STOP THE FAECAL PERIL;

A Technology Review.

Witold Rybczynski

Chongrak Polprasert

Michael McGarry

IDRC Preliminary Report

STOP THE FAECAL PERIL

A Technology Review

Witold Rybczynski

Chongrak Polprasert

Michael McGarry

IDRC Preliminary Report

Note to the Reader

This Technology Review, in the form of an unedited preliminary report, is being circulated widely both to individual specialists working in, or concerned with, the developing countries and to national and international organizations active in the field. With it goes a questionnaire asking for critical comments about the Review and Bibliography and for corrections and additions. These will be incorporated in the final published version.

IDRC, Ottawa. July, 1977

Contents

Acknowledgments

This IDRC study is related to a research project of the World Bank dealing with technologies for water supply and waste disposal. The World Bank has cooperated in providing consultants and information to this review, and particular thanks are due to John M.Kalbermatten and Charles Gunnerson.

Many people and agencies contributed to this Technology Review. Valuable published and unpublished material for the bibliography was provided by D. Donaldson (PAHO, Washington, D.C.), Hemda Garelick (Ross Institute of Tropical Hygiene, London),Edwin W.Lee (WHO, Manila), Harvey F.Ludwig, B.F.Ormières (BCEOM, Paris), S.Unakel (WHO,Geneva) and Victor Wehman (AID). A vital function in the literature search was performed by the external consultants: Eric Carlsson, Balfour Hepher, Duncan D.Mara, Alexander B.Morse, M.B.Pescod and John Pickford.

Helpful suggestions were received from Richard Feachem of the Ross Institute of Tropical Hygiene who is preparing a parallel bibliography on the health aspects of waste disposal technologies.

Thanks are due to Marcel Mercier of the Information Sciences Division whose numerous suggestions greatly improved the bibliography. The literature search could not have been completed without the support of the staff of the IDRC Library, particularly Margaret Carroll, as well as Dolores Rees of the NOAA Library in Washington D.C., and Rafael Rodriguez of the World Bank. Thanks are also due to Dianne Ayad and Lynn Wara for efficient typing of the manuscript.

W.R.
C.P.
M.McG.

Ottawa, June 30, 1977.

I. Technology Review

> "There are some sections of the city where rural sanitation conditions obtain, as, for instance, the areas not reached by sewers. The lack of sewers may be due to any of several reasons, as scarcity of money for sewer extensions, inability to extend sewers due to adverse conditions of nature, or legal limitations, as where a community is contiguous to, but just outside of the city limits. In these sections there is a complication of problems, but the essential requirement remains the same. It is necessary to dispose of the dangerous wastes in a sanitary manner.
>
> Few of these homes are reached by water mains, or have their own water supplies under pressure. Fewer still are financially able to install plumbing fixtures and build a plant to care for the sewerage resulting from the installation. For the great majority the privy will be the method of sewage disposal." (Hardenbergh, 028)

This could very well be a description of the situation that exists in many of the developing countries of the world but in fact it was written by an American sanitary engineer in 1924, and describes conditions in the United States at that time. If the United States, which introduced sewerage seventy five years before was still having difficulties with waste disposal in 1924 it is not surprising that many countries which are now beginning the process of development should be faced with similar problems. But such comparisons can be misleading. They imply that similar problems require similar solutions. They ignore the fact that, as Gunnar Myrdal has pointed out, the underdeveloped countries begin their modern development with significantly different resources and under different conditions than did the now-developed countries when they began their modern development in the mid-nineteenth century. They cannot simply repeat the development process of the developed countries, and nowhere is this more clear than in technological development.

The recognition that the developing countries may follow a different route leads one, in the consideration of waste disposal, to pose three questions. What were the options available in the mid-nineteenth century to these countries then beginning their modern development? To what extent is the situation of a developing country today similar? Is the option that was adopted by the developed countries *then* still the optimal solution for the countries beginning their development today?

The European and American countries in the mid-nineteenth century found themselves with rapidly growing cities and traditional sanitation systems (cesspools, bucket systems, pit latrines, open ditches) that were rapidly becoming inadequate to the new scale and density of population. The first evidence of difficulties appeared in the water supply, which in most cities at that time was provided by individual wells. As the density of the urban areas increased local water supplies became poisoned, and virtually all the major cities were forced to build aqueducts to supply the city with clean water from the unpolluted hinterland. This supply of piped water resulted in greater consumption and required disposal of greater amounts of wastewater. At the same time the availability of pressurized water in the home encouraged the widespread adoption of a recent invention - the water closet, the forerunner of today's flush toilet. This self-cleansing water-sealed device was seen as the ideal solution for isolating the odiferous cesspool, and permitted hygenic indoor toilets for the first time. However, the result of this massive input of wastewater into primitive infiltration systems was to be the straw that broke the camel's back (Stanbridge, 013). It rapidly became clear that the traditional systems could not deal with such quantities of water, and recurring outbreaks of cholera required that an alternative solution be found.

One option that was considered was the transport of wastewater away from the cesspool by the use of horse-drawn tank trucks. The sewage was pumped into the tank manually. This approach, the predecessor of the vacuum truck, was tried in a number of American cities. Its reported failure was due to the inability of the municipal governments of that time to organize and operate such a service effectively. Nevertheless certain better organized European cities, such as Stockholm and Copenhagen, did use bucket removal systems well into the twentieth century.

The option of total or partial biological on-site treatment of wastewater was not really available in the mid-nineteenth century when the commitment to sewers was made. The septic tank was not invented until 1897, by an English engineer Donald Cameron. A simplified version called the "septic closet" was developed by Drs. Lumsden, Roberts and Stiles in the United States in 1918 and was widely used in the rural South. It was later adapted and adopted in Africa and Asia, where it is known as the "aqua-privy".

There had been investigations, in the early nineteenth century of dry excreta disposal systems. Moule in England and Waring in the United States were both proponents of the "earth closet". One of the limitations on the success of these systems was the limited understanding of scientific composting at the time. Composting was brought to the West from China in 1909 by King of the U.S. Department of Agriculture, and the work of the pioneer Sir Albert Howard at Indore was not completed until the 1930's (Grey et al, 245).These developments were too late to influence the course of events, as the widespread adoption of the water-closet had effectively cancelled the dry disposal option.

The solution that was finally adopted, as is well known, was the removal of combined greywater and human excreta by underground sewers.

It should be noted that the problem of waste disposal, as it was then understood, was essentially one of transporting the wastewater out of the urban area and underground sewers did this successfully, albeit at a high price. This choice represented the most easily implementable solution, and by translating a socio-medical problem into an engineering task it followed the characteristic philosophy of that optimistic age. Once this decision was made it set the direction for technological development for a century to come. The problems of BOD reduction, contaminant removal, tertiary treatment and sludge disposal all follow, though unpredicted, the first choice.

A choice of technology is the result of many influences - social, political and economic as well as scientific. Nevertheless, in considering only the latter, two types of information stand out. The actual technological options available at the time, and the extent to which the implications, or cost-benefits, of any particular option are understood. The first is limited by scientific knowledge, and the second by a natural inability to forsee all eventualities. The choice of combined sewerage systems, for instance, was often linked to storm drainage, since treatment of sewage was not considered. Once it was understood that treatment would be required, it became clear that uncontaminated rainwater would be more economically drained separately. All technological decisions generate future sets of, often unknown, decisions. It is impossible to forsee all the effects, both good and bad, of any particular choice. Nevertheless an attempt must be made to see as many as possible.

It is possible for a developing country to take into account at least some of the implications of the waterborne waste disposal option, which were not discerned in the mid-nineteenth century. The associated environmental hazards and increased water consumption are two phenomena which are now well documented. In this sense being a latecomer has its advantages. However, a general consideration of the conditions within which the developing countries face the problem of waste disposal will show that the situation is extremely severe, and differs vastly from that faced by the Western countries in the 1850's.

The population explosion is the most formidable obstacle to development in a developing country. This is evidenced by the overall man/land ratio, which is much higher than in Europe at the time of its industrial revolution, and in the extremely rapid growth of the urban areas. At the time that the decision was made to adopt underground sewers, London had slightly over two million people. All the other cities which initiated sewer construction (Hamburg, Paris, New York) had less than one million inhabitants. Even by 1900 there were only eleven cities in the world (nine of these in America and Europe) with populations of over one million. Today that is considered a small city indeed. Most of the primate cities in Asia surpass five million

inhabitants. Clearly the *scale* of the waste disposal problem faced by a developing country is of unprecedented proportions, and no parallel is possible between their situation and that of the developed countries one hundred years ago.

In all but a few exceptional cases the developing countries are less well endowed with natural resources than were the presently developed countries when they started development. One resource in particular is scarcer, water. Water is plentiful in the temperate zones, where sewers were first constructed, and it is not surprising to find it used as the transportation medium for human wastes. Most developing countries, being in the tropical and sub-tropical regions, find themselves with periodic, or permanent, shortages of water, both for agricultural and domestic uses. This is a most severe constraint for the adoption of any waterborne system.

Climate is another important difference in the conditions under which many underdeveloped countries are developing. The number, and variety of faecally-transmitted diseases is greater in the tropical and sub-tropical regions. Heat and humidity create ideal conditions for pathogen survival. Furthermore, the malnutrition which is endemic with much of the population is a major factor in the high rate of infection. The result is that poor sanitation becomes one of the chief causes for spread of hookworm, diarrhoea, enteritis, cholera and typhoid. It is the destruction of these pathogens which is the first priority of any waste disposal system. Most systems originating in the temperate regions aim at achieving BOD reduction, and are naturally enough less concerned with pathogen destruction.

Prior to the adoption of sewers in the West, nightsoil was collected from the cities, either by bucket systems or by pumping out cesspools, and was used by farmers as fertilizer. (Stanbridge, 013) Once the water closet came into use, the transportation and handling of liquid sewage proved difficult, and the amounts of water mixed with the waste proved to be too much for farming use. This, as well as the development of manufactured fertilizers, discouraged the practice of reusing wastes. In most of the underdeveloped countries agriculture plays a very important role in the development process. The limited availability and high cost of chemical fertilizers mean that compost, manure and human waste have retained their value as fertilizing materials. *The problem of waste disposal, for a developing country, cannot be separated from the problem of waste reuse.*

The adoption of waterborne waste disposal, sewers in the cities and septic tanks in the rural areas, has taken the developed countries quite a long time. Indoor sanitation for almost all of rural Canadian housing was achieved only ten years ago. Only one country, Sweden, has achieved tertiary treatment for all sewage, and that two years ago. *The pressures of population and the requirements of improved health in a developing country will require a much more rapid implementation of effective waste disposal than took place in the developed countries, and at a much larger scale. It is unlikely that the systems that were appropriate to the rather small populations of the resource-wealthy industrialized countries of northern*

Europe in the nineteenth century will be successful in solving the formidable problems of a much poorer, and much more populous, developing country. A World Health Organization survey published in 1976 (Anon, 165) indicates that whereas in 1970 27% of the urban population in developing countries had sewerage connections, in 1975 this figure had actually *declined* to 25%. More serious even is the fact that another 25% has no access to any sanitary facility at all. It would not be an exaggeration to say that for many of the developing countries a crisis has been reached.

The question remains, what are the options currently available to a developing country with regard to waste disposal?

The systematic study of waste disposal is recent, and it would be premature to present it as a science. There are branches in which much pragmatic engineering knowledge exists, such as the design of sewer networks and treatment plants. Recently much scientific study has taken place on the reclamation of sewage effluents for irrigation and agriculture. On the other hand, the most widely used method of disposal, the pit latrine, has been very little studied, and particularly in the rural areas, is based on a combination of rules-of-thumb and folk tradition. A technology review of waste disposal finds itself dealing alternatively with craft, engineering and science, and a scientific classification of this material would be misleading.

This study is based on an exhaustive examination of technical literature from developing and developed countries. This literature is presented in abstracted form in the bibliography that follows. However, it was felt that this review should go further than a mere summary or checklist, and should address itself to three key questions that permeate any discussion of appropriate waste disposal for developing countries.

1. *What are the dry options for excreta disposal in hot climates?*
2. *What are the techniques for reusing human waste.*
3. *In view of the above, what are the waste disposal/reuse options for cities and towns in a developing country?*

QUESTION 1: WHAT ARE THE DRY OPTIONS FOR EXCRETA DISPOSAL IN HOT CLIMATES?

It has already been pointed out that one of the major differences between conditions in a developing country today, and those in the industrial countries in the mid-nineteenth century, is the fact that whereas sewers were a solution to a wastewater problem, only 13% of the population of the underdeveloped countries actually has piped water in house connections (Anon, 165). Even if United Nations goals for the Second Development Decade are met, the majority of people at that time will still have either no access to safe water, or access only to a public standpipe.

This means that, for the moment at least, the main problem of the majority of the population, which is not served by piped water, is not wastewater disposal, but excreta disposal.

The distinction between sewage or wastewater, and excreta, is critical. Too often the emphasis has been put on "sewage treatment for developing countries", in spite of the fact that only six and a half per cent of the population of developing countries are connected to sewers. A search for appropriate options must recognize that the majority of the population produce very small quantities of wastewater, unlike their counterparts in the industrial countries. The technological options differ accordingly.

One of the differences is that dry excreta disposal techniques once again play a role as one of the key options.

PIT LATRINE

The *pit latrine* remains to date the most widely used technique for excreta disposal in the underdeveloped countries, in the urban as well as the rural areas. In the villages, where defacation often takes place "in the fields", when faecally-transmitted diseases are linked to this practice it is the pit latrine which represents the first rung of the sanitation ladder. In spite of its apparent simplicity, the adoption of this technology has met with mixed success. A Tanzanian study (Muhondwa, 010) points out that although the peasant's reluctance to build and use pit latrines is often assumed to be the result of lack of education and restrictive tradition, there are also technical reasons for the failure of many rural latrine programs. Pit latrines were often built, following official direction, in poor soil, with inevitable cave-ins. Consequently many people, particularly children, were discouraged from using the latrine, which largely obviated their usefullness. On the whole it was found that there was little reluctance to build the pit latrine in the first place, but many cases where latrines were abandoned following the departure of the program officials from the village. This had much to do with the smell, flies and uncleanliness associated with pit latrines. The fact is that open-pit latrines, private as well as communal, are often unpleasant and unhealthy places. This has been the experience in a number of countries where pit latrines have formed the basis for rural sanitation (Shelat & Mansuri, 038).

It should not be concluded from this that pit latrines are an inappropriate technique that is doomed to failure. *There is no doubt that the pit latrine remains one of the few technologies affordable by the rural population.* However much work needs to be done to improve the functioning of this "simple" device. A project in Botswana reports considerable success with rural pit latrines as a result of improvements such as: sturdier construction and reinforcement of the pit, larger pits, and most importantly, ventilation pipes and hole covers (Blackmore et al, 051). It should be mentioned here that the *bored-hole latrine,* which is of small diameter and can be drilled by mechanical auger, and has had widespread use because of adaptability to economic and large-scale implementation, seems to be an unsatisfactory solution. The deep pit often intercepts the water table, and has in any case too small a volume (Wagner & Lanoix, 041).

The operational difficulties, and very real health hazards, of many pit latrines are a result of the open nature of the pit which allows free access to flies and mosquitoes which in turn can transmit disease over a fairly wide area, and which permits odours to enter the privy enclosure. The interface between user and the decomposing material, usually a squatting plate, requires close attention as regards design and choice of materials.

A simple device that has been developed in the developing countries and which will improve considerably the environmental and hygenic conditions of the pit privy is the *pour-flush latrine,* or *water-seal squatting plate* (Anon, 005). A plan at the lower portion of the chute maintains a water-seal, and a small quantity of water, usually about one litre, is required to "flush" the contents into the pit. The water-seal arrests the passage of both flies and odours. It is widely used in Southeast Africa, where it is known as the Chiengmai squatting plate (Wagner & Lanoix, 041). It has been reported that the Chiengmai can become obnoxious, not only as a result of blockage, but also because the simple requirement of manual flushing can so easily be neglected, resulting in a building-up of faecal matter exposed to the air (Morgan, 009).

A recent improvement of the pour-flush water-seal has been developed in Rhodesia (Morgan, 009). It consists of a chute and a pan, similar to the Chiengmai, except that the pan is swivelled and counterweighted. The weight of the excreta tilts the contents of the pan into the pit, and a simple valve refills the pan with water, from a nearby storage tank. The reported water consumption is about one litre per visit, and the advantage of the system is that it is resistant to blockage, and operates automatically.

The form of the Asian pour-flush latrine is the squatting plate, based on the indigenous defaecating position. However there are examples of seat-type pour-flush latrines in other cultures. A Colombian model is specifically designed to improve pit latrines and is hand flushed with 3 litres of water.

One latrine design which attempts to overcome some of the operational drawbacks of the pit latrine, while maintaining the undoubted cost advantage, is the *Reid's Odourless Earth Closet,* developed in South Africa in the 1940's (Anon, 016). It consists of an extremely large pit (1m X 2m X 3m deep) covered by a cement slab. The squatting plate, instead of being in the slab, is located to one side and connected to the pit by a sloping chute. A

vent pipe is located in the slab, and so placed that air is drawn down the toilet chute and up the pipe. It is important that construction of the pit is air-tight. It is reported that not only is the R.O.E.C. odourless, but also free from flies, since the darker environment of the pit discourages breeding (Blackmore et al, 051).

One of the factors that may explain the success of the R.O.E.C. is the large volume of the pit, which gives greater surface area for infiltration, extends the life of the pit (reportedly up to twenty years) and probably creates a more stable biological environment than small pits. Experiments are now being carried on in Tanzania with watertight lined pits, in effect, mouldering toilets, which would have to be emptied at long intervals (Eygelaar, 054).

A distinction should be made, at this point, between "septic pits" which receive water in addition to excreta, and "dry pits" to which only faeces and urine are added. It has been observed that the digestion of solids is more rapid and more complete in septic pits than in dry pits, which increases the life of the pit privy by a factor of almost two (Wagner & Lanoix, 041). However this advantage must be weighed against the fact that the septic pit pollutes the sub-soil to a greater distance than the dry pit. Early research on pit latrines in the United States (Caldwell, 024) showed that the presence of water significantly increased the distance that coliform organisms travelled from the pit, whereas a dry pit in sandy soil contaminated a distance around the pit of only one foot.

Where there is a relatively high water table it is clear that a dry pit will reduce the danger of soil contamination. The choice would have to be made between completely dry latrines with hole-covers, R.O.E.C. type latrines which require occasional water to clean the sloping chute, and various water-seal latrines which require from one to three litres per use. The question of dry versus septic pits has particular implications for regions where ablution is the traditional, or religously prescribed, form of anal cleansing.

There is no arbitrary rule governing the density of construction for pit latrines, nor their location with respect to sources of water supply. The work of Baars (023) confirmed the earlier observations of Caldwell (024) that as the soil around the pit becomes saturated with fine faecal particles and aggregates of colloids and organisms, the flow is retarded through this "filter" and the death rate of faecal organisms increases. This lead Wagner and Lanoix (041) to write that "In homogeneous soils the chance of ground-water pollution is virtually nil if the bottom of the latrine is more than 1.5m above the ground-water table." This is particularly true with regard to the dry pit.

It should be emphasized that the success of pit latrines *even in higher density areas,* is mainly a function of homogeneous sandy soils, a low water table, and limited water input. A water supply pipe that passes in the vicinity of the pit can be contaminated in the same fashion as the water-table,

particularly in cases where water pressure varies (Hennessy et al, 133), which is the case in most underdeveloped countries.

VAULTS

One method for preventing soil pollution and ground water contamination is to line the pit with a watertight material, that is, to turn the pit into a vault. At this point there are two alternatives that hinge, once again, on the question of wet versus dry. If no water is added to the vault, or only enough to make the water-seal function, the contents may be removed and disposed of elsewhere. When dry the contents are removed by bucket or cart, when semi-dry by vacuum truck. These methods are described in the section on NIGHTSOIL COLLECTION, and are referred to variously as *pail or bucket system, conservancy system* or *vacuum truck and vault.* They clearly qualify as dry excreta disposal options.

The other alternative, the wet vault, is out of place in this chapter, but needs some description as it is often proposed as a solution to developing country sanitation. The wet vault has two common forms, the *septic tank* and the *aqua-privy.*

The septic tank, which has found very wide application particularly in the United States, consists of a compartmentalized vault within which settlement and some liquefaction of the solids will take place, and a subterranean tile or leaching field where most of the biological treatment of the septic tank effluent occurs. All of the household wastewater goes into the tank in addition to the excreta and flushing water. The costs of septic tank installation, as well as periodic de-sludging, make them completely inappropriate for the rural population of a developing country. The extensive area required for the infiltration field severely limit their application to urban areas. There are indications that in urban areas septic tanks will often cost more on a per household basis than conventional water-borne sewerage (McGarry, 139).

The aqua-privy is a modified septic tank and was first built by Griffin and Williams in Darjeeling in 1917, an adaptation of the early American cylindrical septic tank (Williams, 407). A vertical drop pipe extends from the toilet bowl or squatting hole to just below the water surface within the tank. The tank is charged with water at the outset, and then water is added in sufficient quantities to maintain this water-seal. Household wastewater (greywater) is not usually disposed of in the aqua-privy. Solids sink to the bottom, and the effluent is carried to a leaching field for infiltration into the soil. The tank must be de-sludged periodically. If not enough water is added to the aqua-privy, the water-seal ceases to function and flies and odours enter the house (Wagner & Lanoix, 041). Success with the aqua-privy has been varied. There are positive reports from Nigeria (Oluwande, 109) and the British West Indies (Sebastian & Buchanan, 117), but on the other hand Botswana recently issued a ban on aqua-privies, so unhygenic had they become (Anon, 079). It is difficult to see the advantages of a system that suffers the same limitations as pit latrines as regards soil infiltration and disposal of household wastewaters, at a considerably higher cost.

MOULDERING PRIVIES

A word should be added here with respect to nomenclature. Scientific composting refers to a highly rationalized process which is taking place under controlled conditions, both with regard to ingredients and aeration. It is clear that in a household "compost" privy, though decomposition does take place, neither the ingredients nor the aeration is controlled. It has been suggested that to avoid misunderstanding, they should be referred to as *"mouldering privies"*, which more properly describes the long-term decaying process.

One of the first examples of the dry vault, the *double compartment concrete vault* originated in the United States in military camps in 1917 (Hardenbergh, 028). It consisted of two watertight compartments large enough to provide storage for the wastes of the average family for six months. When one compartment was full it was closed, and the other put into use. It was thought that following the six month period a dry, inodourous substance free from pathogenic bacteria would result. Unfortunately the principles of composting were elaborated only a decade later. Proper composting requires that a Carbon/Nitrogen balance of about 15:1 be maintained. Human excreta does not initially have a favorable C/N ratio and contains large amounts of Nitrogen. To regain the balance either Carbon must be added, or Nitrogen reduced. The former implies adding cellulose materials such as leaves or grass, the latter implies reducing the urine input. Since neither of these things was done in the case of the double compartment concrete vault, the excreta turned septic and liquefied, resulting in strong odours and difficulty in removing the contents. The system was not a success.

The *double-vault latrine* described by Wagner and Lanoix (041) and also referred to as a compost privy, is similar in appearance to the earlier American version, but its operation differs, being an adaptation of the Bangalore process invented by Howard in the 1930's (Gray et al, 245). The compartments are larger, and grass-clippings, food scraps, leaves and animal wastes are added to the human excreta. This mixture initially undergoes aerobic and then anaerobic decomposition for a period of six months.

The anaerobic compost privy merits only three laconic pages in the standard World Health Organization monograph on rural excreta disposal, in spite of its obvious advantages. Some years earlier, in 1956, the Democratic Republic of Vietnam initiated a Five Year Plan of rural hygiene based on three installations: the well with a curb, the bathroom, and the double septic tank. It is the latter which is of interest here.

"The *double septic tank for on-the-spot composting of the excreta* (such is its full name) has two watertight tanks serving by turns as recepticles for defaecation and composting. A hole is made on the face of each, together with a groove to channel urine into a separate vessel, while another aperture is made in the back wall for the collection of the waste after composting. The bottom of the tanks, often paved, should be higher than

ground level so as not to be submerged by rainwater. Before a tank is used, its bottom must be covered with a layer of powdered earth. After use the faeces are covered with kitchen ashes which absorb moisture and deodourize them. Then the hole is covered with a lid which is usually fitted with a long handle. When the tank is two thirds filled its contents are levelled with a stick before it is filled to the brim with dried powdered earth. Then all openings are tightly closed to create an anaerobic space. Anaerobic composting has now been practiced for some years in place of the aerobic process." (McMichael, 060).

The double septic tank for on-the-spot composting originated in South Vietnam in the 1950's when peasants who were using human excreta as manure found that composting reduced the smell and improved its fertilizer value. This became the key component of a rural sanitation program for disease prevention and increased food production begun in North Vietnam in 1956. After much experimentation it was found that the addition of kitchen ashes effectively neutralized the bad odours normally associated with anaerobic composting, and also affected the destruction of intestinal worm ova - after a two month composting period 85% of the ova were found to be destroyed (Anon, 046). The anerobic composting also played an important role in converting the organic nitrogens to a more useful (for the plants) inorganic state.

There are also reports (McMichael, 060) that at present in North Vietnam there is one double septic tank for each 1.4 rural households. They produce the equivalent to 2.3 million tons of protein sulfate (Anon, 046). The DRV experience illustrates the principle that the success of rural sanitation lies in the adoption of waste re-use systems *with obvious benefits to the villager.*

Whether the double septic tank has implications for urban sanitation remains to be seen, though there are reports that it is used in peripheral areas of Hanoi (Anon, 046). It is important to note the advantages of anaerobic composting: the C/N ratio is maintained by eliminating urine and no other organic material need be added to the excreta, hence the vault is quite small - 1.7m long x 1.2m wide x 0.7 m high, for 5-10 persons. The essentially dry condition within means that a variety of indigenous materials can be used to build the toilet, which is usually above ground to prevent flooding. Earth, lime mortar, clay, raw bricks, bamboo as well as concrete or brick are used (Anon, 046) as local conditions dictate.

A system has been proposed which is similar to the Vietnamese double septic tank, but which accepts urine as well (Nimpuno, 063). The C/N is maintained by the addition of organic wastes and the vault is kept dry by providing a perforated bottom. A triple layer of coarse sand and charcoal, crushed limestone and ashes and leaves and coarse sand is placed over the bottom and acts as a filter, neutrilizing the urine, which passes into a soakage pit filled with gravel, below the vaults. Smell is reduced by providing a ventilation pipe. The anaerobic decomposition is allowed to take several months, in which time the adjoining vault is used. No field data are reported on this system.

The main feature of aerobic, as opposed to anaerobic, composting is that the introduction of oxygen promotes rapid decomposition and generates sufficiently high temperatures (50° - 60°C) to destroy the pathogens. The most common method of introducing air when composting vegetable or animal wastes is to manually or mechanically turn the pile. Since this would expose fresh excreta to the air, it was not considered a suitable method for composting human wastes, and it is for this reason that the early mouldering privies were anaerobic.

The original aerobic household composting system, often referred to as the *"multrum"* was invented by a Swedish engineer (Lindstrom, 059) and put into commercial production in 1964. The multrum consists of a watertight container with a sloping bottom. Human excreta (no flushing water) is introduced at the upper end of the container, and mixes with organic kitchen and garden wastes, which are introduced lower down. Air ducts and a vent pipe are provided to promote aeration, and the decomposed material moves towards the low end, from whence it is periodically removed. The decomposition period is long, up to four years, and the container quite large (1m x 1m x 3m long). The main innovations of the multrum are, first of all, the system of ducts and pipes that evaporates much of the humidity and, like the R.O.E.C. eliminates odours, and second the sloping bottom, that permits continuous use of a single container by separating the fresh and the decomposed material.

There are a variety of aerobic mouldering toilets on the commercial market, mainly in Sweden (Anon, 049) and more recently in Canada and the United States. The possibility of adapting this technology, which had been designed for use by an affluent society in temperate regions, to the needs of the poor in the developing countries, particularly in the *urban* areas, was first proposed by Danish architects (Winblad, 077) in 1970, and later elaborated by Winblad (076) and Rybczynski and Ortega (066). Though as yet untried on a large scale, these type of toilets offer enough tangible advantages to merit serious study. The toilet accepts all urine, and, being water-tight, can be built both where there is high water-table, and dense population. Operation is fairly simple as a single container is used, and fresh excreta is not handled. Rural and urban experiments with multrums in Tanzania have indicated that "the majority of users seem to adapt easily to the simple, but essential, special requirements, such as: sparing use of water when cleaning; adding sweepings and grass for the composting process; adding ashes to neutralize acidity" (Ejgelaar, 054). Another experiment is reported from Manila (Rybczynski, 068) where a number of multrums were built in a dense urban area to establish costs and ease of construction.

NIGHTSOIL COLLECTION

The collection and removal of nightsoil has been practiced for centuries, particularly in those areas where it finds reuse in agriculture (Clemesha, 090). The most primitive version of this practice is referred to as the

bucket latrine. The excreta (which may or may not include urine) are deposited directly into a container which is periodically removed for disposal. This system is widely practiced in many African and Asian cities (Anon, 132) (Anon, 129) and has the great advantage of minimal capital outlay on the part of the user and the municipality. However, as usually practiced in the developing countries it is an unhygenic and offensive procedure, that is detrimental both to environmental and health conditions. With more sophisticated technology, specially designed buckets and trucks, the system can be relatively inoffensive and hygenic, as is evidenced by its current use in Sydney, Australia and Oslo, Norway. However these improvements significantly raise the operating cost, and there are indications that at that point other systems, such as the vacuum truck and vault, may be cheaper (McGarry, 139).

The limitations to the bucket latrine include the frequent collection visits required to empty the small container of nightsoil, as well as the difficulty of restricting the passage of flies and odours from the bucket. These have been overcome in the *vault and vacuum truck system* by the use of large watertight household vaults in which the excreta is collected. The contents of the vault are pumped out every two to four weeks or longer by a vacuum truck. Smaller version vacuum carts have also been proposed using hand operated pumps (McGarry, 334). The vacuum truck and vault system is widely used in Japan (Anon, 126) and Taiwan (Thomas, 145) and in Tokyo, Taipei and Tainan it accounts for the majority of the waste disposal services to the population. There is however, much room for upgrading these systems, which have grown up spontaneously over a long period of time, and do not always have water-seal toilets or vaults properly constructed to be insect and rodent proof.

The truck collection of human wastes has many advantages - the capital outlay is low (about a third that for sewers), it is labour intensive, and when properly operated, has been shown to provide a high level of service. Studies have been made of the long term economic implications of truck collection based on an existing situation (McGarry, 138). A cost comparison has been made between nightsoil removal and the use of waterborne sewerage provided with secondary wastewater treatment. The municipality of Tainan, Taiwan estimates its nightsoil collection costs to be equivalent to $M 4.35 per capita computed on an annual basis, and taking into account pasteurization costs as well as a market value for the treated nightsoil. The cost of waterborne sewerage, computed on an annual basis (8% interest and 15 year repayment period) and including operation and sewage treatment by oxidation ponds, would be equivalent to $M 22.75 per capita. The implications of this study, even in such a crude form, are obvious.

NIGHTSOIL TREATMENT

Whether nightsoil is collected by bucket, cart or vacuum truck it must be disposed of hygenically. This usually implies some form of biological treatment. The most primitive, and least satisfactory technique is burial in the ground, which is not only offensive but exposes the fresh excreta to flies and ground runoff (Anon, 129).

There are two alternatives to the expensive activated sludge treatment of nightsoil that is practiced in Japan, (Ikeda, 278) Korea and Taiwan (Anon, 272) which are more appropriate to most developing countries: the faculative stabilization pond, and composting.

"Waste *stabilization ponds* are shallow rectangular lakes in which raw (or screened) sewage is treated by natural processes based on the activities of both algae and bacteria. They are without doubt the most important effective method of sewage treatment in hot climates - not only are they the least expensive but they are considerably more efficient in destroying pathogenic bacteria and the ova of intestinal parasites (Mara, 207)." The technology of stabilization ponds is well understood (Gloyna, 195), and this method of sewage treatment has been widely used in the United States as well as in Latin America (Talboys, 232) and Africa (Stander & Meiring, 229).

Though stabilization ponds have traditionally been used for the treatment of waterborne sewage there is no reason why they could not be used also for the treatment of nightsoil collected by vacuum truck. There is not a great deal of work reported in this area but Shaw (226) reports the effective treatment of nightsoil in a stabilization pond using similar loading as a sewage pond, and adding sufficient water to maintain pond depth at 1.2m.

