.67	50	150	78.06	0.61	0.48	0.48	22.65	-1.00
12	12	13	6.42	55	150	86.30	0.61	0.45	0.45	20.42	-1.09
13	14	13	0.75	55	100	21.37	0.61	2.10	2.10	109.52	1.09
14	13	15	7.92	280	175	59.38	1.10	1.93	0.39	18.04	2.50
15	15	16	13.38	95	175	83.71	1.18	1.58	0.38	11.75	1.58
16	16	17	18.84	88	200	142.77	0.79	0.45	0.37	9.26	1.93
17	17	18	24.30	83	225	93.18	1.56	2.27	0.33	7.80	2.27
18	18	19	29.76	1015	250	107.38	1.48	1.70	0.28	6.82	1.87
19	20	16	5.46	200	100	77.37	0.84	1.25	1.25	20.77	0.60
20	21	18	5.46	200	100	77.37	0.84	1.25	1.25	20.77	0.40

LINK NO.	GROUND ELEV UPSTRM (M)	GROUND ELEV DNSTRM (M)	CROWN ELEV UPSTRM (M)	CROWN ELEV DNSTRM (M)	INVERT ELEV UPSTRM (M)	INVERT ELEV DNSTRM (M)	EXCAVATION DEPTH UPSTRM (M)	EXCAVATION DEPTH DNSTRM (M)
1	167.80	167.10	166.30	165.01	166.20	164.91	1.60	2.19
2	167.10	165.80	165.01	164.01	164.91	163.91	2.19	1.89
3	165.80	163.40	164.01	161.90	163.91	161.80	1.89	1.60
4	165.00	164.50	163.50	161.92	163.40	161.82	1.60	2.68
5	164.50	163.40	161.92	160.72	161.82	160.62	2.68	2.78
6	163.40	160.50	160.72	159.00	160.59	158.88	2.81	1.63
7	162.00	161.20	160.50	159.34	160.40	159.24	1.60	1.96
8	161.20	161.00	159.34	158.68	159.24	158.58	1.96	2.42

LINK NO.	GROUND ELEV UPSTRM (M)	DNSTRM (M)	CROWN ELEV UPSTRM (M)	DNSTRM (M)	INVERT ELEV UPSTRM (M)	DNSTRM (M)	EXCAVATION DEPTH UPSTRM (M)	DNSTRM (M)
9	161.00	160.50	158.68	158.23	158.58	158.13	2.42	2.37
10	160.50	157.60	158.23	156.10	158.08	155.95	2.42	1.65
11	157.60	158.10	156.10	155.86	155.95	155.71	1.65	2.39
12	158.10	158.70	155.86	155.61	155.71	155.46	2.39	3.24
13	159.30	158.70	157.80	156.64	157.70	156.54	1.60	2.16
14	158.70	151.70	155.61	150.20	155.44	150.02	3.26	1.68
15	151.70	150.20	150.20	148.70	150.02	148.52	1.68	1.68
16	150.20	148.50	147.39	147.00	147.19	146.80	3.01	1.70
17	148.50	146.50	147.08	145.00	146.77	144.77	1.73	1.73
18	146.50	127.50	143.29	126.00	143.04	125.75	3.46	1.75
19	151.40	150.20	149.90	147.39	149.80	147.29	1.60	2.91
20	147.30	146.50	145.80	143.29	145.70	143.19	1.60	3.31

NODE NO.	INPUT (LPS)	GROUND ELEV (M)	EXCAVATION DEPTH (M)	DISTANCE HIGH INVERT TO LOW INVERT (M)
1	0.32	167.80	1.60	0.00
2	0.32	167.10	2.19	0.00
3	0.00	165.80	1.89	0.00
4	0.00	163.40	2.81	1.21
5	0.25	165.00	1.60	0.00
6	0.25	164.50	2.68	0.00
7	0.00	160.50	2.42	0.79
8	0.25	162.00	1.60	0.00
9	0.25	161.20	1.96	0.00
10	0.25	161.00	2.42	0.00
11	0.00	157.60	1.65	0.00
12	0.25	158.10	2.39	0.00
13	0.25	158.70	3.26	1.11
14	0.25	159.30	1.60	0.00
15	1.82	151.70	1.68	0.00
16	0.00	150.20	3.01	1.33
17	1.82	148.50	1.73	0.03
18	0.00	146.50	3.46	1.73
19	-9.92	127.50	1.75	0.00
20	1.82	151.40	1.60	0.00
21	1.82	147.30	1.60	0.00

LINK NO.	DIAM (MM)	LENGTH (M)	C O S T
1	100	75.00	106,500.00
2	100	100.00	142,000.00
3	100	100.00	142,000.00
4	100	75.00	106,500.00
5	100	100.00	142,000.00
6	125	100.00	210,000.00
7	100	55.00	78,100.00
8	100	55.00	78,100.00
9	100	50.00	71,000.00
10	150	100.00	285,000.00
11	150	50.00	142,500.00
12	150	55.00	156,750.00
13	100	55.00	78,100.00
14	175	280.00	938,000.00
15	175	95.00	318,250.00
16	200	88.00	340,560.00
17	225	88.00	384,560.00
18	250	1015.00	4,953,200.00
19	100	200.00	284,000.00
20	100	200.00	284,000.00
		T O T A L =	9,241,120.00

LINK NO.	VOLUME OF EXCAVATION (CU.M.)	EXCAVATION COST
1	14.21	2,841.18
2	20.40	4,080.44
3	17.46	3,492.22
4	16.04	3,207.56
5	27.30	5,460.75
6	27.71	5,542.51
7	9.78	1,955.95
8	12.04	2,407.10
9	11.97	2,394.66
10	30.52	6,103.55
11	15.16	3,031.70
12	23.23	4,645.77
13	10.33	2,065.95
14	121.01	24,201.00
15	27.85	5,569.38
16	41.41	8,282.87
17	34.16	6,831.02
18	660.53	132,106.73
19	45.06	9,012.39
20	49.06	9,812.38
	1,215.23	243,045.11

APPENDIX F.

