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URBAN SANITATION PROBLEMS : A STUDY OF CALCUTTA

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A B S T R A C T

Urban health is primarily dependent on the provision of safe drinking water and sanitary disposal. These two services are complementary to each other. Traditionally, provision of filtered water has received priority in national as well as state-level planning, but, it cannot be overemphasized that to achieve the desired benefits from water supply proper sanitation is essential.

This paper gives an historical outline of the development of the sanitation system in Calcutta and various problems related to sanitation including technical and financial resource constraints. It also suggests some low-cost options available for providing sanitation in rural, semi-urban and urban areas. The choice of technology, however, will be guided by various factors like techno-economic feasibility, social-cultural aspects, climate, topography, hydrological conditions.

Further, it is observed that in every sanitation programme, apart from creation of infrastructure and other assets, the operation and maintenance aspects should be given due importance. Some degree of community participation is also desirable.

Views expressed are author's individual opinion.

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I. INTRODUCTION

Human excreta have had always been viewed as an obnoxious filth. Studies indicate that it is the source of more than fifty diseases having different degrees of virulence. Broad estimates suggest that 80 per cent sickness in India is caused by excreta-related diseases. Urban health is primarily dependent on the provision of safe drinking water and sanitary disposal of excreta. These two services are complementary to each other. Traditionally, provision of water supply has received priority in national planning as well as in state-level planning, but, it cannot be over-emphasized that to achieve the desired health benefits from water supply proper sanitation is essential. Many water supply schemes failed to bring about perceptible improvement in the health conditions of the receipient community in absence of complementary sanitation services. This has created a new awareness in the process of planning for urban infrastructural facilities. Over time, there has also been a radical change in the attitude towards water-borne sewerage system; the engineers and planners now readily recognize the need for examining various less costly alternatives of providing sanitation facilities.

A historical background

The sanitation system of Calcutta has gradually evolved with the growth of the city. The original English settlement in Calcutta was primarily confined to the vicinity of the old Fort William in the Tank Square (Dalhousie Square which is presently known as the Benoy Badal Dinesh Bag). The natives settled in the north and east of the Old Fort, by clearing jungles and filling up of marshes and swamps. No steps towards provision of sanitation in the native part of the town were taken by the East India Company from 1690 to 1765. The Company, however, cleared the jungles and dug surface drains and tanks.

Though the battle of Plassey in 1757 made the English the undisputed masters of Bengal, the sanitation system remained primitive for quite some time. The Hooghly river served as the grand outlet for human and other wastes besides receiving unclaimed and half-burnt bodies.

A description of the primitive arrangements of sanitation in Calcutta is available from the remarks of L'de Grandpre, an officer in the French Army. He wrote [1] :

> ''Most of the streets have a small canal on each side, serving as drain both of them and the houses, that could not otherwise be inhabited, on account of their dampness; for the Ganges, in the great swells, rises to the level of many of the streets, so that it is impossible to dig anywhere without finding water. These canals, which are a foot and half and in some places two feet wide, and not more than three deep, are reservoirs of filth; that emit the most unwholesome exhalations. Such animals as die in the streets or in the houses are thrown into them, and they lie there and putrify.''

The people of Calcutta lacked severely in the virtues of cleanliness and civic sense. The natives ''leave even their ordure at the door, or in the street, and though they complain of the stench, will not give themselves the trouble to remove it'', Grandpre added.

When the Justices of Peace took over the municipal administration of Calcutta in 1793, the sanitation system of the town was still its elementary state. The Europeans and Muslims buried their dead bodies in their own cemeteries and the Hindus burn their corpses at two ghats in North Calcutta. The nightsoil was removed from the private privies of the larger houses and European houses by methars (scavengers) privately employed for that purpose. There were Mehtar tatties (communal service latrines) maintained by Tollah Mehtars in different parts of the native town for the public. Excremental and other household filth were collected by Tollah Mehtars in convenient depots all over Calcutta before their final disposal by hired boats in the Hooghly beyond Budge Budge. Garbage was removed by bullock carts and deposited in low lying areas or used for filling marshes. The evidence taken by the Fever Hospital Committee shows that "the mehtar tatties were usually a grave nuisance, the excreta being sometimes thrown into any neighbouring tank or pool, or placed in a narrow trench or even scattered over the adjoining spot and left to remain there for ever to be dried by the sun. The nightsoil of private privies was frequently disposed of by the same insanitary methods.'' [2]

The Governor-Generals, in their morning ride and evening drives, used to pass through different parts of Calcutta everyday. For that reason attempts were made upto a point not to allow filth to accumulate and become a health hazard. Nevertheless, cholera, small pox and other epidemics occurred frequently. Lord Wellesley commented in his epoch-making Minute [3] on June 16, 1803 :

''... the construction of Public Drains and Water-Courses of the town is extremely defective. The Drains and Water-Courses in their present state neither answer the purpose of cleaning the Town, nor of discharging the annual inundations occasioned by the rise of the River, or by the excessive fall of rain during the South-West monsoon ... The health of the Town would certainly be improved by an improvement of the mode of draining and cleansing the Streets, Roads and Esplanade'.

''It is a primary duty of Government to provide the health, safety and convenience of the inhabitants of this great Town, by establishing a comprehensive system for the improvement of the Roads, Streets, Public Drains and Water-Courses and by fixing permanent rules for the construction and distribution of the Houses and Public Edifices, and for the regulation of Nuisances of every description .''

Lord Wellesley, therefore, appointed a Committee 'to suggest what description of Drains or Water-Courses may be best calculated, (1) to prevent the stagnation of rain water in Calcutta and the vicinity thereof, and (2) to cleanse the Town' and 'to consider and report, what establishment may be necessary for cleansing the Drains and Water-Courses, and for keeping them in constant repair'.

Lord Wellesley's Improvement Committee, latter called Lottery Committee, undertook extensive development work for Calcutta by construc ting arterial roads and filling up filthy tanks in the town and excavating new ones. The Committee, apart from opening arterial roads through heavily congested bustees and digging a number of tanks on their sides, constructed a number of deep surface drains. These drains became choked with filth and silt in course of time in the absence of sufficient slope or outlet for discharge.

The appointment of the Fever Hospital Committee in 1836 can be regarded as a landmark in the history of sanitation of Calcutta. The Committee was given full freedom 'to report with perfect confidence that there is no natural obstruction whatsoever to the establishment in the city of Calcutta of a system of Drainage and Cleansing, adequate to the rendering it dry and free from soil and impurities' [2].

One witness to the Committee spoke of the drains as 'merely irregular furrows in the soil without any brickwork ... continually left in a most filthy uncleaned state, emitting the most noisome effluvia, doubtless highly pernicious to the health of the inhabitants' [2]. Deep drains were covered with platform structures used as shops and little room was left for coolies to periodically clean them. The Hurkara wrote on November 18, 1841 :

'As the magistrates are active in setting on foot municipal improvements, there is no doubt but that the state of the drains, bazars and tatties will not be lost sight of by them. With the exception of a few favoured, because aristrocratic, localities, the drains of the larger portion of the town are never to be found in a cleanly condition' [4].

Calcutta, which had by then become the second city of the Empire, eventually experienced the introduction of a modern underground system of drainage and sewerage, the abolition of the service privies or tatties and systems of hygienic disposal of the dead. Lord Dalhousie favoured an underground water carriage system under which human excreta could be transmitted for ultimate disposal. In response the Justices of the Peace, who then looked after the municipal administration, appointed their Engineer-Secretary, William Clark to report upon a scheme for drainage and sewerage for Calcutta on the 12th September, 1855. William Clark submitted his plan [5] on the 28th December, that year, a very important document in the civic life of the city.

The plan had the following leading features :

(i) A constant outfall.

(ii) Sufficient inclination, or fall, to the sewers, to ensure their being kept clean of deposit from the ordinary sewage matters they are intended to convey.

(iii) The sewers should be laid at sufficient depth to afford facilities for the subsoil drainage of a naturally damp site.

(iv) The capacity of the sewers must be sufficient to convey away the waters of all ordinary storms.

(v) The scheme should be sufficiently comprehensive to meet not only the present requirements of the city, but should comprise such arrangements as will provide for those of its probable future limits.

(vi) The sewers should be covered, and all the inlets so guarded as to prevent the possibility of annoyance from the escape of bad smells, yet should be sufficiently ventilated to allow of ingress for the purpose of examination and for completing the connexion of the minor Drains therewith, in a substantial, proper and workmanlike manner'.

Clark's scheme, as finally approved by the Government on the 20th April 1859, was a combined system designed to carry off both rain or storm water, liquid drainage from houses and open drains and privy drainage; the drainage from the Hooghly to the Salt Lakes and the sewage required to be pumped. By 1875, in sixteen years, about 38 miles of brick sewers and 37 miles of stoneware pipe sewers were reported to have been constructed. As the execution of drainage works progressed, it was decided to connect private latrines with the sewers, but owing to deficiency in water supply, such connections had to be prohibited shortly after 1876.

By 1884, only some 2000 private privies had been connected. Even by 1896, the number of private connections was so small that the Corporation Health Officer criticised that little advantage had yet been derived from the sewerage system insofaras the connection of private latrines was concerned; there were still over 32,000 unconnected privies in the town and over 20,000 in the suburbs, requiring a staff of over 2000 mehtars to clean them. Thus the rate of connection of privies with the underground sewerage system was not very encouraging. In 1899 the Chairman acquired the power of requiring the owner or occupier of a house to connect his premises with a public sewer. At the end of the year 1913-14 there were 36,644 service privies or plan-closets and 21,785 connected privies or water closets in Calcutta. The nightsoil from the connected privies passed through the sewers to various pumping stations : the Palmer's Bridge Pumping Station which drained the town proper, the Manicktollah Pumping Station, serving the Added Area east of the town, and the Ballygunge Drainage Pumping Station, serving the Added Area south of the Town. The sewage was then raised and flowed by gravity to the Salt Lakes. The excreta collected by the <u>mehtars</u> from service privies was discharged into the sewers at certain depots, called <u>pail-depots</u>. Steps were taken to close the trenching grounds as the night soil was discharged into the sewers following the completion of drainage schemes in course of time.

Even in those old days some consideration was given for the construction of public latrines and urinals for public use. In 1884 there were 71 public latrines in the town, of which 36 were the property of the Corporation and 35 were privately owned and licensed under the Municipal Act. Some of the municipal latrines contained separate enclosures for females. In all the 'improved' <u>bustees</u> the owners of the land were required to construct latrines of approved type for the use of the <u>bustee</u> tenants. These semi-public latrines were like the municipal latrines, connected with the public sewers. Public urinals were first constructed in 1854 and by 1914 there were 164 public urinals in the town. With the passage of time more and more privies were connected with the sewerage system. In the unsewered areas, which covered the greater part of the town, service privies remained the principal mode of disposal of nightsoil.

Even by 1966 only 54 per cent of the Calcutta Corporation area was sewered. Besides Calcutta, only five other towns in the CMD had sewerage systems. Of these in four - Serampore, Chandernagore, Bhatpara and Titagarh - the system was no more than skeletal. The only other town which had a modern sewerage system designed to collect, treat and dispose of sewage was Kalyani. Thus, the vast majority of the people in the cities and towns of CMD had to depend on the conservancy system of night soil disposal; that is, of periodic collection of night soil from service privies by the Corporation or municipal trailers. These municipal towns outside Calcutta and Howrah contained more than 1,26,000 service privies, while in the city of Calcutta alone there were about 42,000 including 17,000 in the city's <u>bustees</u> [6]. Apart from service privies two other modes of disposal of human excreta were available : (i) pit privies in the non-municipal areas and (ii) septic tanks in newly built houses of relatively richer classes of people in areas where the sewerage system was non-existent.