Stabilization ponds for nightsoil treatment could also treat sewage, or could be specially designed to treat nightsoil and sludges from cesspools and aqua-privies, with the possibility of future expansion or conversion to sewage treatment.

The main drawback to stabilization ponds is the relatively large land area required, which, even when available in urban areas implies high cost. The possibility of offsetting this cost through the reuse of pond effluents for irrigation, or the combination of ponds with aqua-culture or algal recovery, is dealt with in *Question 2*. A second factor could also play a role in offsetting high land costs. The purchase of large land tracts for stabilization ponds could be considered as an investment by the municipality. This land need not be considered for this use indefinitely, and at some future date could be converted easily to commercial or housing use. This might happen in the case of sewer extension and relocation of ponds to a peripheral site. The accrued value of the land could be used to offset sewerage construction costs at that time.

Since the assembly of large tracts of land is usually difficult in urban situations, it would be worth investigating "mini stabilization ponds" serving clusters of housing. Pond requirements are a minimum of $1.3m^2$ per capita so that 10m x 10m ponds could serve up to 90 persons. Successful pond operation would require operation by the municipal body.

The *composting* of nightsoil has been reported in China (Anon, 240) as part of a rural health program in the province of Shantung. Faeces and urine are separated immediately at the squatting plate by means of a "urine drain", and collected separately, often in clay pots whose contents are

collected and transported to the composting site, a centralized location on the outskirts of the village. The separation of the faeces and urine prevents the former from turning septic and simplifies collection. Two kinds of composting are used: pit composting where air is channeled through trenches at the bottom of the pit, and pile composting where air is introduced into holes made by the removal of sticks. The ingredients of the compost are, equally by weight, human excrement and urine, animal faeces, organic rubbish and soil. Humidity is reported to be between 30% and 50%, depending on the time of year. The pile is covered by an earth-mud mixture and left for 20 to 30 days. This cover not only overcomes problems of flies and odours, but also prevents loss of heat. The composted material is used in agriculture.

Anaerobic composting is practiced on a communal basis in India, where it is known as the Bangalore process (Gotaas, 244). City refuse is mixed with nightsoil and high levels of pathogen destruction are reported (Bhaskaran et al, 241).

Composting of both sewage sludge and raw sewage is reported in the United States (Wilson & Walker, 253). The methods used are either the "wind-row" technique, or the forced aeration method. The former requires turning the pile at specified intervals, usually done by specially designed machines. The forced aeration method relies on mechanically induced air movement through the pile, and bears some resemblance to the Chinese method. Dry material, organic waste, sawdust, wood-chips, are usually added to the sewage to bulk the material and prevent clogging during the aeration process.

A third less common technique for treating nightsoil has been reported from China (Anon, 081) (Bradley, 087) which consists in anaerobic digestion of nightsoil with small quantities of water. A household sized plant, called a "two-partition three-tank" system is a variation of the septic tank, except that biological treatment takes place inside the three tanks, which have a retention period of 10, 10 and 30 days respectively. About 2 litres of water per capita are added daily. Complete pathogen destruction is reported in the third tank. There is no tile or seepage field.

GREYWATER

It should be noted that dry excreta disposal systems, whether pit latrines, mouldering privies or vacuum truck and vault, or even wet systems such as aqua-privies, do not dispose of household wastewater, usually referred to as *sullage* or *greywater*. In the rural areas greywater is simply disposed of around the house and allowed to soak into the ground. In the typical urban area greywater is disposed of in street drains or storm sewers. The common practice in Tokyo, where vaults are used is to dispose of greywater into the storm drain (Anon, 126), in the Kampungs in Jarkarta, greywater is carried in paved surface drains which are periodically cleaned by maintenance crews (Anon, 019). Similar means are practiced for greywater disposal throughout the developing world.

It is clear that a trade-off must be made between the beneficial effects of improved excreta disposal for large numbers of people, and the environmental effects of using storm drains, surface or underground, to transport kitchen and washing water.

Studies of Greywater in Sweden (Olsson et al, 447) and in the United States (Siegrist et al, 449) indicate that the share of total phosphorous in greywater is high, due mainly to automatic dishwashers and clothes-washers. Though there is no comparable study of greywater characteristics in a developing country there is data on "hard" detergents, ABS (Alkyl Benzyne Sulphonate), found in municipal sewage. The ABS level in Haifa sewage is reported to be as high as 17 mg/l (Hepher & Schroeder, 365) whereas an Indian study reports a range of 0.08 mg/l for Calcutta, to 1.64 mg/l for Kanpur (Siddiqui, 179). A similar study (Bajaj et al, 304) reports phosphorous levels in Indian sewage that are up to ten times lower than those in the Swedish study (Olsson et al, 447).

Another factor to be kept in mind is the quantity of greywater that is produced. Greywater production in wastern countries varies from 60 litres (Olsson et al, 447) to 120 litres (Siegrist et al, 449) per person per day. The World Bank estimates domestic water consumption in a developing country to be between 20-50 litres per person per day, depending on whether water is available from a standpipe or a house connection. Allowing for losses, this implies a greywater production of probably 15-40 litres per person per day.

There were indications in the Swedish and American studies that greywaters share of faecal coliforms, though much lower than that of sewage, was nevertheless sufficiently high to warrant further investigation. The major source of the coliform bacteria was found to be clothes washing (Siegrist et al, 449). Neither study attempted to identify any specific viruses in the greywater.

The data on greywater is slim indeed. Nevertheless particular care should be taken when applying the results of research from an industrialized country to conditions in a developing one.

QUESTION 2: WHAT ARE THE TECHNIQUES FOR REUSING HUMAN WASTE?

Recycling, or reuse, of resources is widely practiced in the developing countries. This is not done for reasons of environmental control, as in the West, but out of dire necessity. The point has already been made that the developing country is in most cases less well-endowed with natural resources than were the presently developed countries when they started development. When one adds to this the pressures of a population explosion, the developing country faces a situation were meagre resources must be stretched a long way indeed. Nowhere is this more true than in agriculture, where land which has in many cases been farmed for centuries must produce even higher output, and this in spite of adverse climatic extremes such as aridity, or flooding.

The difference in attitude towards the idea of reusing human waste is particularly marked in Asia, where for a long time a large population has supported itself on rather small areas of arable land. Two examples show that human excreta is treated not only as a resource, but as a *valuable* resource.

It is reported that in China during the "Accumulative Fertilizer" campaign that took place in the mid-fifties, the ownership of nightsoil became a great point of controversy. "One commodity was central to the controversy and was of peculiarly private nature, this was nightsoil which was sometimes expropriated at abnormally low prices, payable at a future date by the collective organization. There was a tendency for farmers to withhold the nightsoil they produced for use on their own private plots. At the peak of the fertilizer campaign exhortation was so great as to give rise to the extreme example of houses being torn down to capture the fertilizer value of the earthen walls, (McGarry, 402)." In the event the "nightsoil question" led to a relaxation of regulations and a decentralization of authority.

The area surrounding the city of Tainan in Taiwan is well known for its fish, which are farmed from over 6000 hectares of fish ponds. Nightsoil is used to fertilize the ponds, and the municipality of Tainan, which operates a conservancy system, sells the nightsoil to the fish farmers in the area, in some cases up to 40 km away. Such is the demand for this commodity that in fact a *black market* for nightsoil is reported to exist. This is of some annoyance to the municipality, which counts on nightsoil sales to offset collection costs (McGarry, 334).

The question of human waste reuse is divided into the following sections: fertilization with treated and untreated nightsoil, irrigation with sewage and stabilization pond effluents, fertilization of fish ponds with nightsoil and fish production in stabilization ponds, algae production in high rate ponds, treatment with aquatic weeds, and the production of biogas using anaerobic digestion.

FERTILIZATION

It is often stated that human excreta is 99% water, but it is the one per cent that is left over which is of interest here. Nightsoil contains the three main plant nutrients Nitrogen (0.6%), Phosphorous (0.2%) and Potassium (0.3%) (McGarry, 402) and the most widespread reuse of human wastes, now as in the past, is direct fertilization of crops with nightsoil (Williams, 407). This technique is practiced by farmers throughout Southeast Asia, but particularly in Korea, China and Taiwan, and to a lesser extent in Thailand, the Philippines, Indonesia and Malaysia. The reader ought to be reminded that these countries account for fully half of the population of what are generally called "developing countries". The use of fresh nightsoil as pig-feed is the common rural practice in virtually *all* South Asian countries, including India.

The point being made here is not that the use of untreated nightsoil is desirable from a health point of view, but that any "improvements" in the present situation must recognize the vital role that nightsoil reuse plays in the rural economy of many developing countries.

There are some reports of treatment of nightsoil before reuse, notably in China. One practice, which has already been mentioned is the composting of nightsoil mixed with animal manure, organic rubbish and soil (Anon, 240). Another form of treatment is sedimentation and digestion in a modified septic tank, which is reported to achieve complete destruction of hookworm and schistosoma (Anon, 081). Anaerobic composting is reported in India (Bhaskaran et al, 241) and in North Vietnam (Anon, 046) and in the latter case seems to be practiced on a wide scale.

The humus value of nightsoil is as significant as the nutrient properties, so much so that in Korea and Japan, where chemical fertilizers have largely replaced nightsoil fertilizer, quantities of the latter are still added to the fertilizer to improve soil properties.

Unfortunately there has been little scientific work done on the use of fresh nightsoil as fertilizer. There are many unanswered questions with regard to improved agricultural practices and crop types as well as *simple* techniques for treating nightsoil to reduce health hazard. The current attitude of condemnation of this practice without offering any alternatives or improvements has tended to discourage investigation in this field, and is undoubtedly one of the main reasons for the very slow rate at which rural sanitation is improving in most of the developing countries.

IRRIGATION

Any discussion of irrigation with wastewater in less-developed countries must be preceded by an important caveat. Though a great deal of literature exists on irrigation with sewage, treated sewage or stabilization pond effluents the fact still remains that *only 6½% of the population of the developing countries has access to a sewerage system (Anon, 165)* hence the reuse of sewage, though it may have important implications, inevitably skirts the

main issue. The fact that so much scientific work has been done on wastewater irrigation in many of the developing countries is more a reflection of western-influenced engineering education than of a real need.

Nevertheless, stabilization ponds can be used to treat nightsoil, and for centre city locations sewerage remains one of the few effective options. Since the sewerage option has been chosen already in a number of cities a discussion of wastewater irrigation can still be useful, even if its application is marginal.

The widest use of sewage for irrigation in a developing country is in India, where *untreated sewage* is used directly on the soil. It is reported that almost a third of the sewage produced by about 35 million people (7% of the total population) is utilized for irrigation (Shende, 343). Studies have been made of wastewater characteristics (Bajaj et al, 304), and results show that in general the Biological Oxygen Demand and solids concentration are higher than in Western sewage, due mainly to lower per capita water use (Siddiqui, 179). The nutrient value of wastewater, as of nightsoil, is considerable. Total nitrogen ranges from 25-70 mg/l, phosphates from 7-20 mg/l and potash from 12-30 mg/l, in addition putrescible organic matter ranges from 300-1,000 mg/l and, on decomposition, forms a valuable humus addition to the soil (Shende, 343). It is reported that untreated diluted sewage is used to irrigate forage and pasture grasses and sugarcane (Sivanappan, 347), but root vegetables or leafy low vegetables are not recommended to be grown with raw sewage (Anon, 298). Dilution with water is necessary mainly due to the high initial BOD, but it has been suggested that controlled dilution could be geared to different crops and varying soils (Bishnoi, 307). Sewage farming, as it is known in India, is generally practiced under organized conditions and on a specific range of crops, in order to reduce health hazard to workers, as well as to consumers in the case of edible crops (Kotia, 327).

There are three hazards associated with using untreated sewage directly in irrigation. The danger of transmitting diseases into the food chain. The health hazards of handling untreated sewage in the irrigation process. The possible damage to the soil through salinity and alkalinity development. Some preliminary work in Israel in drip irrigation with untreated sewage of leafy vegetables has yielded surprising results (Goldberg, 324) that indicate that more investigation needs to be done in the use of untreated sewage for irrigation. Cucumbers were grown, in one case in fumigated soil and protected from the sewage by a plastic mulch, and in the other case in direct contact with the untreated sewage effluent. The unexpected result was that in *both* cases there was no difference in bacterial and virus counts, which were relatively low. A second experiment induced an artificial epidemic, and in this case the cucumbers protected by the plastic mulch yielded a safe crop. Once again, as with nightsoil reuse for fertilization, research must be done on techniques and crop types that are appropriate for irrigation with untreated sewage.

The use of treated sewage, or effluent, in irrigation is well-known in the West, but much less practiced in the developing countries, since to the considerable cost of sewerage must be added the not inconsiderable cost of sewage treatment. For the purpose of this section it will be assumed that when treated sewage is used for irrigation in a developing country it will be stabilization pond effluent.

Stabilization ponds are generally considered as the most appropriate method of waste treatment for tropical climates, and are well described by Gloyna (195) and Mara (207). The use of stabilization pond effluent has agricultural, sanitation and environmental benefits, and considerable work has been done in many countries on this and on the general subject of irrigation with sewage effluent (Law, 333). One of the key questions which has been the subject of much research has been the survival of pathogens and viruses in sewage effluent, and their effect on the crops being irrigated. It is now generally accepted that stabilization pond effluents contain both undestroyed coliform bacteria and enteroviruses. Coliform counts may be reduced by chlorination (Shuval, 345) (Kott, 329) although enteroviruses seem to be a more severe problem (Larkin et al, 332), and heavy and long chlorination is required to achieve the same degree of disinfection for poliovirus as is required for coliforms (Shuval, 345). In a review of the subject Shuval (406) concludes that most conventional treatment processes, such as stabilization ponds, cannot completely destroy pathogens and that there is evidence that pathogens may survive long enough in the fields to infect potential consumers of those vegetable crops eaten raw and though total destruction is possible with advanced treatment is is unlikely that most developing countries could technologically or economically afford these. However, "A balanced approach combining low-cost waste treatment methods capable of providing reasonable, although not complete, reductions in pathogen levels with restriction of crops to those presenting a low level of public health risk appears to be the most prudent policy to achieve the maximum social benefits from waste reuse (Shuval, 406)."

An interesting possibility for irrigation with stabilization pond effluents is the growing of non-food crops, thus eliminating the health hazard altogether. There are reports of sugarcane, tobacco, cotton and oil-bearing plants irrigated with effluent (Kotia, 327). Tree plantations have also been irrigated with sewage effluent in the United States (Sutherland et al, 349) and Canada (Gagnon, 320), and irrigation of coconut trees with stabilization pond effluent is reported in Madras.

Practically all methods of irrigation with water can be adapted to use with treated or untreated wastewater irrigation. One of the most common in South Asia is the *furrow method* in which the wastewater is channeled along ditches beside the growing area (Sivanappan, 347). *Wild flooding* of tracts of land is often practiced where large amounts of wastewater are to be disposed of, though studies in India have shown high levels of helminthic infection among farmers engaged in such practices (Sastry, 404). *Sprinkler irrigation* is much in favour in the United States though there are

indications that dispersion of aerosolized enteric bacteria may be considerable (Katzenelson & Teltch, 326) (Shtarkas & Krasil'shchikov, 344), in any case the low level of water-use efficiency as well as the high capital cost make this an inappropriate technique for most developing countries. Sub-irrigation, particularly by *drip-irrigation* has many advantages with regard to low water use, increased yield, direct application to the root system and lower possibility of contamination (Romanenko, 339), though these would have to be balanced against higher capital cost.

Work has recently been done in the United States on the accumulation of heavy metals in soils and crops from extended wastewater irrigation (Sidle et al, 346) (Dowdy & Larson, 313) (Giordano et al, 323). Cadmium, copper, zinc and lead are likely to be present in sewage coming from cities with industrial areas. Cadmium, nickel and zinc are potentially the most harmful to crops (Trout et al, 351). The heavy metal hazard is a particular factor when land applying settled or digested sludges, though not enough work has been done to date on specific crops and soil types. The question of salinity build-up in the soil, particularly sodium and boron, depends heavily on soil type, crops, water-table and climate and like nitrogen build-up can only be determined on a case by case basis. This applies to treated and untreated sewage.

AQUACULTURE

Cultured fish are a major source of animal protein in China, Japan, Taiwan, Indonesia, the Philippines, Hong Kong and Malaysia and fish culture is also practiced in India, Sri Lanka, Thailand, Bangladesh and Pakistan. The most common method of fertilizing these fish ponds is to use organic manures (Prowse, 372) which include human as well as animal wastes. There are basically two techniques for reusing human wastes in aquaculture, either by the fertilization of fishponds with fresh nightsoil, or by rearing fish in waste stabilization ponds. It is no surprise to find that most scientific investigation has concerned itself with the latter, in spite of its marginal nature, and has largely ignored the popular practice of fish pond fertilization with nightsoil.

Throughout Southeast Asia where nightsoil is added to fish ponds the accent is on fish production rather than waste treatment. Six thousand hectares of fish ponds are fertilized with nightsoil collected in the city of Tainan (McGarry, 334), in Calcutta sewage is diverted into the fish ponds (Prowse, 372) and in the many domestic installations latrines are actually built out over the pond (Prowse, 372). It is estimated that there are about 425,000 hectares of ponds in the region (Tapiador, 377).

The nightsoil fed fish pond demonstrates the perfect reuse cycle. The consumer produces nightsoil which is introduced to the fish pond and provides the main source of nutrients for bacterial growth. The byproduct from this process are the primary nutrients for the algae, which in turn are the basic food form for the fish, which in their turn are food for the consumer.

The second technique for combining human waste reuse and aquaculture is to introduce fish into the secondary ponds in a waste stabilization pond system. The accent here is on waste treatment. The presence of fish improves the functioning of the pond with regard to algal removal, reduction of suspended solids as well as reduction of faecal coliform bacteria in the final effluent (Carpenter et al, 362). This has lead to the proposal to integrate aquaculture with agriculture (Hepher & Schroeder, 365) by introducing fish into stabilization ponds and then using the effluent for irrigation. The fish pond could also take care of the seasonal variation in the demand for irrigation water. The integration of different activities, in this case waste treatment, fish farming and irrigation, has important implications for overall economic feasibility and in fact duplicates on a large scale what many peasants in developing countries already practice.

It is important to point out that the productivity of fish ponds using wastewater has been found to be higher than that of inorganically fertilized ponds (Allen & Hepher, 359). An oxidation pond stocked with carp in Madras is reported to have an annual productivity of 7700 kg/hectare (Muthuswamy et al, 371) which is considerable.

The reduction in zooplankton and bacteria reduces the carbon dioxide levels, which in turn raises the pH in the fish stocked stabilization ponds (Hepher & Schroeder, 365) which act together with high oxygen levels results in surprisingly disease-free environmental conditions in the pond. The possibility has been put forward that there is a therapeutic effect on fish from being cultured in certain types of wastewater systems. Fish have been shown to be not susceptible to infections from enteric bacteria that cause diseases in humans and animals, and where human pathogens have been identified they have been isolated in the gut, which can be cleaned by depuration (Allen & Hepher, 359).

The possibility also exists of combining wastewater effluents with marine culture. Ryther (374) describes an integrated project in the United States where secondary sewage effluent, mixed with seawater, is used as a source of nutrients to grow single-celled marine algae, which are in turn fed to shellfish. The phytoplankton removes the nutrients from the sewage effluent, and the shellfish remove the phytoplankton from the water. Solid wastes produced by the shellfish serve as food for secondary commercial crops of marine animals such as lobster and flounder. There are possibilities for adapting such a system to coastal locations in tropical regions, where plentiful solar energy and high water temperatures would promote marine food production.

ALGAE PRODUCTION

Algae play an important role in the photosynthetic process of facultative stabilization ponds. These ponds can be designed specifically to maximize algae production by reducing the pond depth to 20-40 cm to improve sunlight availability throughout. Sewage nutrients' conversion to algae is extremely

rapid under these conditions, taking 3-4 days, and the resulting pond is usually referred to as a *high-rate pond*, or sometimes as *algae pond*. The functioning of high-rate ponds is described by Oswald (394).

One of the main reasons for the interest in algae is the fact that they are usually about 50% protein, and annual yields of algae on a kilogram of protein per hectare basis are significantly higher than conventional crops such as rice, corn or soybean; under operating conditions 150 kg/hectare/day of protein can be produced (McGarry, 389). The importance of algae as an animal feed substitute, (thus liberating grains for human consumption), has been pointed out as having beneficial implications for the poorer countries (Grisanti & Oswald, 386).

Algae need nutrients for growth. Most natural waters do not contain all the required nitrog n, phosphorous or potassium. Human and animal wastes, on the other hand, contain all three, hence algae can be cultivated in sewage with no supplementary nutrients (Grisanti & Oswald, 386), and indeed high-rate ponds provide near optimal conditions for algae production. The nutritive value of algae as food has been extensively studied (Anon, 381).

One of the problems encountered with algae as an animal feed has been the low digestibility of the non-protein component - the cell walls (Hintz, et al, 387). However recent work (Anon, 382) indicates that digestibility can be considerably improved by drum-drying, rather than sun drying and milling. The harvesting of algae requires three steps: initial concentration, dewatering and final drying (Golueke & Oswald, 384).

An interesting proposal to use algae as fish feed (Wachs, et al, 400) is based on the fact that algae constitute their natural food and their digestive system is assumed to be more adapted to algae. The production of algae in high-rate ponds and subsequent use as fish feed would be more efficient than aquaculture directly in stabilization ponds, as well as offering the flexibility of also using the algae for animal feed.

The quality of water discharged from high-rate ponds is considerably improved (Oswald, 394) and can play an important role in agriculture for irrigation (McGarry, 389). Interestingly for urban locations, many industrial wastewaters can also be used for algae production, though requiring in some cases the addition of specific nutrients (Grisanti & Oswald, 386).

High-rate ponds have been built only at a pilot scale so far. The main drawback has been the development of satisfactory harvesting technology (Golueke & Oswald, 384). Two processes have been developed at a laboratory scale-chemical flocculation and filtration. Conventional algae production is currently practiced on a pilot scale in Mexico, Japan and Formosa. Algae production in high-rate ponds is being researched in Israel, West Germany and Singapore (Grisanti & Oswald, 386).

AQUATIC WEEDS

Another form of aquaculture, in addition to fish and algae, is aquatic weeds. A process has been developed in Germany (Seidel, 261) whereby reeds and bulrushes are used to purify sewage. Dissolved organic and inorganic materials are absorbed by the reeds. Oxygen is passed through the root system and into the sludge at the bottom of the pond, which is thus aerated. A second pond, with bulrushes, further purifies the wastewater. An adaptation of this system is reported to be functioning well in the Netherlands (DeJong, 258). Water hyacinth are reported to be used for sewage treatment in the United States (Anon, 254) where they are harvested for animal feed and a recent proposal has suggested converting the water hyacinth into fuel using the biogas process (Wolverton, et al, 266). The interesting aspect of this proposal is the discovery that water hyacinths can be used to produce biogas *without* the addition of any additional materials. Aquatic weeds are grown in ponds to which animal waste and nightsoil is added, and the harvested weeds used for animal feed in Vietnam and throughout Southeast Asia (Anon, 254).

Aquatic weeds are normally grown in shallow ponds which are not strictly speaking stabilization ponds, but also require fairly large land areas. The use of aquatic weeds for wastewater treatment is still experimental, and not all the health implications are yet understood (Anon, 254), and, as most of the scientific investigation of aquatic weeds have taken place in America and Europe, care should be taken in adapting this technology to tropical and developing, conditions. One aspect of aquatic weed ponds which has not been reported to be a problem in temperate climate locations is mosquito breeding. Since this is a problem associated with oxidation ponds in tropical climates, and is usually remedied by removing all grasses, particularly at the pond edge (Yao, 237), it would have to be taken into account with aquatic weed ponds.

BIOGAS

The anaerobic decomposition, or fermentation, of human excreta produces a combustible gas. This gas, which is (incorrectly) referred to as *methane*, is also known as *swamp-gas*, *gobar gas*, *dung-gas* or *biogas*. All anaerobic processes produce this gas (a mixture of about two thirds methane and one third carbon dioxide), but specific installations have been designed to optimize gas production, they are known as "methane digesters" or "biogas plants". Biogas plants on a large rural scale have found application in a number of Asian countries since development began in India in 1938 (Subramanian, 433). It is reported that at the moment there are 80,000 plants in China (McGarry, 139) 36,000 in India and 27,000 in Korea (Subramanian, 433), 7000 in Taiwan (McGarry, 139) and smaller numbers in the Philippines, Thailand, Indonesia and Japan. The majority of these plants are fairly small (1-6m^3) and owned by individual farmers, though larger community-scale (30m^3) plants have been reported on plantations and

associated with schools and co-operatives (Subramanian, 433). Various designs are described for biogas plants, ranging from batch digesters (Fry, 414) to continuous-type family and farm size plants (Singh, 427). The most common uses for the gas are for domestic cooking and lighting (Anon, 411), though it can also be used to power combustion engines (Fry, 414). It has been estimated that to run a 1 h.p. water pump eight hours a day, about 3.5 m of gas would be required, which would need the contribution of six to seven medium sized cows (McGarry, 139). There is considerable variation in what is thought to be the minimum number of animals required, or gas used, by a single household, though reports indicate that in practice consumption may be as low as 0.2m per capita for cooking, and digesters have been found to be operating on one cow and the family nightsoil (Subramanian, 433). It is important to point out that the addition of nightsoil, high in nitrogen, results in higher yields of gas, though the low volume of nightsoil inevitably requires supplementation with animal wastes for adequate gas production.

The slurry or effluent from the digester contains about 2% nitrogen on a dry weight basis and is very valuable for fertilization. The normal practice is to dry the slurry, and subsequently spread it on the land. In larger installations the slurry may be pumped out of the digester and spread on the land by tank-truck immediately.

Studies have been reported in China with regard to the effectiveness for destroying pathogens (Anon, 411). The results indicate that there was 93.6% destruction of hookworm, ascarid and schistosoma eggs. The schistosoma eggs were completely destroyed, and very few hookworm eggs survived, but the survival of ascarid eggs was quite high. This is mainly due to the relatively short retention period within the digester, usually about two months. This implies either additional treatment of the slurry, or redesign of the digester to lengthen retention time or increase ascarid destruction.

There are areas for technical improvements in digester design and materials particularly lengthening the life of the steel tank cover, and of course lowering costs (Pyle, 423). In this connection an important new development is reported in China (Anon, 411). This involves the use of a fixed gas storage tank, unlike the movable covers normally utilized in India. Pressure is maintained by a layer of liquid slurry which is displaced by the expanding gas into a second displacement tank. This permits the construction to be entirely out of concrete, a considerably cheaper material than steel. Previous experiences with movable covers out of concrete have not had a great success due to eventual cracking and leaks (Subramanian, 433).

However the main discussions of wider biogas utilization in developing countries seem to hinge on the economic and social benefits of this technology. It is clear that the capital cost is higher than can be afforded by the poorer peasants (Anon, 412), however the use of biogas in many Asian countries shows that it has a place in the rural economy. The diversity, both of designs and of perceived and real benefits, in the different applications makes it extremely difficult to reach a single conclusion on

the subject (Subramanian, 433). The production of gas, the production of fertilizer, the improvement of environmental conditions and the disposal of human wastes predominate in turn, depending on local conditions and needs. This parallels the case of many of the disposal/reuse techniques in which health, nutritional and environmental benefits are combined.

The majority of biogas applications have to date been in rural areas, where animal manure is available, fertilizer is required and electricity is usually lacking. Nevertheless Subramanian (433) mentions several urban plants, and biogas plants have been proposed for Manila (Adan, 078). The possibility of growing aquatic weeds in urban treatment ponds and then using them for biogas plants (Wolverton, et al, 266) would seem to have particular application in urban areas where animal wastes may be in short supply. It is possible to generate biogas with human excreta alone (Subramanian, 433) though little work has been reported.

QUESTION 3: IN VIEW OF THE ABOVE, WHAT ARE THE WASTE DISPOSAL/REUSE OPTIONS FOR CITIES AND TOWNS IN A DEVELOPING COUNTRY?

The focus of this question is clearly on the urban situation. This is not to imply that rural sanitation is less critical, in fact proper rural sanitation is a numerically greater issue as the majority of the population of developing countries is rural. The statement is often made that "rural sanitation is not a technical problem". Many of the studies identified by the Technology Review have raised serious doubts as to the accuracy of this statement. It is clear that in this field, as in so many others, nineteenth century solutions are not always up to twentieth century problems. Much of the colonial sanitation technology, which is still being applied, represents "top-down" improvements that often reflect foreign (to the peasant) values, and not surprisingly meet with rejection (Muhondwa, 010). In this light the indigenous reuse technologies are particularly interesting, for though there is room for improvement, they seem more closely related to the resources, and needs, of the villagers.

The differences between the conditions facing a country that is beginning its development today, and those under which the now developed countries began their industrial development in the mid-eighteenth century, has already been pointed out. The often meagre physical resources, fast-growing population, particular climatic conditions and extensive poverty apply in both the urban and rural areas, but in the cities they reach unprecedented proportions. Thus urban sanitation is considered separately in *Question 3*, not because it is necessarily the most important problem, but because it appears the most difficult to solve.

A developing country attempting to solve its urban waste disposal problems must choose a course of action. It is the purpose of this review to suggest that waterborne sanitation is only one among many options and not the "unique" solution to urban waste disposal, as it has usually been described.

The options can be lumped into three major categories: *The Waterborne Options*, *The Cartage Options* and *The On-Site Options*. The inevitable question follows - "How to choose one system rather than another?" This question falls outside the scope of this Technology Review, yet it has been impossible to avoid it altogether, particularly as much of the literature itself deals with the subject. The main purpose of this Review has not been to compare or evaluate the various options, or indeed to present a methodology to accomplish that end, although reference is made to studies that have been conducted along those lines. Nevertheless a review of this kind would be incomplete if it did not deal, however briefly, with some of the implications of a shift in attitude from a single-option to a multiple-option approach to the problem of urban excreta disposal. This discussion forms the final section of *Question 3*.

THE WATERBORNE OPTIONS

This study has failed to identify any options, other than sewerage, that could apply to high-density, high-rise housing and commercial areas. It seems that, for the moment at least, underground sewers are the only solution to the central business district, or for those areas where housing is in high-rise buildings. Although there have been proposals for high-rise alternatives (Nesbitt & Seldman, 061), these have been in an industrial country context and speculative in nature. The application of sewerage in the high-rise, high-density context might minimize two of the drawbacks usually associated with waterborne sanitation. First of all piped water is usually available in high-rise housing, and secondly the concentration of population significantly reduces the cost of sewerage. In general sewerage capital costs reduce in proportion to the *density* of population served (Hansen & Therkelsen, 171).

It should be pointed out immediately that, with the notable exceptions of Hong Kong and Singapore, very few cities in developing countries have popular housing contained in high-rise buildings. This is not only due to the economic costs of this form of construction, but also to the social costs, as demonstrated in the failure of the *superbloques* in Venezuela in the 1950's. *The bulk of housing in a developing country city is still likely to be contained in one and two storey buildings.*

One of the technical problems reported with sewerage in low density areas in tropical climates is a tendency to clogging because of insufficient water-usage (Anon, 149). This is particularly true in arid conditions, or when only a small part of the population can afford to be connected to the sewage system. A waterborne alternative has been proposed to overcome this drawback (Vincent, et al, 181) which is called the *aqua-privy/sewerage* system. This system consists of conventional aqua-privies connected to sewer pipes. The vault acts as a settling tank for all the solids, and only liquid overflow passes into the sewage system. It is claimed that smaller diameter pipes and lower gradients will reduce the cost of the sewerage network, and the smaller quantity of water will reduce treatment costs. There are unpublished reports that in Zambia, where the aqua-privy/ sewerage system has been installed, clogging is frequent due to the shallow slope pipes, and that difficulties have been encountered with desludging of the vault. The latter is reported to be the result of high density construction which obstructs access to the vacuum truck, and is more a result of poor planning than an inherent failing of the system. There is no question that the aqua-privy/sewerage system is cheaper than conventional sewerage (McGarry, 138) and in N'Djamena where sewers were deemed necessary, it at least assured easier operation (Anon, 149). However the saving is marginal and the capital cost of pipes, trucks *and* vaults is high indeed.