APPROXIMATE QUANTITIES AND COST ESTIMATES OF ALTERNATIVE SANITATION SYSTEMS

Table F.1 Ventilated Improved Pit (vip) latrine

Item	Description	Quantity	Unit	Rate	Amount ₦	K
A	Excavation of pit starting at formation level, maximum depth not exceeding 2m.	4.884	m^3	2.00	976	80
B	In-situ concrete (1:2:4/19mm agg.) in squat plate and beams.	0.240	m^3	85.00	2040	00
C	Fair finish shuttering to horizontal soffit of squat plate.	2.640	m^2	240	633	60
D	150 x 225 x 250mm block wall in cement mortar (1:4).	15.660	m^2	540	8456	40
E	6mm Φ mild steel bars in squat slab and beams.	24.900	m	80	1992	00
F	30 x 300 x 3600mm planks for roof.	7.200	m	70	504	00
G	Zinc roofing sheets and nails	5.750	m^2	350	2012	50
H	Flush door and frame	1	NO	1,200	1200	50
I	150mm PVC vent pipe, 2.8m long, with stainless steel screen cover at the top.	1	NO	2646	2646	00
				Total =	20,461	30

Table F.2 Ventilated Improved Double Pit (VIDP) latrine

Item	Description	Quantity	Unit	Rate	Amount N	K
A	Excavation of pit starting at formation level, maximum depth not exceeding 2m	10,380	m^3	200	2076	00
B	In-situ concrete (1:2:4/19mm agg.) in squat plate and beams.	0.780	m^3	8500	6630	00
C	Fair finish shuttering to horizontal soffit of squat plate	5,280	m^2	240	1267	20
D	150 x 225 x 450mm block wall in cement mortar (1:4).	20.020	m^2	540	10810	80
E	6mm Φ mild steel bars in squat slab and beams	52.800	m	80	4224	00
F	30 x 300 x 3600mm planks for roof	14.400	m	70	1008	00
G	Zinc roofing sheets and Nails	10.700	m^2	350	3745	00
H	Flush door and frame.	2	NO	1200	2400	00
I	150mmPVC vent pipe, 2.8m long, with stainless steel screen cover at the top.	2	NO	2646	5292	00
				Total =	37,453	00

Table F.3 Septic tank

Item	Description	Quantity	Unit	Rate	Amount N	K
A	Excavation of tank, starting at formation level, maximum depth not exceeding 2m.	8.584	m^3	200	1716	80
B	In-siṭu concrete (1:2:4/19mm agg.) in tank's floor, walls and roof.	1,202	m^3	8500	10217	00
C	6mm Φ mild steel bars in tank's slab.	27.300	m	80	2184	00
D	Fair finish shuttering to faces of concrete	15.480	m^2	240	3715	20
E	W.C. complete with accessories	1	NO	8500	8500	00
F	150mm Φ P.V.C. pipe	3.500	m	920	3220	00
			Total	=	29,553	00

Table F.4 Soak away pit

Item	Description	Quantity	Unit	Rate	Amount N	K
A	Excavation of pit, starting at formation level, maximum depth not exceeding 2m	36.000	m^3	200	7200	00
B	In-situ concrete (1:2:4/19mm agg.) in pit's cover.	1.089	m^3	8500	9256	50
C	150 x 225 x 450 block wall in cement mortar (1:4)	32.000	m^2	540	17280	00
D	6mm Φ mild steel bars in pit's cover	96.000	m	80	7680	00
			Total	=	41416	50

Table F.5 Sewerage and sewage treatment facility

F.5.1 Pipe network and man hole

Item	Description	Quantity	Unit	Rate	Amount ₦	K
A	Excavation of trench, starting at formation level, average depth not exceeding 2.5m	1215.23	m^3	200	243046	00
B	Ditto Manhole	20.00	m^3	200	4000	00
C	100mm Φ concrete pipe in trench, average depth not exceeding 2.5m	1065.00	m	1420	1512300	00
D	Ditto 125mm Φ	100.00	m	2100	2100	00
E	Ditto 150mm Φ	205.00	m	2850	584250	00
F	Ditto 175mm Φ	3375.00	m	3350	1256250	00
G	Ditto 200mm Φ	88.00	m	3870	340560	00
H	Ditto 225mm Φ	88.00	m	4370	384560	00
I	Ditto 250mm Φ	1015.00	m	4880	4953200	00
J	Concrete (1:2:4/19mm agg.) in manhole foundation and walls.	48.00	m^3	8500	408000	00
K	Cast iron frame and cover to manhole	8	NO	5000	40000	00
L	Earth back filling around excavation	300	m	100	30.000	00
			Total	=	9966166	00