Problems with sanitation as envisaged in the Basic Development Plan

Given the combined nature of the drainage and sewerage system, the problems of drainage and sewage disposal interlinked. It has been pointed out in the BDP [6], 'The extremely flat topography of the CMD, with its maximum elevation of about thirty feet above mean sea level, increases the difficulties of providing satisfactory sewerage and drainage even where 'high' is available. The area has little natural drainage. The numerous minor rivers and streams throughout the Metropolitan District are more often than not in an advanced state of deterioration through heavy silt deposition ... Especially during periods of concentrated heavy rainfall - and over 80 per cent of Calcutta's annual average of 64 inches of rain falls during the three and one-half months of monsoon - the effects of inadequate drainage become visible and real. Streets are quickly flooded, and water stands knee-deep, paralysing traffic and commerce, adding much to the miseries of life throughout the city, particularly in the mud huts of the bustees. The close relationship between drainage and public health becomes readily apparent as the frequent flooding increases disease and pollution through the spreading of faecal material in the roads and lanes and elsewhere when the city's combined drainage and sewerage systems become overloaded.'

The service privies always carry a high risk of health hazards. The earthenware bowls or buckets which receive the droppings of human excreta are usually fully exposed to flies and to human view and very often are overflowing with excreta due to inefficient and irregular cleaning by the municipal staff. The condition becomes worst during the monsoon floods when the contents of the service privies are carried freely throughout the bustees to infect and pollute the tanks in which people bathe and wash their utensils and clothes. In addition, waste water and urine from homes are discharged into the open surface drains throughout the Calcutta Metropolitan District. With very poor drainage, these drains act as open septic tanks offering fertile breeding grounds for disease.

The insanitary condition of the CMD, as noted by the BDP, encourages the spread of cholera and of all gastro-intestina diseases, and also of small pox and tuberculosis, both of which have a high incidence in the Metropolitan District. The BDP noted that in CMD, Cholera was endemic throughout the year, with peaks from March to June and, periodically, the disease broke out in epidemic form, as in the year 1958 when 4900 cases and 1765 deaths occurred in the Calcutta City alone.

Major recommendations of the BDP

The significance of improved water supply and sanitation in improving the health of the CMD was widely acknowledged in the BDP which also dealt with other aspects viz., housing, transportation, education, health and recreational facilities, bustee improvement, employment, etc., as being essential for an overall improvement of condition of living in CMD. As regards sanitation a major emphasis was given on upgrading the sewerage system in the perspective plan for the period 1966-86 as proposed in the BDP. The major recommendations are given as below :

(i) The planning programme for sewer facilities was treated in two parts : (a) a Master Plan layout of service zones for providing sewer facilities to all portions of the CMD, and (b) a first-phase programme which dealt with the sewer facilities then under construction or planned for construction, as well as additional items required to meet the other immediate needs of CMD.

(ii) Existing sewer systems within CMD were either combined (as in the Calcutta Corporation) or partially combined (as in Kalyani) in that individual conduits were provided with hydraulic capacity to accommodate both sewage and stormwater. Flows from street inlets, roof leaders, and the like, were connected to the same sewers as were the sanitary house connections. It was proposed that separate sanitary sewerage and drainage systems be constructed in urban areas which were then unsewered and were without sub-surface stormwater drainage systems.

(iii) Separation of the two systems had several advantage under the conditions prevailing in the CMD. Because the range between the minimum and the maximum flow was considerably less in a separate system it was possible to provide conduits which performed satisfactorily under all normal conditions. Given the prevailing topographic conditions in CMD, it was frequently found desirable to convey drainage and sewage to different outfall locations, e.g. it was intended that no discharge of sewage into the Hooghly River and its tributaries would be permitted without treatment, and also, if possible for sewage discharged into the Kulti River. Moreover, because of the heavy expenditures called for and the limited availability of economic resources, it was necessary to provide a substantial degree of public health protection at a minimum cost. It was felt that this objective could be best achieved by constructing sanitary sewers at an early date and generally allocating a lower priority to drainage while combined systems did not permit such flexibility of scheduling. Partially combined systems, were also not recommended, as these would be readily overloaded during storm periods and would discharge sewage into public streets through back-flows at street inlets, manholes and other outlets. However economic considerations made it necessary for BDP to retain the existing combined system serving the Calcutta Corporation area.

(iv) For design purposes the quantity of sewage generated by residential areas has been estimated to be 80 per cent of the established per capita water supply allowances. Since the industrial peak and the domestic peak were not likely to coincide, the flows used as a base for design were therefore the peak domestic flows plus the average industrial flows.

(v) It was felt that the public sewer system should be capable of absorbing all liquid industrial waste which would otherwise create a health hazard or public nuisance. Certain types of industrial wastes would require pre-treatment prior to their being discharged into the public sewers, in order to provide proper protection to the system. Suitable control ordinance was expected to be worked out for this purpose.

(vi) Sewage effluent from a substantial portion of the CMD area would be discharged into the Hooghly River or its tributaries after suitable treatment, the type and degree of which would be subjected to further study. Except for the planned discharge of highly diluted sewage and stormwater flows for the relief of the combined Calcutta system during periods of heavy rainfall, sewage from areas along the east bank - approximately between Tolly's Nullah and Kamarhati - was to be discharged into the drainage systems flowing east, to final discharge in the Kulti River. Since Hooghly River was used as the main supply source for drinking water, something more than primary treatment of the discharges into the river was considered for long-range planning. In addition, secondary treatment was considered necessary for effluent discharges into drainage channels regularly in use by a large number of people. BDP found no compelling reason for treatment, in the near future, of sewage from Calcutta and adjacent areas which would

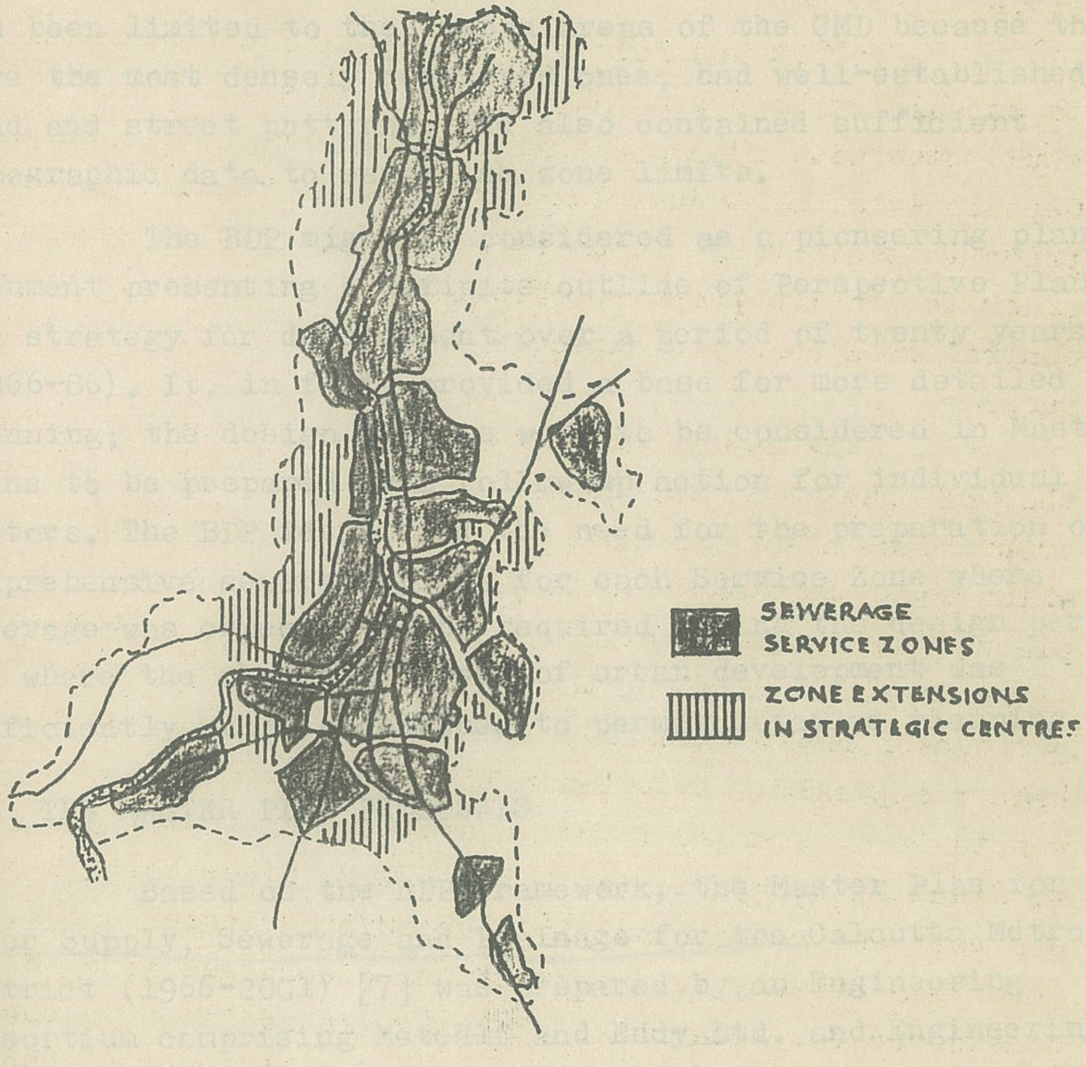

FIG. 1. SEWERAGE SERVICE ZONES AS RECOMMENDED IN BDP (6)

use the existing Calcutta Corporation outfall system, though the Master Plan for water supply, drainage and sewerage was expected to provide for appropriate plant sites, if and when such treatment become necessary.

(vii) The CMD area was divided into 19 Sewerage Service Zones as shown in Figure 1. Delineation of the Service Zones had been limited to the urban areas of the CMD because these were the most densely developed ones, had well-established road and street patterns, and also contained sufficient topographic data to establish zone limits.

The BDP might be considered as a pioneering planning document presenting a definite outline of Perspective Plan and strategy for development over a period of twenty years (1966-86). It, in fact, provided a base for more detailed planning; the design aspects were to be considered in Master Plans to be prepared as a follow-up action for individual sectors. The BDP identified the need for the preparation of comprehensive sewerage plans for each Service Zone where sewerage was expected to be required during the design period and where the physical layout of urban development was sufficiently well established to permit detailed planning.

II. THE MASTER PLAN PROPOSALS

Based on the BDP framework, the Master Plan for Water Supply, Sewerage and Drainage for the Calcutta Metropolitan District (1966-2001) [7] was prepared by an Engineering Consortium comprising Metcalf and Eddy Ltd. and Engineering Science Inc., two USA based consulting engineering firms. The plan envisaged the provision of sewerage facilities throughout the Metropolitan District in two stages. In the first stage the plan concentrated on the more thickly populated and highly developed areas with well established road and street patterns and for which sufficient topographical data were available. In the second stage new areas would be added to the original zones as their urban development would warrant. According to the Master Plan, the entire CMD was divided into 18 sewerage zones as given below along with a category of future zones in the extreme south which at the time of preparation of the plan were insufficiently developed for delineation of sewerage areas.

1. Calcutta
2. Tollygunge
3. Maniktala
4. Northern Salt Lake
5. Howrah
6. Konnagar
7. Khardah
8. Chandernagore
9. Garden Reach
10. Dum Dum
11. Barasat
12. Barrackpore
13. Bhatpara
14. Kalyani
15. Bansberia
16. Serampore
17. Budge Budge
18. Rajpur

Out of the above 18 zones early action was recommended for the first 10 zones. These 10 zones contained more than 75 per cent of the CMD population at the time of plan preparation and nearly 70 per cent of the population estimated for the year 2001.

Comprehensive proposals were made for strengthening the existing combined sewerage system of Calcutta, and for providing sewers in unsewered pockets such as Maniktala, Salt Lake and Tollygunge. A separate sewerage system was proposed for the whole of Howrah Zone with gradual build up of treatment facilities. In addition priorities were assigned to Dum Dum, Chandernagore, Khardah, Konnagar and Garden Reach area where the emphasis was more on laying of trunk sewers with branches and laterals at a later date.