Where waterborne systems are already in use, or where they represent the only viable option two points should be kept in mind. The reuse potential of the wastewater, and the quantity of water consumed.

The reuse potential of wastewater has already been pointed out. There exists the possibility to recoup at least some of the capital cost of the sewerage system by the development of algae production and fish ponds and secondary use of water for irrigation. One of the constraints on the proposed sewerage system in Yemen was that the water should be recharged to the aquifer, so important a resource was it considered (Anon, 269). It is unfortunate that most urban sewerage projects, since they eat up funds in underground pipes, inevitably approach disposal from a short-term "least cost" point of view, which generally leads to primary treatment and river disposal, as at Rangoon (Singh, 180), instead of taking advantage of the long-term benefits of reuse.

WATER-SAVING

The quantity of water consumed rises sharply when it is available in pressurized house connections. The World Health Organization estimated in 1961 that whereas consumption was about 38 litres/capita/day from a standpipe or well, it could be expected to rise to as much as 190 litres/capita/day with a piped house connection and interior plumbing. As a result not only does *wastewater* become a problem of marked dimensions, but the consumption of water rises steeply, and, in respect to the entire population, disproportionately. Taken as a group, even if only one quarter of the population is served by house connections it will consume *more water than the rest of the urban population* that is served by public standpipes or vendors. Thus, though it might appear that water-saving is a side issue in countries where less than half of the urban population has access to piped water, an equitable distribution of this often scarce resource demands that attention be paid not only to distribution, but to the quantities consumed.

The result of water-saving practices has several important implications. A reduction in use, particularly by that portion of the urban population served by piped water, will have an effect on water treatment costs. In the case of those served by piped water, but lacking adequate greywater drainage, reduction in wastewater quantities could have significant health benefits (Morse, 474). A third benefit will affect those who buy water from street-vendors, often at a higher price than paid for by those with house connections. Methods of using less water to effect personal washing could also have health benefits, without necessarily increasing the quantity, and cost, of water consumed.

There have been a number of studies in the United States dealing with methods for reducing domestic water consumption (Hershaft, 470) (Fowell et al, 465) (Bailey et al, 460), not surprisingly the *flush toilet* is found to be the main water consumer. A recent British study (Anon, 456) has identified simple modifications to toilet cisterns that could reduce water consumption by 40% and is developing a 4½ litre flush toilet-pan. A simple variable flush-water-cistern is reported to be used in Uruguay (Rybczynski & Ortega, 476)

and dual-flush cisterns have shown reductions of 26% in water use (Sobolev & Lloyd, 482). All of these devices could be adapted to developing country use.

Another water-saving technique is worth mentioning as it could have important implications in greywater reduction, especially for those people who do not have access to sewers to dispose of their household water. Atomization of water has been proposed as a technique for reducing the amount of water needed for washing and showering. A low-cost prototype has been tested that uses 2 litres of water for a 6 minute shower, under manually induced pressure (Morse, 474). Atomization devices replacing conventional showering fixtures have shown water savings of 25% for total household water consumption in a typical British home (Anon, 456).

It would be a mistake for the developing countries to follow the lead of the industrial countries and wait for 100% piped water connections before attacking the problem of water conservation.

THE CARTAGE OPTIONS

One of the principles of sewerage is the *removal* of human wastes to locations, usually outside the city, for treatment and/or disposal. There are a series of options that accomplish this without the use of underground pipes, but by some form of cartage, either handcarts, trucks or vacuum trucks, depending on the level of sophistication. Cartage is widely practiced throughout the cities of developing countries and is one of the most common non-conventional systems. It is reported in China (Sebastian, 405), Japan (Anon, 126), Nigeria (Anon, 129), and Taiwan (McGarry, 138).

The technology of cartage is not complicated (see NIGHTSOIL COLLECTION, p. 15) and the main criticism levelled against it is the high degree of efficient central organization required for successful operation. The costs of cartage systems vary from case to case, but two factors stand out: the periodicity of collection, and the distance from vault to disposal point. In most Asian countries the contents of the vault are pumped out every 2-4 weeks (Anon, 126). If this time were increased by utilizing larger vaults, important cost reductions would result. The distance from the vault to the point where the vacuum truck discharges its contents also affects the size of the truck fleet, as well as the travel cost. This is pointed out in specific studies for Yemen (Anon, 269) and Chad (Anon, 149).

It should be pointed out that little work has been done on reducing the cost of vacuum trucks, or on low-cost methods for nightsoil treatment. It is clear that vacuum truck systems from relatively advanced countries such as Japan will have to be adapted to the conditions in the poorer developing countries. Smaller-scale vehicles, such as hand operated vacuum carts (McGarry, 334) which could be locally fabricated, would make the cartage system much more adaptable to incremental adoption by the informal sector.

One of the advantages of cartage is that it can be used to upgrade conditions in existing built-up areas, where the construction of underground sewers would be impossible. Cartage can also be used in conjunction with on-site systems. An example of this is reported in Jarkarta (Anon, 019) where existing cesspools have been made operable by periodic pumping out, in spite of high groundwater and poor soil conditions. It was found that the cost of this service was affordable by the low-income community.

It seems likely that the only cartage system which can be hygenically operated is the vacuum truck, or the smaller scale version vacuum cart, into which the nightsoil can be sucked directly from the vault. This avoids the problems of odour, uncleanliness and unpleasantness associated with the pail or bucket systems, both for the user and scavenger.

It should be emphasized that proper organization, either at the municipal, neighbourhood or commercial firm level, is a prerequisite for successful cartage applications.

THE ON -SITE OPTIONS

All of the urban options identified in this Review require large-scale activity in the planning phase, whether it is to design a sewerage network or to organize a truck and vault system. The same is true of the on-site options - adequate systems must be designed and information disseminated throughout the community. The unique characteristic of this third option, as distinct from the first two is that the *on-site options can be implemented and operated by the individual.*

It has become recently recognized that the informal sector in many developing countries is more successful at providing services such as housing, than the central authority. This concept goes some way beyond the tradional "self-help" approach, where people provide the labour component of centrally administered projects. Most urban slum-dwellers out of necessity build their own houses, roads and community buildings. In many cases they also install water, electricity and drainage. Even in those developing countries with avowed centralist goals, the informal sector plays an important role. Any strategy for improving sanitation, particularly in urban squatter settlements, must take this into account.

The simplest on-site system is the pit latrine, or its urban offshoot, the cesspool. There are reports of urban pit latrines working satisfactorily in India (Kharkar, et al, 030) and the already mentioned practice in Jarkarta, where individual cesspools are operated by periodic pumping out (Anon, 019). The density of use of pit latrines varies greatly with soil conditions (Wagner & Lanoix, 041). It is reported that in African site-and-service projects, pit latrines are used with population densities of up to 150 persons/hectare. It is unlikely that pit latrines or cesspools could function in the restricted conditions of inner city slums without periodic emptying, in which case they would really be a primitive sort of cartage system.

The most common on-site treatment in the industrial countries (in the rural areas) is the septic tank. The developing country version of this is the aqua-privy, which is used in urban areas, but which is limited by soil conditions to an even greater extent than the pit privy, being a wet system. There has been a recent proposal, for the periphery of Manila, to install aqua-privies connected to mini-oxidation ponds for about half the population who could not afford sewerage (Adan, 078). A modification of the septic privy that increases the retention time to 90 days might have application in urban areas (Teodorovic, 121). Aqua-privies, periodically desludged by vacuum trucks have been proposed as public latrines in Belize (Anon, 128). Although put forward in recent literature as an appropriate alternative (Oluwande, 109) (Mann, 108) there is evidence of operational difficulties (Anon, 079).

The possibility of urban applications for biogas plants has already been mentioned. Two areas in particular have not been reported on in the literature. One is the production of biogas with human excreta alone. The second is the optimal scale for urban biogas plants, whether "block" scale to service 20-30 families, or individual mini-plants for an individual household.

This Technology Review has identified only one excreta disposal system that has been developed since 1950, the mouldering privy. Not surprisingly there is more speculation than concrete evidence as regards its large-scale urban implementation. The largest single example is the Vietnamese program of double mouldering toilets (Anon, 046), this is primarily a rural technology but with some application in suburban areas. There have been suggestions that the aerobic mouldering toilet, or multrum, could be adapted to urban tropical conditions (Winblad, 076) but so far this has only been done on a pilot scale in Tanzania (Eygelaar, 054) and in Manila (Rybczynski, 068).

It should be noted that mouldering privies should not be regarded as an "interim solution". Although greywater could be disposed of by surface drains, this could ultimately be done by underground pipes, *while maintaining a dry on-site system for excreta disposal.* The now-developing countries have an opportunity that was not available to the industrial countries in the mid-nineteenth century to choose a dual system, dry treatment of excreta and underground drainage of greywaters. This is a crucial decision that could avoid many of the difficulties that only now are becoming evident in Europe and North America.

ECONOMIC COMPARISONS

There are a number of studies (Holland, 029) (Hansen & Therkelsen, 171) (McGarry, 138) that have attempted an economic comparison between different urban systems. The general method is the same, that is, to determine the

least cost solution while varying certain factors such as population density and interest rates. Only the capital and operating costs are considered. The fact that these studies utilize an abstract site limits their application to actual conditions, though the methodology is instructive. Adams (267) has suggested that only a *cost-benefit* evaluation can take into account multiple benefits and considerations, but though the point is made that this is desirable, it is not clear if it is in fact possible. A computer program has been developed to evaluate a number of technologies on the basis of collected field data (Reid & Muiga, 289) but limits itself to the more engineering-type sewage treatment systems, which avoids the main issue of non-sewerage systems. A number of engineering master plans have made economic comparisons of two or more systems (Anon, 269) (Anon, 149) but these are also least cost calculations, which give a very crude picture indeed as they cannot take into account side benefits.

The difficulties with evaluating different systems on the basis of economic comparisons are multiple. The cost-benefits of the different technologies are not all equally understood, and the data on some of the systems is quite meagre. It is difficult, if not impossible, to take account, in money terms, of the social-cultural-medical aspects of sanitation without distorting them or losing their significance (Adams, 267). It is difficult to incorporate important factors such as the extent of *off-shore costs* versus the use of locally-available materials. Finally it is impossible to compare the economics of systems which are essentially engineering works (cartage and waterborne) with systems that could be implemented on an individual scale (on-site).

The following table summarizes in a very general way some of the significant characteristics of the three classes of systems: Waterborne, Cartage and On-Site.

TABLE 1

	Waterborne	*Cartage*	*On-Site*
Capital Cost	*High*	*High/Low*	*Low*
Operating Cost	*Low*	*High*	*Low*
Offshore Cost Component	*High*	*High/Low*	*Nil*
Water Consumption	*High*	*Low/Nil*	*Low/Nil*
Optimal Density	*High Density (High Rise)*	*High Density (Low Rise)*	*High & Low Density (Low Rise)*
Adaptability to Incremental Implementation	*Nil*	*High*	*High*
Adaptability to Self-Help	*Nil*	*Low*	*High*

It should be understood that *Table 1* is not a cost-effectiveness table. It may be that the models that have served to establish optimal sewerage solutions in the past are not suitable when confronted with non-conventional systems. It may be that the *approach* to establishing the "optimum" solution will have to be revised.

A NEW APPROACH TO IDENTIFYING WASTE DISPOSAL SOLUTIONS

Sewerage has been regarded as a *universal solution*. This fact, more than any other has played such an important role in the widespread adoption of underground sewers in American and European cities, and, with less successs, in the rest of the world. The same engineering formulas have been applied, often by the same engineers, whether it is in Madras, Mexico City or Manila. Once the variables are known for any particular situation, tried and true techniques have been used to achieve a predetermined result. A technical solution which is universal, such as the bicycle, has enormous durability, and instead of being *adapted* it can simply be *adopted*. As long as the advantages outweigh the compromises there is tremendous advantage in adopting a solution which has been developed over a long period of time. The fact that the universal solution ignores many variables is, from an engineering point of view, only advantageous as far as implementation is concerned.

However, universality is not the goal of engineering, rather an occasional achievement. All attempts to universalize housing, for instance, have been a failure, and it is becoming accepted that the optimal solution, and often the only possible solution, is the one that takes into account local and circumstantial resources, both human and material. The same may be said of agricultural practices, which vary widely as functions of climate, topography and technological complexity. Just as particular solutions should not be maintained only out of a misplaced sense of ethnocentrism, so universal solutions should be discarded if it turns out that they are not doing the job.

The argument has been put forward earlier in this Review, that for a variety of reasons the sewerage option is a poor choice for most developing countries. The scale of the waste disposal problem coupled with the resources available require other options to be examined. There is a danger, however, in assuming that the alternative lies with another universal solution.

It is very unlikely that any alternative to sewerage will be a universal solution. It is much more probable, based on this review of the technical literature, that it will be a combination of solutions, adapted to different situations, and the "universality" of solutions may only extend within one country, or even within one region of a country. *The fact that a universal solution is replaced by particular solutions should not be seen as a disadvantage.* There is a danger that the main criticism levelled at any non-conventional waste disposal system will be that it is *not* universal, that it will be difficult to implement, that new standards will have to be set, that personnel will have to be trained, and so on. All this is undoubtedly true, but it must be weighed against the "universality" of a waste disposal system which so far has been able to reach only 6½% of the people in the developing countries.

The appreciation that the solution to urban waste disposal may be *particular* rather than *universal* implies a significant change in attitude towards urban waste disposal. It must be understood that the solution to a problem is very much a function of the way that the problem is defined. *Alternative solutions emerge as the result of an alternative statement of the problem.* As long as the problem of urban sanitation is not restated, a consideration of the technological options will inevitably lead back to the sewerage solution. There are three assumptions in the current approach to urban sanitation in a developing country that must be reconsidered. Firstly, that any improvement to urban sanitation implies drastic change to the existing condition. Secondly, that this change must follow a Master Plan model. Thirdly, that the goal is to dispose, or get rid of, the human waste.

Sewerage, like a railway system or an electrification net, is a discreet self-contained system. It must be implemented whole, or not at all (though it may be phased) and it need not take much account of the preceding technology it is replacing, as it is essentially a self-sufficient system. Over the years, as sewerage has become synonymous with sanitation, it has been assumed that improved sanitation implies drastic change. It is probably for this reason that so little literature has been identified dealing with indigenous excreta disposal practices - it has been assumed that these are of little importance as they will be replaced by sewerage. As a result, the potential for upgrading existing practices has been largely ignored, except in a half-hearted manner as an interim measure "until a sewer system can be provided". *It is important to recognize that improvements, however humble, to existing waste disposal practices, are the first step to improving urban sanitation.* This will have an important bearing on identifying waste disposal solutions that have the ability to upgrade, or be used in combination with, existing techniques. This is well illustrated in the project for maintaining urban cesspools in Jarkarta (Anon, 019) for over one million people who could simply not afford sewerage.

The implementation of underground sewers is a massive engineering project, similar to the construction of highways or a transportation system. The key device of such endeavors is the Master Plan, and the implementation usually follows a planning construction model that may last 20-30 years. Thus urban sanitation becomes defined as appropriate planning followed by phased, but inevitable, construction. There is no allowance, nor need there be, for improvements or adaptations to the system as it is being implemented. Sewerage is seen as a frozen, once-for-all solution, and often the same attitude is applied to other waste disposal options. *It is a mistake to assume that the Master Plan model can be applied to the On-Site or Cartage Options.* It is much more likely that these technologies will follow a construction improvement construction model, during which problems are regulated and solutions refined. An example of this model is the development of the double septic tank in North Vietnam, which took more than a decade (McMichael, 060). Conversely, if the Master Plan model is applied to a non-conventional technology such as was done in Botswana where a mass-produced aqua-privy was installed on a very large scale, the results can be disastrous (Anon, 079).

The process of *adaptation* rather than *adoption* has important ramifications for the way in which urban waste disposal systems are implemented. It implies a dynamic process of problem-solving, a model for which might be the housing sector, in which designs are continually adapted to local conditions, and in which the scale of planning is very much reduced, even though the aggregate of a number of years production may be significant. It is obvious that the developmental model puts the emphasis on *local* problem-solving and that there is consequently less need for international expertise.

Sewerage is an anser, though an expensive one, to the question of how to get human excreta out of the city. Sewage treatment answers the question of how to dispose of the sewage and cause the least problems. Neither is an answer to the question of how to make use of the nutrients in human excreta, and if any of the reuse technologies that have been described in *Question 2* are to have application, it is clear that the first questions must be rephrased. *Options should be evaluated on the basis of reuse capability rather than disposal capability.* Reuse of nightsoil in farming is a traditional practice. Reuse of excreta in fish culture, algae production and aquatic weed/energy production are new and promising technologies that radically change the context of urban sanitation.

A new approach to urban sanitation based on a re-assessment of previously accepted models, such as has been described above, will have no difficulty in identifying suitable options. Once existing conditions are understood it will be clear that only certain options are compatible with existing practices for upgrading the situation. It will also be clear that there are certain options which integrate with reuse possibilities that reflect energy, food or agricultural needs of a particular society. Finally the success of such programs can be assured by discarding the Master Plan model and adopting a dynamic development process, which, after all, parallels the process that is going on in a country which is developing.

Witold Rybczynski
Consultant to
IDRC

II. A Note on the State of the Literature

This technology review is supported by an abstracted Bibliography of 483 references which are the result of an intensive literature search lasting several months. It was the purpose of this search to identify specific technical literature that could form the basis for a planner, engineer or decision-maker in a developing country to understand, evaluate and implement specific technologies. The inappropriateness of conventional wastewater technologies to solving the sanitation problem of the urban and rural poor in a developing country has been pointed out in the Technology Review and though many national governments and international organizations appreciate that different approaches to waste disposal must be adopted, non-conventional wastewater and excreta disposal technologies are, by definition, less well-known and less well documented. It is the aim of this Technology Review to begin to fill in some of the gaps, and to facilitate access to valuable technical documents which would otherwise remain obscure.

LITERATURE SEARCH

The unconventional structure of the literature search is an inevitable result of the subject matter being documented - non-conventional technologies. This has led to a two pronged investigation : a rationalized *computer search* of a number of North American data bases, and an ad-hoc *manual search* of a selected number of information centres.

A *computer search* was carried out by the IDRC library in Ottawa and supplemented by the National Oceanographic and Atmospheric Administration library in Washington, D.C. It was found that access to information in the data bases is not indexed for developing country needs, and hence it is not possible to retrieve literature on the basis of "low-cost", "developing country" or "non-conventional technology". The search technique that finally evolved required casting a very broad net using the subject matter "wastewater" and "waste disposal" and eliminating only obvious fringe areas such as "industrial", "nuclear" or "tertiary treatment". This produced a *long list* of titles that was manually sifted, on the basis of title, author and keywords, to a *short list*. The objective at this point was to eliminate all literature dealing with waterborne sewerage, sophisticated treatment processes as well as documents judged to be of purely regional interest (economic studies, environmental impact statements). The documents on the *short list* were acquired, and after reading, the *final choice* was made. The criteria for this *final choice* were

threefold. The document should be technical in nature and contain data which would be useful either for evaluating or implementing a technology. The document should deal with non-conventional methods of collecting, treating and reusing human waste. The third criterion was the most important, and the most elusive; the document should deal with a "level of technology" that was appropriate to the needs and resources of a developing country. The third criterion places more stress on labour-intensiveness than on automation, emphasizes low capital-cost, and takes into account differences in standards of living. Most of all it places the accent on documents that *describe experiences in a developing country.* The results of the computer searches are summarized in *Table 1.*

TABLE 1

Data Base	*Long List*	*Short List*
Agricola	*2,023*	*148*
Aquarius	-	-
Biosis	*1,487*	*86*
Congressional Information Service (CIS)	-	-
Compendex	*3,321*	*125*
Environmental Data Base Directory (EDBD)	-	-
Enviroline	*3,316*	*29*
Information Service in Mechanical Engineering (ISMEC)	*146*	*4*
National Technical Information Service (NTIS)	*2,669*	*50*
Pollution Abstracts	*1,253*	*192*
Sci Search	*1,543*	*72*
SCORPIO	-	-
Solid Wastes Information Retreival System (SWIRS)	-	-
Selected Water Resources Abstracts (SWRA)	*2,788*	*20*
TOTAL	*18,546*	*716*

Out of the 716 titles approximately 240 were relevant, however a second screening, eliminating documents of marginal importance and overlapping data, yielded a *final choice* of 187 references for the Bibliography. It is not surprising that the data bases do not provide a large amount of references on non-conventional wastewater technologies. Most data bases are, after all, enterprises which reflect the informational requirements of their clientele - which is universities, engineering firms and government agencies in North America and Europe. As a result *more than 99% of the published literature on wastewater is of no practical value to the urban and rural poor in the developing countries.* Published should be here understood as published in a form readily available to the

international reader. It has been the experience of this study that much valuable technical literature is in fact published as studies and reports that tend to be hard to acquire.

The ad-hoc *manual search* was carried on by eight External Consultants (engaged by the World Bank). The criteria used for selection were essentially those used in making the final choice in the computer search. In many cases the consultants are recognized experts in a related technical field. The information centres visited by the consultants are summarized in *Table 2*.

TABLE 2

Asian Institute of Technology (AIT), Bangkok, Thailand.

Bureau Central d'Etudes pour les Equipments d'Outre-Mer (BCEOM), Paris, France.

Centro de Investigaciones Multidisciplinarias en Desarrolo Rural (CIMDER), Cali, Colombia.

Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente (CEPIS), Lima, Peru

Department of Civil Engineering, University of Dundee, U.K.

Empresa de Sareamiento de Lima (ESAL), Lima, Peru.

Fish and Aquaculture Research Station, Dor, Israel.

Instituto Nacional para Programas Especiales de Salud (INPES), Bogota, Colombia.

Israel Engineers and Architects Association, Tel Aviv, Israel.

Israel Oceanographic and Limnological Research Library, Haifa, Israel.

Ministère de la Cooperation pour l'Afrique, Paris, France.

National and University Library, Jerusalem, Israel.

National Environmental Engineering Research Institute (NEERI) Nagpur, India.

Ross Institute of Tropical Hygiene, London School of Hygiene and Tropical Medicine, London, U.K.

Royal Institute of Technology, Stockholm, Sweden.

Secréteriat des Missions d'Urbanisme et d'Habitat (SMUH), Paris, France.

Technion-Israel Institute of Technology, Haifa, Israel.

Tel-Aviv University, Tel Aviv, Israel.

University of Technology, Loughborough, U.K.

World Bank, Washington, D.C., U.S.A.

World Health Organization, Geneva, Switzerland.

Selected documents have been provided by the Agency for International Development (AID), the National Institute for Water Research (NIWR), South Africa and the International Reference Centre, the Hague.

It is clear that this is a short list indeed for exigencies of time, personnel and budget precluded personal visits to information centres in all the regions; notably Africa and the Middle East. Nevertheless the project team is confident that this Bibliography represents the most comprehensive collection of documents on the subject of waste disposal technologies for developing countries that has been available to date. It is hoped that it will form the basis for a data base in this important, but neglected, field.

The external consultants had a copy of the *short list* in order to minimize duplication. The documents identified by the consultants differed from the computer-retrieved documents in a number of respects. The computer search was limited to documents published after 1970, the date when most of the data banks were established. The consultants were not under this restraint, and selected a number of useful older documents. Some of the documents identified by the consultants are undoubtedly in the computerized data bases but were missed by the initial broad search due to anomalies of indexing. About 35% of the manually retrieved documents are unpublished reports, field studies or unpublished papers. *Out of the total 483 references in the Bibliography, 119 (25%) are unpublished documents.*

The final Bibliography includes the documents retrieved by the computer search, those provided by the external consultants' ad-hoc manual search, a number of World Bank Appraisal Reports, as well as additional literature, both published and unpublished, that was identified by the team during the course of the project.

TABLE 3

	Unpublished	*Published*	*Total*
Computer Search	-	*187*	*187*
External Consultants	*82*	*152*	*234*
World Bank Reports	*17*	-	*17*
Additional Literature	*20*	*25*	*45*
TOTAL	*119*	*364*	*483*

The subject of waste disposal is correctly linked to that of water supply, the assumption being that whoever takes care of one will take care of the other. The experience of this study has been that most information classified under "water supply and waste disposal" in fact deals almost

entirely with the former, and hardly at all with the latter. Information on waste disposal/reuse tends to be concerned with public health, engineering, biology, town planning and medicine, and careens wildly across institutional boundaries. As a result, *no organizations were identified during this study that document, co-ordinate and disseminate information on waste disposal/reuse technologies, either nationally or internationally.* The fact that nowhere was there a comprehensive listing of documents dealing with non-conventional waste disposal motivated this Technology Review and Bibliography.

The type of literature cited in the Bibliography is varied. It includes, in addition to journal articles, engineering master-plan reports, pamphlets, feasibility studies, governmental reports and papers from international, national and academic institutions. As in so many fields the majority of research is going on in the richer industrial countries, nevertheless 37% of the references in the Bibliography originate in developing countries, and an additional 17%, although originating in Europe or North America, deal specifically with conditions in developing countries. The balance of the literature, 46%, originates in the industrially developed countries, but is considered relevant to conditions in developing countries.

It might be useful to briefly review the state of the literature, following the technology categories of the Bibliography.

LITERATURE

There is generally very little data on *deposition,* and though designs for water-seal toilets and squatting plates are often described, little is reported of actual experiences. It seems likely that deposition devices play a key role in public health, and work needs to be done to improve designs, based on field surveys. Solutions to deposition are often local in character, and if documented, which they seldom are, could be adapted from one region to another.

The literature on *on-site collection and treatment* tends to focus on the septic tank, which is widely used in the United States, but not generally appropriate to a developing country for reasons of cost. The much more adaptable pit-latrine tends to be ignored, and little serious scientific work has been done on this simple technology since the 1930's. Two questions in particular need elaborating: how the operation of the pit latrine could be improved to overcome problems of flies, smell, and cleanliness, and how the non-technical aspects of rural latrine programs contribute to their success or failure. Most of the literature assumes the latrine to be a purely technical problem, though it is clear that "faecal sociology" a yet-to-be-born science, plays a key role in rural, and also urban, sanitation programs. Most of the literature takes it for granted that privies are a rural solution, ignoring the fact that for many urban slum dwellers they have been, and will continue to be, the only *affordable* solution. A large gap exists in the literature when it comes to the question of urban pit latrines or mouldering toilets - how can they be improved and upgraded, what are the risks (tolerable or intolerable) and limitations?

The literature on *off-site collection and treatment* tends to focus on sewage treatment for developing countries, while ignoring the fact that sewerage serves such a small fraction of the population. Consequently the subject of stabilization ponds is thoroughly documented by researchers in both developed and developing countries, though the method of getting the excreta to the pond remains unexamined. Not enough operating data is known concerning truck collection, even though this system is quite widely used. Extremely little data is reported on the various cart and nightsoil conservancy systems that are practiced throughout the developing countries, even though these form the backbone of existing urban waste disposal.

The *reuse* of treated sewage and sludges is well-documented in Western literature with regard to irrigation and aquaculture, both in hot and temperate climates. However the use of nightsoil, which is so widely practiced in fertilization and fish culture, is virtually ignored and little data is reported on actual practices. Biogas technology is well described, particularly in the Indian literature.

The characteristics of *greywater* have only recently been studied in the industrial countries and data is not extensive. Nothing has been reported from a developing country in this area.

A number of *water-saving* techniques are described in the Western literature that might have application, particularly in areas with water supply problems. Even though the sewered population in developing countries is small their proportion of water consumption is so high that water-saving measures could play an important role.

In general this Technology Review has found that the differences in climate, socio-economic conditions and the sheer scale of the problem make it difficult to apply technical data from an industrial country directly to conditions in a developing country, even when the data is of a "scientific" nature. This is particularly true with respect to non-conventional waste disposal technologies. The influence of conventional Western research in wastewater collection and treatment on attitudes in most developing countries cannot be overestimated. The result is that in many cases wastewater research, *even when it is going on in a developing country,* follows Western models and turns its back on local traditions and practices. *The result is that very little is known about what is actually going on.* Any attempt to upgrade or improve the existing situation, and this is surely the only strategy that has any chance of success, will have to be based on sound understanding of existing resources, limitations and possibilities.

Witold Rybczynski
Consultant to
IDRC

III. Bibliography

The Bibliography includes author's corporate affiliation, keywords and a brief informative abstract to assist in identifying documents for retrieval. The more important documents have been abstracted in some length, which makes this Bibliography useful as an information source as well as a reference guide. Standard reference texts on a subject are denoted by a single dot ○ . Documents which the authors have identified as throwing new light on non-conventional waste disposal are denoted by a double dot ●●.

1. Deposition Devices

001 Anon. Blair Research Laboratory, Salisbury. Rhodesia.

SANITATION AND HYGIENE IN RURAL AREAS
Unpublished report. 11 pp. 1974.
RURAL: PIT LATRINE: WATER-SEAL PRIVY: DESIGN: RHODESIA: HOUSEHOLD: WATER-SAVING.
*The problems of inadequate rural sanitation are reviewed and standard solutions discussed. It is felt that an adequate seal reduces the fly and odour problems. A mechanical self-flushing water seal privy system (Watergate) is proposed, which requires very little water to operate (one liter per visit) and is durable and non-clogging.

002 Anon. The Central Public Health Engineering Research Institute, Nagpur, India.

PROCEEDINGS OF THE SYMPOSIUM ON EVALUATION OF RURAL LATRINE DESIGNS
The Central Public Health Engineering Research Institute, and The Institution of Engineers, Nagpur Centre. India. 216 pp. Appendices (mimeographed). October 28, 1964.
21 papers, discussions, speeches.
RURAL SANITATION: EXCRETA DISPOSAL: LATRINES: INDIA: FERTILIZER: ON-SITE TREATMENT.
* Twenty-one papers discuss various aspects of the design, installation, performance and evaluation of latrine programmes in India. Personnel training, use of pit contents and ground water pollution are also subjects covered. Included is a report on the discussion by participants of Indian needs for the pan, pit and superstructure for latrines and of economic aspects of latrine programme development.

003 Anon.

Directorate General of Health Services,
Ministry of Health,
New Delhi, India.

RURAL LATRINE PROGRAMME
Central Health Education Bureau Brochure. India. 19 pp. 1962.
4 plates, 9 figures.
PIT LATRINES: SQUATTING PLATES: RURAL: CONSTRUCTION: DESIGN: PUBLIC HEALTH: SOCIAL FACTORS: INDIA: DISPOSAL.
* This practical brochure describes the organization and implementation of rural latrine programs in India. Latrine construction is discussed as well as educational, social and organizational aspects. Designs are provided for water-seal squatting plates.

004 Anon.

INTRODUCTION TO WATERGATE
Booker McConnell Ltd. U.K.
Manufacturer's sales leaflet.
EXCRETA: LATRINE.
*The patented self-flushing and self-sealing 'Watergate' latrine is described. Designed as a squatting plate the unit has an integral self-tipping pivoted pan which operates automatically when excreta are deposited on it; water or sullage is then admitted under low pressure into the pan in order to remake the water seal.

005 Anon.

SANITARY METHODS OF EXCRETA DISPOSAL IN VILLAGES
Directorate General of Health Services, Ministry of Health, Government of India, New Delhi. India. 8 pp. 1955.
4 drawings.
INDIA: RURAL: WATER SEAL LATRINE: DESIGN: CONSTRUCTION.
*This pamphlet describes methods for fabricating and installing water-seal squatting plates over pit latrines. The squatting plate is cast from concrete in a sheet-metal and wooden mold that is also homemade. The water-seal prevents odours from leaving the pit and keeps flies and mosquitos from the fresh faeces. It requires about ½-1 gallon to flush the water-seal trap.

006 Bhaskaran, T.R.

All-India Institute of Hygiene and Public Health, Calcutta, India.

A DECADE OF RESEARCH IN ENVIRONMENTAL SANITATION (1951-1960) LATRINE FOR RURAL AREAS
India Council of Medical Research. India. Special Report No. 4. 67 pp. 1962.
1 photograph, 6 tables, 2 diagrams.
PIT LATRINES: INDIA: HELMINTH: SEPTIC TANKS.

* A report of work to evolve an improved pan and trap for pit latrines. Details of construction and cost are given. Ten different types of lining for pit latrines in water-logged ground were tested and compared. The performance of four designs of septic tanks suitable for rural areas was found with respect to removal of suspended solids, BOD and helminthic ova.