F.5.2 In-house collectors

Item	Description	Quantity	Unit	Rate	Amount N	K
A	W. C. Complete with accessories	356	NO	8500	3026000	00
B	150mm Φ P.V.C pipe 3,500m.	356	NO	3220	1146320	00
			Total	=	4172320	00

F.5.3 Waste stabilization ponds

Item	Description	Quantity	Unit	Rate	Amount ₦	K
A	Lands for ponds	25000	m2	66.67	1666750	00
B	Earth work excavation	26631	m3	200	5326200	00
C	Compaction of pond's foundation by vibrating rollers	12200	m2	100	1220000	00
D	Compaction of slopes around the ponds	10,000	m2	100	1000000	00
E	Clay lining, average thickness not exceeding 150mm	20,000	m2	120	2400000	00
F	Grout riprap around the slope of the ponds, average thickness not exceeding 50mm.	2000	m2	9500	19000000	00
G	Screen, including excavation and concrete works.	1	NO	1300000	1300000	00
H	Automatic recording pershall flume	1	NO	50000	50000	00
I	250mm Φ PVC pipes	350	m	1840	644000	00
J	250mm Φ cast iron pipe stand and footings, max height not exceeding 2m	12	No	6000	72000	00
K	Sump well, including excavation and concrete works	1	NO	1300000	1300000	00
L	Scum guards for pipe inlets	3	NO	1000	3000	00
M	Excavation for inlet channels, starting from formation level maximum depth not exceeding 2m.	180	m3	200	36000	00
N	Leveling and compaction of the bottom of excavation to receive concrete.	120	m2	100	12000	00
0	Concrete (1:2:4/19mm agg.) in inlet channels.	12	m3	8500	102000	00
P	Road network, approximately 400m.	1	NO	3000000	3000000	00
Q	Fence, 150mm blocks, maximum height not exceeding 2.0m, total length 850m	1	NO	848000	848000	00
				Total =	37979950	00

F.5.4 Activated sludge treatment plant

Item	Description	Quantity	Unit	Rate	Amount ₦	K
A	Land for treatment plant	2500	m^2	66.67	166,675	00
B	Inlet channels, including excavation and concrete works	1	N0	1500.00	1500.00	00
C	Screen, including excavation and concrete works	1	N0	1300:000	1300.000	00
D	Automatic recording pershall flume	1	N0	50,000	50,000	00
E	Sump well, including excavation and concrete works	1	N0	1300.000	1300.000	00
F	Grit chamber including excavation, concrete works and accessories.	1	N0	2500.000	2500.000	00
G	Aeration tank, including excavation, concrete works and aerators	1	N0	10,000.00 0	10000.000	00
H	Primary and final settling tank, including excavation, concrete works and other accessories.	2	N0	8,000.000	16000.000	00
I	Sludge drying beds, including excavation, concrete works, and pipe work.	1	No	4,000.000	4,000.000	00
J	Laboratory and office, floor area $136m^2$ (12.6 x 10.8m)	1	N0	3,635,000	3,635,000	00
K	Car park, floor area $105m^2$ (21 x 5m)	1	N0	900,000	900,000	00
L	Fence, 150mm blocks, maximum height not exceeding 2.0m, total length 300m	1	N0	299,300	299,300	00
M	Main gate	1	N0	50,000	50,000	00
N	Landscaping	1	N0	300,000	300,000	00
				Total =	40,650,975	00