The Master Plan solution to the Calcutta City sewerage problem rested upon the renovation and completion of an existing sewerage system coupled with a division of most storm-waters away from that system. After implementation of proposed improvements the renovated system should function effectively in normal weather condition. As has been stated, the proposed measures for dealing with storm waters do not guarantee a total cessation of all flooding in the worst monsoon conditions, especially at high tides. But there should no longer occur what has always been the most serious menace namely, overloaded sewers discharging sewage into the flood-waters and creating the gravest health hazards due to insanitary conditions.

The Tollygunge zone was indentified as a rapidly developing residential suburb of quality housing, institutional buildings and open spaces. It also contained some unplanned and overcrowded pockets of low quality housing. There were considerable underdeveloped areas where industrial expansion was foreseen. Sanitation condition was poor with serious health hazards deriving from polluted open drainage ditches. As a provisional measure, the situation was accepted that a certain volume of little-treated (i.e. brief detention in basins only) sewage would be carried to the main collecting point at Bantala in two open-channels passing through underdeveloped areas. But as these areas become populated the channels will be first fenced off, and later closed in.

In the Maniktala zone some work was already in progress based on a Calcutta Improvement Trust plan for a 'Combined' system drawn up in 1956. This was a low-lying area in which considerable urban development was taking place. Flooding was frequent and severe. An area of salt marshes which used to receive excess waste-waters was being filled in for building purposes, thus calling for urgent action. Since the 1956 plan was found to be inadequate in consideration of the future growth the Master Plan recommendation was for some modification and expansion of the 1956 plan and its early implementation as a system for sewerage only. A number of open channels would be eliminated in the process.

The Northern Salt Lake zone was largely uninhabited in 1961 and partly water logged. Reclamation was in progress with a view to building up Salt Lake Township based on an integrated Town Plan previously prepared by a Yugoslav Consultant group. Certain alterations in the proposals for sewerage and drainage were suggested, all of them designed to take advantage of spare capacities available in adjacent zones in the Master Plan, and thereby to make economies in respect of pumping stations and treatment plants.

In 1966, Howrah has no underground municipal sewers and relied on manual collection, trenching, etc., for the disposal of human wastes, while rain- and flood-waters were carried to various discharge points by open drains. The Howrah Improvement Trust in 1962 had prepared a comprehensive plan of a partly combined type which was capable of dealing with a certain promotion of storm-waters. This plan, though otherwise sound and well engineered, required considerable modification in view of the necessary extension of the municipal area to include certain adjacent developing pockets such as Bally and of the decision to apply the principle of separate sewerage and drainage systems. The necessary adjustments were made and a separate sewerage system was designed providing adequate facilities for the whole zone. It was proposed to make full use of the existing Howrah Drainage Canal which encircled the zone to the west; but as this canal ultimately leads to the Hooghly River, treatment plants were considered necessary to avoid pollution of down-river waters. The Master Plan recommended gradual build-up of treatment facilities keeping pace with the development of the sewerage system and culminating in full two-stage treatment plus chlorination of effluents, which would continue to include a high proportion of industrial wastes.

The Master Plan recommended sewerage network and full treatment of wastes in Konnagar zone, since the wastes must be discharged into the Hooghly up-river.

According to the Master Plan the Khardah zone required a complete sewerage system in place of existing open drains. It was recommended that the existing treatment plant, which was in poor condition, be taken out of service, since effluents are carried eastwards towards the Kulti River. As in other cases, they considered this situation acceptable while higher priority tasks awaited attention. The necessity of some additional pumping facilities was, however, identified and recommended.

The situation of the Chandernagore zone was approximately the same as the above mentioned two zones, except that no heavy population growth or industrial expansion was foreseen. Since this zone is only 8 km. up river from Palta, the main raw-water intake point for Calcutta city and neighbouring areas, the Master Plan recommended for complete treatment of sewage effluents before discharge into the Hooghly River.

Heavy population expansion was anticipated in years ahead in the Garden Reach zone together with heavy industrial development. The Master Plan proposals were accordingly elaborate, but it was recommended that implementation should be done gradually to keep pace with urban development. Thus, the sewerage system had high priority in built-up areas, but the treatment plant could for some time be of a primary type provided the effluent was chlorinated before discharge into the Hooghly River. It was, however, stressed that effluent discharges into the river should receive complete treatment and disinfection before the Garden Reach Water Works and Howrah Water Works (across the river) start functioning.

Lying immediately to the north of Calcutta the Dum Dum zone was very convenient for receiving the city's overflow of population. Moreover, there was rapid urban development under the additional stimulus of the international airport on the eastern border of the zone and of two newly built super highways. Sewerage systems to service two highly populated sectors were under construction. There was also a recently completed drainage canal traversing the whole zone and fed by networks of open storm water channels. The Master Plan envisaged a phased extension of these facilities as a priority undertaking. The whole zone was low-lying and disposal of wastes and storm waters was therefore tobe eastwards towards the Kulti River.

The other zones were at that time less developed and sparsely populated. **Wherever** urban development was impending the Master Plan made provision for eventual extension of the sewerage or drainage systems. Elsewhere action was to be taken as situation demand within the overall perspective of the Master Plan. It was noted that in sparsely populated areas, primitive methods of sanitation were not necessarily a danger to health, while drainage, even under the exceptional conditions obtaining in the monsoon season, only became a problem where roofs and pavements covered a high proportion of the ground and thus producing a large volume of run-off water.

The Master Plan solutions to the problem of sanitation in the Calcutta city and adjoining areas chiefly centred around the provision of underground sewerage system with full treatment of wastes in the ultimate phase. Thus, the recommendations were biased towards the practices prevailing in the developed countries particularly in the North American cities. It could see only two alternatives (i) continuation of the primitive methods of sanitation till urban development warranted sewerage system and (ii) the provision of sewerage system with gradual build up of treatment facilities in the areas already developed or where development was impending in the near future. However, the BDP or Master Plan approach failed to appreciate fully the various resource contraints, especially of the financial resources, that might come in the way of the implementation of the recommendations within a specific time frame. Nor did they make any attempt to consider alternative methods of sanitation and suggest low-cost, more economically viable solutions.

Alternative sanitation options

A number of such low-cost options are available for providing sanitation in rural, semi-urban and urban areas. As a matter of fact, some of these techniques have been in use in this country for many years and can easily be adopted with suitable modifications for wide-scale applications. The choice of technology will be guided by various parameters viz., techno-economic feasibility, socio-cultural aspects, climate, topography, hydrogeological conditions and the like. The purpose of this section is to suggest that, although waterborne sanitation remains the ultimate solution for many, it may not be immediately realizable. In that case, other options may offer the possibility of step by step improvement.

Some general sanitation options are briefly discussed below for an understanding of the general readers. (Figures for various sanitation technologies are presented in Appendix I).

(i) Pit latrines

The pit latrine can be regarded as the users' earliest attempt to enhance the convenience of defecation by providing privacy not available in the field. This is a very simple type of latrine built by digging a pit into the ground into which excreta fall and covering the pit by a squatting slab on the top. Surrounding the squatting slab is a superstructure to ensure privacy. When the pit is about three-fourth full, the superstructure and squatting plate are removed and the pit is filled up with earth excavated from a new pit dug nearby. The pit latrines are characterized by odour and insect (flies and mosquitoes) problems. These problems are, however, taken care of in VIP (Ventilated, Improved Pit) latrines.

In a VIP latrine, the pit is provided with a vent pipe external to the superstructure. For maximum odour control, the vent pipe should be at least 150 mm in diameter, painted black, and located on that side of the latrine which receives maximum sunlight. The solar heat will heat up the air inside the vent pipe and create an updraft ensuring adequate ventilation of the latrine. If the vent pipe allows enough light into the pit, and if the superstructure is fairly dark, flies will have a tendency to escape through the vent rather than back into the superstructure. Provision of a gauze screen at the top of the vent pipe will prevent flies from escaping through that route and thus minimize the health hazard from the insects.

A modified design of the pit latrine is the ROEC (Reed Odurless Earth Closet) in which the pit is completely separated from the superstructure and connected to the squatting plate by a curved chute. For trouble-free operation it is necessary to keep the chute clean by means of a long-handled brush or a small amount of water. As in the VIP, a vent pipe is provided to minimize fly and odour nuisance.

Still another modification to VIP latrines is VIDP (Ventilated Improved Double-Pit) latrines in which under the same superstructure two pits are dug side by side. The two pits are used alternatively, with the squatting plate being moved from the full to the empty pit as necessary. Under anaerobic conditions, the contents of a pit become practically free from pathogenic organisms after remaining buried for atleast 12 months after which the pit may be emptied manually without any fear of health hazards, and put back into use. Thus with a combination of two pits a VIDP latrine can be used indefinitely.

Pit latrines may pose problems in areas that are prone to flooding or where ground water table is high and ground water is used for drinking purposes. In such areas, the latrines should be raised partly above the ground and they should be atleast 30 metres away from a well or other drinking water source; the distance may need to be increased if the soil is fissured. In sandy soil it may be necessary to line the pits to prevent collapse and in rocky areas it may be difficult to dig. Apart from these limitations, the pit latrines are technically good, their costs are low and their potential for health benefits is high. They are most suitable for low and medium density areas (300 to 600 persons per hectare) and in view of their low costs they may provide affordable sanitation services to the majority of people in rural and urban fringe areas. The other advantage is that the pit latrines can be easily upgraded to pour flush (PF) toilets described in a latter part of this chapter.

(ii) Composting latrines

Functionally, compost toilets are almost similar to pit latrines except that destruction of pathogens is accelerated by composting with addition of waste organic matters rich in carbon, viz., garbage, vegitable leaves, grass, sawdust, etc. Such latrines may be of two types - continuous and batch. In a batch system, two latrines are constructed side by side, each having a pit or vault below the closet.

The pit constructed of masonry or concrete, is provided with a removable cover to permit periodical addition of waste organic materials as mentioned above. By proper control of C/N (Carbon : Nitogen) ratio (20-30) and moisture content (20 - 60 per cent) if the temperature in the composting chamber is raised by bacterial activity during anaerobic digestion to above 60°C, all pathogens in the excreta will be destroyed. A detention time of three months will generally produce a product free from all pathogenic **organisms** , except, perhaps, the more persistent helminthic ova, The composted humus can be used as soil conditioner and fertilizer if there is no taboo strongly objecting to the re-use of excretal matters in agriculture.

The continuous composting toilets are developed from a Swedish design known as 'Multrums'. In view of the fact that in such composters there is always a risk of **fresh** excreta occasionally sliding into the humus pile and thus limiting the compost's potential for safe re-use they should not be recommended for use in either the urban or the rural **topics.**

(iii) <u>Bucket latrines</u>

The bucket latrines, as already described, are generally very unhygienic and offensive. The act of emptying the buckets into the wheel barrow or cart typically involves spillage and the area becomes malodourous and a centre for fly breeding and cockroaches. The same thing happens at the depot where the carts are emptied for transportation in trucks or for treatment or composting. For a proper operation a bucket system needs close supervision and tight institutional controls which are often lacking in the municipalities of the developing countries.

(iv) Vault latrines

The problem of odour, uncleanliness, and unpleasantness associated with bucket latrines are practically non-existent in the case of vault latrines. In this type of latrine the excreta falls directly into a vault (an enclosed chamber) which is cleaned periodically (every 2-4 weeks) by pumping out the contents by vacuum trucks. This system, however, requires a very efficient central organization capable of dealing with the financial and organisational problems associated with running a fleet of vacuum trucks. Thus, it is only suitable for a town or city with an efficient and established municipal administration. The vault latrines can be used to upgrade conditions in existing built-up areas where the construction of underground sewers would not be possible.