007 Boparai, M.S.
Varma, R.N.

(Both) Office of the D.G., A.F.M.S., Ministry of Defence, New Delhi. India.

PROCEEDINGS OF SYMPOSIUM ON ENVIRONMENTAL POLLUTION
Central Public Health Engineering Research Institute. India. pp. 244- 254. 1973.
3 figures, 2 references, 1 appendix, discussion.
RURAL SANITATION: FIELD SANITATION: TRENCH LATRINES: WATER-SEAL LATRINES: INDIA: SQUATTING PLATE.

* A review of waste disposal methods adopted in the field by the Indian Armed Forces. A deep trench latrine, a water seal latrine and a field hand flush latrine are described with dimensional drawings and their advantages and disadvantages compared. The hand flushed pan connected to a detached covered pit or located over a deep trench, in either case with water sealing, are now preferred for military use in India.

008 Langshaw, C.L.

SANITATION IN THE BRITISH WEST INDIES
Journal of the Institution of Sanitary Engineers. U.K.
Volume 51. pp. 82-109. 1952.
7 photographs, 6 diagrams.
BRITISH WEST INDIES: SANITATION: PIT LATRINES: AQUA-PRIVIES: STORM DRAINS: SEPTIC TANKS.
*The paper describes the work of the public health engineering unit of the Windward and Leeward Islands 1944-1950. The unit was set up to train local personnel. Work on low-cost housing, water supply, storm drainage, malaria control and refuse collection is described. Improvement of latrines was an important function. Standard pre-cast concrete box seats, squatting slabs etc. were made for pit and borehole latrines. Details are given of household aqua-privies and public latrines.

●● 009 Morgan, P. Booker McConnell Ltd., London, U.K.

A NEW SELF-FLUSHING TOILET FOR USE IN RURAL LATRINES
Submitted for publication in American Journal of Tropical Medicine and Hygiene. U.S.A. 10 pp.
4 references.
EXCRETA: LATRINE DESIGN: WATER SEAL TOILET: PIT LATRINE.
*A self-flushing squatting plate, the "Watergate" has been designed specifically for people living in rural areas. The device consists of three basic parts: a chute and squatting plate; a swivelling pan mounted at the base of the chute; and a valve that regulates the level of water in the pan. The pan is pivotted and counter-balanced so that it holds approximately 3 litres of water to form a seal around the lower rim of the chute. The addition of excreta and water causes the pan to tip its contents into the pit. It then returns to the resting position and refills with water. The defice normally flushes once during two visits.

The first prototype was tested in August 1973, and both the pivot and the valve, the only moving parts, have withstood considerable abuse. A rural installation, which was inspected daily for over 16 months, showed that water consumption per visit varied between 1.29 and 1.11 litres.

It is felt that an advantage of this system is that the pit latrine is turned into a "septic pit" by the continual addition of small quantities of water. The presence of water promotes digestion and also increases exfiltration, thus prolonging the life of the pit.

Based on actual experiences it is concluded that simplicity of operation is a distinct advantage, and the lack of flies and odours significantly improves the traditional pit latrine.

010 Muhondwa, E.P.Y.

Department of Sociology,
University of Dar es Salaam,
Tanzania.

LATRINE INSTALLATION AND USE IN BAGAMOYO DISTRICT...A STUDY OF SOCIOLOGICAL FACTORS

Thesis for a Master of Arts in Sociology, University of Dar es Salaam. Tanzania. v - 75pp. June 1976
26 references.

LATRINES: TANZANIA: SOCIAL ACCEPTANCE: EXCRETA DISPOSAL.

*This study is about the social phenomenas of peasants' reluctance, if not objection, to build and use latrines. The observations are based on a two-months stay, and formal interviews and surveys of 60 households, in a village where a state program of rural latrine building was underway with varying degrees of success.

Although two thirds of the households had built latrines, (mostly under compulsion) a high incidence of abuse or non-use of latrines was found. The health benefits of latrines are not sufficiently understood by the peasants, and the connection between hookworm and unsanitary latrines is often not acknowledged. Another serious reason for non-acceptance is traditional etiquette which sees defecation as a rather shameful activity which more properly should go on in the bush.

There are also certain technical difficulties which are seen to discourage latrine use. Soil conditions require shoring of the pit and since lumber is not available this is often done with small sticks, the result being pit collapse. Cleansing after defacation is by ablution, and since the floors of the latrine are usually earth, poor environmental conditions result, as well as weakening of the squatting plate. In addition, smelly and unpleasant interiors further discourage adoption of "localized" defacation, and peasants revert to traditional practices.

011 The Ross Institute Industrial Advisory Committee

London School of Hygiene and Tropical Medicine.
U.K.

RURAL SANITATION IN THE TROPICS

The Ross Institute Information and Advisory Service. U.K. Bulletin No. 8. pp. 7-17 and 29-32. April 1972.
1 table, 14 figures, 7 references.

POUR-FLUSH LATRINE: SEPTIC TANK: SEEPAGE PIT: OPERATION:MAINTENANCE: FAMILY: COMMUNITY: PUBLIC TOILETS.

*Family and communal water-borne latrines (cistern-flushed and pour-flush types) are described. These systems which are recommended for locations having sufficient water supply require from 3 to 10 gallons per user and their effluent can be discharged to either septic tanks or seepage pits. Methods of operation and maintenance of the latrines are also discussed.

012 Sikkema, A.V.

Asian Regional Institute
for School Building
Research,
Colombo. Sri Lanka.

SEWAGE DISPOSAL FOR RURAL SCHOOLS
Building for Education, Asian Regional Institute for School Building Research, Technical Note Number 6. Sri Lanka. pp. 15-20. 1972.
6 diagrams, 2 tables.
SEPTIC TANK: CONSTRUCTION: DESIGN: INFILTRATION: COMMUNITY: RURAL: ABSORPTION TRENCH: SEEPAGE PIT: PUBLIC HEALTH: SQUATTING PLATES: WATER SUPPLY: SOCIAL ATTITUDES: PUBLIC TOILETS: SRI LANKA.

* A practical guide to the design and installation of squatting plates, septic tanks, absorption trenches and seepage pits for communal toilets in rural areas. The relationship between adequate sanitation and water supply is discussed, and the importance of social customs with respect to proper use of sanitary facilities is pointed out.

○ 013 Stanbridge, H.H.

HISTORY OF SEWAGE TREATMENT IN BRITAIN.I. INTRODUCTION OF THE WATER CARRIAGE SYSTEM
Institute of Water Pollution Control, (Publishers). U.K. Chapter one "Introduction of the Water Carriage System". pp. 1 - 16. 1976.
11 figures.
ENGLAND: HISTORICAL ASPECTS: MIDDENS: PRIVIES: EARTH CLOSETS: CESS POOLS.

* Chapter 1 reviews sanitation practices in England prior to the introduction of waterborne sewerage in the mid-nineteenth century; these included middens, water-closets connected to cess pools, simple privies, pail conservancy systems, earth closets and 'slop-water' (sullage) closets, the last mentioned being for use by the working class in water-scarce areas.

014 Thakor, V.H.

Health and Medical
Services,
Gujarat State,
Ahmedabad. India.

BAVLA TYPE RURAL LATRINES
Papers for Seminar on Environmental Health Problems of Ahmedabad, Civil Engineering Department, L.D. College of Engineering. India. pp. B-4-1 - B-4-6. 1972.
1 Appendix
RURAL SANITATION: LATRINE: INDIA.

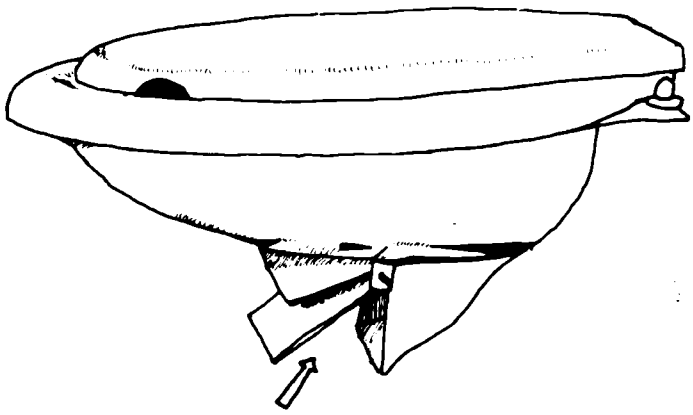
* Brief review of Waterseal latrine programme in Gujarat State includes details of latrine design and gives numbers of latrines installed between 1963 and 1970.

015 Watt, S.B.

Intermediate Technology
Development Group,
London. U.K.

VILLAGE SANITATION IMPROVEMENT SCHEME, INDIA.
Appropriate Technology. U.K. 3 (4). pp. 5-6. 1976.
1 diagram, 2 photographs, 3 references.
WATER-SEAL LATRINE: INDIA: VILLAGE SANITATION.

* The article gives detailed instruction for the construction of a water-seal latrine with soakage pit, as provided in a village near NEERI, India.



2A. On-Site Collection and Treatment: Pit Latrine

016 Anon.

Bestobell Engineering (SA) Ltd./Bpk. Durban. South Africa.

R.O.E.C. SANITATION
Patent No. 991/1944. Bestobell Engineering (SA) Ltd./Bpk. S. Africa. 11 pp.
11 figures.
COMPOSTING TOILET: INSTALLATION: URINAL: CONSTRUCTION: VENTILATION: NUISANCE.

* These instructions cover the installation of both the Pedestal and Squat types of a composting toilet system, the principles involved being the same but fittings slightly different. Construction of a urinal system for males is also described. Each closet of the toilets and urinal which is water-tight works independently with its own ventilator shaft. These systems are reported to provide satisfactory results, as they are odourless and free from flies.

017 Anon.

Central Public Health Engineering Research Institute (CPHERI - Now NEERI), Nagpur, India.

EVALUATION OF RURAL LATRINE DESIGN
Proceedings of a symposium held at CPHERI, India.on October 28, 1964. about 190 pp.
A compilation of 21 papers including numerous figures and tables.
INDIA: LATRINE DESIGN: RURAL: CONSTRUCTION: OPERATION: MAINTENANCE: DEPOSITION DEVICES: PITS.

*The use of sanitary latrines is the only economical satisfactory method for excreta collection and disposal to effectively deal with the harmful parasites and infections present in human faeces. The problems of rural sanitation in India have been recognized and are considered of vital importance for the improvement of national health. These reports deal extensively with methodology of rural latrine design, its criteria, methods of construction, operation and maintenance.

Nine types of deposition devices (pans) designed for rural uses in India are described along with various types of pits for disposal of nightsoil. The pan shape is suggested to be as much as possible smooth without sharp corners to collect the nightsoil material. Then, physical comforts of seating during use should determine the top shape and dimentions of the pans rather than any arbitrary designs. A pit design can generally be classified as a circular or a square pit with vertical walls and some supporting masonary in mud or cement mortar with brick work and a suitable cover. Factors affecting the pit designs include its volume to retain the sludge and infiltration capacity of the soil to absorb water. The shape of the pit also plays important part in its durability prevention against collapse and the conical design with apex towards bottom appears to be more suitable for all general purposes, but it results in reduced capacity. Special design for collapsible soils is considered a must for good latrines.

Other papers address some aspects of rational design of latrine superstructure, economics of latrine installation, use of pit contents as fertilizer, social acceptance of latrines, and pollution aspects of nightsoil affecting rural water supply. Dissemination of the available data has led to conclusions that installation of latrines in rural areas is a safe and economical means of excreta disposal provided that proper design, construction, operation, and maintenance of the latrines are well carried out.

Many useful schematic diagrams of how to construct the deposition devices, pits, and superstructures are also included.

018 Anon.

Cowiconsult,
Copenhagen, Denmark.

AREA 15, SINZA, DAR ES SALAAM
Unpublished report of preliminary engineering for the United Republic of Tanzania, Ministry of Lands, Housing and Urban Development, Sites and Services Directorate. 49 pp. August 1973.
8 appendices.
TANZANIA: URBAN: PIT LATRINE: AQUA-PRIVY: SOAKAGE TESTS.

* This engineering study of a 234 hectare area with unfavourable soil conditions for pit latrines or septic tanks evaluates a number of alternatives - privy vault and vacuum truck, pit latrines, aqua privies and aqua-privies connected to small diameter sewers. The alternatives are evaluated from an administration, cost and operational point of view.

●● 019 Anon.

Nihon Suido Consultants Co. Ltd., Tokyo, Japan.

IMMEDIATE PROGRAMME FOR SANITATION FOR KAMPUNG IMPROVEMENT PROGRAMME OF JARKARTA

In "Jarkarta Sewerage and Sanitation Project, Indonesia". A report prepared for the Government of Indonesia/WHO/UNDP, Project INO-P1P-00Z (INS/72/068), Draft, 1977. Volume VII, comprises about 250 pages.

INDONESIA: SANITATION: LOW INCOME-HIGH DENSITY COMMUNITIES: CESSPOOLS: SULLAGE: COMMUNAL TOILETS.

*This report summarizes an analysis made in 1975-77 of sanitation improvements made in 88 kampungs, i.e., low income-high density native village communities with an aggregate populatuon of about 1.2 million, included within the metropolitan Jarkarta area. The sanitation improvements were made as part of an overall slum infrastructure improvement programme, called "KIP Pelita I", carried out by the Municipality of Jarkarta over the period 1969-74. The sanitation improvements, comprising about 30 percent of the total programme, included improvements in:

(a) water supply through installation of public taps,
(b) facilities for utilized water for hygienic purposes (drinking and cooking, washing, bathing, toilets),
(c) waste disposal,
(d) surface drainage, and
(e) solid waste handling.

With respect to disposal of excreta from toilets (mostly water-seal type), it was found that provision of piped sewers will hardly be affordable in the foreseeable future but reasonably satisfactory disposal can be achieved very economically by use of cesspools, despite the high groundwater and poor soil leaching conditions prevalent in much of the area, provided that service is made available for periodic pumping out of the cesspools at a frequency ranging from a few months to two years, depending upon groundwater/soil/loading conditions, and moreover that the cost of such surface is readily affordable by the low income families, and that the total cost of this solution is small compared to septic tank/leaching systems.

A second key feature in the village waste disposal picture is the role of the paved surface drains furnished by the programme; it was found, for these to be operative for removing sullage including kitchen wastes, and not to be used for trash disposal, the ditches must be periodically cleaned by crews responsible to the village headman. Also, these drainage ditches discharge to the local rivers, and their dry-weather flow will be intercepted by a system of sanitary sewer interceptors planned to be located along the rivers under the master sewerage plan. Also, for lower low income families in the kampungs with home toilet facilities, a system of communal toilet/washing/bathing stations has proven successful if designed to be within ready walking distance of intended users and provided arrangements are made by the village headman to recruit and support a station operations manager who will maintain cleanliness, and that when cleanliness is maintained the stations are used and the users

are willing to pay fees sufficient to finance the maintenance costs. A program of work is recommended which would further upgrade the improvements built by the city to achieve an overall system meeting minimum desirable standards applicable over the next several decades. A pilot program including quantification of the socio-economic acceptance of the improvements is proposed to demonstrate the feasibility of the recommendations at four selected kampungs before undertaking the full-scale program.

020 Anon.

Port Moresby Office,
Division of Building Research,
CSIRO, Boroko.
Papua New Guinea.

Proceedings of the Seminar on Sewage Disposal in Urban Development (with particular reference to low-cost housing). Papua New Guinea. 67 pp. July 19, 1971.
SEWAGE TREATMENT: HOUSING: PAPUA NEW GUINEA: INDUSTRIAL WASTEWATER: EXCRETA: STABILIZATION PONDS: SEPTIC TANKS: SOCIAL ATTITUDES: ECONOMICS.

* Six papers were presented at this Seminar, mainly dealing with waterborne sewerage systems and their advantages in terms of health and convenience over other forms of sanitation. One paper, however, draws attention to the widespread use of pit latrines and open defecation in areas of traditional urban housing. In another paper the use of septic tanks in urban areas is discouraged; instead it is recommended that the effluent should be discharged into a percolation trench laid in the middle of the adjacent access road, the pipe in this trench should be the same size as a conventional sewer; this 'septic pipe' can eventually be used as a sewer proper, discharging into a waste stabilization pond.

021 Anon.

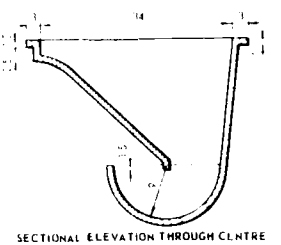
PROTOTYPICAL SEWAGE DISPOSAL SYSTEM DESIGN FOR SMALL LOW COST HOUSING SCHEMES ON DEEP BLACK COTTON SOIL
Unpublished pre-investment report, Housing Research and Development Unit, University of Nairobi. Kenya. 13 pp. April 1973. 5 appendices.
KENYA: RURAL: WASTE DISPOSAL: ARID CLIMATE.

* A description of sanitation systems suitable for semi-rural housing groups of approximately ten dwellings. Dry sanitary systems are considered appropriate where constant water supply cannot be assumed. Semi-wet systems are proposed for dry climate conditions when water supply is reliable. Water is evaporated in a top soil layered vegetation bed. Wet sewage disposal linked to oxidation ponds is also described.

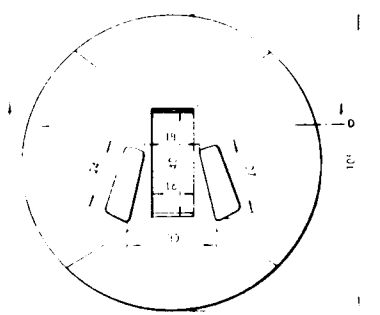
022 Anon.

VITA,
Mt. Rainier, U.S.A.

VILLAGE TECHNOLOGY HANDBOOK
VITA Publication. U.S.A. pp. 147-181. January 1975.
19 figures
DEVELOPING COUNTRIES: WATER-SEAL PRIVIES: THE PHILIPPINES: THAILAND: CONSTRUCTION.
* A description of sanitary latrines for developing countries with special emphasis on water-seal privies that have been in practices in the Philippines and Thailand. Details of construction techniques are included such as how to make the mold, the bowl, and install the toilet etc.



WATER-SEAL TRAP AND SQUATTING PLATE



023 Baars, J.K.

National Health Research Council, The Hague, Netherlands.

TRAVEL OF POLLUTION, AND PURIFICATION EN ROUTE, IN SANDY SOILS.
Bulletin of the World Health Organization. Switzerland.
Volume 16. pp. 727-747. 1957.
9 references, 7 figures, 4 tables.
PIT LATRINE: NETHERLANDS: SAND: INFILTRATION: SUBSURFACE DISPOSAL.
*The travel of pollution in sandy soils and the extent to which purification takes place en route are discussed. Two types of soil pollution are considered (a) severe pollution of the surface layers with matter concentrated in a small volume of water (e.g. pit privy) and (b) moderate pollution of the surface layers with matter contained in large quantities of water. It is shown that in both types the self-purification is sufficient to prevent contamination of ground water, provided that the soil is fine and - in the case of pit privies - dry and well aerated, and provided that the water table is not too high or the rate of infiltration too great.

○ 024 Caldwell, E.L.

Alabama State Dept. of Health,
Andalusia. U.S.A.

STUDIES OF SUBSOIL POLLUTION IN RELATION TO POSSIBLE CONTAMINATION OF THE GROUND WATER FROM HUMAN EXCRETA DEPOSITED IN EXPERIMENTAL LATRINES

Journal of Infectious Diseases. U.S.A. Volume 62.
pp. 272-291. 1938.
7 figures, 6 tables, 6 references.
PIT LATRINE: POLLUTION: GROUND WATER: HOUSEHOLD: SANDY SOILS: GRAVITY FLOW: LATERAL FLOW: PATHOGENS: EXCRETA.

*A report of a six month study on the effects of pollution from human excreta deposited in experimental pit latrines located in unconsolidated soils above the water table.

The general observations show that intestional organisms are confined to the vicinity of the pit unless transported by water flow, and furthermore this transportation is generally downward with gravity flow, in previous soils. Hence in a pit receiving only excreta, seepage of fecal organisms extended less than one foot. In a similar pit with vain seepage, organisms were carried less than four feet below the pit. Another pit, receiving 100 gallons of water daily, showed a deeper penetration of fecal matter, but less than seven feet down. In all three cases lateral penetration was less than one foot. It was observed that lateral carriage did occur if soil conditions at the bottom of the pit impeded penetration.

The results of the test demonstrate that in all moisture conditions not only is there a limit to the depth of penetration, but sooner or later, a regression of the bacterial stream. The uniform mantle of contents at the bottom-fecal mass or sludge - serves also to retard penetration of fresh organisms and the clogged sands constitute an impervious, or semi-impervious, layer constantly increasing in thickness. The intestinal bacteria die off at a faster rate than the fresh supply, and there is a steady regression back towards, and sometimes into, the pit.

025 Campos de Carvalho, M.E.

Direccas de Servicos de Urbanismo e Habitacao de Ministerio de Ultramar. Angola.

A STUDY OF SANITATION SYSTEMS FOR LOW INCOME PEOPLE (CONTRIBUCAO PARA A VESOLUCAO DE SANEAMENTO DE AGUAS NEGRAS EM AGRUPAMENTOS DE ECONOMICAMENTE DEBEIS)

Segundas journades de Engenharia e Arqintectura de Ultramar. Angola. Volume 5, Paper 118. pp. 290-310. May 26-31, 1969.
ANGOLA: PIT LATRINES: SEPTIC TANKS: COMMUNAL LATRINES: DESIGN: WATER.

* A description of a number of sanitation systems of varying complexity for low-income people. The choice of system is based on the availability , or absence, of running water. Ventilated pit latrines and bore-hole privies use no water. Collective aqua-privies are reported to need close supervision for adequate operation. Individual septic tanks are also described.

(Original paper written in Portugese).

026 Coffey, K.
Reid, G.W.

(Both) Bureau of Water and Environmental Resources Research, The University of Oklahoma, Norman, Oklahoma, U.S.A.

HISTORIC IMPLICATION FOR DEVELOPING COUNTRIES OF DEVELOPED COUNTRIES, WATER AND WASTEWATER TECHNOLOGY

A report published by the Office of Research Administration, University of Oklahoma, U.S.A. for the U.S. A.I.D. December 1976. 183 pp.
8 tables, 34 figures, 56 references.
DEVELOPING COUNTRIES: HISTORICAL ASPECTS: TECHNICAL ASPECTS: WASTE TREATMENT.

*The thought behind this report throughout its preparation was that certain lessons could be learned from past developments in the technology of water handling and usage in developed areas that might be of benefit in accelerating progress in improvements in this field in the developing areas. Information from less developed regions was included in certain instances where it seemed of interest. The general purpose was to show that certain historically used techniques in developed regions might be applicable today in less developed areas. The idea was to find historical evidence of alternatives for those less developed regions.

The first section comprised an inventory of historically used techniques, together with associated health conditions when possible. It was mentioned in connection with this section that it was difficult in many instances to determine the actual data, place, or originator of an invention, since often successive ideas of only partial success can eventually lead to a successful conclusion. In addition, it was noted that inventions or patents are often in existence long before the item is actually put into use. The second section contained a description of the chronological development of water usage and handling, first in Great Britain, particularly London, and also in the United States, these being the two areas for which the most complete information was available. In the last section an attempt was made to describe life-style levels as a chronological concept in the developed areas. In addition, levels of technology were developed as a chronological concept. Finally, an attempt was made to tie historical technology levels to the life-style levels. A time scale was developed for the principal historical regions covered by the inventory. Each regional scale was correlated with the other regional scales as well as with the chronological scales of technology levels and life-style levels.

027 Handa, B.K.
Panickar, P.V.R.C.
Kulkarni, S.W.
Gadkari, A.S.
Raman, V.

(All) National Environmental Engineering Research Institute, and Governmental Medical College, Nagpur. India.

AN INTEGRATED APPROACH TO RURAL SANITATION TOWARDS BETTER HEALTH.
Unpublished Report. 14 pp. 1977.
5 tables, 4 figures, 5 references.
RURAL SANITATION: LATRINES: HEALTH EFFECTS: RURAL HEALTH: INDIA: HOOKWORM.
*A report on a rural sanitation pilot project looking into the health effects of sanitary latrines, protected water supply, health education and specific drug treatment in ten villages near Nagpur. The whole population (793) of one village was examined for stools, blood and clinical history. Twenty-five per cent of the people in five other villages were examined for base-line health conditions. Hookworm was the most prevalent infestation and deworming medicine was administered in one village. After latrines and protected water supplies are in use by the majority of the population, stool and blood samples will be examined over time to follow the impact of rural sanitation on health.

O 028 Hardenbergh, W.A.

Jefferson County Board of Health,
Alabama, U.S.A.

HOME SEWAGE DISPOSAL
J.B. Lippincott Co. U.S.A. Part 2 (Chapters 5 - 10) "Sewage Disposal for Unsewered Sections". viii 274 pp. 1924.
SEWAGE: EXCRETA: HOUSEHOLD: PIT PRIVY: VAULT PRIVY: BOX AND CAN PRIVY: BUCKET CONSERVANCY: SEPTIC CLOSETS: AQUA-PRIVIES: CHEMICAL CLOSETS: NIGHTSOIL BURIAL: NIGHTSOIL INCINERATION: TREATMENT.

*The need of sanitation for areas not reached by sewers is emphasized. These chapters describes an early American experience (prior to 1924) in household sewage disposal with particular reference to on-site waste disposal systems.

The earliest known form of sanitary privy is the pit. For an average privy for one family, with one or two seat holes, design of the pit should be 36-44 inches in length, 30-36 inches wide, and 48-60 inches deep. For each additional privy seat, 24 inches should be added to the length, but no changes made in width and/or depth to prevent groundwater pollution. Sheeting of the inside of the pit will be necessary in soils subject to caving, such as sand or loose loam. The lining should also extend above the ground surface 4 to 8 inches, forming a curb around which earth should be banked to prevent the inflow of surface water. Methods of pit construction and operation are described in details and photographs of each construction step included. The main advantages of the pit is its initial cheapness with ease of operation while among disadvantages of pits is the danger of water pollution and the chance of their acting as fly and mosquito breeders.

The double compartment concrete vault privy consists of a concrete box built in the ground, a central wall dividing it into two compartments, the rear wall 60° sloped to allow for easier cleaning, a seat riser and seats on top, and the whole covered with a privy house. Each compartment serving by turns consecutively has a capacity of 75 to 100 gallons, or theoretically sufficient to provide storage for the wastes of the average family for 3 to 6 months. Scavenging is through the rear, where a removable cover is provided. Main disadvantages of this system are high cost, difficulty in maintaining proper cleaning service, and rapid deterioration of flytightness. Odors cannot be prevented entirely but may be reduced somewhat by liberal use of dust, ashes, lime, or other absorbent material added immediately after using the privy.

The box and can type of privy is so-called because it is essentially a fly proof box, within which is contained a waterproof receptacle or can for the catchment of the excreta. Scavenger service is carried out by removing the filled cans to dumping stations by single or double-deck wagons. The main problem is maintenance of proper scavenging service at regular intervals.

Final disposal of the excreta can be done through burial land disposal or by dumping through sewers to the final treatment and disposal systems.

029 Holland, R.J.

World Health Organization,
Geneva, Switzerland.

UNIT COSTS OF DOMESTIC SEWAGE DISPOSAL IN KENYA
University of Nairobi, Department of Civil Engineering. Kenya. November 16, 1973.
2 diagrams, 1 table.
COSTS: SEWAGE: UNSEWERED SYSTEM.

* The paper provides comparative costs of sanitation by bucket latrine, pit latrine, aqua privy, cesspit, and by sewerage with conventional treatment or waste stabilization ponds. The mode of use of each method is defined. Capital costs, life and running costs are estimated and the total annual costs are presented, calculated using interest rates of 6% and 10%.

030 Kharkar, C.B.
Tiwari, A.R.
Venkatesan, T.L.

COMMUNITY WASTE WATER DISPOSAL WITH REFERENCE TO LABOUR COLONIES AROUND BHILAI TOWNSHIP
Proceedings of Symposium on Community Water Supply and Waste Disposal, Central Public Health Engineering Research Institute. India. Volume 2. pp. 55-61. December 19-21, 1966.
2 figures, 1 appendix.
RURAL SANITATION: INDIA: LABOUR CAMPS: COMMUNAL LATRINES: PIT LATRINE: BOREHOLE LATRINES: SEPTIC TANKS: SOAKAGE PITS: STABILIZATION PONDS.

*A review of methods used to dispose of wastes from camps housing construction workers around Bhilai Township in India. Central sanitary blocks with stand post water supply draining through communal latrines, as flushing water, to septic tanks and drainage fields are described. Pit latrines served lower category housing, a 3ft. 6in. diameter x 7ft. deep pit lasted a family of 5 for 3 years and similar pit latrines were used as public latrines, designed for 20 users per pit to last 1 year. Borehole latrines 15in. diameter 15ft. deep were accepted by the public but trench type latrines were not popular. Soakage pits collecting sullage water were unsuccessful and promoted mosquito breeding. The problems of at source waste disposal are considered and costs compared but the authors' preference is for wastewater collection and treatment in stabilization ponds with subsequent reuse in agriculture. A pond scheme serving 12,000 population is described and the per capita capital cost given as 25 rupees.

031 Kouete, J.R.

ORGANIZING THE FIGHT AGAINST THE FECAL PERIL IN REGION OF THE CONGO (MOSSAKA)
(ORGANISATION DE LUTTE CONTRE LE PERIL FECAL DANS UNE LOCALITE DU CONGO (MOSSAKA)
Unpublished report of the Para - Medical Section, Ecole Nationale de la Sante Publique. France. 69 pp. 1975-76.
5 references.
CONGO: PIT LATRINES: PUBLIC HEALTH: SOCIAL.
* A description of existing conditions with regard to sanitation in the town of Mossaka. The prevalence of enteric diseases is regarded to be directly linked to unhygenic excreta disposal. Improved practices for the construction and use of pit latrines are described.

(Original paper written in French)

032 Leich, H.H.

OIL-FLUSHED TOILETS GAIN
Compost Science, U.S.A. Journal of Waste Recycling. Vol. 18 No. 1. pp. 25.
SANITATION: TOILET: OIL-FLUSH: DISPOSAL OF HUMAN WASTES: WATERLESS TOILET.
*Describes a sanitation method that uses no water in disposing of body wastes. A colorless, low-viscosity mineral oil replaces water as the flushing media and wastes are carried to a holding tank where the oil floats to the top and the water-saturated wastes sink to the bottom where they are removed and disposed of. After filtration the oil is piped back to the toilet in a continuous recycling process.

033 Majumder, N.

National Environmental Engineering Research Institute,
Nagpur. India.

SANITATION FACILITIES FOR SLUMS AND RURAL AREAS
National Environmental Engineering Research Institute. India. 24 pp. 1975.
2 appendix tables, 15 figures.
RURAL SANITATION: EXCRETA DISPOSAL: LATRINES: ON-SITE DISPOSAL: COMMUNAL LATRINES: SLUM SANITATION: INDIA.
* A concise review of sanitation provisions for slum areas and communities including communal washing and bathroom units, communal latrine blocks and individual household latrine units. Dimensional drawings of each type are given and estimated costs tabulated.

034 Morton, S.D. — Warf Institute, Wisconsin. U.S.A.

Sawyer, E.W. — Pennsylvania Glass Sand Corp., West Virginia. U.S.A.

CLAY MINERALS REMOVE ORGANICS, VIRUSES AND HEAVY METALS FROM WATER
Water and Sewage Works. U.S.A. pp. 116-118. 1976.
4 tables, 6 references.
VIRUSES: ADSORPTION: PERCOLATION: SEWAGE: CLAY: SOIL.
*Various grades of Attapulgite clay, Sepiolite, and an Amorphous Zeolite exhibit a high degree of adsorption for enteric viruses when contacted with contaminated water. The effects of contacting time on polio-virus adsorption, the effects of clay concentration on polio-virus adsorption, and the removal of organics by percolation with granular low volatile matter are examined.

035 Pedregal, H.
Viera, J.L. — Direccion de Malariologia y Saneamiento Ambiental Oficina de Estudios Especiales, Planeacion y Presupuesto, Caracas. Venezuela.