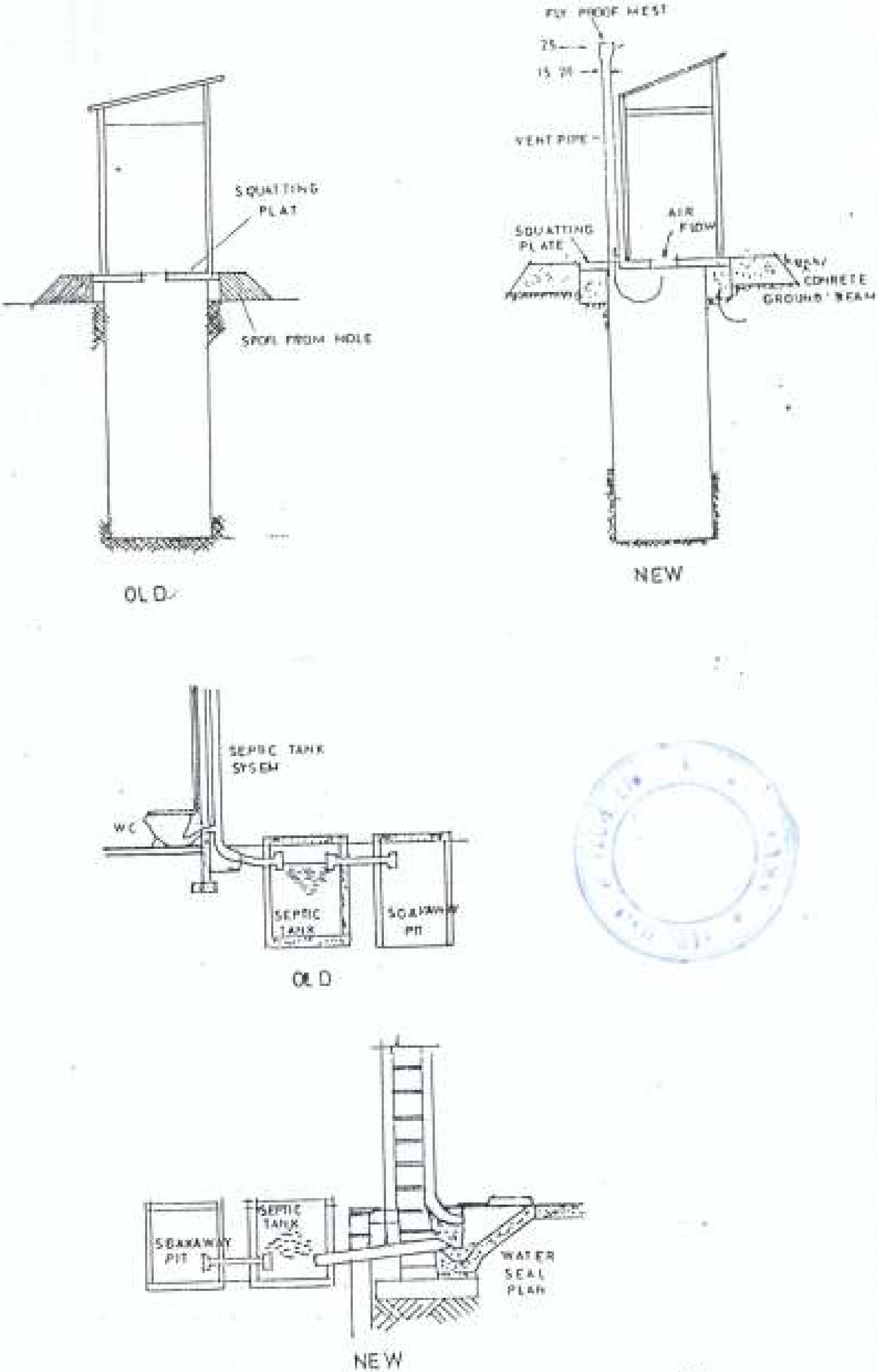


Fig F.1: VIP Septic Tank and Soakaway systems

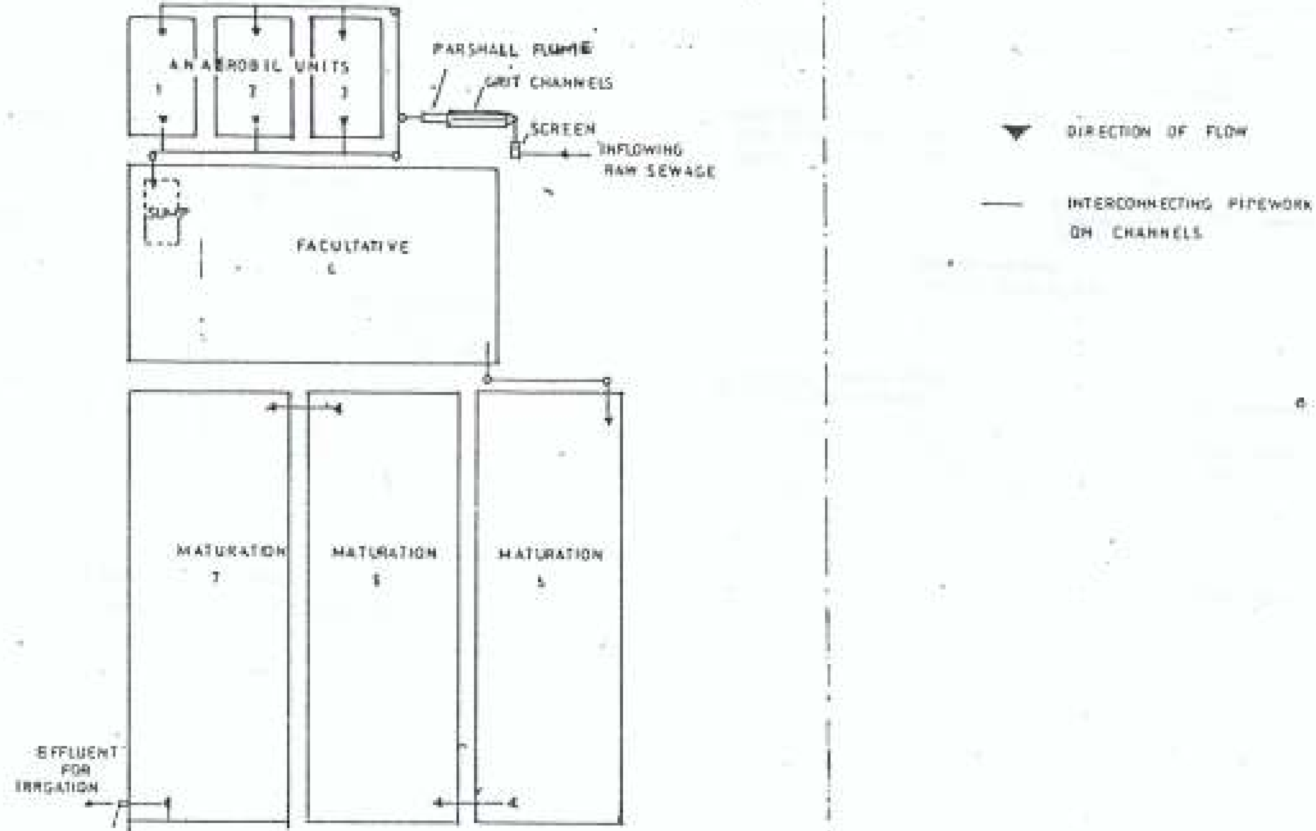