(v) Aqua-privies

An aqua-privy consists of a squatting plate directly above a water-filled tank that discharges its effluent into an adjacent soakaway. The squatting plate is fitted with a tube or chute which should remain submerged into the water in the tank to form a simple water seal which prevents odour and insect nuisance. The tank allows the solid material to settle and form a 'sludge' to be digested **anaerobically at the bottom**, while the liquid effluent flows out through an outlet pipe. In order to maintain the water seal two things are important. First, the tank must be watertight and second, the user must flush sufficient water into the tank to make up the water loss due to evaporation. Desludging of the tank is carried out when the tank is about two-thirds full, usually at 2 to 3 years' interval. The effluent from the aqua-privy may also be fed into a sewerage system.

(vi) Pour-flush latrines

There are two basic types of pour-flush latrines. The first is a simple modification of the ordinary pit latrine in which the squatting plate is provided with a 25 mm water seal, other features remaining unaltered. About 1-2 litres of water (even sullage water can be used) are poured in by hand for flushing the excreta into the pit. Where anal cleansing by water is a practice, the water used for anal cleansing may also serve the purpose of flushing. The second type of pour-flush latrine may have the pit constructed away from the closet which is connected with the pit by a 100 mm diameter communicating pipe. Due to presence of the water-seal in the PF-bowl this type of toilet is free from odour and fly nuisance and can therefore be located inside the premises, especially when the toilet fixture is displaced from the pit. In the case of single pit PF latrines, when the pit is full, a new pit is dug and the latrine is connected to it. Alternatively, the PF latrines may be constructed with two leaching pits from the very beginning, keeping a minimum distance between the two pits at least equal to the effective depth of the pits. In case of any space constraints, as may be encountered in urban areas, the pits may be constructed side by side with an impervious barrier between the two. When there are two pits, one pit is put to use and the other pit remains empty. In course of time when the first pit is filled up, it is sealed and the latrine is connected to the second pit. When the filled up pit is left for about two years, the contents turn into a rich organic humus which is quite safe for handling. After the maturation period the pit may be emptied any time and the contents may be used as manure. It is then ready to be put back into use when the second pit is filled up. Thus, using the two pits alternatively, the two-pit pour-flush latrine can be used indefinitely.

Since the toilet can be located inside the house in the case of pour-flush latrines, they are more readily acceptable by the users from the aesthetic and psychological points of view. Moreover, as water use increases, the pit(s) can be fitted into an outlet that connects to a soakaway or a small-bore sewer system. The simple technical design, users convenience, low cost and high potential for upgrading of pour-flush toilets make them an attractive solution to the sanitation problems in many areas.

(vii) Septic tanks

The septic tank, which has found very wide application as individual household sanitation system in various parts of the world, consists of a compartmentalised rectangular chamber or vault within which settlement and digestion of solids take place. All of the household wastewater often goes into the tank in addition to the excreta and flushing water. The toilet connected to the septic tank may be cistern-flushed or pour-flushed. During the 1 to 3 days of hydraulic retention time in the tank, the solids settle to the bottom where they are digested anaerobically. The accumulated sludge requires periodical cleaning at an interval of 3 to 5 years. The effluent of septic tank is generally discharged into soakaway pits or disposed of in subsurface drainfields. So sufficient land with permeable soil is necessary for scientific effluent disposal. In impermeable soils either evapotranspiration beds or upflow filters can be used. An important modification, aimed at improved performance of the septic tank, is the provision of three compartments in place of the usual two compartments. In such septic tanks, excreta is discharged into the first compartment and sullage (wastewater from kitchen and bathroom) into the second, with the effluent discharged from the third. This arrangement improves the settling efficiency of wastes along with better separation and inactivation of pathogens. In addition, the effluent carries less of suspended solids, making it amenable for better soil absorption and permits effluent's limited re-use. In a situation where a conventional sewerage system cannot be built in view of financial constraints, septic tanks offer an acceptable sanitation option providing the disposal of effluent from the tanks is possible in a sanitary manner. It is worth pointing out here that the disposal of septic tank effluent in open surface drains cannot be regarded as a satisfactory method for reasons explained later on.

(viii) Conventional sewerage system

In developed countries the standard solution for the sanitary disposal of human excreta has been the provision of water-borne sewerage system. The conventional sewerage system consists of a cistern flush toilet connected to a network of sewers laid underground, which collect the transport sewage and sullage to a treatment plant or any other disposal facility. The cistern-flush toilet is a water-seal squatting place (Indian W.C.) or pedestal unit (European Commode) from which excreta are flushed away by 6-20 litres of water stored in an automatically refilling cistern connected to the household water supply. Sanitary sewers are generally constructed of well burnt bricks masonry, precast concrete pipes and stoneware pipes. Now-a-days asbestos cement pipes, polyvinyl chloride (PVC) pipes and high density polyethylene pipes are also used for sanitary sewers. The sewers are normally laid with a steep slope to ensure a self-cleansing velocity of 1 metre per second in order to avoid chokages. The principal advantage of the conventional sewerage system is the high degree of users' convenience, but it has also many disadvantages. The principal disadvantages include the requirement of a large volume of water, high cost of construction, difficulty in excavation in densely populated areas or in poor ground conditions, difficulty in laying sewers in fairly straight lines through areas of unplanned growth without susbstantial demolition of existing housing, corrosion of sewers especially in hot climates and difficulty in getting existing households connected to sewers immediately after their construction inviting problems in maintenance of sewers due to unnecessary blockages owing to underutilization of capacities. Another serious problem associated with the conventional sewerage system is the environmental hazard created by point discharge of such large volumes of wastewater which calls for elaborate and expensive treatment methods to make the effluent suitable for safe discharge to the water bodies.

(ix) Small-bore shallow sewerage system

The relatively recent development in sanitation alternatives is the provision of small-bore shallow sewerage system. In such a system sewers are designed to accept all household wastewater sewage containing excreta and toilet flush water as well as sullage in their fresh state, for off-site tr treatment and disposal. The sewers consist of a network of small diameter (100 mm in place of 225 mm diameter used in conventional system) pipes laid at flat gradients (1 in 167 in place of 1 in 90 used in conventional system) in locations away from heavy imposed loads of vehicular traffic, usually in the backyards or narrow back alleys. This will allow shorter overall pipe lengths to be laid in shallow trenches with only 0.3 m earth cover in place of usual 1 m cover to the pipes where there is vehicular traffic load. The sizes of inspection chambers provided for the facilities of house connections and sewer maintenance are also smaller than the conventional ones. The sewers may also be laid under footpaths immediately adjoining to property boundaries and when they are to cross streets suitable protective covers (suitably designed concrete collars) around the pipes may be provided. There may be three options for disposal of wastewater coming out of the small-bore shallow sewers. First, they may be connected to conventional street sewers, if any are existing in the area. Second, the wastewater may be discharged into a communal septic tank and thence, by a small-bore sewer, to waste-stabilization ponds or other treatment process. Third, the wastewater may be directly discharged into ponds. The septic advantage of small-bore shallow sewers is that they do not require as much volume of water as is required for conventional water-borne sewerage system. These sewers, in fact, rely on the high frequency with which wastewaters pass through the system and the densely populated areas offer ample opportunity for this in view of a large number of houses being connected to the system. The solids in the wastewater are flushed along the sewers by successive waves of waste water. If any solids settle out on the sewer invert, wastewater builds up behind the deposit until the pressure is great enough to get it moving again. To generate successive waves of wastewater it is important that the designed number of house connections are ensured within the shortest possible time after the construction of sewers. The small-bore shallow sewers thus fulfils the aspiration of a sewerage system at a low cost even for low-income and densely populated areas, for example, in urban slums. Of course, one has to bear in mind that this system depends on off-site treatment and disposal.

The engineering designs of the various on-site and off site sanitation methods are well established and a large amount of literature exists on them [8, 9, 10 and 11].

Implementation of the Master Plan Proposals

There was no concerted effort in the field of sewerage and sanitation improvement works until 1970, when Calcutta Metropolitan Development Authority was established.

The programmes initiated by the CMDA have been continued in IDA-I, IDA-II and CUDP-III programmes and involve a total investment of Rs. 1117.8 millions in Sewerage and Drainage Sector.

The BDP recommended a sanitary sewer system including necessary sewers and appurtenances and conversion of service privies into sanitary privies as a part of the <u>bustee</u> improvement programme.

In the field of environmental hygiene programme of CMDA the major emphasis has been put on the replacement of service latrines with sanitary latrines. At the beginning of the programme it was estimated that there were about 1,50,000 dry latrines in the CMD. A sizeable number of these were located in bustees. It was decided to replace them by sanitary latrines free of cost under the Bustee Improvement Schemes. For the other, i.e., those in non-bustee areas, CMDA offered subsidy to the tune of 75 per cent of the cost with a ceilling for replacement with either septic tank or sewer connection, as the case may be. Under the CUDP III programme the local bodies determine the quantum of contribution to be made by the beneficiaries in this regard. CMDA introduced a pre-fabricated variety of R C sanitary latrines for the conversion programme which, however, had a mixed response. The prefabricated latrines did not gain much popularity with the Calcutta Municipal Corporation area and preference is still for the brick-built structure. Recently introduced Ganga, Action Plan has also undertaken projects for the conversion of 30,000 service latrines into sanitary latrines (including pour-flush type) in 16 towns (including towns within the CMD) abutting the river Ganga. The necessity of making provision for public conveniences as a part of overall improvement in the sanitation of Calcutta has not been overlooked either. CMDA also undertook a programme of providing public conveniences on 'pay and use' basis to meet the expenses for running and maintenance on no-loss no-profit basis. These have been provided at six important locations and are designed to provide facilities of 181 latrines, 79 baths and 68 urinals. This may be considered a successful experiment in-as-much as people willingly pay for using of them.

Under the IDA-I and IDA-II programmes CMDA has invested Rs. 60.8 million for the conversion of service latrines to sanitary latrines. Under the CUDP-III programme provisions have been made of Rs. 89 millions and Rs. 20 millions respectively, for the municipal and panchyat areas for this purpose.

III. POLICY OPTIONS

Several alternatives are available for dealing with the problem of safe disposal of excreta. A broad comparative picture is presented in Table 1. Until recently attention, particularly in urban areas, had chiefly been paid to the septic tanks with soak pit (mostly individual enterprise) and to the conventional sewerage with treatment facilities (municipal enterprise). While the service latrines are no longer acceptable, socially and environmentally, both the conventional sewerage and septic tanks are highly cost intensive and in most cases beyond the financial resources of the municipal authorities/state governments or individual householders other than those in upper, middle and high income groups. In the case of conventional sewerage system, apart from the needed large investments by the government or municipal bodies for laying of sewers and the construction of treatment facilities, it requires a great deal of expenditure by the individual householders for sewer connections. This acts as a determent to the effective utilization of the already built facilities. In Howrah, CMDA constructed the trunk sewers and some of the lateral sewers and completed the Sewage Treatment Plant at a cost of Rs. 40 millions. Despite this, no urge was noticed on the part of the house owners to connect their houses to the city sewers at a cost of two to three thousand rupees for laying sewer pipe inside the premises and connecting it to the nearest manhole through the intercepting chamber [12]. They rather preferred to continue with their existing service privies or privies connected to their septic tanks with effluents discharging into the nearest surface drains or soakage pits. As a consequence, the massive investment made for building the sewerage infrastructure remains grossly under-utilized. Another great disadvantage of the off-site excreta disposal facilities such as the conventional sewerage systems is that its construction requires a long span of time often exceeding ten years, resulting into cost overrun in most cases. Being essentially a waterborne system, it also requires a large amount of water for smooth functioning. A per capita water supply figure of 150 litres per day is recommended by the Government of India [13], though instances are there in arid areas of the country where the sewerage system has been envisaged at a lower rate of per capita water supply of 100 litres per day. Where the supply of water is less than this amount, such sanitation system would not work.