CONSTRUCTION METHODS FOR LATRINES
(SISTEMAS CONSTRUCTIVOS PARA LETRINAS)
Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente (CEPIS). Peru. 23 pp.
2 tables.
VENEZUELA: ASBESTOS: CEMENT LATRINES: CONSTRUCTION: FIBREGLASS LATRINES: LATRINES: LOW COST TECHNOLOGY: TABLOPAN LATRINES.
* Asbestos cement, fibreglass and tablopan are evaluated in terms of cost, availability and labour requirements for the construction of latrines in Venezuela. Tablopan, a kind of pressed wood, was found to be the most desirable alternative for building latrines given its low cost, the reduction of the numbers of assembly parts, its weight and time required for construction.

(Original paper written in Spanish)

036 Richard, C.

South Pacific Commission
Nouméa. New Caledonia.

SIMPLE ENVIRONMENTAL SANITATION ON THE SMALLER ISLANDS
South Pacific Bulletin. New Caledonia. pp. 21-23. Fourth Quarter, 1972.
2 figures, 1 table.
EXCRETA: DISPOSAL: RURAL: PIT LATRINE: WATER SEAL TOILET.
*Rural sanitation measures are described for improving conditions in small Pacific islands. Pit latrines are seen as the first step towards eventual septic tank and water supply installation.

037 Saldias, A.
Gutierrez, L.
Boquin, G.

(All) Universidad Tecnica de Oruro,
Facultad Nacional de Ingenieria,
Bolivia.

EXCRETA, WASTEWATER AND GARBAGE DISPOSITION MANUAL
(MANUAL DE DISPOSICION DE EXCRETAS, DESAGUES Y BASURAS)
Facultad Nacional de Ingenieria, Departamento de Publicaciones, Universidad Tecnica de Oruro. Bolivia. 78 pp. 1970.
14 figures, 4 tables.
BOLIVIA: CESSPOOLS: CHEMICAL LATRINES: CHLORINATION: COLLECTION: DISINFECTION: DISPOSAL: GARBAGE: INCINERATION: LANDFILL: MAINTENANCE: SANITARY LATRINES: SEPTIC TANKS: SOIL POLLUTION.
* The paper is divided into three parts. The first one refers to garbage collection and disposal and presents several alternatives for it, such as land refill, incineration. The author recommends land refill as a most viable solution for developing countries where land is available. Further utilization of garbage for the production of fertilizers is highly recommended.

The second part discusses the most common off and on-site excreta disposal systems. Design criteria for latrines, septic tanks, etc. are provided, as well as guidelines and requirements for their operation and maintenance. The last section of the paper is dedicated to reviewing the methodology for project preparation and appraisal.

(Original paper written in Spanish)

038 Shelat, R.N.
Mansuri, M.G.

(Both) S.V. Regional College
Surat. India.

PROBLEMS OF VILLAGE SANITATION
Journal of the Institution of Engineers. India. Volume 52.
pp. 21-24. October 1971.
2 tables, 2 figures, 8 references.
EXCRETA: INDIA: POUR-FLUSH LATRINE: NIGHTSOIL COLLECTION CARTS: SEPTIC TANKS: SEWERAGE: SEWAGE TREATMENT: STABILIZATION PONDS.

* Current sanitation practice in Gujarati villages (up to 5000 pop.) is reviewed and methods for sanitary improvement are suggested; these include the conversion of pit latrines and pail latrines to pour-flush latrines connected to a brick-lined seepage pit, septic tanks to serve groups of latrines, improved containers and wheelbarrows for nightsoil and, where a piped water supply is available, sewage treatment in waste stabilization ponds. The importance of community education in matters of sanitation is strongly advocated.

039 Subrahmanyan, K.
Bhaskaran, T.R.

(Both) All India Institute of Hygiene and Public Health, Calcutta, India.

THE RISK OF POLLUTION OF GROUND WATER FROM BOREHOLE LATRINE
The Indian Medical Gazette. India. Vol LXXXV, No. 9.
pp. 418-423. September 1950.
1 table, 1 graph, 4 references.
INDIA: BOREHOLE LATRINE: PIT LATRINE: EXCRETA: POLLUTION

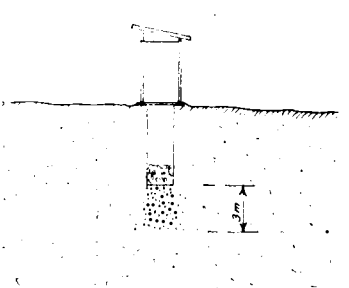
*The use of borehole or pit latrines as a means of safe disposal of human excreta is considered practical in India. These latrines do not require any handling of nightsoil; they are cheap and can be made fly-proof and free from the risk of hookworm propagation. The extent of pollution diffusing from a borehole latrine into the ground water is reported to depend mainly on the velocity of flow of ground water. Hence the safe distance between a borehole latrine or leaching cess pit and a ground water source may be taken as 25 feet or about 8 days travel of the ground water. However, the above distance may have to be increased correspondingly if the soil is fissured, or spongy or contains large voids, as in the case of badly shattered rock, limestone or gravel.

040 Susikaran, M.

Research Cum Action
Project,
Poonamallee. India.

AN ANALYSIS OF 296 INDIVIDUAL HOUSE SANITARY LATRINES IN VILLAGES IN POONAMALLEE AREA (MADRAS STATE)
Proceedings of the Symposium on Evaluation of Rural Latrine Designs, the Central Public Health Engineering Research Institute. India. pp. 73-80. October 28, 1964.
5 tables, 2 references.
RURAL SANITATION: EXCRETA DISPOSAL: LATRINES: INDIA: RURAL HEALTH: ON-SITE TREATMENT.

*A review of factors affecting the success of latrine programmes in South India. Among the subjects discussed are health education to promote latrine acceptance, influence of religion, influence of house superstructure, effects of distance of house from water source and distance of latrine from house, importance of type of enclosure for the latrine. The importance of the availability of latrine materials and need for follow-up advice and checking usage of latrines is stressed.



MOVEMENT OF POLLUTION IN DRY SOIL

041 Wagner, E.G.
Lanoix, J.N.

EXCRETA DISPOSAL FOR RURAL AREAS AND SMALL COMMUNITIES
World Health Organization Monograph No. 39. Switzerland. pp. 25-120. 1958.
46 references, 57 figures.
PIT LATRINE: DISPOSAL: DESIGN: CONSTRUCTION: PRIVY: INFILTRATION: EXCRETA: RURAL: HOUSEHOLD: SQUATTING PLATE: COMPOST PRIVY.

*A review of a number of well-known rural on-site disposal techniques, including engineering factors, human factors, criteria for selection and detailed descriptions of specific techniques.

042 Watson, M.

The Ross Institute of
Tropical Hygiene,
London School of Hygiene
and Tropical Medicine,
U.K.

A NOTE ON THE CONSTRUCTION OF BORED-HOLE LATRINES
The Ross Institute Memorandum, London School of Hygiene and Tropical Medicine. U.K. 4 pp. June 15, 1936.
3 figures.
BORED-HOLE LATRINE: HUMAN EXCRETA: CONSTRUCTION: OPERATIONS.
* The bored-hole latrine, one for each family or small group, can provide a means of disposing of human excreta which have proved successful in several different countries. Methods of latrine construction are described and a hole diameter of 16 inches is recommended to avoid soiling of the sides near the top and to ensure a sufficient cubic capacity. Some advantages and disadvantages of the bored-hole latrines and ways to overcome the difficulties during operation periods are included.

043 WATSON, M.

Ross Institute of Tropical
Hygiene,
London. U.K.

AFRICAN HIGHWAY...THE BATTLE FOR HEALTH IN CENTRAL AFRICA
Publisher: John Murray. U.K. Chapter 33 "Latrines". pp. 165-168. 1953.
1 figure
SHALLOW-TRENCH LATRINES: SMOKING PIT LATRINE: BORED-HOLE LATRINE: AFRICA.
*Chapter 33 describes simple types of latrines suitable for use in labour camps on agriculture estates. The need for strict maintenance and supervision of sanitary facilities is strongly emphasized.

044 Yeager, C.H.

WELL POLLUTION AND SAFE SITES FOR BORED HOLE LATRINES
The Malayan Medical Journal. Singapore. 4(4). pp. 118-125, December 1929.
9 figures, 1 table.
EXCRETA: SINGAPORE: BORED HOLE LATRINES: SHALLOW WELLS: WATER POLLUTION: GROUNDWATER.
* Experiments were conducted to determine the distance of travel of faecal coliform bacteria in very permeable soil from bored hole latrine, in order to determine the minimum spatial separation between the latrine and a shallow unprotected well. The bacteria were found to travel at least 23m but not as far as 31m. It was found that flourescein could not be used satisfactorily as a chemical tracer of bacteriological pollution.

2B. On-Site Collection and Treatment: Mouldering Privy

045 Anon.

CLIVUS MULTRUM IN PUBLIC USE FACILITIES
Report of Clivus Multrum U.S.A. Inc. U.S.A. 9 pp. 1976.
11 diagrams
COMPOSTING TOILET: COMMUNITY: DISPOSAL: SWEDEN: DESIGN: CONSTRUCTION: OPERATION: PUBLIC TOILETS.
* The Clivus Multrum composting toilet has been used in public installations, and this report describes two such installations in state parks in Sweden. One of these facilities is used by 600-1000 persons per week on a year-round basis. The design and operation of those facilities is described in detail.

●● 046 Anon.

The Department of Hygiene and Epidemiology,
Ministry of Health,
Democratic Republic of Viet Nam.

DOUBLE SEPTIC TANKS
A booklet published by the Department of Hygiene and Epidemiology, Ministry of Health, Democratic Republic of Viet Nam. Viet Nam. 33 pp. 1968.
3 tables, 12 figures.
VIET NAM: DOUBLE SEPTIC TANKS: EXCRETA: URINE: COMPOST: AGRICULTURE: HEALTH: MOULDERING TOILET:
*A system has been developed in the Democratic Republic of Viet Nam for on-the-spot composting of excreta. It consists of a two-compartment watertight vault. The compartments serve by turns for defaecation and for composting. A groove channels the urine to a separate container so as not to flood the interior of the vault. Before initiating use, a layer of ashes or lime is applied to the floor of the vault to absorb humidity as well as to prevent the faeces from sticking to the floor when being removed. After each use, wood ashes are sprinkled over the faeces to absorb odours, and the hole is sealed with a wooden lid.

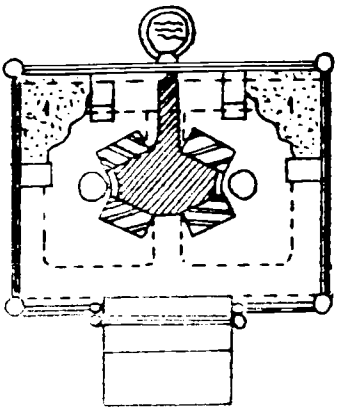
When the tank is almost full the contents are levelled with a stick, and it is filled with ashes. Then openings are sealed with lime cement or clay and the adjoining compartment goes into use as a vault. The composting (anaerobic) is allowed to go on for at least 2 months before the contents are removed by a rear access door. It has been found that following an 8 week period 85% of the intestinal worm ova are destroyed. Two factors are felt to contribute to more effective pathogen destruction - the use of kitchen ashes, which promote the anaerobic process, and as long a composting period as possible.

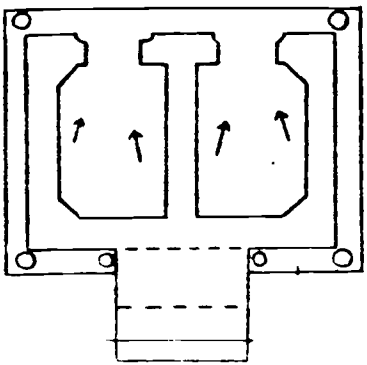
After 8 weeks, 98% of organic nitrogen is changed into useful inorganic form, and the percentage of inorganic nitrogen (ammonium nitrate) increases rapidly in the latter stages of the composting process.

The use of the double septic tank has resulted in a recorded drop in disease due to handling fresh excreta used for fertilization, as well as an increase in crop production due to the fixing of the nitrogen in the compost product.

The compost product is used to fertilize rice, as well as secondary food crops, mainly vegetables, and the quantity of fertilizer is estimated to be the equivalent to 2.3 million tons of protein sulfate per year.

To serve a family of 5-10 persons the vault required is 1.2m wide, 0.7m high and 1.7m long. A variety of construction materials can be used, depending on local availability. Clay, lime montar, stone, rammed earth, bamboo wattle, unbaked bricks, and concrete, are used in various regions to fabricate the container. In certain mountain regions where human wastes are not used in agriculture, the vault is dug as a pit and only a movable lid is constructed, which is removed to a new site once the pit is full.





047 Anon.

International Reference Centre
for Community Water Supply,
The Hague, Netherlands.

CONTRIBUTION TO A MAIL SURVEY ON PRACTICAL SOLUTIONS IN DRINKING WATER SUPPLY AND WASTES DISPOSAL FOR DEVELOPING COUNTRIES
A report prepared by the International Reference Centre for Community Water Supply, The Hague, under Contract with the University of Oklahoma Project, USAID Contract no. AID/CM-ta-C-73-13. Netherlands. 156 pp. February 1977.
Numerous figures included
DEVELOPING COUNTRIES: SANITATION: LATRINES: AQUA PRIVIES: LAGOONS: SEPTIC TANKS: MOULDERING TOILETS.

*This mail survey was conducted for the purpose of collection of field experience and unpublished data with particular reference to practical solutions in drinking water supply and wastes disposal in developing countries. A need was felt for a compilation of information on alternative techniques which would be uncomplicated, easy to work with, require less maintenance, and which could be managed by the local people. These could be non-current techniques, adaptions of existing ones or new developments. Made widely available, such a compilation would enable engineers to select the solutions which would best suit the social, cultural, and economic conditions of the country and technical level of their personnel.

048 Anon.

Konsumentverket
Fack
Sweden.

TOILETS FOR RECREATION (KLOSETTER FOR FRITID)
ISBN 91-7398-068-4. Sweden. 40 pp. Issued April 1976.
1 figure, 4 tables, 10 references.
ON-SITE TREATMENT: RECREATION HUTS: PRIVY: MOULDERING TOILET: FLUSHING TOILET: INCINERATOR TOILET: EXCRETA-DISPOSAL.

*The document is meant as a handbook to owners of recreation huts in their choice of toilet.

It is a follow up of the 1973 edition of "Toilets for Recreation Huts" and is adding the new types introduced since 1973, especially since the range of mouldering toilets have increased.

Principals for different toilet types on the market are described. For each individual toilet price, operating cost, manufacturer and any special technical requirements needed for the type of toilet are tabulated.

A judging from environmental point of view of the effects of the different types of toilets is done.

The influence of given preconditions like purifying demands, given technical standard, service available and soil conditions on the choice of toilets is also discussed.

(Original paper written in Swedish)

○ 049 Anon.

Mikrobiologisk institutt
Norges lanbrukshogskole,
1432 As, Norway.

21 BIOLOGICAL TOILETS, MOULDERING TOILETS FOR RECREATION HUTS
(21 BIOLOGISKE KLOSETTER, KOMPOSTERINGSKLOSETTER FOR HYTTER OG FRITIDSHUS)
Reprinted from "Forbruker-Rapporten nr 10. Norway. 15 pp. 1975.
3 figures, 4 tables.
MOULDERING TOILET: DECOMPOSING: EXCRETA: ON-SITE TREATMENT: NORWAY: RECREATION HUTS.

* Twenty-one different mouldering toilets appearing at the Norwegian market have been tested at the Agricultural University, Norway.

The toilets were grouped as follows:
(1) Big toilets with a flat container (1200-1600 liters)
(2) Big toilets with an inclined container (1200-1600 liters)
(3) Small toilets with a warming-up system (80-200 liters)
(4) Small toilets without a warming-up system

The report is meant as a guide for choosing toilets to recreation huts. The tests were carried on for five months and during that time the different toilets were charged with excreta according to instructions given by the producers.

The results are given both in tables for each toilet and in a summing up for the four groups separately.

Group 1 - toilets gave an unsatisfactory aeration of the material, anaerobic conditions and as a consequence of this the mouldering effect was low. None of the types worked satisfactory as a mouldering toilet.

In group 2 some of the types gave a better decomposing. Problems occurred with the inclination, a steeper angle than 20% made all excreta fall to the bottom of the container straight away and it was filled up very quickly. Problems with the urine was also noted. As a whole, somewhat better than group 1.

Group 3 gave a better mouldering, thanks to the increased temperature and the better aeration resulting from built-in levers for stiring the excreta. This higher activity is important because of the small size of the container.

One toilet from group 4 was tested and it was found to work less efficient than group 3 - toilets.

(Original paper written in Norwegian)

050 Berry, W.

A COMPOSTING PRIVY
Organic Gardening and Farming. U.S.A. 20(12). pp. 88-97. December 1973.
6 figures.
HOUSEHOLD: DESIGN: CONSTRUCTION: ON-SITE: DISPOSAL: COMPOST PRIVY: U.S.A.
*An experiment with an on-site composting privy is described. The container has four compartments which permit alternative use and composting of excreta and dry organic matter. The humus product has been used in fertilizing non-food crops. The composting process is primarily anaerobic.

051 Blackmore, M.D.
Boydell, R.A.
Mbere, N.
Moselele, P.

LOW COST SANITATION RESEARCH PROJECT FIRST INTERIM REPORT
Unpublished Report to the Ministry of Local Government and Lands, Republic of Botswana and to the International Development Research Centre. Botswana. 75 pp. September 1976.
9 appendices, 18 diagrams, 10 tables.
BOTSWANA: COMPOST PRIVY: AQUA-PRIVY: PIT LATRINE: SOCIAL: ECONOMIC.
* Problems arising from unplanned migrations to urban areas have necessitated a search for low-cost sanitation systems which will be low (or non) water consuming, hygienic and socially acceptable. Following a review of local conditions and regional experiences, three systems are proposed for consideration: aqua-privies, composting toilets and modified pit latrines.

○ 052 Blanc, M. Service de l'habitat et de l'urbanisme, Paris. France.

THE FECAL PERIL AND WASTE TREATMENT IN THE TROPICS
(LE PERIL FECAL ET LE TRAITEMENT DES DECHETS EN MILIEU RURAL TROPICAL)
Bureau central d'etudes pour les équipments d'outre mer. (B.C.E.O.M.). France. 139 pp. May 1957.
AFRICA: RURAL: CONSTRUCTION: PIT LATRINES: COMPOST PRIVIES: SQUATTING PLATES.
*A review of rural excreta disposal techniques for African villages. These range from pit and bore-hole latrines to septic tanks and aqua privies. Emphasis is placed on the desirability of separating feces and urine in dry latrines, and a number of squatting plates are described that accomplish this purpose. A movable dry compost privy is recommended. The decomposition of dry feces is reported to take 6-8 weeks.

(Original paper written in French)

053 Danielsson, K.

TOILETS FOR RECREATION HUTS
(KLOSETTER FOR FRITIDSHUS)
Konsumentverket, Fack. Sweden. 53 pp. 1973.
9 figures, 3 tables.
MOULDERING TOILET: FREEZE TOILET: BURNING TOILET: EXCRETA: ON-SITE TREATMENT: COMPOSTING: SMALL-SCALE PURIFYING PLANT.

* The publication is meant as a guide to owners of recreation huts in planning the sanitary part of the house.

The following types of toilets have been tested:
(1) Traditional type of dry toilets
(2) Composting toilets
(3) Freeze toilets
(4) Packeting toilets
(5) Burning toilets
(6) Flushing toilets

The toilets are judged from both private-hygiene point of view and from their polluting effects on the environment. In addition to this,costs and technical requirements (e.g. electricity, water, space needed) are listed in a table.

Four mouldering toilets are tested, three smaller types working with electricity and one bigger type, not demanding electricity (CLIVUS).

The results show that in the smaller toilets the excreta is not completely decomposted and needs "after-composting" for some time in addition to the treatment in the toilet itself. In contrast to this the product coming from CLIVUS is satisfactory decomposted and can be used immediately.

The other types of toilets discussed do not imply any final treatment of the excreta (except for the burning toilet), because the sludge produced has to be treated another time in a central purifying plant.

Altogether 23 different toilet types are presented.

Finally a summing up of 13 smaller purifying plants for single houses or small house-groups is given, with prices and test-results.

(Original paper written in Swedish).

054 Eygelaar, J.

COMPOSTING TOILETS - REPORT OF A VISIT TO THE ALTERNATIVE WASTE DISPOSAL PROJECT, DAR-ES SALAAM, TANZANIA.
Unpublished Report, Housing Research and Development Unit, University of Nairobi. Kenya. 9pp. April 4, 1977.
1 diagram.
TANZANIA: COMPOSTING TOILETS: RURAL: SOCIAL: PIT LATRINE.

* A description of a research project in Tanzania testing four types of improved latrines - continuous composting, double vault, odourless ventilated pit latrine (R.O.E.C.), ventilated pit latrine. Only preliminary results are given. Operation so far is said to be satisfactory and the majority of users seem to adapt easily to the required operation.

055 Fogel, M.

Clivus Multrum USA
14A Eliot Street,
Cambridge. U.S.A.

CHEMICAL ANALYSIS OF CLIVUS MULTRUM COMPOST
A Report issued by Clivus Multrum. U.S.A. 9 pp. February 1977.
4 tables, 9 literature references
MOULDERING TOILET: COMPOST: SOIL AMENDMENT: PLANT NUTRIENTS: TOXIC METALS: ON-SITE TREATMENT.

* Samples of finished compost from seven Swedish CLIVUS Multrum were collected. The units had been in use for between four and fourteen years.

These samples were analysed for organic matter, major plant nutrients, minor and trace plant nutrients and toxic metals.

The Multrum compost averaged 58% organic matter. The concentrations of the major plant nutrients, N, P, K, were respectively 2.4%, 3.6% and 3.9%, which is higher than in ordinary garden compost, municipal compost or composted sewage sludge.

The values are about 1/3 of those for ordinary fertilizers. Also regarding minor and trace plant nutrients the compost had suitable concentrations.

For toxic metals (Zn, Cu, Ni, Cd, Pb, Cr, Bo) the concentrations were far below the recommended safe levels (USDA). The values were lower than in common sewage sludge.

Concentrations of soluble salts were also measured and found acceptable.

056 Jounge, L.D.

Enviroscope, Inc.
Corona del Mar.,
California, U.S.A.

THE TOA-THRONE-A NEW COMPOST TOILET
Compost Science. U.S.A. 17(4). pp. 16-17. September/October 1976.
2 tables.
COMPOST TOILET: KITCHEN WASTE: SWEDEN: NORWAY: PATHOGENS: FERTILIZERS: SOIL CONDITIONER: EXCRETA.

* A Swedish Toa-Throne compost toilet capable of processing both human and kitchen organic wastes is described. The unit which can accommodate from 4 to 6 persons is small, comnact (1300 liters gross volume), and its overall cost in Europe is about $1,000 U.S. Experiments conducted in Norway show that reduction of mass solids after composting is from 72% to 92% and the end product is free from pathogenic organisms such as Salmonella and Poliovirus, hence its suitability for uses as fertilizers or soil conditioners.

●● 057 Lindstrom, C.R.

Institutionen for Uppvarmnings- och ventilationsteknik KTH
S-100 44 Stockholm, Sweden.

MULTRUM, INVESTIGATION OF THE WORKING CONDITIONS OF A MOULDERING ESTABLISHMENT FOR ORGANIC HOUSEHOLD-WASTE (MULTRUM, UNDERSOKNING AV DRIFTSFORHALLANDEN HOS EN FORMULTNINGS-ANLAGGNING FOR ORGANISKT HUSHALLSAVFALL)
A report issued by CLIVUS AB, Sweden in 1969. 44 pp.
5 figures, 9 diagrams, 5 tables, 6 literature references.
MOULDERING TOILET: ON-SITE TREATMENT: EXCRETA: KITCHEN-WASTE: TEMPERATURE.

*The construction and function of Clivus Multrum is described. It is pointed at the differences between Clivus and a normal privy. These are primarily the addition of kitchen waste, the aeration and the inclination that prevents the urine from staying with the excreta, making it too wet. These factors make it possible for a decomposition to take place in the mouldering toilet, which is not the case in a normal privy.

The investigations concern the question of balance between added and removed amount of solid materials and water in the toilet, if an equilibrum is reached and the importance of temperature to this process. Through calculations of the heat-balance it is found that at 19 C a steady state is reached for water and organic material, when the toilet is used by four persons.

The temperature in the mixture of excreta and kitchen waste had a maximum about 10 cm below the surface (+35C) and sank to average room-temperature at about 50 cm depth. The decomposing activity was also highest where the temperature was at maximum.

(Original paper written in Swedish)

058 Lindstrom, C.R.

THE CLIVUS-MULTRUM SYSTEM...COMPOSTING OF TOILET WASTE, FOOD WASTE, AND SLUDGE WITHIN THE HOUSEHOLD
Water Pollution Control in Low Density Areas,
University Press. U.S.A. pp. 429-444. 1975.
7 figures, 5 tables.
HOUSEHOLD: TREATMENT: COMPOSTING: TOILET: ENVIRONMENT: WASTEWATER.

* The use of household composting is proposed as a way to reduce water pollution. Properly constructed ground infiltration systems for wastewater from bath, sink and laundry will have little or no impact on the environment. Swedish experiences are cited.

059 Lindstrom, R.

A SIMPLE PROCESS FOR COMPOSTING SMALL QUANTITIES OF COMMUNITY WASTES
Compost Science. U.S.A. pp. 30-32. Spring 1965.
2 figures.
COMPOSTING: DISPOSAL: HOUSEHOLD: AEROBIC DECOMPOSITION.

*An experimentally-tested process is described that achieves an aerobic biological change in organic wastes. The key to this process is that excreta is deposited into a naturally ventilated chamber and moves, by gravity along the sloped bottom, to a second chamber. This second chamber holds organic refuse from the kitchen and garden. The garden refuse add the important nitrate bacteria which increase slowly but must be present in adequate numbers later so that a complete change of the ammonium carbonate into ammonium nitrate occurs.

The slope of the tank bottom provides continual movement of decomposed refuse to the third (storage) chamber as additional wastes are added to the other two compartments. When more refuse is added, the lower layer is compressed and decays. The waste volume is reduced to a fraction of the original during this process. Experiments have shown that the bottom slope must be between 140° and 18.5°.

The unit is not connected to any drain pipes and the moisture content from urine is sufficient for the conversion process. Aeration of the wastes is of primary importance in the decomposition process. Air movement is achieved by natural ventilation via an exhaust stack, which also eliminates odours.

The size of the tank, which is of impervious material such as concrete, can be varied. Minimal dimensions are 1m. wide and 3.5m. long.

The major advantage of this process is that it is fully automatic does not require fuel, chemicals or water, and the end product contains large amounts of humus-forming substances.

060 McMichael, J.K.

HEALTH IN THE THIRD WORLD...STUDIES FROM VIETNAM
Spokesman Books. U.K. pp. 40-50. 1976.
7 references, 4 diagrams.
VIETNAM: ANAEROBIC COMPOSTING: COMPOSTING: RURAL: SANITATION: PUBLIC HEALTH: HYGIENE: CUSTOMS: DOUBLE SEPTIC TANK.
*A description of the Five Year Plan (1961-1965) of the Democratic Republic of Vietnam for rural hygiene, with particular reference to experiences with the double septic tank, an anaerobic compost privy. This successful program is based on social, cultural, economic as well as technical solutions. The double vault septic tank received faeces only and produces significant quantities of disinfected fertilizer.

061 Nesbitt, P.M.
Seldman, N.N.
(both) Institute for Local Self-Reliance, Washington. D.C.

CITIES NEED SEWERLESS TOILETS
Building Systems Design. U.S.A. 73(3). pp. 11-17. April-May 1976.
URBAN: COMPOST TOILETS: U.S.A: AEROBIC.
* Advanced sewage treatment facilities in the Washington D.C. area alone will cost $2 billion to build and $70 billion to operate. If one million biological toilets were installed the initial outlay would be about $800 million plus a minimal annual maintenance expense. Advantages of compost toilets in urban areas are discussed.

062 Nichols, H.W.

ANALYSIS OF BACTERIAL POPULATIONS IN THE FINAL PRODUCT OF THE CLIVUS MULTRUM
Report of the Center for the Biology of Natural Systems, Washington University. U.S.A. 16 pp. December 7, 1976.
6 tables, 13 references.
COMPOSTING TOILET: HUMUS: BACTERIA: FERTILIZER: SOIL: ANALYSIS: TESTING: SOLID WASTE: EXCRETA.
*The Clivus Multrum is a mouldering toilet designed and produced in Sweden and the United States. An evaluation was made of the bacterial populations that occur in the final product of the Multrum, and was compared with the populations ordinarily encountered in soil, particularly with respect to pathogenic species. It was found that the bacterial composition of the composted product is similar to that of soil, the number and species of pathogenic bacteria present are similar to soil, and the final product appears to be suitable for use as a soil conditioner.

063 Nimpuno, K.

Dept. of Architecture,
Chalmers Technical University,
Gothenburg, Sweden.

EXCRETA DISPOSAL WITHOUT WATER
Appropriate Technology. U.K. Volume 3 No. 4. February 1977.
1 diagram, 1 table.
EXCRETA DISPOSAL: WATERLESS LATRINE: LOW-COST LATRINE: DISPOSAL: URBAN: RURAL: CRITERIA: HOUSEHOLD: COMPOST PRIVY:
*Describes a low-cost latrine that uses a two stage bio-chemical process. First is a two stage decomposition process (aerobic and then anaerobic). Finally a chemical treatment is obtained through using household ashes.

Ample supplies of national oxygen ensure a rapid breakdown of the excreta. To neutralize the urine acids, household ashes are thrown in each day. Paper and other household wastes supply the cellulose needed in the process. Sustained high temperatures destroy pathogenes and help to break down large organic molecules.

Latrine serves for a family of six for 9 to 12 months.

064 Pedersen, T.A.

Mikrobiologisk Institutt
Norges landbrukshogskole
1432 As, Norway.

BIOLOGICAL TOILETS - FUNCTION AND POSSIBILITIES (BIOLOGISKE KLOSETTER - VIRKESMATE OG MULIGHETER)
Vann, Number 4. Norway. pp. 240-267. 1974.
4 figures, 11 tables, 8 literature references.
COMPOSTING: MOULDERING TOILETS: EXCRETA: ODOUR: DECOMPOSITION: MICRO-ORGANISMS: HUMIDITY: TEMPERATURE.
*A summary of existing toilet-types is made, and their suitability for use in recreation huts is evaluated. The mouldering toilet is pointed at as the most acceptable alternative in recreation - areas.

The factors of importance for obtaining an effective composting-process are discussed. These are aeration, humidity, temperature, C/N-ratio and others.

Then a laboratory-test is described where excreta was composted for two months under various conditions. The factors alterated were temperature, air humidity and composition of the material composted. After one and two months of composting, samples were taken and analysed with respect to rate of decomposition, odour, production of CO_2, bacteria-content, development of actinomycet-colonies and fungoid growth. The C/N-ratio in some samples was measured at the start and at the end of the test.

The results show among other things that a humidity of 40% seems to give the best decomposition, while higher humidity has a negative effect on the process. An addition of kitchen waste had a positive effect and also higher temperature gave a faster decomposition. The existence of actinomycet-colonies at the surface and the development of CO_2 in the material gave a good indication of the decomposition-activity.

(Original paper written in Norweigan)

065 Reid, G.

PRACTICAL SANITATION
Charles Griffin & Co. Ltd. U.K. pp. 163-165. 1905.
EARTH-CLOSET: COMPOSTING: DISPOSAL: HOUSEHOLD: ENGLAND.
*A waterless privy, Moule's earth-closet is described. Dry earth is used to "flush" the waste into a container. Following a suitable holding period (three months) the composted matter is removed.

○ 066 Rybczynski, W.
Ortega, A.

(Both) Minimum Cost Housing Group,
McGill University,
Montreal. Canada.

STOP THE FIVE GALLON FLUSH! A SURVEY OF ALTERNATIVE WASTE DISPOSAL SYSTEMS
Minimum Cost Housing Group, McGill University. Canada.
82 pp. April 1976.
18 references, 77 figures.
SANITATION: DISPOSAL: WATER REDUCTION: COMPOSTING: DESIGN: MATERIALS.
* This survey described 66 on-site disposal systems, both proposed and commercially produced, that are alternatives to water-borne sanitation, both from developed and developing countries. The emphasis is placed on systems that reduce water consumption. Composting toilets are described in detail and a low-cost model is proposed.

067 Rybczynski, W.

Minimum Cost Housing Group,
McGill University,
Montreal. Canada.