Fig F.2: STABILIZATION PONDS

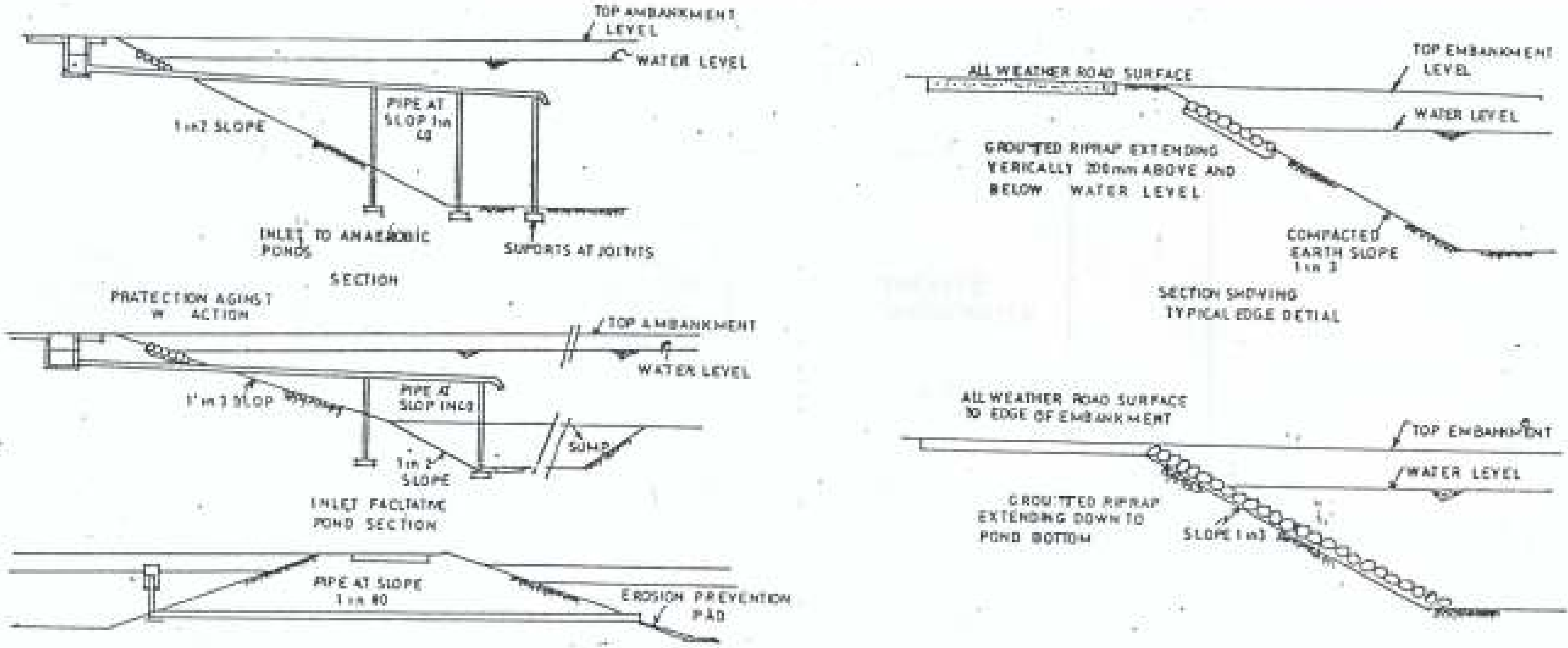


Fig F.3: DETAILS OF PONDS

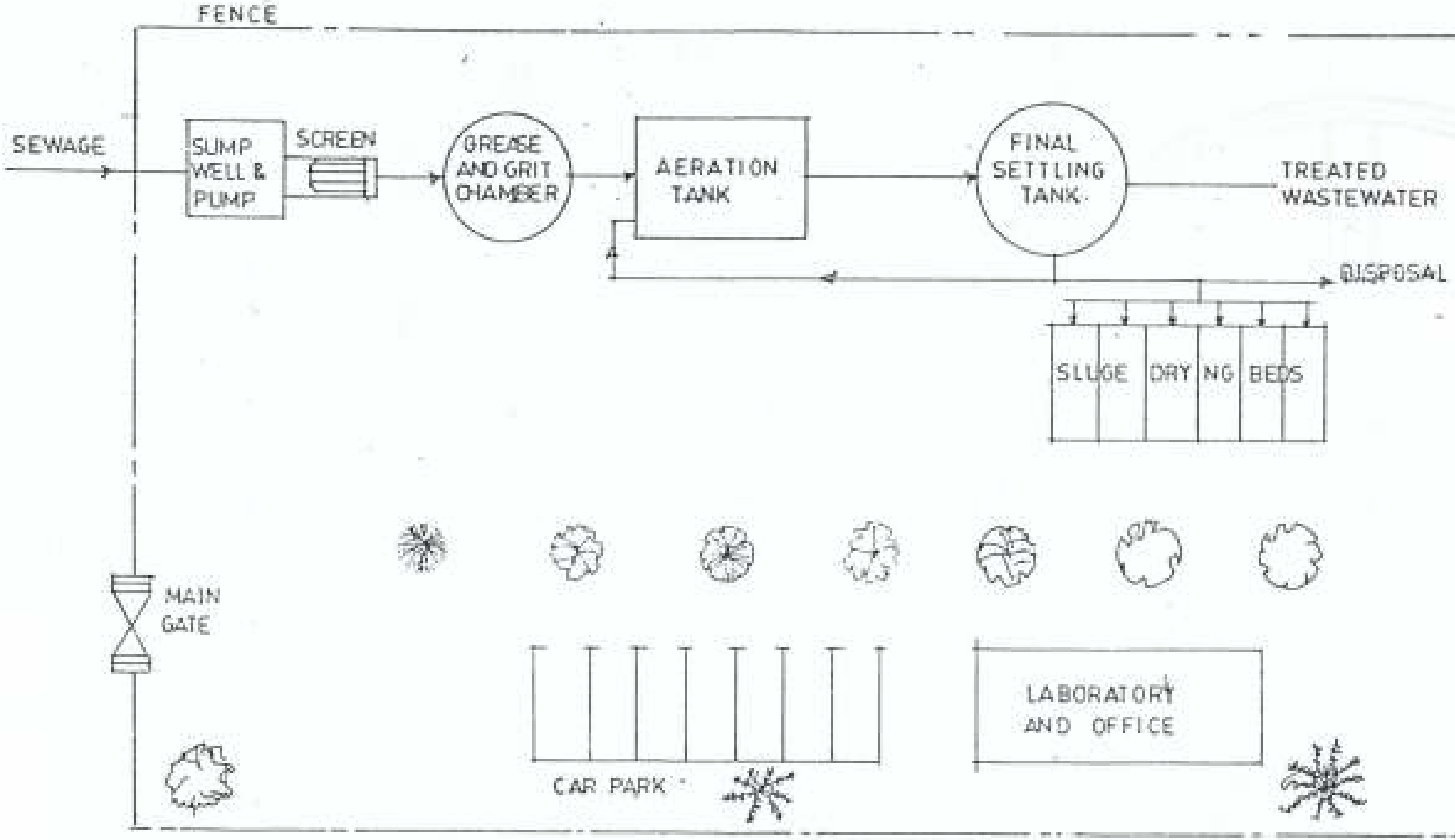