As already mentioned, septic tanks are beyond the economic reach of the majority of the population. Moreover, since the effluent of the septic tank is only partially treated, in many cases its direct discharge into surface drains creates environmental problems, viz., pollution of water bodies, insect breeding, etc. The presence of hookwarm and <u>ascaris</u> eggs in septic tank effluents poses a potential health hazard [14]. The desludging of septic tanks creates a major maintenance problem in the absence of proper municipal facilities and gradual disappearance of the effective service of the scavengers in the cities. In addition, disposal of septic tank sludge after clearance poses a problem and the cost of clearance and scientific disposal of sludge is significant. Functioning of septic tank is greatly dependent on good design practices; a poor design may result into malfunctioning and sanitation problems. Sometimes, effluent coming out of septic tanks is passed through a chlorination chamber before its discharge into surface drains; which renders the effluent relatively harmless, but adds to the cost of construction and maintenance.

Amongst the other forms of sanitation composting latrines, aqua-privies, vault latrines, ROEC type pit latrines, VIP and VIDP latrines have not seen their uses in the CMD area. Small bore shallow sewerage system is still in its infancy even in other parts of the world and may take some more time to gain a wide acceptance. The primitive pit latrines and bore hole latrines are still a major form of sanitation in rural areas of the CMD and in municipal area bucket latrines are still in vogue awaiting conversion. In the choice of low cost technology for sanitation the ordinary pit latrines and bore hole latrines are gradually being outrated due to space and other constraints and because of unacceptable levels of fly and odour nuisance. Nevertheless, for areas without organised public water supply or individual hand tubewells or usable community sources ventilated improved pit (VIP) latrines may be recommended as a suitable alternative to dispense with the existing practice of open-air defaecation. Where the users have a preference for a solid superstructure which can not be shifted or where space is not available for relocating a VIP latrine, the ventilated improved double pit latrine (VIDP) can be used.

The requirement of a highly efficient central organization to deal with the financial and managerial problems associated with the running a fleet of vacuum trucks rules out the adoption of vault latrines in the CMD area in view of weak municipal organisations. Similarly, the taboo associated with the use of night soil manure, unless very old, and the Indian custom of using water for ablution do not hold out compost latrines as an acceptable alternative either. On the other hand, the introduction of aqua-privies as a new sanitation alternative in the CMD presupposes a major public campaign apart from a consideration of the difficulties associated with essentially water-tight construction and sufficient use of water to make up the water loss. The problem of desludging will, however, be similar to that in the case of septic tanks. From various considerations, pour-flush latrines rather stand out as a promising sanitation alternative in the Indian context and are gradually gaining ground as a feasible on-site sanitation method even in urban areas. The construction of pour-flush water seal latrines is easy and does not involve very high skill once the location of leaching pits is carefully selected. Construction can be carried out under various site conditions for which detailed designs have already been developed.[9].

However, one of the important aspects of such sub-surface excreta disposal is the pollution of ground water located near the leaching pits. The lack of correct information on the hydrogeological conditions of the sites and insufficient care in the design and construction of latrines may give rise to ground water contamination and thereby expose people to disease risks. Ground water pollution due to on-site excreta disposal largely depends on the type of soil and the nature of occurance of ground water. Under proper site conditions, the soil provides an excellent treatment medium. Critical site factors include soil profile characteristics and permeability, soil depth over water tables or bedrocks. When water is drawn from deep confined aquifers, on-site sanitation is not likely to pose any major problem provided due care is taken during the construction of the well to preclude direct flow of water from the unconfined zones and to prevent surface contamination. Pollution problems may arise in the case of unconfined aquifers and there may be two possible situations : first, when the water table is high and the leaching pits are entirely located in the saturated zone; and second, when the pits encounter both the saturated and unsaturated zones. Studies carried out in different countries indicate that in the alluvial soil (where there is a predominance of soil mixed with fine sand) there is no bacterial pollution from pits located in the unsaturated zone, provided the bottom of the pit is at least 2 metres above the maximum ground water table and hydraulic loading in pit does not exceed 50 mm/day. The latter is the usual loading rate of pour-flush latrines. When the pit extends in the saturated zone the pollution travel chiefly depends on the velocity of ground water flow. In alluvial soil, the distance of pollution travel is equivalent to about 10 days' travel of ground water. However, with the continued usage of pit, sooner or later, some clogging of the soil around the pit takes place resulting in the regression of bacterial stream which finally stablizes at about 1 metre distance.

Under adverse hydrogeological conditions such as coarse sand, high water table and high ground water velocity, and when the pit bottom is submerged or less than 2 metres above the water table, suitable modifications in the pit design would be necessary and are practicable. These would involve provision for an envelope of fine sand (average particle size less than 0.2 mm) for a minimum thickness of 500 mm all round and sealing of the pit bottom by an impervious material, viz., fine clay, puddle clay or polythene sheet. Conditions such as rocks with fissures, chalk formations, old root channels, etc., may create special problems because in such cases pollution can travel a long distance. These conditions would therefore require very careful investigation and suitable modification of the system or adoption of alternative excreta disposal systems. It may be pertinent to point out here that any form of sanitation becomes problematic in high water table areas or areas prone to flooding during certain parts of the year. Although due to predominantly alluvial soil in the CMD area the ground water pollution problem is not likely to assume unmanageable proportions, the need for further and more intensive research under varying site conditions can not be overemphasized.

People's reaction to excreta disposal schemes depends on deep rooted social and cultural values as well as on cost, convenience and comfort. In our culture, privacy is a very important factor, especially for women. From the point of view of convenience and comfort pour-flush water seal latrines are as good as other forms of sanitation systems insofar as the users are concerned. As regards cost, this type of latrine is certainly less costly than the conventional sewerage and septic tank system as shown in Table 2.

Small bore shallow sewerage system, though a very recent concept, has a great potential for high density low-cost housing areas and a policy may be taken to try this system on an experimental basis to judge its efficacy in the CMD context. This system may also be useful for upgrading pour-flush toilet system and septic tank system.

A quick survey of the entire situation immediately suggests four important facts :

(a) The sanitation of Calcutta, and one may say of the CMD, has improved over time as evinced in increasingly low incidence of excreta-related diseases.

(b) However, the feasibility of bringing the entire CMD under conventional sewerage system with treatment facilities does not appear bright because of the enormous financial requirement this would involve and also other constraints.

(c) While the programmes that have already been taken by the CMDA towards the (partial) realization of the goal should be completed, in future programmes, the major emphasis should be on the adoption of low-cost sanitation technologies, with an encouragement, whereever possible, on individual enterprises, supported and supplemented by the public authorities.

Operation and maintenance

Any sanitation programme planning should take into consideration the important aspect of operation and maintenance. Our countrywide experience suggests that operation and maintenance of infrastructure and other assets are overtly neglected. CMD provides no exception. Consequently, sewage treatment plants built at a huge cost fall into disrepair or disuse within a short period due to lack of proper operation and maintenance. Conventional sewerage with sewage treatment facilities requires a high degree of skilled maintainance. Operation of treatment plants calls for qualified and experienced engineers and technicians in view of complexities involved in the processes. Proper and effective control of the process parameters is essential for optimal functioning of the treatment system. From this point of view, O and M becomes much easier if low-cost treatment technologies, viz., stabilization ponds or oxidation ditches are adopted in place of trickling filters or activated sludge processes. On the other hand, properly operated sludge digestion tanks can generate sufficient combustible gas which can be used to generate power or for domestic cooking. Negligence of the task of regular maintenance of sewers may cause immense damage to the system as has been experienced in the city of Calcutta. Maintenance requirement is much less in the case of septic tank system; since individual households own the system, the primary responsibility of proper upkeep of the system rests with themselves, while municipal help is required only at the time of desludging the tanks periodically. The increasing difficulty in getting desludging personnel makes the municipalities seriously consider mechanisation of the desludging process. Use of vacuum desludging trucks can provide a solution. Within the Calcutta Municipal Corporation area individual households get the service of the vacuum desludging at prescribed fees. The service of vacuum desludging provided by the Calcutta Municipal Corporation has proved to be highly acceptable to the users. The other municipalities also may try it. Fees should be related to the economic costs. However, it would be necessary to have different capacities of units to suit various road widths. The problem of maintenance becomes much simpler in the case of pour-flush water-seal latrines. The users themselves can empty the pits or at best can engage daily labourer for the job. Since the filled up pit is left for two years before cleaning, the taboo associated with handling comparatively fresh excretal matters does not work. Moreover, as stated above, the rich organic humus, which is quite safe for handling can be used as manure. Being individual enterprises, the users themselves are likely to pay more attention to the proper maintenance of their facilities. This may be considered as a major plus point in the case of pour-flush toilets from the maintenance point of view. The operation and maintenance problems of other sanitation methods will vary between the two extremes of conventional sewerage with sewage treatment facilities and PF toilets.

Due consideration about O and M should be given from the very first stage of conception of any system. Negligence in this respect may create immense problem at a latter stage. It is a common scenario in our country that the maintenance authority is not selected even when the project is completed and ready for commissioning. Sometimes it requires several years to select maintenance authority or to make permanent institutional arrangements for O and M with the allocation of adequate fund for the same. Judging from this angle it may be worthwhile to make built in provision in the project cost for O and M at least for a period of 3 to 5 years which may be used as a preparatory period for making some permanent arrangements.

Community participation

It is now widely believed that some degree of community participation is one of the most desirable components of any sanitation programme. Studies investigating the widespread failure of community water supply and sanitation programmes in developing countries from the point of view of long-term successful operation and usage hint at the need to study carefully the perceptions and attitudes of the people towards programmes in their socio-cultural mileu. It is stressed that, in addition to technical and financial considerations, the socio-cultural factors also should guide the choice of technology. Direct involvement of the target population in decision-making over what should be done and how, in the implementation of the decision, in matters of operation and maintenance and in the evaluation of benefits can provide some guarantee of the long-term success of a project [16]. Experimentation with community participation reveals that participation may take different forms largely depending on the objective and circumstances. The objectives of community participation in sanitation may be :

(a) to find out the felt-need of the community (whether of sanitation or of any other service);

(b) to select sanitation technologies that are acceptable to the community and affordable by them;

(c) to find out what importance is given by the community to the benefits in relation to the costs;

(d) to select most effective materials (with regard to locally available materials) and methods of construction;

(e) to select technologies that can be operated and maintained by the local population without much dependence on outside agencies;

(f) to evaluate the benefits (health and otherwise) from a particular investment programme.

It is envisaged that it would be easier to organise community participation in smaller and isolated rural areas with a greater degree of identity as a community marked by a more intense solidarity among its members than in urban communities which are characterised by impersonal relations and a lack of social cohesion. Moreover, the increasingly important role of government and local self government in various spheres of urban life is believed to have diminished the chances of success in urban areas of the kinds of community development projects which are encountered in rural areas. Nevertheless, some citizen-participation in planning has become a characteristic of the urban renewal programmes in many countries. In some countries even legislations exist which aim at a greater participation of the public in the planning process. For example, the British Town and Country Planning Act, 1968 actually provides the citizen with a statutory guarantee [17] :

''... that he must be given information about a given situation and an opportunity to make the views known to his local planning authority. The authority must be then consider them''.

To achieve the objectives of public participation in sanitation, the organisational programmes should be structured [18] :

(a) to ascertain formal or informal channels for community leadership and communication;

(b) to determine the community's existing practices for water use and excreta disposal and its attitudes towards them;

(c) to determine the community's willingness to pay for desired improvements through cash, labour or material contribution;

(d) to formalise organisation and 'modus operandi' for the execution of self-help construction;

(e) to fix responsibilities for the operation and maintenance of communal facilities;

(f) to ascertain whether any assistance is required for the users for maintaining individual facilities;

(g) to organise collection of funds for the operation and maintenance and for the repayment of loans.