SMALL IS BEAUTIFUL...BUT SOMETIMES BIGGER IS BETTER,
NEW DEVELOPMENTS IN COMPOSTING AND MOULDERING TOILETS
Solar Age. U.S.A. 1(5). pp. 8-11. May 1976.
8 diagrams
EXCRETA: DISPOSAL: COMPOSTING: FERTILIZER: TREATMENT:
DESIGN: RURAL: HOUSEHOLD: OWNER-BUILDER: COMPOSTING PRIVY.
* A review of recent world developments in one-family composting and mouldering toilets. Eight designs, both tried and untried, are discussed. Four of these designs are intended for use in developing countries, the others are for use in the United States and Scandinavia. The author concludes that a large holding volume is required for successful continuous composting.

●● 068 Rybczynski, W.

Minimum Cost Housing Group,
McGill University,
Montreal, Canada.

THE MINIMUS COMPOSTING TOILET...AN INEXPENSIVE SANITATION SOLUTION FOR THE PHILIPPINES
Unpublished Report to U.N.E.P. Philippines. 3 pp. September 13, 1976.
2 figures.
PHILIPPINES: COMPOSTING TOILETS: URBAN: ECONOMICS.
*The MINIMUS Composting Toilet is based on the realization that the combination of human excreta with organic kitchen wastes under conditions of extreme aeration will, with time, result in first class fertilizer. The chamber where this takes place is provided with air ducts and a vent pipe to promote aeration, as well as a sloped bottom to move the decomposing matter towards the low end from whence it is removed, after a mouldering period of two to three years. The odorless product, called humus, is a nutrient-rich fertilizer.

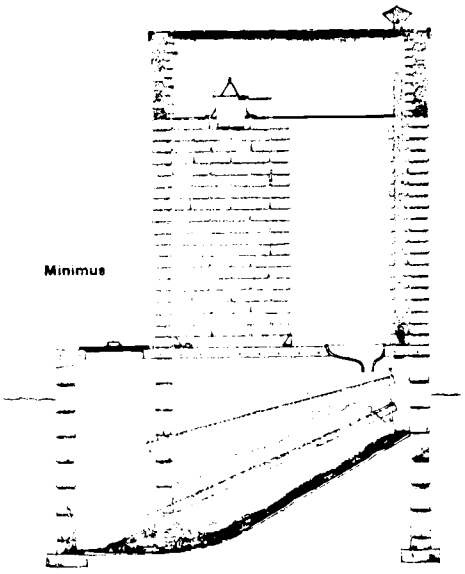
The chamber (2.5 m. long x 1.0 m. wide) is built out of cement blocks plastered inside, and has a concrete floor. It is covered with G.I. roofing. The vent pipe is galvanized metal, and the air ducts are P.V.C. or asbestos cement.

The main advantages of the composting toilet are:

1. Operation is hygienic, odorless and maintenance free.
2. No water is used.
3. It accommodates all the organic household garbage.
4. Nutrient-rich fertilizer is produced.
5. It is self-contained and hence not affected by high-water table.
6. Low-cost and ease of construction.

The first Philippine MINIMUS, completed in September 1976 at the Manpower Skills Training Centre in Magsaysay Village, has shown that no particular problems occur in the construction process, which can be undertaken by anybody with some skill in masonry. This has also permitted a fairly accurate cost estimate to be made on the basis of actual experience.

The total material cost is $385.00. Construction time is about 6 man-days. A second toilet, located in an actual household in the project area has also been built.



069 Rybczynski, W.

Minimum Cost Housing Group,
McGill University,
Montreal. Canada.

APPROPRIATE SANITATION FOR THE WORLD'S POOR
Paper presented to the Seventh Annual Composting and Water Recycling Conference, University of Amherst. U.S.A. 9 pp. May 4-6, 1977.
DEVELOPING COUNTRIES: COMPOSTING: DRY TREATMENT.

* A review of dry excreta disposal alternatives for tropical countries with specific examples of successful applications in China, the Democratic Republic of Vietnam and India. The author concludes that dry biological decomposition processes are an appropriate disposal technique, though certain questions still remain to be answered - maintenance, availability of additional organic materials for composting, the cost-benefits of producing fertilizer and social costs.

070 Save, U.

Ekoteket,
Box 7287,
S-103 85 Stockholm, Sweden.

CULTIVATION - FOOD - DECOMPOSTING - REUSE
(ODLING - FODA - KOMPOSTERING - ATERANVANDNING)
Rapport fran EKOTEKET (Report from 'EKOTEKET'). Sweden.
No. 5. 4 pp. 1976.
3 figures.
MOULDERING TOILET: COMPOSTING: EXCRETA: ON-SITE TREATMENT: SWEDEN.

* The article is a popular description of CLIVUS mouldering toilet, its function and use.

In the mouldering toilet one person produces about 40 kg of soil amendment, instead of polluting 25 000 l of water a year with excreta.

Waste from the kitchen and excreta are mixed and decomposted together, without addition of neither chemicals nor electrical heat.

The author points at the fact that CLIVUS is both uncomplicated and cheap to use, and it should therefore be possible to use also in developing countries where water often is a limited resource.

CLIVUS is the oldest mouldering toilet on the Swedish market and also the most efficient one, much because of its big size.

(Original paper written in Swedish)

071 Torbjoernsson, K.

Ministry of Works and
Communications,
Dar es Salaam,
Tanzania.

DRY CLOSED TOILET
Daily News, Tanzania. 4 pp. March 6, 1974.
AFRICA: COMPOSTING TOILET: EXCRETA: REFUSE.

* The operation of the 'Biopot' toilet is described; this is a composting toilet for household excreta and refuse which requires ashes to be added daily to counteract the acidity of urine. The composting action is started by initially filling the toilet pit or vault with fresh green leaves; after the compost is removed a new 'filter' of leaves, sand and ashes is placed in the toilet pit or vault. Advice is given on building the toilet superstructure and the advantages of the system are listed.

072 Valdmaa, K.

Dept. of Soil Sciences,
Section for Waste Biology,
The Royal Agricultural
College,
Uppsala, Sweden.

THE MULLBANK TOILET
Compost Science. U.S.A. 15(5). pp. 23-27. 1974.
4 tables, 3 figures.
SWEDEN: ANALYSIS: COMPOSTING TOILET: BACTERIA: FERTILIZER.
* The results of an investigation into the functioning of a particular electric composting toilet are reported here. The composition of the final product of eight tested toilets is identified, and occurrence of bacteria determined. The product is comparable to farmyard manure and is well suited as a fertilizer or soil conditioner.

073 Van Der Ryn, S.

COMPOSTING PRIVY
Technical Bulletin No. 1. The Farallones Institute. U.S.A.
17 pp. January 1974.
8 references, 9 illustrations.
HOUSEHOLD: RURAL: COMPOST PRIVY: DISPOSAL: CONSTRUCTION: DESIGN: OPERATION.
*Instructions for building a two compartment compost privy. A discussion of composting theory indicates that the privy is designed to optimize the size of the pile for aerobic decomposition.

074 Van Der Ryn, S.

THE FARALLONES COMPOSTING PRIVY
Compost Science. U.S.A. 17(3) pp. 15-17. 1976.
COMPOST PRIVY: HOUSEHOLD: DISPOSAL: DESIGN: U.S.A.
* A general discussion of a two compartment composting privy. The compost is moved manually to the second compartment for a total decomposition period of one year. Sawdust is added with each use. The humus product is used for fertilizing non-food crops.

○ 075 Wagner, E.G.
Lanoix, J.N.

EXCRETA DISPOSAL FOR RURAL AREAS AND SMALL COMMUNITIES
World Health Organization Monograph No. 39. Switzerland. pp. 115-119. 1958.
COMPOSTING: RURAL: DISPOSAL: DESIGN: HOUSEHOLD: COMPOST PRIVY.

* The author describes the construction and operation of a double vault compost privy. The human waste is left undisturbed for at least six months to ensure destruction of pathogens and ova of helminths.

●● 076 Winblad, U.

COMPOST LATRINES - A REVIEW OF EXISTING SYSTEMS
Unpublished Report, Environmental Sanitation Research Project. Tanzania. 46 pp. July 1975.
23 figures, 24 references.
COMPOST PRIVY: CONSTRUCTION: OPERATION: EXCRETA: PUBLIC HEALTH.

* A review of 23 existing systems of compost privies that have been used worldwide. The discussion is related to advantages and disadvantages of the systems, and their methods of construction and operation. Figures of each system are also included.

077 Winblad, U.

EVALUATION OF WASTE DISPOSAL SYSTEMS FOR URBAN LOW INCOME COMMUNITIES IN AFRICA
SPC Report No. 3. Scan Plan Coordinator. Denmark. 34 pp. 1972.
45 references.
AFRICA: SANITATION: DISPOSAL: CRITERIA: URBANIZATION: COMPOSTING: COMPOST PRIVY.

* A description of conditions in urbanizing Africa leads to the conclusion that an intermediate solution is required for urban utilities, particularly waste disposal, which will reduce per capita investment while increasing population density. General performance criteria for such a waste disposal system are formulated. A review and evaluation of existing systems indicates that no system fulfills all the criteria, though those based on microbiological decomposition such as composting toilets seem to offer the best possibilities for development.

2C. On-Site Collection and Treatment: Septic Tank and Aqua-Privy

073 Adan, B.

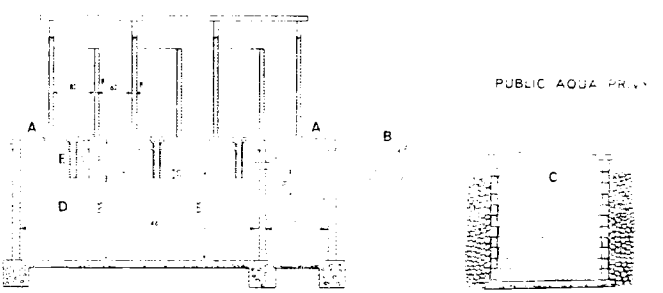
Water Quality Management Program,
Laguna Lake Development Authority
Rizal Provincial Capital, The
Philippines.

INTERIM REPORT ON PLANNING FOR HOUSEHOLD WASTE DISPOSAL FOR LAGUNA LAKE BASIN
An In-House Draft (April 1977) to become part of an overall report on the Lake Laguna Water Quality Control Program to be completed December 1977 by the Laguna Lake Development Authority, The Philippines, together with UNDP/WHO and ADB. WATER SUPPLY: NUTRIENTS: EUTROPHICATION: THE PHILIPPINES: COMPOST BIN: SEPTIC TANK PLUS POND SYSTEM: COST.

*The Laguna Lake basin, located close to Manila, contains a large shallow fresh water lake expected to furnish 50 m^3/sec to the water supply of metropolitan Manila by about 1990; however, continuing growth in the Manila capital region will increase the basin population from about 1 to about 4 million during this same period, with accompanying industrial development. The key uses of the lake water, in addition to water supply, are fisheries (including large-scale aquaculture) and irrigation, and the pollution control problem requires not only limiting organic loads (BOD) discharged to the lake but nutrients (especially nitrogen) to prevent massive eutrophication. A considerable portion of the population in the basin, and most of the industry, will be sewered, but for a large part of the population (about 2 million) sewers will probably not be affordable. The report describes proposed less-costly alternatives, one of which would be use of biogas units. Another would be use of a home system comprising a septic tank plus oxidation pond (with no overflow, due to evaporation) together with a compost bin. The system to be recommended will be consistent in cost with the prevalent minimum wage in the area, about one US dollar per work day.

079 Anon.

AQUA PRIVY OUTLAWED FOR THE TIME BEING
Daily News, Botswana. No. 218. pp. 1. November 13, 1975.
1 figure.
BOTSWANA: AFRICA: AQUA PRIVY.
* A newspaper report of a Governmental ban on the construction of aqua-privies in Botswana. The ban was introduced because of severe odour problems experienced with aqua-privies and would remain in force until design improvements have been made to overcome this problem.



080 Anon.

College of Agricultural and Life Sciences,
College of Engineering,
University of Wisconsin,
Madison, U.S.A.

ON SITE DISPOSAL OF SMALL WASTEWATER FLOWS
Small Scale Waste Management Project. University of Wisconsin - Extension Division of Economic and Environmental Development. U.S.A. 85 pp. January 1976.
103 references, 23 figures, 10 tables.
ON SITE DISPOSAL: WASTEWATER: SEPTIC TANKS: SYSTEM DESIGN: CONSTRUCTION: SOIL ABSORPTION: SEEPAGE FIELDS: EVAPOTRANSPIRATION.
*The report illustrates the scope of the problem of on-site wastewater disposal and describes the general nature of the research and demonstration studies completed and in progress by the Small Scale Waste Management Project. Objectives of the project are to determine and understand the causes of septic tank system failure, to improve methods of site characterization, system design and system construction for on-site wastewater disposal, to develope more efficient management techniques of on-site wastewater disposal systems and to assess the implication of new wastewater disposal technologies for land use planning.

●● 081 Anon.

The Epidemic Prevention Station
Department of Hygiene and
Revolution Committee of the
Districts of Chiong, Province of
Kiangsu, China.

THE TWO-PARTITIONS-THREE-TANKS TYPE HYGIENE TOILET
In "Compilation of Data on Experience and Sanitary Management of Excreta and Urine in the Village". Unpublished report of the International Development Research Centre. Canada. Translated from Chinese by Lee Thim Loy. pp. 33-43.
3 tables, 26 figures.
TWO-PARTITIONS-THREE TANKS SYSTEM: EXCRETA: URINE: CHINA: NITROGEN.

*This article describes the design and construction and operation of the chinese three tank toilet system in which only human excreta and a minimal amount of flushing water (2 liters/capita/day) are passed through three tanks in series. Studies of the contents of the tanks indicated that the first acts as a settling chamber for the heavier solids; the excreta in the second is liquified and undergoes fermentation; the third tank used for excreta storage before its extraction and use as fertilizer. The detention periods of the first, second and third tank are 10, 10 and 30 days. The tanks are normally circular but could easily be rectangular. The settled excreta is drawn of at about 3/4 depth from the first tank and passed through the second tank entering at the same depth. Through its ten day residence in the second tank it rises to the overflow pipe at the surface which leads to the bottom of the third tank. The water levels of the first two tanks are therefore equal whereas that of the third tank depends on how much nightsoil is being used. The design of the system ensures that even during periods of high fertilizer demand the excreta undergoes at least twenty days of araerobic treatment.

Samples were drawn from typical systems and analyzed for ascarid egg viabilities and nitrogen levels. Liquid temperatures were generally below 8°C. More than 2000/gm of ascarid eggs were observed in the upper layers of the first tank, more than 80% of them living. No eggs were observed in the third tanks upper and middle layers. 2263/gm were found on its bottom, however all of these were dead. Active nitrogen levels (as being available in inorganic form to plant life) were compared to total nitrogens which includes organic nitrogen. At one plant in Shih Chiao the total nitrogen before and after the three tank treatment was dropped from 0.39% to 0.25% indicating an overall loss of 35%, however the active nitrogen rose from 0.08% to 0.23%. While at the Lu Ben plant it rose from 0.08% to 0.35%, illustrating the degree to which anaerobic treatment in the three tanks can transform the wastes into a more assimilatable form for plant growth.

(Original paper written in Chinese)

082 Anon.

Housing and Home Finance Agency, Office of the Administrator, Division of Housing Research, Dept. of Housing and Urban Development, Washington. U.S.A.

SEPTIC TANKS -- THEIR USE IN SEWAGE DISPOSAL
Housing Research Paper No. 18, Government Printing Office, U.S.A. 16 pp. 1952.
8 figures.
SEWAGE: SEPTIC TANKS: SOIL PERCOLATION.
*A short guide to the design and construction of septic tanks and drainfields for their effluent. Soil percolation test methods are described.

083 Anon.

Institution of Civil Engineers, London. U.K.

WATER AND WASTE WATER ENGINEERING FOR LOW INCOME COMMUNITIES IN DEVELOPING COUNTRIES, DISCUSSION
Proceedings of the Institution of Civil Engineers. U.K. Part 1, Volume 62. pp. 163-165. February 1977.
DEVELOPING COUNTRIES: LOW INCOME: WATER SUPPLY: STABILIZATION PONDS: SEWAGE TREATMENT.
* Arguments were put forward for providing more people with inferior water, and for the provision of water only if it was of safe quality. Sewerage was too costly for most developing countries. The aqua-privy sewerage system with treatment in waste stabilization ponds was advocated. Nightsoil and sewage effluent could both be utilized beneficially.

○ 084 Anon.

MANUAL OF SEPTIC TANK PRACTICE
Public Health Service Publication No. 526, U.S. Dept. of Health, Education and Welfare. U.S.A.
92 pp. 1969.
29 figures, 6 appendices, 34 references.
SEPTIC TANK: HOUSEHOLD: COMMUNITY: DESIGN: CONSTRUCTION: OPERATION: U.S.A.
*This guide deals in a comprehensive way with the design and construction of septic tanks and soil absorption systems, both for private residences and community installations. Particular attention is paid to the absorption capacity of different soils and its effect on design.

085 Anon.

Ministry of Environmental Protection.
Norway.

WASTEWATER-DISPOSAL FROM HOUSEHOLDS IN THINLY POPULATED AREAS
(KLOAKKUTSLIPP FRA SPREDT BOLIG - OG FRITIDSBEBYGGELSE)
Ministry of Environmental Protection Publication. Norway.
52 pp. June 1975.
18 figures, 7 tables, 6 appendices.
WASTEWATER: INFILTRATION: RESORPTION: BIOLOGICAL BEDS: SANDFILTER BEDS: LOW-DENSITY AREAS: ON-SITE TREATMENT: CONSTRUCTION: GUIDELINES: SINGLE-HOUSES: NORWAY.

* The publication is issued by the Norwegian Ministry of Environmental Protection and contains guide-lines for the solution of wastewater-problems in low-density areas.

The definition of "low-density" is given as seven dwellings or less in a limited area.

The main principle given for the treatment is that wastewater should be infiltrated in the ground or alternatively purified in a sand-filter bed and then be disposed of into a lake or a stream.

As concerns treatment in the ground infiltration or resorption can be used. Before infiltration in the ground or in a sandfilter the water has to be de-sludged.

Detailed instructions are given for the construction of infiltration- and resorption plants as well as for sand-filter beds.

Tables to dimension pipes and recharge-wells are prepared for different ground-conditions. A diagram showing the importance of grain sizes for the infiltration-capacity of the soil is given, and limitations are set up for soils recommended for infiltration.

To give the infiltration-plant a longer life-time it is recommended that two infiltration-pipes or more should be in alternate use, and that the water should be distributed intermittent rather than with a constant flow.

(Original paper written in Norwegian)

086 Bouma, J.
Converse, J.C.
Otis, R.J.
Walker, W.G.
Ziebell, W.A.

(All) Small Scale Waste Management Project, University of Wisconsin, Madison. U.S.A.

A MOUND SYSTEM FOR ONSITE DISPOSAL OF SEPTIC TANK EFFLUENT IN SLOWLY PERMEABLE SOILS WITH SEASONALLY PERCHED WATER TABLES

Journal of Environmental Quality. U.S.A. 4(3). pp. 382-388. 1975.
6 figures, 3 tables, 9 references.
SEPTIC TANK: EFFLUENT: DISPOSAL: MOUND SYSTEM: SEEPAGE TRENCHES: DESIGN: CONSTRUCTION: CRITERIA.

*Slowly permeable soils with seasonal high water tables cannot be used for conventional subsurface disposal of septic tank effluent. An alternative mound system is described which consists of soil-covered seepage trenches on top of 60 cm. of sand fill deposited on the original soil surface. The bottom area of the mound is sufficiently large to allow soil absorption of the effluent. Monitoring data for four experimental mound systems and their design and construction criteria are discussed.

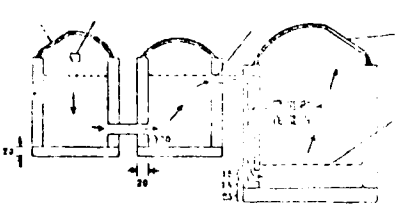
087 Bradley, D.J.

Ross Institute of Tropical Hygiene, London School of Hygiene and Tropical Medicine.

REPORT ON A UNEP SCHISTOSOMIASIS STUDY TOUR OF CHINA

Unpublished Report. U.K. pp. 1 and 8-10. 1977.
1 figure.
EXCRETA: CHINA: SEPTIC TANKS: ASCARIS SCHISTOSOMIASIS CONTROL: SANITATION: HOOKWORM.

*A three-compartment septic tank is described for use in sanitation programmes designed specifically for parasite control. The parasite ova are retained in the sludge zones of the first two compartments, the liquid effluent from the 3rd compartment containing only relatively few ova. In one area prevalence rates for hookworm and ascariasis fell from 78% and 98% respectively to 2% and 36% respectively, after one introduction of septic tanks.



088 Chowdhry, N.A.

Pollution Control Planning Branch,
Ontario Ministry of the Environment,
Canada.

SAND AND RED MUD FILTERS...AN ALTERNATIVE MEDIA FOR HOUSEHOLD EFFLUENTS

Water and Pollution Control. Canada. 113(2). pp. 17-18. February 1975.
2 tables, 1 figure, 3 references.

TILE FIELD: SAND FILTER: SEPTIC TANK: EFFLUENT: DISPOSAL: RED MUD: HOUSEHOLD: SEWAGE: PHOSPHORUS.

* For an area where the physical characteristics or depth of soil are not suitable for installing a conventional tile field, a sand filter of specific effective size and uniformity coefficient appears to be an effective device for the disposal of household waste. Filter sand mixed with "red mud", a waste by-product in the Bauxite purification process, are reported to reduce the phosphate content in the waste by 90%.

089 Chuang, F.S.

C.E. Maguire Inc.,
New Britain. U.S.A.

TREATMENT OF SEPTIC TANK WATER BY AN ANAEROBIC-AEROBIC PROCESS

Water Pollution Control Federation Deeds and Data. U.S.A. Pages D3, D8, D9, D10. July 1976.
1 diagram, 6 references.

SEPTIC TANK: SLUDGE: ANAEROBIC-AEROBIC TREATMENT.

* A report of laboratory studies of the treatment of septic tank wastes. Pumped wastes were retained for 15 days in an anaerobic digester heated to 32°C. The supernatant liquor was aerated for 40 days at ambient temperature and then passed through a sand bed. 99% reduction of BOD, COD and suspended solids was achieved.

090 Clemesha, W.W.

University of Calcutta, India.

SEWAGE DISPOSAL IN THE TROPICS
Thacker, Sprak & Co. India. 232 pp. 1910.
Chap. 2 "The design of the latrine"
Chap. 10 "Miscellaneous matters connected with the septic tank latrine"
Chap. 14 "The dumping septic tank"
Chap. 16 "The final disposal of septic tank effluent"
Chap. 17 "The management and laying out of 'trenching grounds'"
Chap. 18 "The incineration of nightsoil"
SEWAGE: NIGHTSOIL: INDIA: SEPTIC TANK: AQUA-PRIVY: INCINERATION: ABSORPTION TRENCHES: MANAGEMENT.
*A well illustrated textbook on sewage and nightsoil treatment practices in India up to 1910; many of the designs are still suitable for use in tropical developing countries nowadays. Improved pit latrines, pour-flush latrines and septic tanks are described, together with details of septic tank effluent disposal. The management of nightsoil collection and treatment systems is discussed, with particular reference to incineration and trenching.

091 Duchinskii, B.M.

Department of Environmental Hygiene,
Kiev Medical Institute, USSR.

EFFECTIVENESS OF SUBSURFACE FILTRATION BEDS WITH RESPECT TO SALMONELLAS
Journal of Hygiene and Sanitation. USSR. 35(10).pp. 117-119. 1970.
USSR: SALMONELLA: LOADING: SEPTIC TANK: EFFLUENT: CONTAMINATION: SAND FILTERS: SUBSURFACE FILTRATION.
*An experiment conducted to determine the effectiveness of salmonella removal from septic tank effluents using subsurface filtration beds. The filtering bed is made of medium-grained sand having a thickness of 1 meter. No contamination of groundwater is observed when an applied loading is less than 15 l/day per running meter of the surface area. However, with a biologically matured-filtration bed, a loading of 30 l/day per running meter of irrigation network can be safely applied.

092 Englov, P.

CONSIDERATIONS ABOUT INFILTRATION OF WASTEWATER
(SYNPUNKTER PA INFILTRATION AV AVLOPPSVATTEN)
Proceedings of Nordisk hydrologisk forening (Scandinavian Hydrologic Association) Conference. Denmark. pp. 64-73. July 23 - 26, 1974.
3 figures, 2 tables.
WASTEWATER: INFILTRATION: SMALL COMMUNITY: GROUND-WATER POLLUTION: INFILTRATION CAPACITY: BIOLOGICAL FILM: GRAIN-SIZE.

* Some Swedish infiltration-plants for smaller communities have been examined in order to find out the effect of the treatment, the degree of ground-water pollution and how the infiltration capacity is decreasing with time.

The results show very high purifying effects in all of the infiltration plants. Soil analysis at different depths below the works show that the main biological and physical-chemical purification takes place in the upper part of the soil-layers.

Analysis of ground-water in the surroundings of the works point at a BOD_7-reduction of at least 90% and an almost complete phosphorus and colibacteria-reduction.

The polluting influence on the groundwater is noticed through increases in chloride-, nitrate- and sulphate ion-concentrations.

Regarding the decreasing infiltration-capacity it is shown that a biological film is developed in the surface-layer of the soil which lowers the infiltration-capacity. In this process the grainsize-distribution is of importance. After resting periods the infiltration-capacity can rise again.

The article is a summary of the results of a bigger investigation concerning wastewater-infiltration carried out by the Swedish National Environmental Protection Board between 1970 and 1973.

(Original paper written in Swedish)

093 Fetter, C.W. Jr.
Sloey, W.E.
Spangler, F.L.

(All) Department of Geology, University of Wisconsin/Oshkosh, Wisconsin. U.S.A.

POTENTIAL REPLACEMENT OF SEPTIC TANK DRAIN FIELDS BY ARTIFICIAL MARSH WASTEWATER TREATMENT SYSTEMS
Ground Water. U.S.A. 14(6), pp. 396-402, November/December, 1976.
3 tables, 3 figures, 16 references
SEPTIC TANK: EFFLUENT: BULRUSHES: ORGANICS: COLIFORM BACTERIA: LOADING: RETENTION TIME.

* A pilot scale waste treatment system using emergent marsh vegetation (bulrush Scirpus validus) is employed to treat septic tank effluent. The plant, which grows in a gravel substrate in a plastic-lined trench, is capable of removing more than 70% organics and 99.9% coliform bacteria when it is loaded at 29 liters per square meter of surface area and a retention time of about 10 days. The author cites potential uses of this system for areas such as rural or summer houses where growth of bulrushes is possible.

094 Fitzgerald, E.L.

Institute of Public Health,
College of Medicine,
National Taiwan University,
Taiwan.

STUDY OF TWO KINDS OF JAPANESE SEPTIC TANKS
Memoirs of the College of Medicine of National Taiwan University. Taiwan. 13(12). pp. 138-153. April 1968.
5 tables, 10 figures, 8 references.
TREATMENT: EFFICIENCY: SEPTIC TANK: JAPAN: TAIWAN: ANAEROBIC: FILTER: AEROBIC: LOADING: OPERATION.

*A study of treatment efficiencies of two septic tank systems being in operation in Japan and Taiwan. Although the system employing an anaerobic filter is reported to provide better organics and solids removal than the aerobic filter, information concerning their loading rates and operation are not available. Schematic drawings of the two systems are presented and the author urges further exploratory study towards a standard design.

○ 095 Goldstein, S.N.
Moberg, W.J. Jr.

(Both) National Demonstration Water Project,
Washington, D.C. U.S.A.

WASTEWATER TREATMENT SYSTEMS FOR RURAL COMMUNITIES
Commission on Rural Water Publication. U.S.A. 340 pp. 1973.
WASTEWATER: TREATMENT: RURAL AREAS: EQUIPMENT: SELF-CONTAINED SYSTEM: COLLECTION: CONVEYANCE: SEPTIC TANK: WATER SAVING.

*This book is a guide to systems and components available for treating wastewaters in rural areas. A representative selection of equipment is present in Appendix C which contains illustrations and data sheets abstracted from manufacturer-supplied information. Major categories of the contents include: self-contained systems, wastewater collection and conveyance subsystems, septic tank systems, and water consumption reduction techniques.

096 Howard, J.
Lloyd, B.
Webber, D.

(All) Oxfam, U.K.

OXFAM'S SANITATION UNIT
Oxfam Technical Paper, U.K. 14 pp. July 1975.
References, 8 tables, 2 diagrams.
BANGLADESH: CONSTRUCTION: OPERATION: SEWAGE: TREATMENT: COMMUNITY: PUBLIC HEALTH: DISEASE: ANAEROBIC: DESIGN: PUBLIC TOILETS.

* Following three years research and development work including microbiological studies, a prototype sanitation unit was tested during November and December 1974 at Dacca, Bangladesh. The unit consists of 20 squatting plates connected in series to two 21,000 liter flexible rubber sedimentation tanks which provide an 8-10 day retention time. Tests demonstrating reduction in cholera vibrio and salmonellae counts are described.

097 Hvatum, O.O.

PRA-PROJECT 3.5 - INFILTRATION OF WASTEWATER AND SLUDGE
BINDING OF PHOSPHORUS FROM INFILTRATED WASTEWATER IN SOIL
(PRA-PROSJEKT 3.5 - INFILTRASJON AV AVLOPSVANN OG SLAM
BINDNING AV FOSFOR I JORD VED INFILTRASJON AV AVLOPSVANN)
The publication is issued in the series "PRA-project 3.5-
Infiltration of wastewater and sludge" from:
Agricultural University of Norway,
Environmental Pollution Research Group,
P C Boks 57, 1432 As-NLH, Norway. 58 pp. February 1977.
17 figures, 20 tables, 11 literature references.
PHOSPHORUS: WASTEWATER: INFILTRATION: PHOSPHORUS-BINDING.

* Laboratory-tests have been made to investigate the phosphorus-binding in various soil-types.

Cylinders were filled up with soil and both wastewater and phosphorus-solutions of known concentrations were infiltrated. The changes in phosphorus-content were measured after the tests in both the soil and the water.

The results show that the binding-capacity in soil from the B-horizon in a podsol-profile is much higher than that of the parent-material. Addition of lime to the soil also proved to have a positive effect on the phosphorus-binding.

The main part of the phosphorus was bound very weakly and could be leached out with distilled water.

At high phosphorus-charging (> 200 mg/l) the soil was saturated with phosphorus after 1 - 2 weeks of infiltration and thereafter the purifying effect sank below 20%.

The highest purifying effect (72%) was obtained in soil from the B-horizon with limestone-powder spread in the soil.

(Original paper written in Norwegian)

098 Impey, L.H.

SEWAGE TREATMENT AND DISPOSAL FOR SMALL COMMUNITIES AND INSTITUTIONS...THE DEVELOPMENT AND USE OF THE SEPTIC TANK
Journal of the Proceedings of the Institute of Sewage Purification. U.K. No. 3. pp. 311-317. 1959.
2 tables, 4 diagrams.
SEPTIC TANKS: SUBSURFACE IRRIGATION.

* The paper gives points governing a decision to install a septic tank and deals in some detail with the design of sub-soil irrigation systems. Three proved designs of septic tank are given.

099 Jewell, W.J.
Howley, J.E.
Perrin, O.R.

(All) Cornell University,
Ithaca. U.S.A.

DESIGN GUIDELINES FOR SEPTIC TANK SLUDGE TREATMENT AND DISPOSAL
Progress in Water Technology. U.K. 7(2). pp. 191-205. 1975.
8 diagrams, 4 tables, 21 references.
SEPTIC TANK: SLUDGE: AERATED LAGOONS: DEWATERING: AEROBIC DIGESTION.

* A report on laboratory tests to ascertain the treatability of septic tank sludge. Methods used were aerated lagoons and aerobic digestion. Settling and dewatering chacteristics of untreated and treated sludge were examined.

100 Kamppi, A.

EXPERIENCES FROM SYSTEMS WITH INFILTRATION TRENCHES IN FINLAND (ERFARENHETER FRAN SYSTEM MED INFILTRATIONSDIKEN I FINLAND)
Proceedings of Internationella vattenvardsutstallningen Varlden, Vattnet och V.
(International water management exhibition the World, the Water and Us). Sweden. Chapter 7. pp. 161-171. September 1 - 5, 1975.
2 figures. 2 tables. 8 literature references.
WASTEWATER: INFILTRATION: OPEN DITCHES: ON-SITE TREATMENT: PEAT-BOG: FINLAND.