Fig F.4: GENERAL LAYOUT OF TREATMENT PLANT SITE FOR ACTIVATED SLUDGE PROCESS

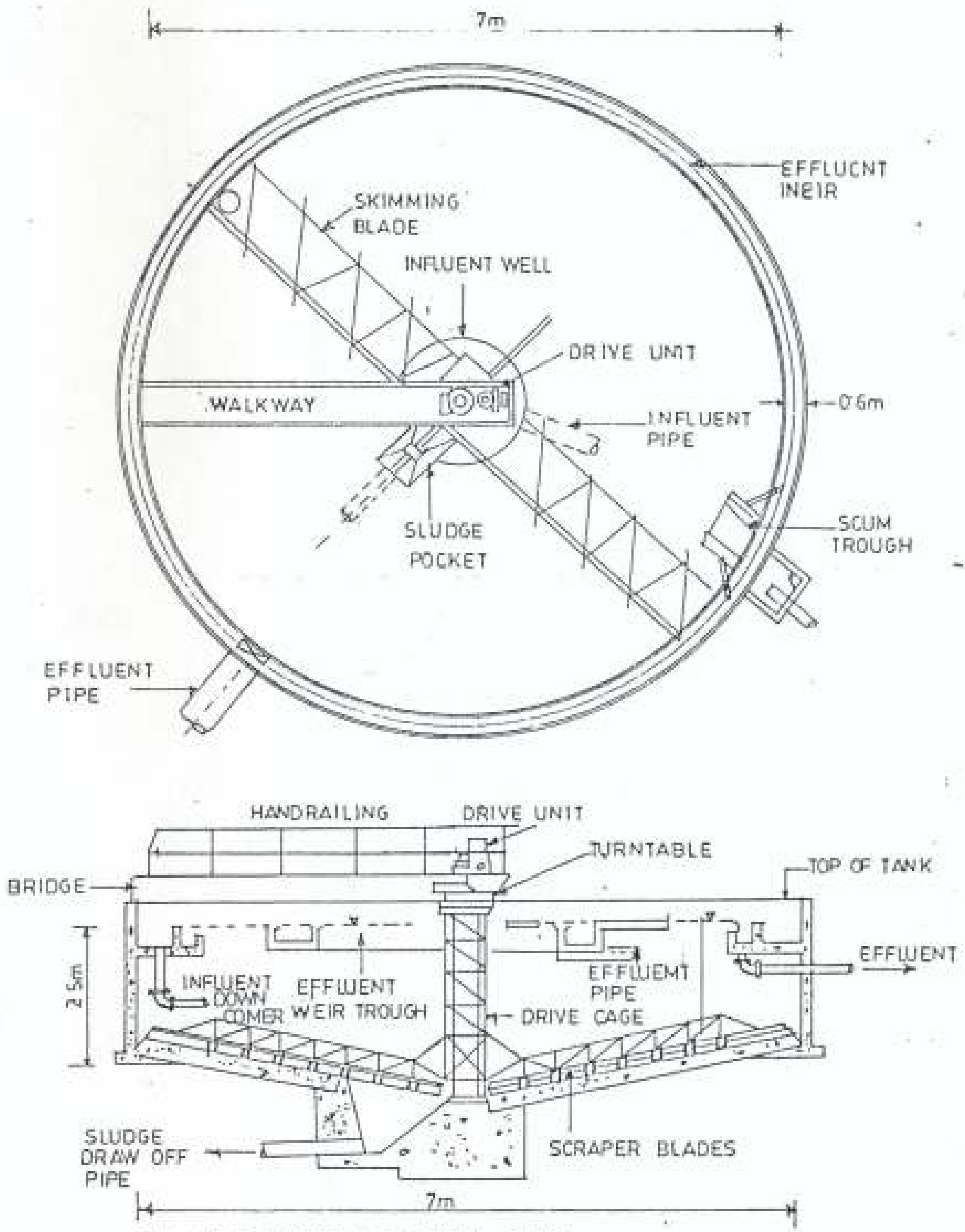