There are various methods and models for eliciting community participation in the planning and management of public utility services like sanitation and it is difficult to provide a single recipe that will suit every situation. The involvement of community leaders, political bosses, social welfare organisations and voluntary organisations is very important. Community participation has a special relevance to low-cost sanitation programmes. In a survey [10] carried out in an urban setting of Lohanipur Mohalla of Patna it was observed that motivating people for adopting the programme and extending their co-operation in its successful implementation was very important. The change agents of the Sulabh International had a significant role in this respect since personal cosmopolite channels were found to be more important than the impersonal localites channels of communication. They served as a communication link between the implementing agency and the beneficiaries and engaged themselves in persuasive dialogue with the client population. Voluntary organisations have also been very helpful in motivating people and promoting the low-cost sanitation programme in Gujrat and Rajasthan. The idea of emancipating scavengers from the demanding job of carrying night soil had a great appeal [12]. In CMD, apart from members of legislative assembly, ward councillors, elected commissioners of municipalities and panchayet members, nagarik committees, bustee development committees, panchayat samitys and local youth organisations may play an important role in motivating people and in enlisting their co-operation and participation in the successful implementation of sanitation programmes and a proper use of sanitary facilities. Maintenance becomes easier when there is full co-operation from the users. Finally, it will no doubt require considerable flexibility and commitment on the part of the engineers, planners and administrators to be amenable to suggestions by others - especially the service population. Citizens may generate useful inputs to the planning process and an effective two-way dialogue with the community is most likely to contribute to finding the right solution to a complex problem.

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TABLE - 1

BROAD COMPARISON OF SANITATION TECHNOLOGIES

Sl. No.	Sanitation technology	Urban application	Rural application	Construction cost	Operation cost
1.	Ventilated Improved Pit latrines (VIP) VIDP/ROECS	Suitable in low/medium density areas	Low	Low	Low
2.	Composting Latrine	Suitable if society permits	Suitable if society permits	Medium	Low
3.	Bucket Latrines	Should be discouraged	Should be discouraged	Medium	Medium
4.	Vault Latrine and Cartage	Suitable	Not suitable	Medium	High
5.	Aquaprivies	Suitable in low/medium density areas	Suitable	Medium	Low
6.	Pour-Flush Toilets	Suitable	Suitable	Low	Low
7.	Septic tanks	Suitable	Suitable for rural institutions	high	High
8.	Conventional sewerage	Suitable	Not suitable	Very high	High
9.	Small-bore shallow sewerage system	Suitable	Not suitable	High	Medium

Source : Compiled from John M. Kalbermatten et al., Appropriate Technology for Water Supply and Sanitation : Technical a.d Economic Options. The World Bank, Washinton, 1980.

TABLE - 1 (Contd.)

Sl. No.	Ease of construction	Self-help potential	Water requirement	Required soil	Complimentary off-site
1.	Very easy except in wet or rocky ground	High	None	Stable permeable soil; groundwater at least 1m below surface	None
2.	Requires skilled labour	High	None	Can be built over ground	None
3.	Requires skilled labour	High	Low	Normally built over ground	Nightsoil disposal facilities required
4.	Requires skilled labour	High (for vault construction)	Water near toilet	Can be built overground	Nightsoil disposal facilities required
5.	Requires skilled labour	High	Water near toilet	Permeable soil; ground water at least 1 m below G.L.	Disposal facilities for sludge
6.	Requires semi-skilled labour	High	Water near toilet	Stable permeable soil; ground water preferably 1 m below G.L.	None
7.	Requires skilled labour	Low	Water piped to house and toilet	Permeable soil; groundwater at G.L.	Disposal facilities for sludge
8.	Requires skilled technical personnel	Low	Water piped to house and toilet	None	Sewage treatment facilities
9.	Requires skilled technical personnel	Low	Water piped to house	None	Sewage treatment facilities

TABLE - 1 (Contd.

Sl. No.	Reuse potential	Institutional requirements	Health benefits
1.	Low	Low	Good
2.	High	Low	Good
3.	High	High	Poor
4.	High	Very high	Very good
5.	Medium	Low	Very good
6.	Low	Medium	Very good
7.	Medium	Medium	Very good
8.	High	High	Very good
9.	High	High	Very good

TABLE - 2

COMPARISON OF CAPITAL COSTS OF ALTERNATIVE SANITATION TECHNOLOGIES

Type of system	Present day relative per capita cost (approx)
Conventional sewerage with sewage treatment facilities	100
Septic tank with soak pit	60
Pour-flush water latrines	20

A P P E N D I X

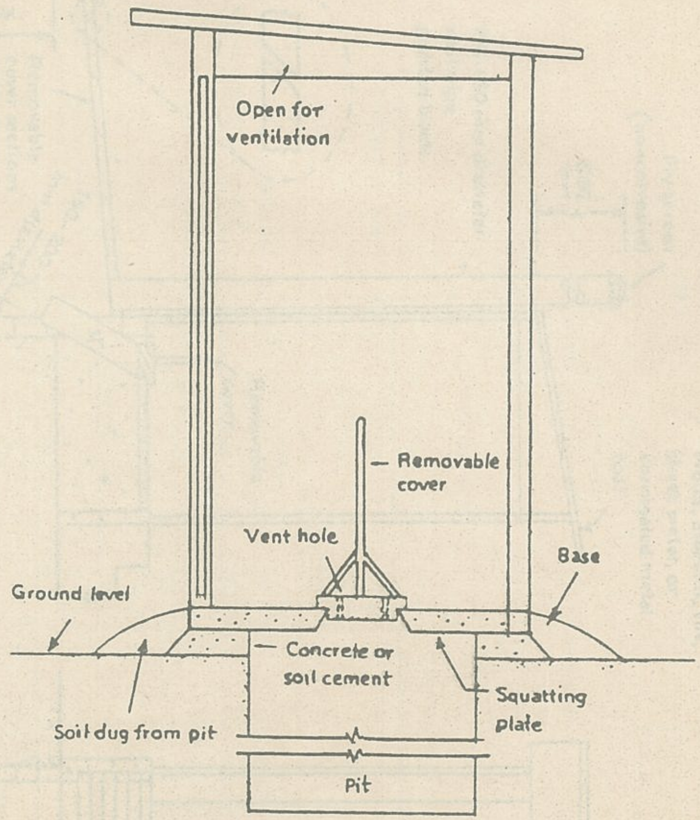


Figure 2a. Conventional Unimproved Pit Latrines

Source: World Bank Document (20)

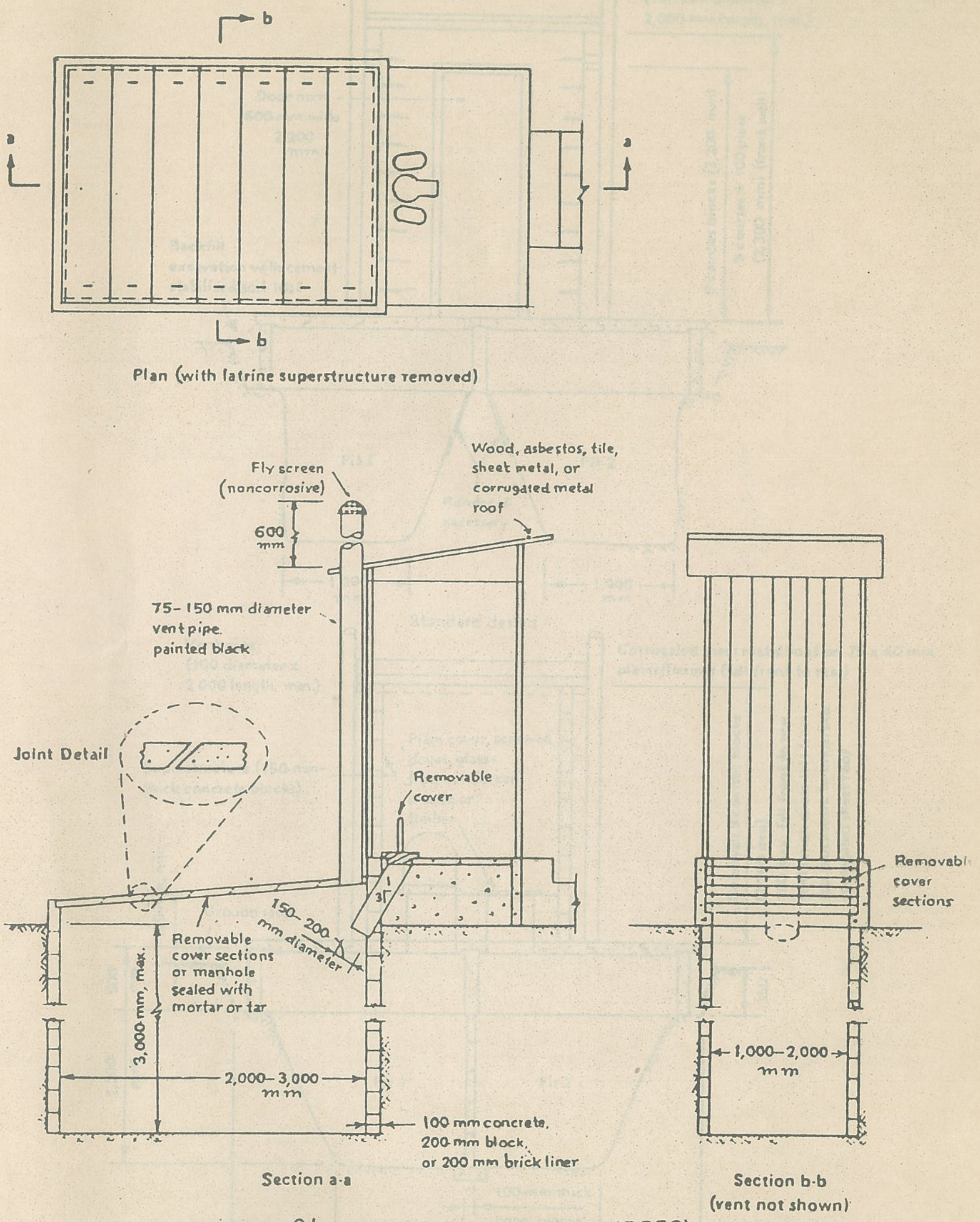
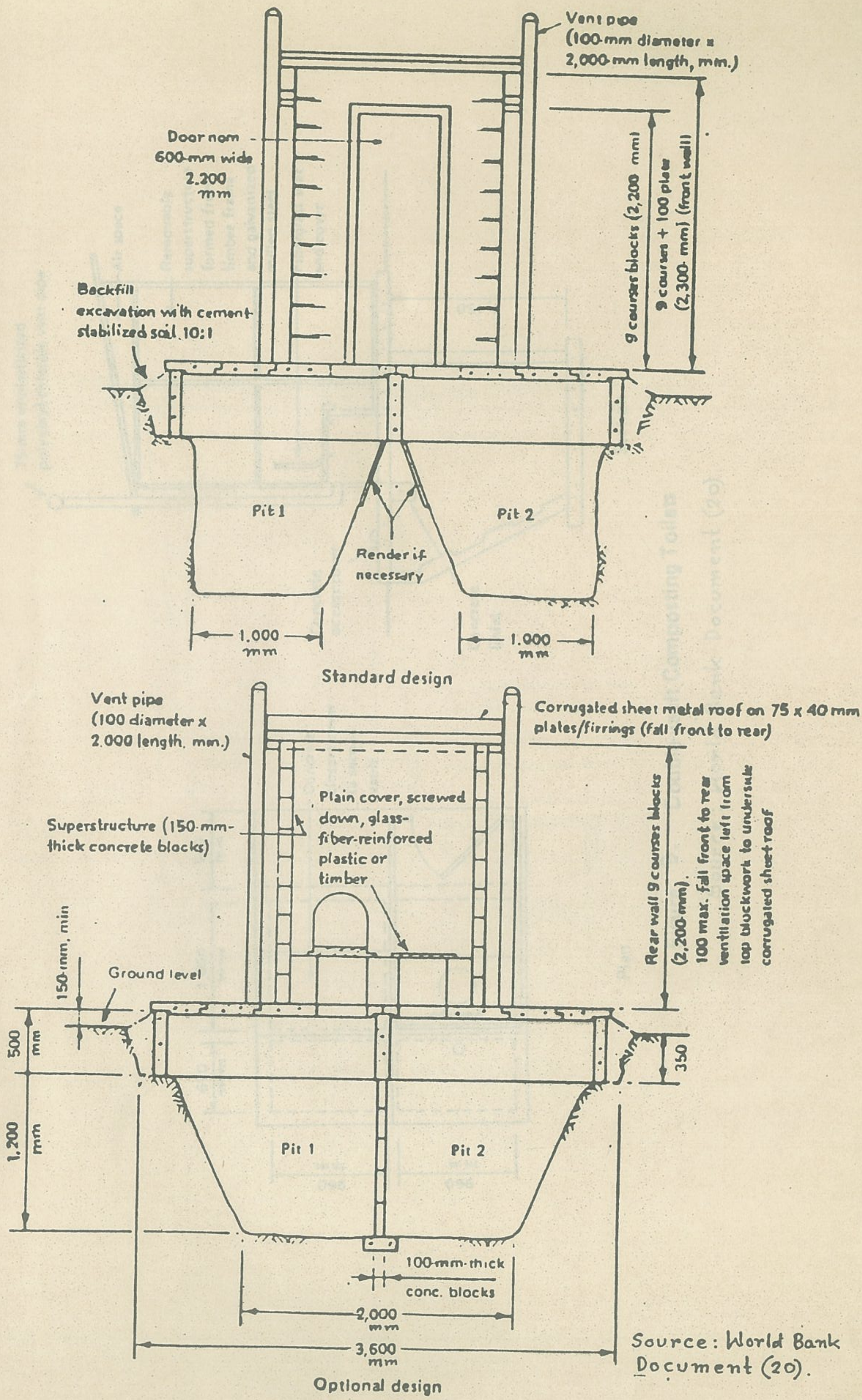