* In Finland there are huge areas of peat-bogs. Therefore some fifteen smaller communities have chosen to infiltrate their wastewater in open ditches in the peat.

The water is supplied to one ditch and after infiltration in the peat it is led away in another ditch some 15-30 meters aside from the first ditch. It is important for the function that the ground is flat.

The purification of the wastewater takes place in the upper part of the peat. The flat surface of the peat-bog gives the water a low velocity, which is important from purifying point of view.

Comparisons between in-coming and out-going water shows a purifying effect of around 60% for BOD_7, 30% for phosphorus, 40% for nitrogen and some 80% decrease in enterococks.

The system works most efficiently in the summer, when the evapotranspiration is high. During the winter the biological activity is low and the purification is therefore also low. During snowmelting in the spring and after heavy rains overflows may occur which naturally lowers the purifying effect considerably.

The method does not stand up to the demands set up by the authorities for permanent dwellings, but according to the author it is a good solution for recreation huts with wastewater problems.

(Original paper written in Swedish)

101 Khan, A.N.
Siddiqi, R.H.

(Both) National Environmental Engineering Research Institute, Nagpur. India.

WASTEWATER TREATMENT BY ANAEROBIC CONTACT FILTER
Indian Journal of Environmental Health. India. 18(4). pp. 282-291. October 1976.
5 tables, 2 figures, 7 references.
SEWAGE TREATMENT: ANAEROBIC CONTACT PROCESS: ANAEROBIC FILTER: INDIA.

* A report of a two year laboratory study treating a synthetic sewage in an upflow anaerobic filter at ambient temperatures in the range 24 to 33°C. Reductions of the order of 80 per cent of the applied COD were achieved at a loading rate of 225 lb. COD/1000 ft.^{3} day, giving 8 hour detention time. The efficiency of treatment did not improve above a height of 4 ft. of stone medium for the waste used (approximately 900 mg/l COD).

102 Klein, S.A.

Sanitary Engineering Research Laboratory, University of California, Berkeley, California.

NTA REMOVAL IN SEPTIC TANK AND OXIDATION POND SYSTEMS
Journal of the Water Pollution Control Federation. U.S.A. 46(1). pp. 78-88. January 1974.
11 figures, 2 tables, 12 references.
NTA: WASTEWATER: DETERGENT: PERCOLATION FIELDS: SEPTIC TANK: EFFLUENT: OXIDATION POND.

* Trisodium Nitrilotriacetate (NTA) is being considered as a partial replacement for phosphate builders in synthetic detergents. Field experiments indicate that aerobic percolation fields can degrade essentially all of the NTA from septic tank effluents containing concentrations up to 60 mg/l. Little degradation of NTA is accomplished in anaerobic (saturated) soil columns. In oxidation ponds, after a 2-month acclimation period, removal of NTA is observed to be in excess of 90% when influent concentrations are in the range normally expected in wastewater (up to 30 mg/l).

103 Krafft, R.J.G.

World Health Organization, Geneva. Switzerland.

WASTES DISPOSAL AND DRAINAGE, IBADAN.
Unpublished Report No. AFR/EH/131. Switzerland.
16 pp. July 21, 1972.
NIGERIA: PUBLIC TOILETS: AQUA PRIVY: PUBLIC HEALTH: DESIGN: CRITERIA: PLANNING: CONSTRUCTION: OPERATION: MAINTENANCE.

* A public toilet demonstration project has been conducted in Ibadan, Nigeria. An aqua privy system is introduced because it can satisfy many health requirements if properly used and maintained. This report includes a design criteria, planning and construction procedures, and operation and maintenance of the demonstrated aqua privy system.

104 Lindbak, P.

PRA-PROJECT 3.5 - INFILTRATION OF WASTEWATER AND SLUDGE - WASTEWATER FROM HOUSES IN THINLY POPULATED AREAS (PRA-PROSJEKT 3.5 - INFILTRASJON AV AVLOPSVANN OG SLAM - AVLOP FRA SPREDT BOLIG - OG FRITIDSBEBYGGELSE)
Published by Agricultural University of Norway, Department of Hydro-technique. Norway. 296 pp. February 1977.
52 figures and tables, 1 appendix, 68 literature references.
WASTEWATER: INFILTRATION: RESORPTION: SANDFILTER TRENCHES: BIOLOGICAL FILTER: BIOLOGICAL PURIFICATION: ON-SITE TREATMENT: RURAL: SINGLE-HOUSE.

* De-sludged wastewater from single houses and smaller communities (up to 1,100 population equivalent) in Norway has been infiltrated in artificial sand-filter trenches, and in some cases in natural soil-layers.

One test with combined resorption and infiltration has also been carried out.

The purification-effect regarding BOD_7, suspended material, phosphorus and nitrogen has been measured. For six single-house sand-filter trenches the mean reduction of BOD_7 was 95%, of suspended material 68%, of phosphorus 75% and of nitrogen 47%.

No decline in the purifying effect during the testperiod (1972-77) was noticed.

From technical-, managing- and pollution-point of view no upper limit for the size of a sand-filter trench was found. Due to the areal-need and need of pipes an economical upper limit is supposed to be around 100 population equivalent, above which conventional purifying plants are preferable.

If the geological and hydrological pre-conditions for infiltration in natural soil-layers are good that method is found to be superior to artificial filters.

(Original paper written in Norwegian)

105 Machmeier, R.E.

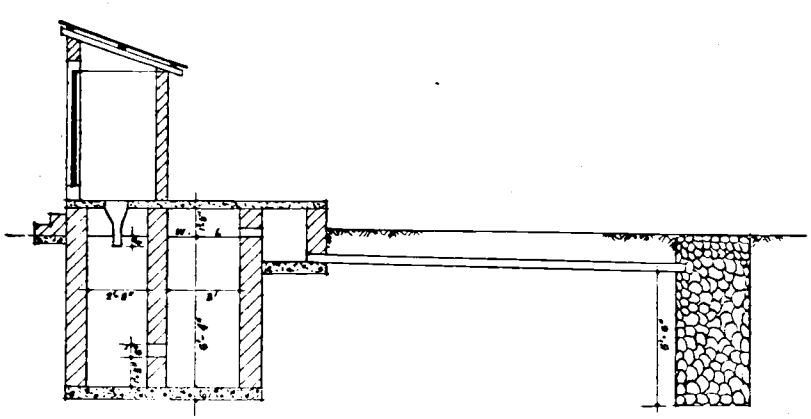
Agricultural Extension
Service,
University of Minnesota, U.S.A.

HOW TO RUN A PERCOLATION TEST
Extension Folder 261, Agricultural Extension Service, University of Minnesota. U.S.A. 6 pp. 1971
2 tables, 2 figures.
U.S.A: PERCOLATION: TRENCH AREA: SEPTIC TANK: EFFLUENT.
*A manual describing how to run a percolation test for the determination of trench bottom area required to absorb septic tank effluent. Methods of percolation measurement and calculation of the percolation rates are presented.

106 Majumdar, N.
Prakasam, T.B.S.
Suryaprakasam, M.V.

(All) Section of Sanitary Engineering,
All-India Institute of Hygiene and Public Health,
Calcutta. India.

A CRITICAL STUDY OF SEPTIC TANK PERFORMANCE IN RURAL AREAS
Journal of the Institution of Engineers. India. pp. 743-761. 1960.
10 tables, 5 figures, 10 references.
SEPTIC TANKS: SEWAGE: INDIA: HOOKWORM: ASCARIS: EFFLUENT: PUBLIC HEALTH: HYGIENE: SUBSURFACE DISPOSAL: DIP PIPE.
*In the absence of underground sewers, septic tanks may be used for treatment of sewage. A survey conducted in India indicates that they can function well even when the sewage is comparatively strong. However, the presence of hookworm and Ascaris eggs in septic tank effluents poses a potential health hazard. Some hygienic techniques are suggested such as a subsurface disposal of the septic tank effluents and the use of dip pipes for withdrawal of septic tank sludges.



107 Malan, W.M.

National Institute for
Water Research,
Pretoria. South Africa.

A GUIDE TO THE USE OF SEPTIC TANK SYSTEMS IN SOUTH AFRICA
CSIR Research Report 219, Council for Scientific and Industrial Research. South Africa. pp. viii + 40. 1964.
6 tables, 12 figures.
AFRICA: SEPTIC TANKS: SOIL PERCOLATION: EVAPO-TRANSPIRATION.

* The basic scientific principles underlying the design of septic tank systems and the considerations that will ensure the most successful functioning of the tank and disposal of the effluent, are discussed. The influence of a scientifically designed septic tank system of sewage disposal on public health is considered, as well as the effects of such factors as synthetic detergents, disinfectants, grease traps and racial diets on the design and operation of the system. The relative merits of the separate and combined methods of disposal are given together with instructions on starting a new tank and the maintenance of the system.

Design criteria are suggested and useful data are given on the volume of sewage to be expected, the best location for the tank and the capacities suitable for different communities, provision for the storage of sludge, ventilation, and the materials suitable for the construction.

A soil percolation system designed in terms of soil type as indicated by a percolation test or visual observation and the possibility of applying the principle of evapo-transpiration to soils relatively impervious to water as well as to areas with a high water table, are described.

108 Mann, H.T.

Water Research Centre,
Stevenage, U.K.

SANITATION WITHOUT SEWERS - THE AQUA-PRIVY
Overseas Building Note #168. U.K. 8 pp. June 1976.
3 figures.
AQUA-PRIVIES: LATRINES: PRIVIES: NIGHTSOIL: EXCRETA: SEPTIC TANK.

*Following a review of the principal methods of excreta disposal in sewerless areas, the author described in detail the aqua privy and gives sketch designs of its various modifications: (1) a conventional aqua-privy connected to an evapo-transpiration trench (2) a double chamber aqua-privy made from standard precast concrete pipe discharging into a seepage pit and (3) a simple aqua-privy made from 5 oil drums connected in series, drums no. 3 and 4 being filled with loose twigs and drum no. 5 discharging into a seepage pit.

109 Oluwande, P.A. University of Ibadan, Nigeria. Africa.

A SIMPLIFIED APPROACH TO AQUA PRIVY CONSTRUCTION
Appropriate Technology. U.K. 3(3). pp. 26-28. November 1976.
6 figures, 1 table, 4 references.
AQUA PRIVY: PIT LATRINE: SEPTIC TANK: CONSTRUCTION: MATERIALS.
*An aqua privy system is considered to have greater potential for use in developing countries than the pit latrine or septic tank systems, because if properly managed, it can function without odour or fly breeding and with less cost. Three simple methods of construction for incorporating an inlet drop pipe to the aqua privy floor slab are described in detail, with the use of local materials suggested.

110 Patterson, J.W. (All) Illinois Institute of
Minear, R.A. Technology,
Nedved, T.K. Chicago. U.S.A.

SEPTIC TANK AND THE ENVIRONMENT
Report No. IIEQ 71-2. U.S.A. 107 pp. June 1971.
4 figures, 7 tables, 127 references.
SEPTIC TANK: PUBLIC HEALTH: ENVIRONMENTAL QUALITY: DESIGN: CRITERIA: INSTALLATION: OPERATION.
*This report reviews and evaluates the available literature on septic tanks, and influence of septic tanks on public health and environmental quality. The consistently poor performance of septic tanks indicates that other waste disposal methods are necessary in densely populated areas and that more rigorous regulation of design criteria, installation, and operation are required in sparsely inhabitated areas suitable for septic tank installations.

111 Peel, C. Elsan Sewage Systems Limited,
London. U.K.

DESIGN, OPERATION AND LIMITATIONS OF SEPTIC TANKS
Public Health Inspector, U.K. pp. 328-334. April 1966.
6 tables, 6 references.
SEPTIC TANKS: DESIGN: OPERATION: MAINTENANCE: EFFLUENT: PERFORMANCE: TRICKLING FILTERS.
*The article describes the pollution resulting from untreated discharge of septic tank effluents and the biological processes in the tank. Secondary aerobic treatment by percolating (trickling) filters and subsurface irrigation are compared, and previously-published reports of performance of septic tanks and filters in terms of suspended solids, BOD and E.Coli are cited and discussed. Design criteria and advice on maintenance are outlined.

●● 112 Raman, V.

All India Institute of
Hygiene and Public Health,
Calcutta. India.

SECONDARY TREATMENT AND DISPOSAL OF EFFLUENT FROM SEPTIC TANK - 1 - DISPOSAL BY SUBSURFACE SOIL ABSORPTION SYSTEMS, - 2 - DISPOSAL ON LAND, UNDERGROUND AND WATER, - 3 - METHODS OF TREATMENT

Journal of Institution of Engineers, Public Health Division. India. 48(10). Part PH3. pp. 213-221. June 1968; 49(2). Part PH1. pp. 23-30. October 1968; 49(6). Part PH2. pp. 86-89. February 1969.
16 diagrams, 24 references.
SEPTIC TANK: EFFLUENT DISPOSAL: SUBSURFACE IRRIGATION: PERCOLATION: EVAPO-TRANSPIRATION: SEEPAGE PITS: SEPTIC TANK EFFLUENT: TREATMENT: SAND FILTERS: STABILIZATION PONDS: TRICKLING FILTERS.

Raman, V.
Chakladar, N.

(both) National Environmental Engineering Research Institute, Zonal Laboratory, Bombay, India.

UPFLOW FILTERS FOR SEPTIC TANK EFFLUENTS

Journal of the Water Pollution Control Federation. U.S.A. 44(8). pp. 1552-1560. August 1972.
3 figures, 3 tables, 5 references.
INDIA: ANAEROBIC: FILTERS: UPFLOW FILTERS: SEPTIC TANK: EFFLUENT: SUSPENDED SOLIDS: ODOUR: BOD.

* The use of septic tanks for treatment of sewage from individual houses or isolated institutions is well recognized. However, the septic tank itself does not fulfill the object of complete sewage treatment because its main function is to remove suspended solids from the sewage, to liquefy the major portion of solids that have been retained and to condition the sewage to facilitate further disposal in a soil absorption field. The pathogenic bacteria, cysts and worm eggs may pass through the tank practically unharmed; the effluent is highly septic and stale, becomes malodorous and has a high oxygen demand. Due to its potential health hazard and nuisance, further treatment or means of satisfactory disposal of the effluent from the septic tank becomes necessary prior to its discharge to the environment. These four papers describe the secondary treatment and disposal methods of the septic tank effluent which are usually based on biological degradation and/or discharging it into land, surface water course, subsurface and underground water, respectively.

The sub-surface tile field disposal or soakage gallery is the most common system used where sufficient land is available, the sub-soil is reasonably porous and ground water table is at least 1.5-1.8 meters below ground level. Tile pipes which are placed at a depth of 45-100 cm from the ground surface should be laid to an average gradient of 0.25-0.50% and the filtering materials employed be washed gravels, broken stone or burnt slags of 12-60 mm size and should surround the pipe with a minimum of 100-150 mm at the bottom and 50 mm at the top. Design formula to determine the absorptive capacity or the allowance rate of application of sewage per area of soil is presented which is based on a standard percolation test at the site. However, recent investigations have shown that the infiltration rate of sewage into the soil is a factor more critical than the rate of percolation within the soil to control failure of the subsurface percolation systems. On the other hand, the ability of soil to infiltrate water or sewage is a function of the clogging materials rather than of the original soil. Thus, the largest contributing factor to percolation system failure is microbiological activity when suspended and dissolved solids are present. The most probable cause of ultimate clogging is the occurrence of ferrous sulphide in association with the anaerobic activity within the systems.

The optimum combination of criteria for preventing failure of the soil absorption system are as follows:

(i) Avoidance of continuous inundation of the infiltrative surface;
(ii) Maintenance of aerobic conditions in the soil;
(iii) Maintenance of the infiltrative surface initially similar to the internal plane of undisturbed soil;
(iv) Uniform and simultaneous loading of the entire infiltrative surface if feasible;
(v) Filling the trench with material graded uniformly from coarse gravel at the centre of the trench to sand of almost the same size as soil particles at the side wall;
(vi) Provision of maximum of side wall surface per unit volume of effluent and a minimum of bottom surface; and
(vii) Proper functioning of septic tank resulting in effluent with minimum amount of suspended solids and nutrients.

Alternatives to the sub-surface soil absorption system for disposal of the septic tank effluent are available. They include: evapo-transpiration: surface irrigation: soakage pit: dilution in water courses: sand filters, sub-surface or open: trickling filters: oxidation ponds or ditches: and chlorination. Design criteria and construction methods of those systems are briefly discussed. However their applications are relatively limited as compared to the sub-surface soil absorption system and their uses should only be considered on a case by case basis.

Another promising alternative is the use of an anaerobic upflow gravel filter operating under submerged conditions for treatment of septic tank effluent. Results of laboratory and field studies in India are encouraging. After a maturing period of 3 months,

a BOD removal from 65 to 75 percent is achieved when influent BOD is from 170 to 240 mg/l. Suspended solids removal averages 53 to 60 percent with influent ranges between 350 to 450 mg/l. Flowrates of the septic tank effluent are reported to be intermittent and range from 40 to 60 liters per day for the systems employed. The authors report that the filters can function continuously for at least 18 months without any need for cleaning. Wasting of sludge from the filter which should be done once or twice yearly can be accomplished by emptying the filter through the bottom and pouring water from the top.

Experience with the use of upflow filters favors 1.25-1.90 cm medium filled to a depth of 68-90 cm. For better efficiency, the top 7.5 cm may be filled with 0.32-0.64 cm media. Per capita filter capacity for these filters is 42.5 to 58.0 liters. Effluent from the upflow filters can also be disposed of into the sub-surface soil absorption system.

113 Reid, G.W.

Bureau of Water and Environmental Resources Research, The University of Oklahoma, Norman, Oklahoma, U.S.A.

A CATALOG OF WATER SUPPLY AND WASTE DISPOSAL METHODS FOR INDIVIDUAL UNITS
A report prepared for the US AID project on Lower Cost Methods of Water and Wastewater Treatment in Less Developed Countries. U.S.A. October 1975. 183 pp.
183 figures.
DEVELOPING COUNTRIES: WASTE DISPOSAL: SMALL COMMUNITIES: INDIVIDUAL UNITS.

*The purpose of this manual was to provide a collection of methods of water supply and waste disposal for individual units; however, some practices compiled are also applicable to groups of housing units. This manual consists of 183 figures taken from published literature listed in the references table. A list of subjects assists in locating topics of interest. No explanation nor discussion was given of the various possible methods, further documentation being possible by consultation of the references list.

Many of the methods compiled are currently used in small communities of developed countries, though it is believed that the various methods in the manual would be appropriate for less developed countries.

114 Ross Institute Industrial Advisory Committee

London School of Hygiene and Tropical Medicine, London. U.K.

RURAL SANITATION IN THE TROPICS
The Ross Institute Information and Advisory Service. U.K. Bulletin No. 8. pp. 18-22 and 33-35. April 1972.
5 figures, 7 references
AQUA PRIVY: FAMILY: COMMUNITY: ARID: SEPTIC TANK: SEEPAGE PIT: OPERATION: MAINTENANCE: PUBLIC TOILETS.
An aqua privy system for family and communal types is described which is essentially designed for arid areas. Effluent from the privy tank is discharged into either septic tank or seepage pit. Although this system costs approximately the same as the water-borne latrine, it can stand more abuse. Methods of operation and maintenance are also described.

115 Sauer, D.K.
Boyle, W.C.
Otis, R.J.

(All) Dept. of Civil and Environmental Engineering, University of Wisconsin, Wisconsin. U.S.A.

INTERMITTENT SAND FILTRATION OF HOUSEHOLD WASTEWATER
Journal of the Environmental Engineering Division, American Society of Civil Engineers. U.S.A. 102(EE4). Proceeding Paper 12295. pp. 789-803. August 1976.
3 figures, 10 tables, 9 references.
SAND FILTERS: OPERATION: SEPTIC TANK: WASTEWATER: TREATMENT: COST: U.S.A.
* Intermittent sand filtration of septic tank and aerobic unit effluents is investigated as a feasible on-site wastewater treatment technique and disposal system. Sand filters have been constructed and monitored at two home sites in Wisconsin. The hydraulic loading rates ranging from 2 to 20 gpd/sq.ft. are used. Operating data including effluent qualities, methods of rejuvenation, and costs of the sand filters, are presented.

116 Schwiesow, W.F.

Soil and Water Division, Steering Committee, American Society of Agricultural Engineers, St. Joseph, U.S.A.

BIBLIOGRAPHY OF RURAL AND SUBURBAN SEWAGE TREATMENT AND DISPOSAL PUBLICATIONS
Special Publication SP-03-73 published by the American Society of Agricultural Engineers. U.S.A. 27pp. 1973.
ON-SITE TREATMENT: U.S.A.: RURAL: SUBURBAN: SEPTIC TANKS: PIT LATRINES: BIBLIOGRAPHY.
*A compilation of bibliography of on-site rural and suburban sewage treatment that have been in practices in various states of the U.S.A. The common system employed is the septic tank while some literature on pit latrines are available but dated back to the early 1900. A total of 401 bibliography titles are included.

117 Sebastian, S.
Buchanan, I.C.

(Both) Medical and Health Dept., Anguilla. British West Indies.

FEASIBILITY OF CONCRETE SEPTIC PRIVIES FOR SEWAGE DISPOSAL IN ANGUILLA, B.W.I.
Public Health Reports. U.S.A. 80(12). pp. 1113-1118. December 1965.
3 figures.
ANGUILLA: CARIBBEAN: AQUA PRIVY: NUISANCE.

* A two compartment septic privy (aqua privy with box seat rather than squatting plate) made from two 3ft. (0.9m) lengths of 3 ft. (0.9m) diameter precast concrete pipe is described for use in households of up to 5 people. Effluent disposal is by evaporation and percolation from a long, shallow, rubble-filled trench. Experience over 7 years showed that there was minimal sludge accumulation in the privy and no odour nuisance. Public acceptance of the system was reported to be good.

118 Shetty, M.S.

College of Military Engineering, Poona. India.

SEPTIC TANK DESIGN, CONSTRUCTION AND MAINTENANCE PRACTICES
Seminar on Water Supply and Sanitation Problems of Urban Areas, Public Health Engineering Division, The Institution of Engineers. India. Volume II. Paper D-5. 21 pp. April 8-9, 1971.
3 tables.
SEPTIC TANK: DESIGN: CONSTRUCTION.

* From a study of literature the author makes recommendations of tank capacity and construction methods of effluent disposal and tank maintenance are reviewed.

119 Skaarer, N.

PRA-PROJECT 3.5 - INFILTRATION OF WASTEWATER AND SLUDGE USE OF RESORPTION AS WASTEWATER TREATMENT
(PRA - PROSJEKT 3.5 - INFILTRASJON AV AVLOPSVANN OG SLAM BRUK AV RESORPSJON SOM MOTTAKER AV AVLOPSVANN)
The publication is issued in the series "PRA-project 3.5 - Infiltration of wastewater and sludge" from:
Agricultural University of Norway,
Environmental Pollution Research Group,
P.C. Boks 57, 1432 As-NHL, Norway. 47 pp. December 1976.
5 figures, 11 tables, 4 appendices, 59 literature references.
WASTEWATER: RESORPTION: EVAPOTRANSPIRATION: NUTRIENT-UPTAKE: ON-SITE TREATMENT: NORWAY.

* The report discusses resorption as a method for wastewater treatment. The theory behind resorption is described. The amounts of different pollutants from households (total amount of water, phosphorus and nitrogen) are estimated.

On basis of the hydrological balance-equation the space for additional supply of wastewater to the ground under Norwegian conditions is discussed.

It is noted that in most places in Norway it is only during a few summer-months that there is a space for resorption. During the rest of the year the rainfall is higher than potential evapotranspiration.

In spite of this the author finds the method interesting, and he feels that more research and practical tests should be done in this field.

Advices and guide-lines for construction of resorption-plants as well as figures of areal demand and the need of pipes are given.

120 Sproul, O.J.

Dept. of Civil Engineering,
University of Maine,
Maine. U.S.A.

VIRUS MOVEMENT INTO GROUNDWATER FROM SEPTIC TANK SYSTEMS
Proceeding of a Conference on Water Pollution Control in Low Density Areas. U.S.A. Paper No. 12. pp. 135-144. September 26-28, 1973.
4 tables, 18 references.
U.S.A: VIRUSES: EFFLUENT: SOIL: SAND: SEPTIC TANK: ABSORPTION: CRITERIA: RESEARCH: FILTERS.

* Data from many experiments conducted in the U.S.A. indicates the presence of viruses in the effluents from soil and sand columns receiving septic tank effluents. However, with a long absorption distance such as filtration through 200 feet of an 8 to 12 foot layer of sand and gravel, no viruses could be detected in the effluents. The author proposes criteria to promote virus removal in the soil and discusses some research needs for this area.

●●121 Teodorovic, B.

University of Zagreb,
Yugoslavia.

A MODIFIED SEPTIC (LRS) PRIVY
World Health Organization. Switzerland. Pamphlet No. WHO/WD/68.3. 5 pp. 1963.
2 figures, 13 references.
AQUA-PRIVY: EXCRETA: PATHOGEN SURVIVAL: ASCARIS: ANCYLOSTOMA: YUGOSLAVIA.

* A modified septic privy (aqua-privy with a raised covered seat rather than a squatting plate) with two compartments is described. The retention time in the first compartment is 90 days (capacity 0.3m^3 for a family of five) and in the second compartment 180 days. Samples of digested excreta taken from 30 modified privies in Yugoslavia during April - August 1965 (mean monthly temperatures: 9-20°C) indicated the absence of viable Ascaris ova, although in 12 of 13 unmodified privies having only one month excreta retention in the first compartment, viable eggs were found.

122 Viraraghavan, T.
Warnock, R.G.

(Both) Department of Civil Engineering,
University of Ottawa,
Ottawa. Canada.

TREATMENT THROUGH SOIL OF SEPTIC TANK EFFLUENT
Paper presented at International Conference on Land for Waste Management. Canada. 17 pp. October 1973.
4 tables, 4 graphs.
TREATMENT: SEPTIC TANK EFFLUENT: SUBSOIL IRRIGATION.
* Results of a field investigation of the disposal of septic tank effluent through an 8-metre lay field drain. The soil removed a high percentage of BOD COD, ammonia nitrogen, total phosphorus, iron and bacteria.

○ 123 Wagner, E.G.
Lanoix, J.N.

EXCRETA DISPOSAL FOR RURAL AREAS AND SMALL COMMUNITIES
World Health Organization Monograph No. 39. Switzerland. pp. 121-155. 1958.
46 references, 13 figures.
WATERBORNE: COLLECTION: RURAL: DISPOSAL: DESIGN: CONSTRUCTION: SEPTIC TANK.
* The author describes small-scale water-borne waste disposal systems for rural areas, with particular emphasis on the design and construction of septic tanks and the proper disposal of effluent.

124 Webber, D.G.

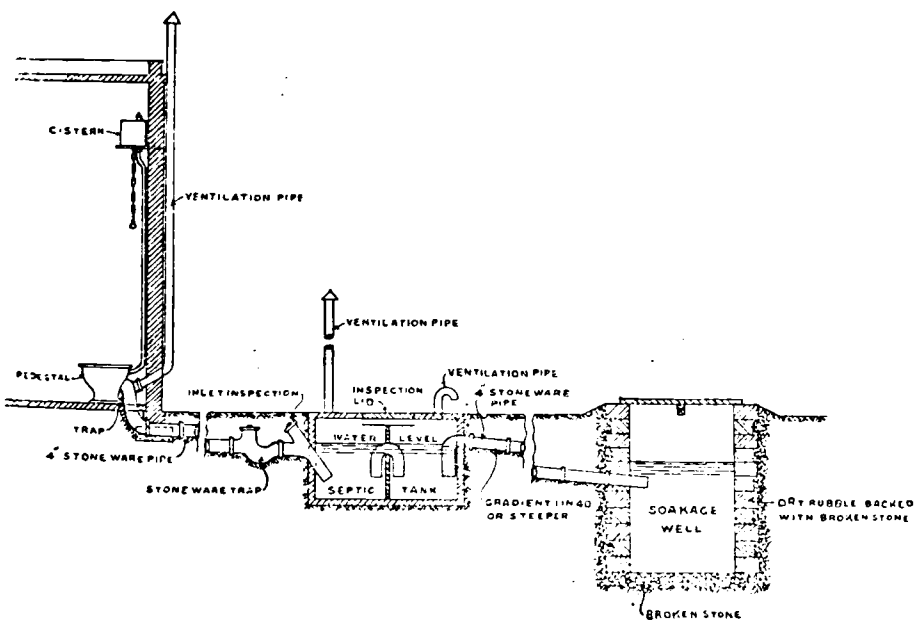
Department of Biological Sciences
University of Surrey,
Guildford. U.K.

AN INVESTIGATION OF THE SURVIVAL OF VIBRIO CHOLERAE BIOTYPES IN ANAEROBIC SEWAGE SLUDGE LIQUOR, IN RELATION TO THE DEVELOPMENT OF EMERGENCY SANITATION SYSTEMS
A B.Sc Thesis in Microbiology, Department of Biological Sciences, University of Surrey. U.K. 89 pp. 1974.
9 tables, 6 figures, 82 references, 2 appendices.
VIBRIO CHOLERAE: ANAEROBIC SEWAGE SLUDGE LIQUOR: PATHOGEN DIE-OFF: URINE: pH: SOLIDS.
* An investigation of factors involved in the survival of Vibrio cholerae biotypes in anaerobic sewage sludge liquor. The experimental conditions employed are designed to simulate those of the Oxfam emergency sanitation system. The results indicate a rapid decline in organism numbers over a two week period, however, higher numbers of them survive this period with increasing solid concentration. The addition of urine caused a marked rise in the pH of the liquor, although with no significant difference in the survival levels of the organisms. A broad survey of survival of Vibrio cholerae in different mediums is included.

125 Winneberger, J.H.T. Septic Tank Systems, Berkeley, U.S.A.

RYON'S SEPTIC-TANK PRACTICES CORRECTED
Proceedings of the National Home Sewage Disposal Symposium. U.S.A. pp. 215-221. December 9 - 10, 1974.
8 references.
U.S.A.: SEPTIC TANK: ABSORPTION TRENCHES: EFFLUENT: DISPOSAL.

*Contrary to traditional belief, studies conducted in the U.S.A. have demonstrated that bottom areas of absorption fields for disposal of septic tank effluents are considerably less useful than side wall areas. A concept of alteration of disposal fields is proposed in which two absorption fields are used one year at a time. This system is reported to be capable of extending many times the lifespan of the disposal fields.



3Ai. Off-Site Collection: Cartage

●● 126 Anon.

Camp Dresser & McKee
International Inc.,
Boston, Massachusetts, U.S.A.

SEWERAGE PLANNING IN THE GREATER TAIPEI AREA
A Master Plan Report WHO/UNDP/SF/CHA-27 prepared for the World Health Organization as Executing Agency for the United Nations Development Program, 1970. Volume II, Technical Report, Part 2, "Interim Measures for Nightsoil Disposal". pp. 175-197; Volume IV, Appendix XVII, "Data from Japan", pp. XVII/1 - XVII/13.

Part 2: 5 tables, 7 figures
Appendix XVII: 8 figures

TAIWAN: JAPAN: NIGHTSOIL TREATMENT: NIGHTSOIL DISPOSAL: FLUSH TOILETS: SEPTIC TANKS: LATRINE VAULTS: VACUUM TRUCKS: CARTAGES: DIPPER AND BUCKET: HEALTH: SEWERAGE: COST-BENEFITS.

*In most parts of Taiwan, including Taipei, older buildings have nightsoil latrines while newer ones have flush toilets with septic tanks. Removal of nightsoil from the latrine vaults is done periodically either by public collection services or by private individuals through vacuum trucks and manual cartages (using dippers and buckets). The estimated quantities of nightsoil generated in 1969 are 1600 cu.m./day in the urban areas and 300 cu.m./day in rural areas. Some of the nightsoil is used as fertilizers in agriculture and some is dumped into local drains, canals and the main rivers. Although several covered detention tanks have been constructed for the purposes of destroying pathogenic organisms before the nightsoil is used by farmers, or alternatively of reducing the oxygen demand before discharge to the rivers, the retention periods (10 days) are reported to be too short for any effective treatment. Another finding is that more than half of the latrine vaults surveyed are very insanitary from which it is estimated that the cost of converting the nightsoil latrines to flush toilets with suitable septic tanks would be less than the resulting economic benefit deriving from improved health, even without considering aesthetic and other social benefits, as long as the new facilities will have a useful life of about 5 years or more.