Fig.F.5:5 FINAL SETTLING TANK

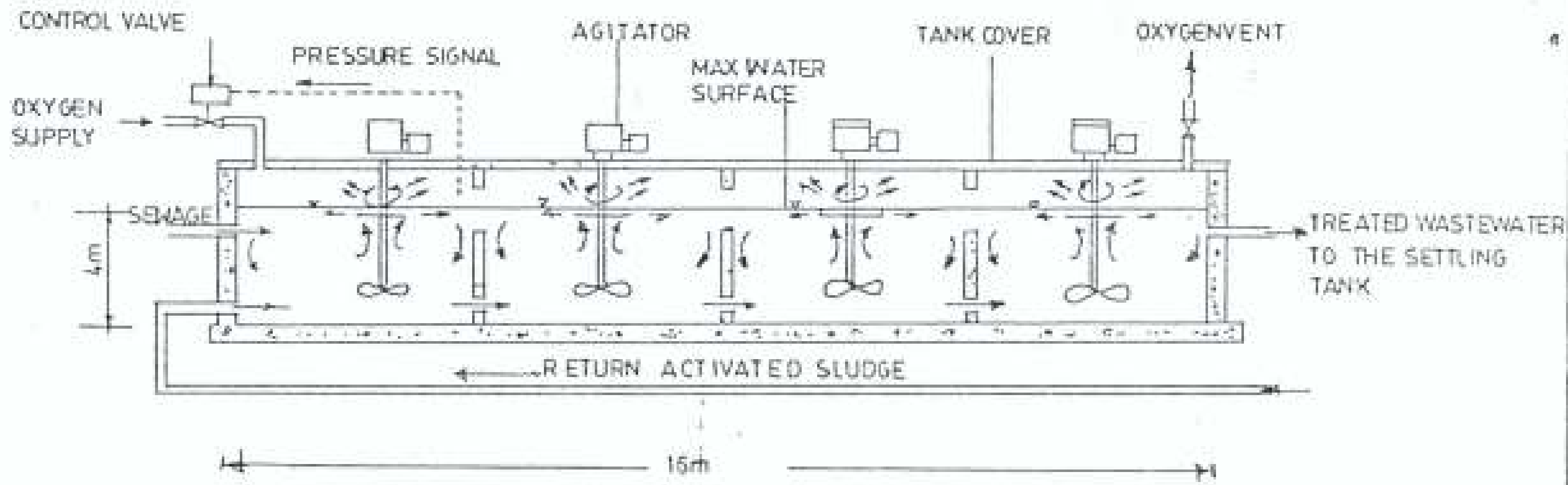


Fig F.6 ACTIVATED SLUDGE AERATION TANK