Figure 2b. Reed Odorless Earth Closet (ROEC)

Source: World Bank Document (20)



Source: World Bank Document (20).

Figure 2c. Ventilated Improved Double-pit Latrine

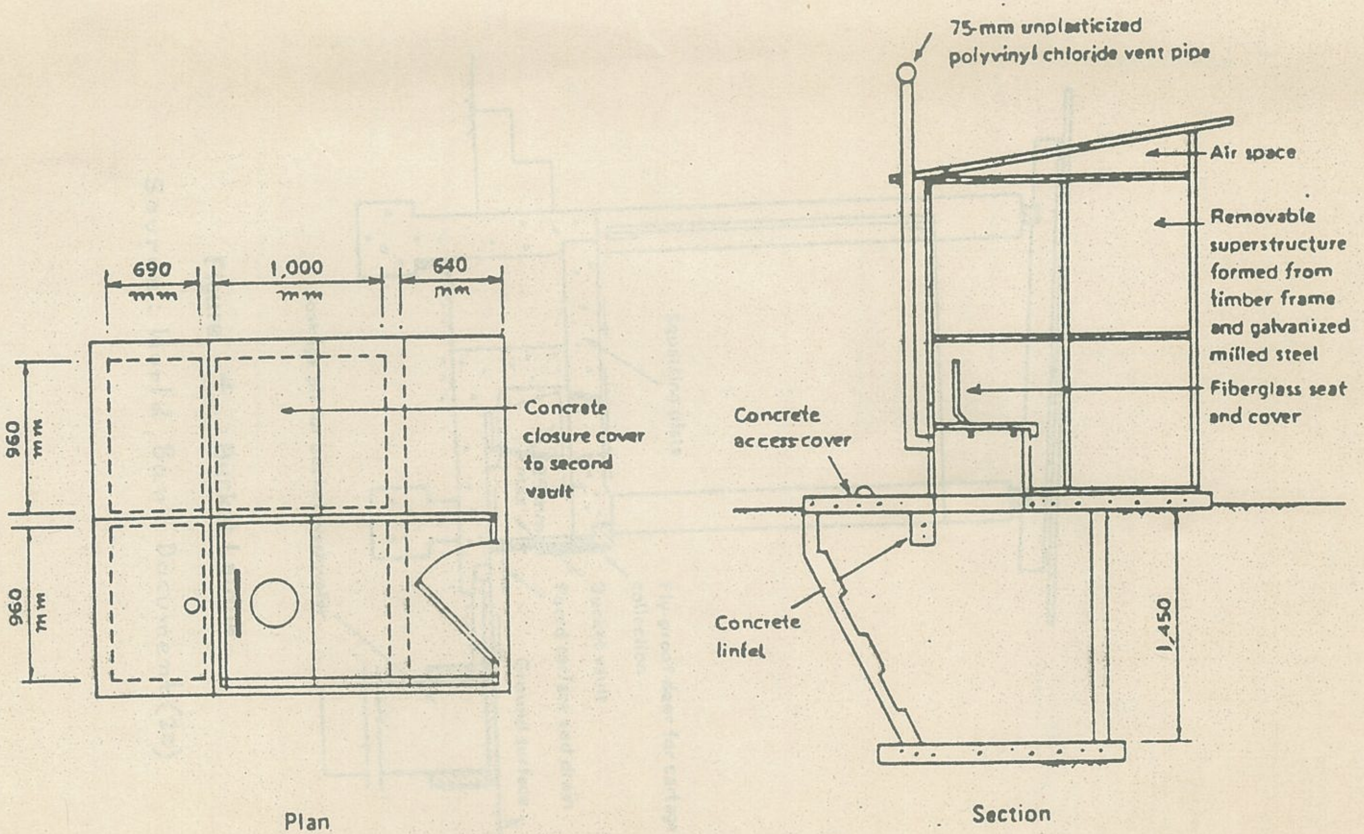


Figure 3. Double-vault Composting Toilets

Source: World Bank Document (20).

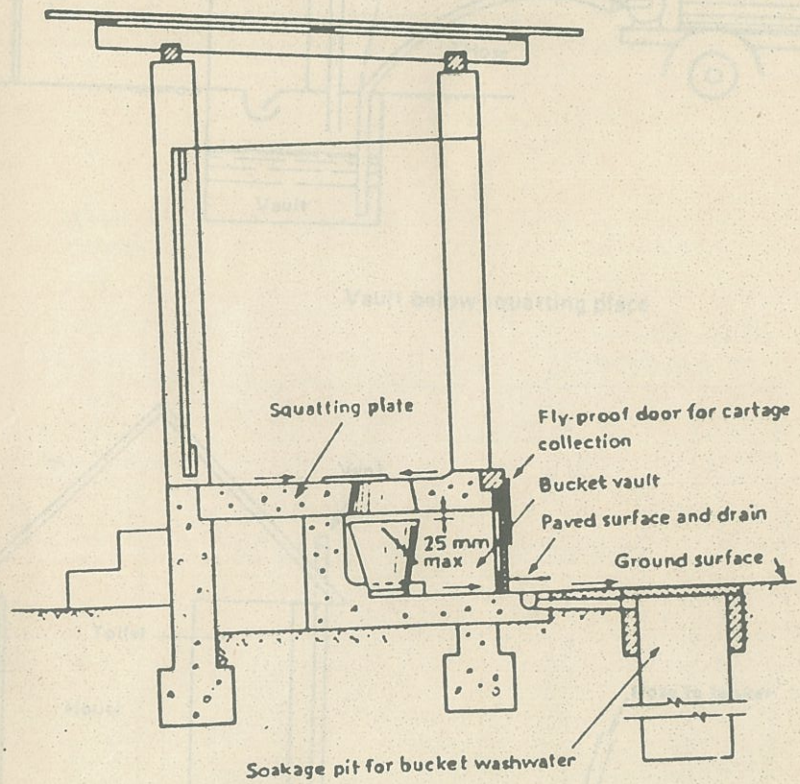
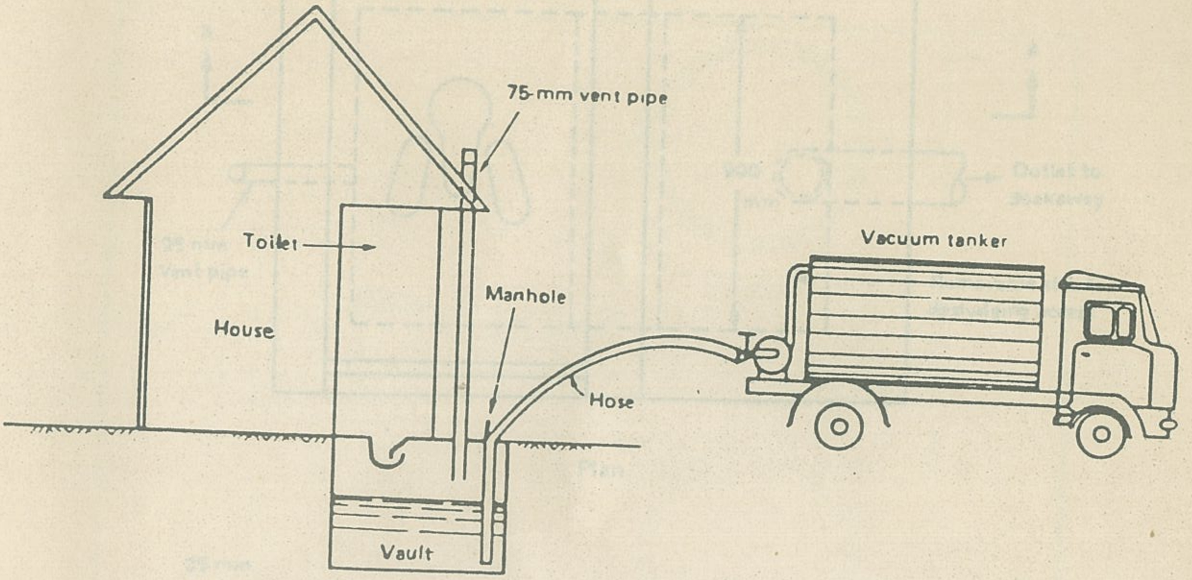
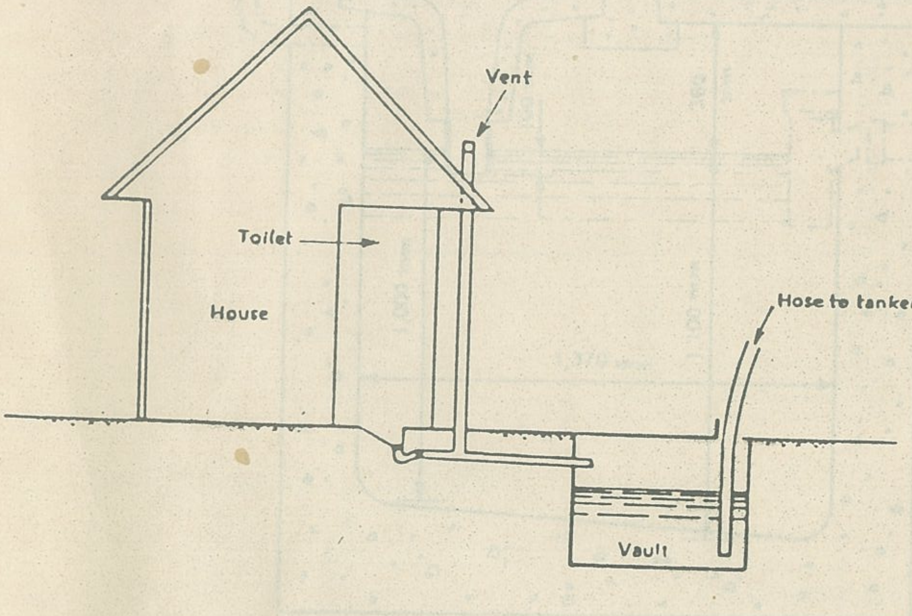


Figure 4. Bucket Latrine

Source: World Bank Document (20)



Vault below squatting place



Offset vault

Figure 5. Vault Toilets

Source: World Bank Document (20)

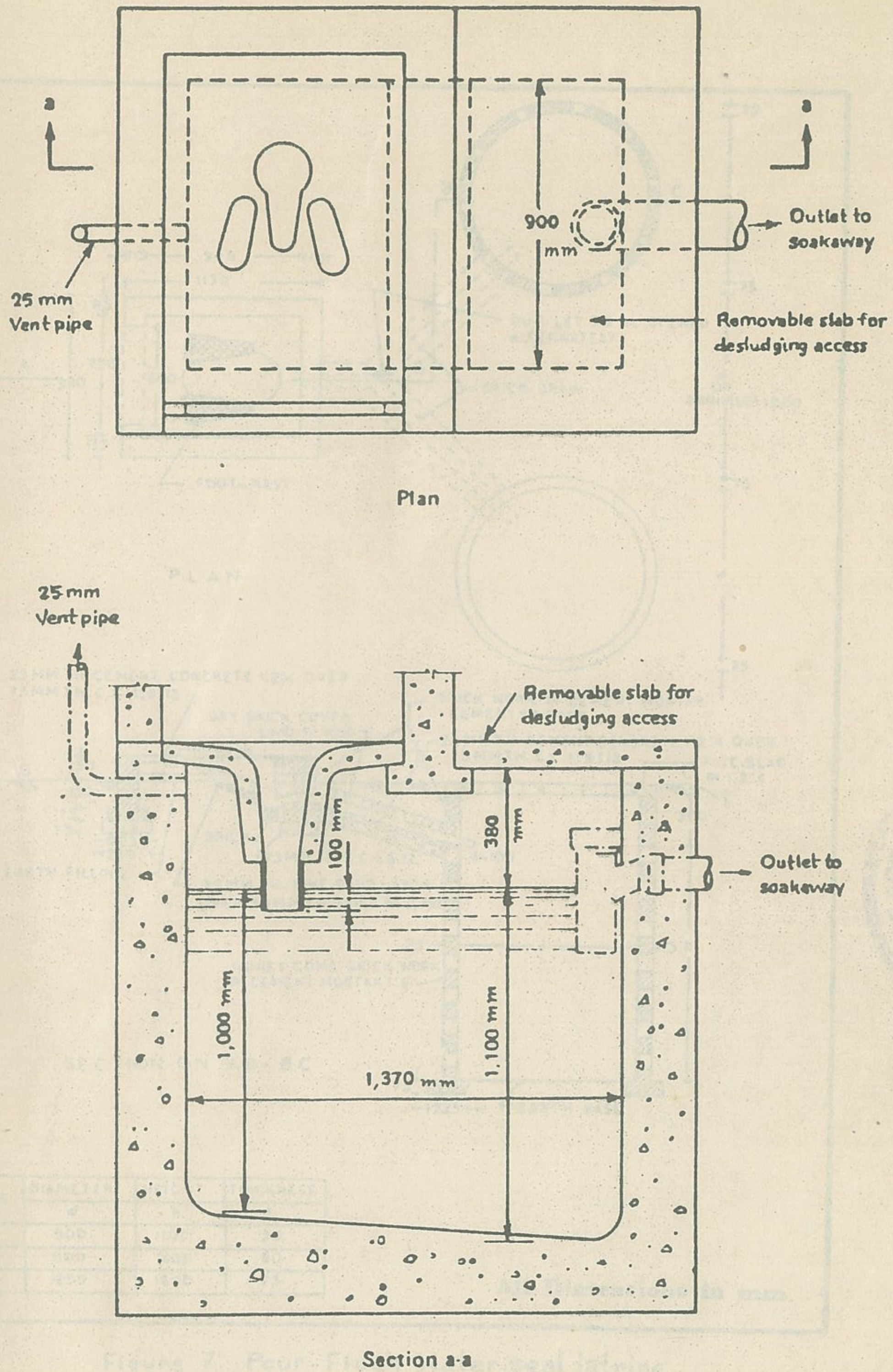
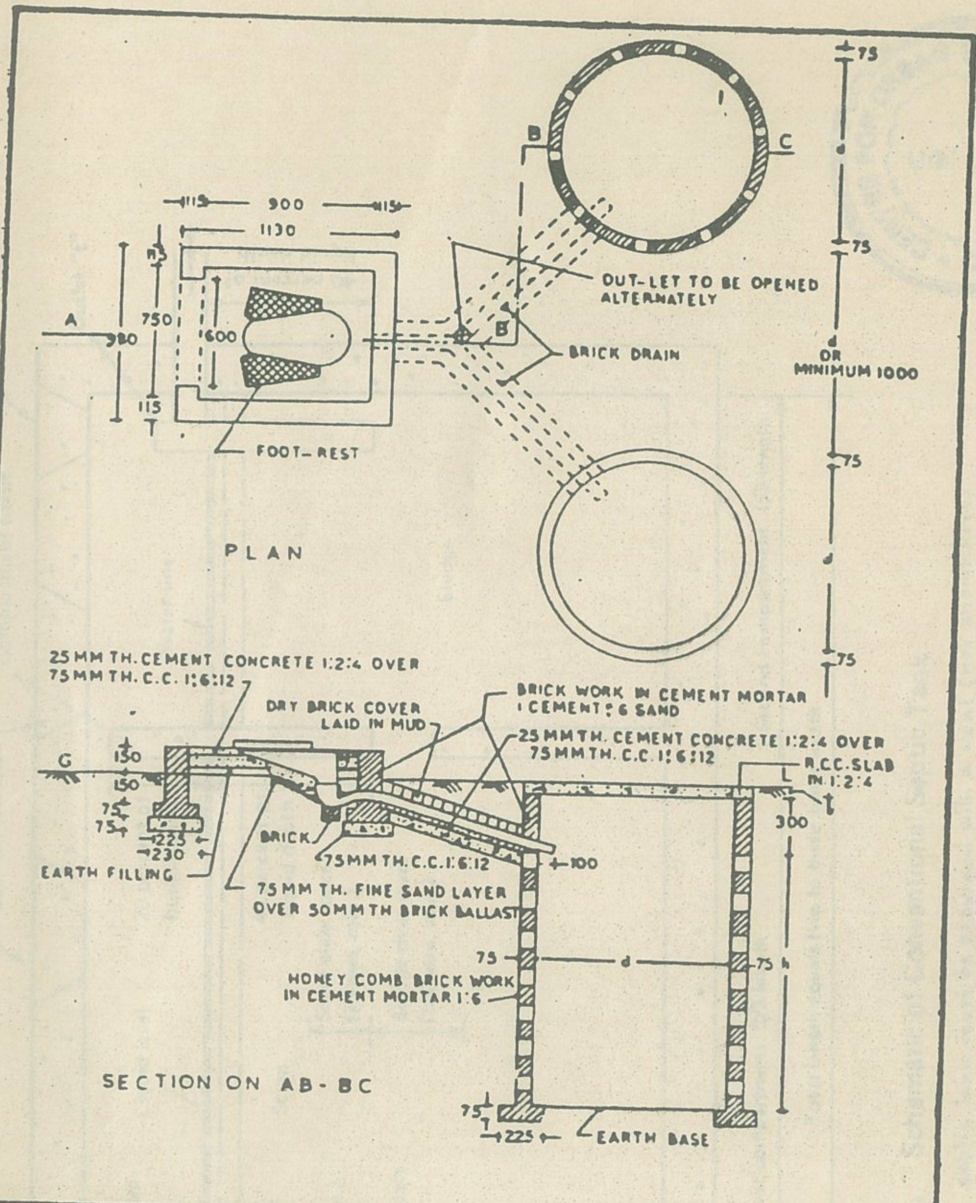


Figure 6. Conventional Aquaprivy

Source: World Bank Document (20)



USERS	DIAMETER d	HEIGHT h	THICKNESS t
5	900	1100	50
10	1100	1400	60
15	1250	1600	75

All Dimensions in mm.

Figure 7. Pour-Flush Water-seal latrine

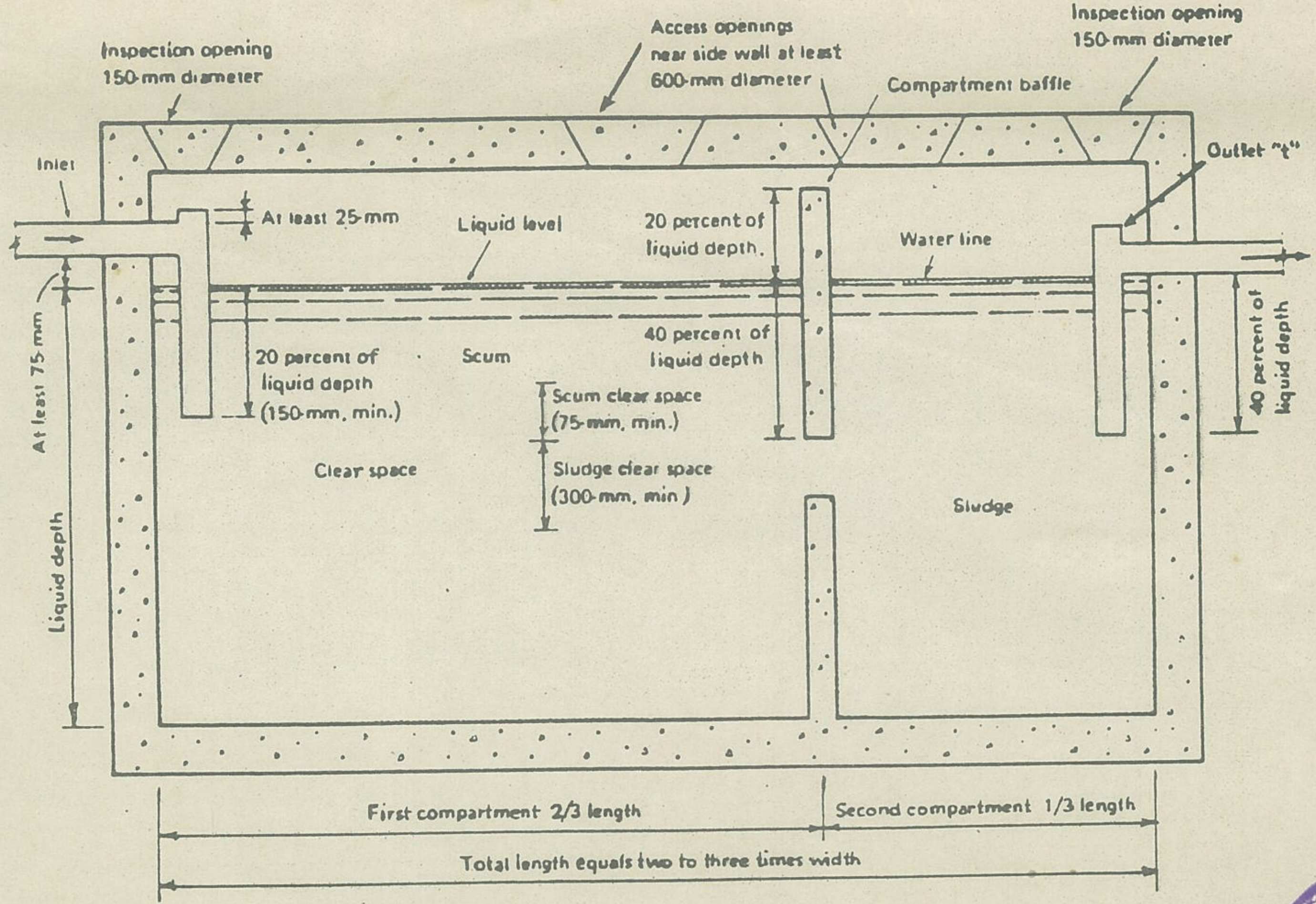


Figure 8. Schematic of Conventional Septic Tank

NOTE: septic tank must be provided with a vent (not shown here)

Source: World Bank Document (20).