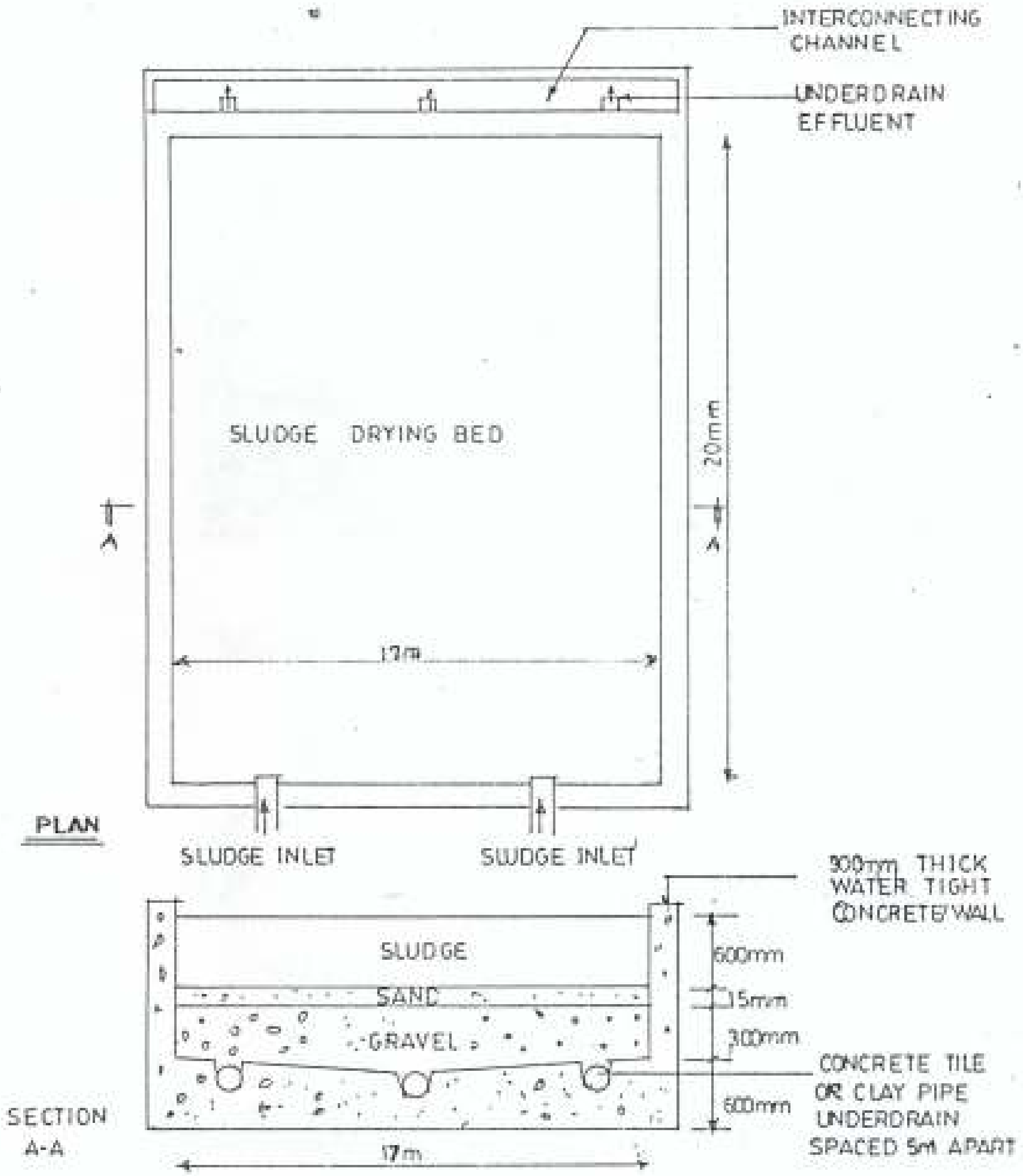


Fig F.7 SLUDGE DRYING BED

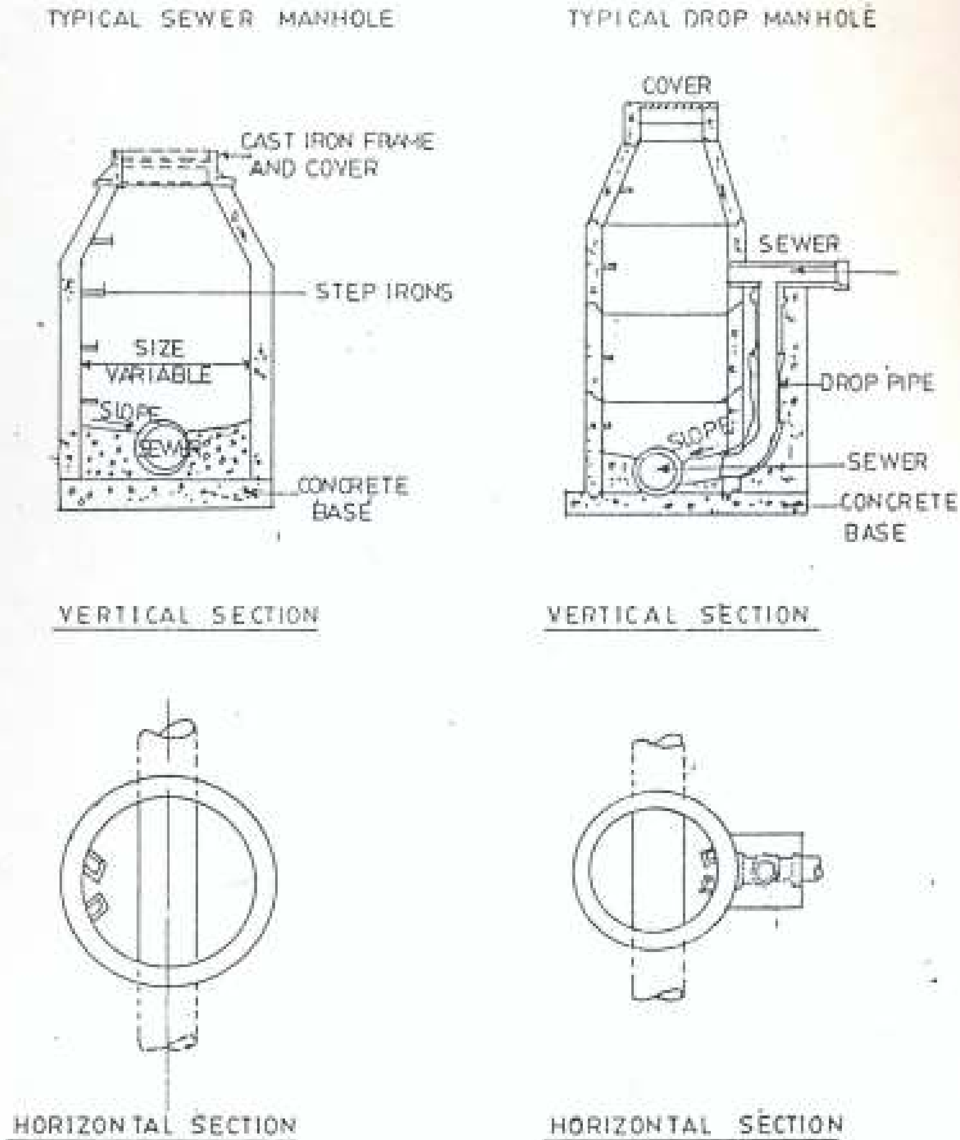


Fig F.8 **TYPICAL MANHOLE DETAIL**