Treatment of nightsoil to make it safe for agricultural use is technically but not economically feasible. A carefully planned disposal or dumping of nightsoil into the river or estuary is considered practical because of the relatively very small portion of total organic pollution load that would be contributed from the nightsoil. As soon as sanitary sewers are available, nightsoil should be dumped into them for disposal with sewage. A nightsoil dumping station is needed to be included in the sewerage program.

A survey of nightsoil data from Japan reveals that the population served by public nightsoil collection and disposal facilities is about 6 times that served by sewerage systems. Collection is usually done by vacuum tanker truck, because of the inefficiency and insanitary nature of collection by dipper and bucket. The general nature of the latrine and that of the nightsoil are similar to those in Taipei, except that a good deal of newspaper is introduced which is needed to be removed prior to treatment. Several treatment and disposal methods that have been tried include:

a) chemical conditioning;
b) anaerobic digestion;
c) wet oxidation;
d) activated sludge treatment (small plants only because of expense); and
e) ocean disposal by barge and by pipeline.

Sewerage progress in Japan is reported to be slow and resulted in several years (5 - 20 years) delay between the start of construction and completion of the basic components necessary for an operating system. The major causes of delay involve high cost and difficulty in sewer construction and the need for public education on the need and desirability of the installation of modern plumbing including flush toilets.

127 Anon.

Camp Dresser and McKee International Incorporated, Boston, U.S.A.

SUPPORTING MATERIAL CONCERNING NIGHTSOIL, APPENDIX X
Sewerage Planning in the Greater Taipei Area. A Master Plan report prepared for the World Health Organization as executing agency for the United Nations Development Programme. Taipei. Volume IV, Appendices, pp. X/1 - X/17. 1970.
3 tables.
NIGHTSOIL: TAIWAN: LATRINE VAULT: TRUCK COLLECTION: SOCIAL: DISEASE: PUBLIC HEALTH: URBAN: HYGIENE: CUSTOMS: HOUSEHOLD: ECONOMICS: SURVEY.

* A survey was made of a random sampling of 1286 latrines served by truck collection in Taipei. The data was accumulated by a questionaire which covered both the characteristics of the households, the condition of the latrines and social habits of the users. The survey questionnaire is discussed in detail. A check survey showed up certain discrepancies in surveying techniques.

128 Anon.

CBA Engineering Ltd.,
Vancouver, Canada.

BELIZE CITY, FEASIBILITY STUDY, WATER SUPPLY AND SEWERAGE
Report No. 7321. Prepared for the Canadian International Development Agency. Volume 2. Water Supply and Sewerage. pp 6-1 to 6-9. December, 1973.
2 figures.
BELIZE CITY: EXCRETA: SULLAGE: DISPOSAL: HOLDING TANK: DUMP TANK: BUCKET.
*A sani-station system is proposed for Belize City for the disposal of excreta and sullage. The system which can be used as a private facility or public facility consists of an on-site holding tank and a dump tank for discharging of the waste to the ocean. Transportation of wastes from the holding tank to the dump tank is done by buckets.

129 Anon.

Maclaren International Ltd.
Willowdale, Ontario, Canada.

MASTER PLANS FOR WASTES DISPOSAL AND DRAINAGE, IBADAN, NIGERIA
Volume III "Sewerage", Report prepared for WHO acting as Executing Agency for UNDP. Nigeria. 287 pp. May 1971.
45 figures, 96 tables.
NIGERIA: CONSERVANCY SYSTEM: TRUCK COLLECTION: STABILIZATION PONDS: SEWERS.
* A conservancy system is practiced in Ibadan. Nightsoil is collected manually to storage depots, and thence removed by truck to trenching grounds outside the town. Operating problems of this system are described and improvements recommended. Nightsoil waste stabilization ponds are proposed. A general sewerage plan including improved aqua privies and public toilets is also proposed.

130 Anon.

NIGHT SOIL WHEEL BARROWS
Technical Digest No. 32, Central Public Health Engineering Research Institute. India. 1 pp. August, 1972.
1 diagram, 1 table.
NIGHTSOIL: MANUAL COLLECTION: WHEELBARROW: DESIGN: PUBLIC HEALTH: COMMUNITY: INDIA.
*Designs for night-soil wheelbarrows intended for use by scavengers. Public health and personal hygiene are improved by using closed buckets mounted on a push-cart.

131 Anon.

Projects Department,
Europe, Middle East and North
Africa Regional Office,
International Bank For Reconstruction
and Development,
Washington, D.C. U.S.A.

APPRAISAL OF THE KABUL WATER SUPPLY AND SANITATION PROJECT AFGHANISTAN
International Bank for Reconstruction and Development. Report No. 746-AF.
U.S.A. 27 pp. of main text and 32 of annexes. May 1975.
14 annexes, 9 tables, 4 graphs, 1 map
AFGANISTAN: WATER SUPPLY: SEWERAGE: URBAN: SANITATION:
NIGHTSOIL COLLECTION: HOUSEHOLD LATRINES.

* Water supply in Kabul is totally inadequate for the community requirements. Supply is intermittent for a few hours daily. Proposed works to improve water supply include the drilling of 20 deep wells and construction of rusted transmission and storage facilities. Over 200 km of distribution mains will be laid.

In addition the project would improve sanitation by financing modifications to 8000 household latrines and the purchase of vehicles and trailers to collect night soil on a regular basis for total is estimated at US$ 11 million.

The Afghan Water Supply and Sewerage Authority (AUSSA) will be the executing agency.

Feasibility studies were prepared by Proctor and Redfern International Ltd. (PRIL) of Canada.

(See note on World Bank Appraisal Reports, p. 307)

132 Anon.

URBAN LATRINES (CONSERVANCY TYPE) AND PUBLIC URINALS
Central Public Health Engineering Organization, Directorate General of Health Services, Ministry of Health, New Delhi.
1965. 13 pp.
4 appendices
INDIA: LATRINE: URINAL: NIGHTSOIL COLLECTION: CONSERVANCY SYSTEM.

*Two thirds of the urban population in India are not served by sewers and the conservancy system remains the most popular method of excreta disposal. Water-sealed toilets are proposed as a method of upgrading pit latrines into septic tanks. These can be built safely to discharge effluent in sandy soil. In poor soils the effluent will have to be removed periodically by truck. Removal of nightsoil can be improved by use of mechanized vehicles instead of nightsoil depots.

133 Hennessy, P.V.
Langer, W.F.
Lin, Y.S.
Rhodes, F.

(All) James M. Montgomery, Consulting Engineers Inc., Pasadena. U.S.A.

MASTER PLAN FOR DEVELOPMENT OF WATER SUPPLY, SEWERAGE AND DRAINAGE FOR KHULNA, EAST PAKISTAN
Section IV "Proposed Sewerage System" from an Unpublished Report to the Directorate of Public Health Engineering, Government of East Pakistan. U.S.A. 23 pp. April 30, 1965.
7 tables, 7 figures.
WATERBORNE: SEWERS: EAST PAKISTAN: ECONOMICS: NIGHTSOIL: TRENCH COLLECTION.

* Phase 1 of a proposed sewerage system for a city of 265,000 persons includes the construction of public latrines and the removal of nightsoil by vacuum truck to treatment ponds, as well as water supply via street hydrants. Future phases are including widespread water distribution and full sewerage and treatment in oxidation ponds. Investigation of the present economic level, family income and tax structure of the city of Khulna indicates that the community could not repay the capital costs of even the Phase 1 programme.

134 Hillmer, T.J. Jr.

U.S. Environmental Protection Agency, Washington, D.C., U.S.A.

TRANSPORTING LIQUID SEWAGE SLUDGE BY TANK TRUCK: AN ECONOMIC PERSPECTIVE
Compost Science. U.S.A. 17(4). pp. 28-32. September/October 1976.
6 figures, 7 references.
SLUDGE: TRANSPORTATION: U.S.A: ECONOMICS: PLANNING: DECISION-MAKERS: MILEAGE: TANK TRUCK.

* Costs of sewage sludge transportation in 15 municipalities throughout the United States of America are presented in graphic models. These economic analyses which include factors such as mileage of hauling, loading and unloading times, and per cent solids of the sludge are intended for decision-makers as an aid in environmental planning.

135 Hogg, C.
Dyer, E.A.

(Both) J.D. and D.M. Watson, U.K.

MAIN SEWERAGE AND SEWAGE PURIFICATION, KUALA LUMPUR, MALAYA.
Proc. Conf. Civil Engineering Problems Overseas. U.K. The Institution of Civil Engineers. pp. 173-185. 1958.
5 figures, Appendix.
SEWERAGE: SEWAGE TREATMENT: MALAYSIA: NIGHTSOIL TREATMENT: SLUDGE DIGESTION: TRUCK COLLECTION.
*The planning and construction of the nearly-completed foul sewerage system at Kuala Lumpur are described. At the Pantai sewage treatment works nightsoil collection vehicles would unload buckets and be washed by pressure-hoses. Bucket contents and washwater would be pumped to sludge-digestion tanks where they would be mixed with primary sludge. Digested sludge would be dried on open beds.

136 Huat, T.T.

Sewerage Branch,
Public Works Department,
Singapore.

SEWERAGE, SEWAGE TREATMENT AND DISPOSAL IN SINGAPORE
Regional Workshop on Water Resources Environment and National Development. Singapore. Volume 2. Selected papers.
pp. 143-180. 13 - 17 March, 1972.
9 figures, 3 tables, 6 references.
SINGAPORE: SEWERAGE: SEWAGE TREATMENT: NIGHTSOIL.
*Despite the existence of a waterborne sewerage system since 1915, some 700,000 people (34% of the population) in Singapore are served by a bucket nightsoil collection system, partly operated by the Ministry of Health and partly by private contractors. The nightsoil is dumped into three special nightsoil pumping stations from where it is pumped to one of the two main sewage treatment works. The nightsoil is digested anaerobically in admixture with sewage sludge.
The paper also gives full descriptions of Singapore's sewage treatment works.

137 Lien, J.C.

Camp Dresser and McKee International Incorporated, Boston, U.S.A.

PRELIMINARY REPORT ON THE FLIES BREEDING IN LATRINE VAULTS IN THE GREATER TAIPEI AREA
Sewerage Planning in the Greater Taipei Area. A master plan prepared for the World Health Organization as executing agency for the United Nations Development Programme. Volume IV, Appendix X, pp. X/18-X/21. 1970.
1 table, 9 references.
TRUCK COLLECTION: DISEASE: PUBLIC HEALTH: LATRINE VAULTS: FLIES: TAIWAN: NIGHTSOIL: URBAN.
*A report of a study of the species of flies breeding in latrine vaults in 14 districts of Taipei. The largest percentage identified were chrysoma magacephala (blow flies) and boettcherisca peregrina (flesh flies). In addition hermetia illucens (soldier flies), telematoscopus albipunacatus (moth flies) and brachymeria paraplesia (chalcidids) were found. Public health implications of fly breeding are discussed.

138 McGarry, M.G.

International Development Research Centre, Ottawa Canada.

DEVELOPING COUNTRY SANITATION
A report prepared for the International Development Research Centre, Canada. Chapter 5 "The Choice Between Technology" pp. 5.1 - 5.21.
3 figures, 6 tables, 2 references.
COST BENEFITS: SANITATION: SEWERAGE: AQUA PRIVY-SEWERAGE SYSTEM: VACUUM TRUCK AND VAULT SYSTEM: SEPTIC TANK.
*This chapter deals with a decision-making process to determine the most cost effective wastewater management system for a town of evenly distributed population, one square meter in area. The kilometer analysis and assessment are done through a cost/sensitivity exercise on a well defined hypothetical urban model. Four technologies considered include (i) the conventional sanitary sewerage system, (ii) the aqua-privy cum sewer system, (iii) the Japanese vacuum truck and household vault and (iv) the septic tank. On a comparative basis, the vacuum truck and vault is more attractive than the other systems because of its low capital cost and annual costs and there is little change in unit costs over population densities under variations in interest rates. However, each of the above systems has trade-offs in itself and further investigations are recommended for each specific location condition.

139 McGarry, M.G.

International Development Research Centre,
Ottawa, Canada.

WASTE COLLECTION IN HOT CLIMATES...A TECHNICAL AND ECONOMIC APPRAISAL
"Water, Wastes and Health in Hot Climates". A Wiley-Interscience Publication. U.K. Feachem, R., McGarry, M., Mara, D. (Eds.).
ISBN 0 471 99410 3. Chapter 13, pp. 239-263. 1977.
6 figures, 10 references.
EXCRETA DISPOSAL: COSTS: URBAN SANITATION SYSTEMS: RURAL SANITATION SYSTEMS: DEVELOPING COUNTRIES.

* A broad spectrum of technologies available to rural and urban areas of developing countries for hygienic excreta disposal is described. The pit privy, bored-hole latrines, PRAI latrines, overhung latrine or the fueillée, and excreta composting and the biogas plant have been employed for rural sanitation. Other systems for urban sanitation include the septic tank, conventional sanitary sewerage, bucket latrine, aqua-privy, aqua-privy- sewerage system, vacuum truck and vault, compost toilet, and chemical and other individual toilet units. The choice for any of the above technologies depends on many criteria. Under empirical conditions, vacuum truck and vault is found to yield the lowest costs when compared to the other urban sanitation systems.

140 Miller, N.

Lagos Executive Development Board,
Nigeria. Africa.

THE SANITATION OF LAGOS
Journal of the Institution of Municipal Engineers. U.K. 88(12). pp. 441-446. December 1961.
1 photograph, 1 map, 1 diagram, 1 table.
NIGERIA: NIGHTSOIL COLLECTION.

*The paper describes a century of sanitary progress in Lagos, Nigeria. A system used for nightsoil collection between 1907 and 1933 is described. Subsequent improvements in sanitation are outlined.

141 Mohanrao, G.J. CPHERI Nehru Marg, Nagpur, India.

WASTE COLLECTION, TREATMENT AND DISPOSAL IN INDIA
Indian J. Environmental Health. India. 15(3) pp. 222-235, July 1973.
6 tables, 7 references.
INDIA: SEWERAGE: NIGHTSOIL TREATMENT: SEWAGE TREATMENT.
*The present deficiency of sewerage in India and the high cost of providing it for those not served lead the author to query whether satisfactory alternatives to water-carried sewerage can be found. In India the majority of sewage is at present discharged untreated to land or water. Waste stabilization ponds can provide a lower-cost alternative to conventional treatment. About 70% of the urban population is still served by bucket latrines, and efficient treatment of nightsoil should be developed. Improved refuse collection methods are needed.

142 Morrow, D.

SANITARY WASTE DISPOSAL IN LOW-INCOME COMMUNITIES IN JAKARTA
Unpublished Report Workshop II, Public Policy Program. 77 pp. May 6, 1975.
Bibliography
INDONESIA: URBAN: COLLECTION: VACUUM CARTS: AQUA PRIVY: NIGHTSOIL: SANITATION: ECONOMICS.
*The present conditions with regard to waste disposal practices in Jakarta are described, with particular reference to health dangers and environmental pollution. Various alternatives are described and their feasibility evaluated. The author concludes that a nightsoil collection system utilizing vacuum carts and steam pasteurization and eventual use as fertilizer is not only the most economic but has the best chance of easy implementation.

143 Pradt, L.A. Zimpro Inc., Rothschild, Wisconsin, U.S.A.

SOME RECENT DEVELOPMENTS IN NIGHT SOIL TREATMENT
Water Research. U.K. Volume 5. pp. 507-521, 1971.
4 tables, 5 figures, 15 references.
JAPAN: NIGHTSOIL: COLLECTION: TREATMENT: VACUUM TRUCK: ECONOMICS: WATER-BORNE: WET AIR OXIDATION: AQUA PRIVY: CONSERVANCY TANK.
* The collection and treatment of night soil in present-day Japanese cities is described. Three treatment processes (digestion, chemical treatment and aerobic oxidation) are described in detail. The author concludes that the night soil collection and treatment systems as practiced in Japan are more practical for most Asian and underdeveloped communities than a Western style water-borne system, at least for the next 10-20 years.

144 Tabago, J.L.

Asian Institute of Technology,
Bangkok, Thailand.

EVALUATION OF NIGHT SOIL COLLECTION, TREATMENT AND UTILIZATION IN AGRICULTURE

Master Thesis No. 586. Asian Institute of Technology. Thailand.
111 pp. October 1973.
30 tables, 15 figures, 44 references.
NIGHT SOIL: COLLECTION: TANK TRUCK: TREATMENT: THAILAND: UTILIZATION: ASCARIS: PASTEURIZATION: REUSES: HANDLING.

*A promising alternative waste disposal system for urban areas in developing countries is that of nightsoil (excreta) collection by vacuum trucks, treatment and utilization. The nightsoil collection operation for a residential city or town of 50,000 population would require about 17 units of 8 cubic meter (m^3) tank truck at 8-hour working day. For a 16-hour working period (2 shifts), 9 units of the tank truck would be needed. The cost of nightsoil collection depends on many factors but the use of the larger tank truck and transfer stations (tank trailers) will significantly reduce the unit cost of the collection. For a system using 8 m^3 tank truck with 2 crew, collection frequency at 2 weeks interval, amount of flushing water at 2 liters/capita-day, and distance of collection area to treatment plant equal to 2 km, the collection cost is estimated to be US $ 0.40/m^3 or US $ 0.60/capita-year.

A laboratory study indicated that destruction of the harbouring parasites including Ascarid eggs in the nightsoil can be accomplished by moist heat treatment under atmospheric pressure at 60°C and an exposure time of 10 minutes. The proposed heat treatment facilities include a receiving facility for the collected raw nightsoil, heat exchanges, and a temporary storage coupled to a series of anaerobic and aerobic lagoons having a required area of 3.0 hectares. The boiler capacity is estimated at 1,880 kg steam/hr that could treat nightsoil at a rate of 25 m^3/hr. The cost of this treatment system is estimated to be US $ 0.30/m^3 or US $ 0.45/capita-year. The overall cost of nightsoil collection and treatment is therefore US $ 0.70/m^3 or US $ 1.05/capita-year. Considering the fertilizer value of nightsoil (US $ 3.5 - 4.5/m^3) and the cost of land application (US $ 1/m^3), the treated nightsoil may be sold at about US $ 2.5 - 3.5/m^3. These analysis imply that the collection and treatment of nightsoil is economically feasible provided that a market exists for the utilization of the human waste.

145 Thomas, R.H.

Camp Dresser & McKee International, Inc.,
Boston, U.S.A.

WASTEWATER SYSTEM FOR TAIPEI, TAIWAN,
Journal of the Water Pollution Control Federation. U.S.A.
44(8). pp. 1611-1622. August 1972.
4 diagrams, 4 tables, 1 reference.
TAIWAN: SEWERAGE: SEWAGE TREATMENT: NIGHTSOIL.

* The present nightsoil collection method is described. Alternative watercarried sewerage systems are compared and some details are given of the proposed system, which include a staging program and construction costs. Partly-treated sewage would be discharged to sea. The proposal includes a nightsoil dumping station for six vehicles. Nightsoil and washwater would pass to the sewer.

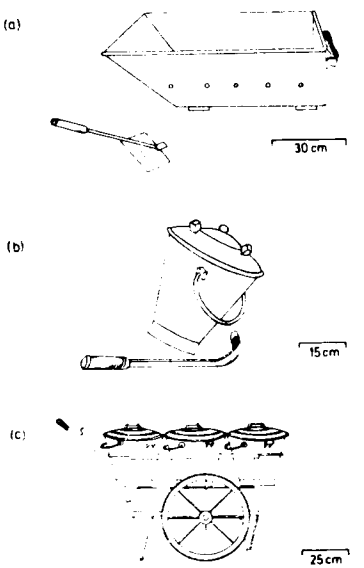


Figure 16.2 (a) Nightsoil container (made from 24 gauge galvanized iron sheet) and scraper. (b) Nightsoil bucket and scraper. (c) Wheelbarrow for three or six buckets. (Designs by Department of Social Welfare, Ahmedabad)

3Aii. Off-Site Collection: Waterborne

146 Anon.

Asia Projects Department,
International Bank for
Reconstruction and Development,
Washington, D.C. U.S.A.

APPRAISAL OF BOMBAY WATER SUPPLY AND SEWERAGE PROJECT
International Bank for Reconstruction and Development. Report No. 88a-IN. U.S.A. 76 pp. 22 of main text, 54 of annexes.
14 annexes, 9 tables, 4 graphs, 6 maps.
INDIA: WATER SUPPLY: SEWERAGE: SEWAGE REHABILITATION: URBAN COMMUNITIES: PUBLIC HEALTH DETERIORATION: SEWAGE DISPOSAL: SEPTIC TANKS: FLUSH TOILETS.

* This report covers the appraisal of a US $58 million project to increase water supplies and the rehabilitate and commence expansion of existing sewerage systems in Bombay. The objectives are to improve living conditions for over 6 million people by providing 7-8 hours of water supply and expand sewage collection, treatment and disposal systems.

The engineering designs ever carried out by the Bombay Municipal Corporation (BMC), Binnie & Partners and tata engineers.

(See note on World Bank Appraisal Reports, p.307)

147 Anon.

Asia Projects Department,
International Bank For
Reconstruction and Development,
Washington, D.C. U.S.A.

APPRAISAL OF THE SINGAPORE SEWERAGE PROJECT - SECOND STAGE - SINGAPORE
International Bank for Reconstruction and Development. Report No. 1602-SI. U.S.A. 42 pp. 13 of main text, 29 of annexes. June 1973.
12 annexes, 7 tables, 3 graphs, 1 map.
SINGAPORE: SEWERAGE: URBAN RENEWAL: NIGHT SOIL COLLECTION: URBAN COMMUNITY.

* The report covers the appraisal of a US $29.5 million equivalent sewerage project to improve and expand sewage collection and treatment. The project is a second stage of an on-going sewerage program. Its objective is to continue a program to provide sewer service to urban renewal and new housing areas. The project consists of extensions of the sewer system, and the construction of new pumping stations and treatment works. These facilities will provide sewer services to all estimated 400,000 people not now served and reduce the number of households under night soil collection.

(See note on World Bank Appraisal Reports, p. 307)

148 Anon.

Asia Projects Department,
Water Supply Division,
International Bank for
Reconstruction and Development,
Washington, D.C. U.S.A.

NEPAL WATER SUPPLY AND SEWERAGE PROJECT
International Bank for Reconstruction and Development. Report No. 270Z-NEP. U.S.A. 91 pp. 19 of main text, 72 of annexes, April 1974.
17 annexes, 19 tables, 3 graphs, 5 maps.
NEPAL: WATER SUPPLY: SEWERAGE: VILLAGE WATER SUPPLY: RIVER CONTAMINATION.

* This report covers the appraisal of a US $10.4 million equivalent Water Supply and Sewerage Project directed to improve and extend the service in Kathmandu and Talitpur. The water supply component includes two new springs sources for Kathmandu and Pokhara, a pumping station, a service reservoir, transmission and distribution mains etc.

The sewerage component consists of some 40 Km of sewers, a pumping station and two waste stabilization lagoons for Kathmandu and Talitpur, that will prevent raw sewage from contaminating near by popular bathing places.

Technical studies were carried out by Binnie and Partners of London.

(See note on World Bank Appraisal Reports, p. 307)

149 Anon.

Black & Veatch International,
Kansas City. U.S.A.

MASTER PLAN, FEASIBILITY AND PRELIMINARY ENGINEERING STUDY FOR STORM DRAINAGE AND SANITARY SEWERAGE FOR THE CITY OF N'DJAMENA, CHAD.

* A final report of a Master Plan prepared for the African Development Bank as executing agency for the Government of Chad. Africa. pp. 12-1 to 12-8, 13-1 to 13-12, A3-1 to A3-10. 1975.
Chap. 12 "Existing sanitary sewerage facilities",
Chap. 13 "Sanitary sewage concepts"
Appendix 3 "Economic comparison between aqua privy and conventional sewerage systems".
CHAD: AQUA-PRIVIES: CONVENTIONAL SEWERAGE: STABILIZATION PONDS: COST: STORM WATER: DRAINAGE.
Chapter 12 of this Master Plan reviews existing sanitation systems in N'Djamena; the principal systems in use are septic tanks and pit privies although defecation in the open is common. Septic tank effluent disposal is by leaching well. Chapter 13 discusses the comparative merits of conventional sewerage and a combined aqua-privy sewerage system and concludes, on the basis of cost, that the latter is the system of choice for N'Djamena.

150 Anon.

East Asia and Pacific Projects Dept.,
Water Supply Division,
International Bank for Reconstruction
and Development,
Washington, D.C. U.S.A.

MALAYSIA - APPRAISAL OF THE KUALA LUMPUR SEWERAGE PROJECT
International Bank for Reconstruction and Development. Report No. 890a-MA. U.S.A. 64 pp. 22 of main text, 42 of annexes. February 1976.
12 annexes, 18 tables, 4 graphs, 1 map.
MALAYSIA: SEWERAGE: URBAN COMMUNITY: SEWAGE LAGOONS.

* This report covers the appraisal of a US $60.5 million equivalent project to improve and extend sewage collection and treatment facilities in Kuala Lumpur. It is the first stage 1976-1981 of a 30 year Master Plan for sewerage development. In addition the project would provide service to three newly created zones by means of new sewers, treatment plants, pumping stations and sewage lagoons.

The Sewerage Department of the City of Kuala Lumpur is responsible for carrying out the project.

(See note on World Bank Appraisal Reports, p. 307)

151 Anon.

Europe, Middle East and North
Africa Projects Department,
International Bank For Reconstruction
and Development,
Washington, D.C. U.S.A.

APPRAISAL OF THE AMMAN WATER SUPPLY AND SEWERAGE PROJECT II
International Bank for Reconstruction and Development. Report No. 71a-JO U.S.A. 72 pp. 20 of main text, 52 of annexes. May 1973.
19 annexes, 18 tables, 3 graphs, 3 maps
JORDAN: WATER SUPPLY: SEWERAGE.

* This report covers the appraisal of a US $11.5 million equivalent water supply and sewerage project which will extend the water service to the entire municipality, reduce the unaccounted for water, provide new sewer laterals and service connections, to meet the Amman's requirements until 1982.

The Amman Municipal Water and Sewerage Authority (AWSA) is the agency in charge of the project.

(See note on World Bank Appraisal Reports, p. 307)

152 Anon.

Projects Department,
International Bank For
Reconstruction and Development,
Washington, D.C.
U.S.A.

APPRAISAL OF THE SINGAPORE SEWERAGE PROJECT SINGAPORE
International Bank for Reconstruction and Development. Report No. TO-644a. U.S.A. 42 pp. 23 of main text, 19 of annexes. June 1968.
14 annexes, 9 tables, 4 graphs, 2 maps
SINGAPORE: SEWERAGE: URBAN COMMUNITY: URBAN RENEWAL: SLUDGE TREATMENT: PUBLIC HEALTH: LOW INCOME.

* The report covers the appraisal of a 4 year, US $22.4 million equivalent sewerage project which is part of the Singapore overall development plan. The project provides for the construction of main sewers and pumping stations in nine areas. Several sludge treatment and disposal facilities will be upgraded and constructed.

Planning, design and construction were the responsibility of Public Works Department (sewerage branch) of the Government of Singapore.

(See note on World Bank Appraisal Reports, p. 307)

153 Anon.

Projects Department,
Europe, Middle East and North
Africa Regional Office,
International Bank For
Reconstruction and Development,
Washington, D.C. U.S.A.

APPRAISAL OF A HODEIDA WATER SUPPLY AND SEWERAGE PROJECT YEMEN ARAB REPUBLIC
International Bank for Reconstruction and Development. Report No. 773a-YAR. U.S.A. 40 of annexes.
16 annexes, 20 tables, 6 graphs, 2 maps.
YEMEN ARAB REPUBLIC: WATER SUPPLY: URBAN SEWERAGE: INTERMITTENT SERVICE: OCEAN DISPOSAL: WATER REUSE: IRRIGATION: STABILIZATION PONDS.

* This report covers the appraisal of a US $31.2 million equivalent project that is part of the Hodeida's Master Plan to the Year 2,000. The Waters supply component will provide house connections to 70% of the population and public taps to the remainder. The sewerage component provides for sewers to be constructed in all streets where water mains are to be laid, thus eliminating the unsanitary conditions which exists in the city as a result of the difficulty of disposal of sewage in septic tanks or cesspools. The sewage treatment and final disposal has not been selected. Among the possibilities are: ocean disposal, conventional complete treatment or treatment in stabilization ponds followed by reuse for irrigation.

Feasibility studies were prepared by Italconsult of Italy.

(See note on World Bank Appraisal Report, p. 307)

154 Anon.

Public Utilities Projects Division,
Eastern Africa Regional Office,
International Bank For Reconstruction
and Development,
Washington, D.C.
U.S.A.

SWAZILAND - APPRAISAL OF THE WATER SUPPLY AND SEWERAGE PROJECT
International Bank for Reconstruction and Development. Report No. 5092-SW. 46 pp. 16 of main text, 30 of annexes. October 1974.
13 annexes, 11 tables, 2 graphs, 1 map.
SWAZILAND: URBAN COMMUNITY: RURAL COMMUNITY: OXIDATION PONDS: SEPTIC TANKS.

* This report appraises a water supply and sewerage project in Mbabane Manzini and Nhlango at a cost of US $4.5 million equivalent.

The project includes pumping stations used pipe lines for the Mbabane Water supply as well as the extension of the reticulation system, a new trunk sewer system used oxidation ponds to serve the population.

(See note on World Bank Appraisal Reports, p. 307)

155 Anon.

Regional Projects Department,
Europe, Middle East and North
Africa Regional Office,
International Bank For
Reconstruction and Development,
Washington, D.C. U.S.A.

APPRAISAL OF THE FIRST URBAN SEWERAGE PROJECT TUNISIA
International Bank for Reconstruction and Development. Report No. 5812-TN. U.S.A. 25 pages of main text, 36 of annexes. January 1975.
18 annexes, 7 tables, 5 graphs, 5 maps
TUNISIA: SEWERAGE: URBAN: DRYWEATHER: FLOWS: INTERCEPTORS CANALS: POLLUTION CONTROL: DIGESTED SLUDGE.

* This report covers the appraisal of an US $86.11 million equivalent project. The major component of the project consists of facilities to improve the existing inadequate sewerage of greater Tunis. The sewer network will be renewed and expanded and collector sewers constructed to intercept the dry weather flows and carry them to sewage treatment plants. Interceptor canals will be constructed to prevent storm water overflows from polluting the Lake of Tunis. The major benefits are land appreciation and some revenues devised from the sale of treated sludge for fertilizer use.

The Office National de L'Assainissement (ONAS) has the design,construction and operation of the project.

(See note on World Bank Appraisal Reports, p. 307)

156 Anon.

Regional Projects Department,
Latin America and the Caribbean
Regional Office,
International Bank For
Reconstruction and Development,
Washington, D.C. U.S.A.

APPRAISAL OF KINGSTON SEWERAGE I AND WATER SUPPLY PROJECT - JAMAICA
International Bank for Reconstruction and Development. Report No. 615a-JM. U.S.A. 61 pp. 19 of main text - 42 of annexes.
13 annexes, 16 tables, 5 graphs, 2 maps.
JAMAICA: WATER SUPPLY: SEWERAGE: HARBOUR POLLUTION: GROUNDWATER CONTAMINATION: HEALTH HAZARDS.

* The report covers the appraisal of a US$30 million equivalent sewerage and water supply project for the Kingston - St. Andrew area in Jamaica.

The objective of the water portion is to satisfy water decreased driving 1976-1980. The project considers the development of the Blue Mountain rivers and the Wag Water river.

The sewerage port is intended to reduce health hazards that arise from contamination of ground water and pollution of the harbour and its tributary streams.

The Water Commission of Kingston - St. Andrew is responsible for carrying out the project.

(See note on World Bank Appraisal Reports, p. 307)

157 Anon.

Regional Projects Department,
Latin America and the Caribbean
Regional Office,
International Bank For
Reconstruction and Development,
Washington, D.C. U.S.A.

APPRAISAL OF MEDIUM CITIES WATER SUPPLY AND SEWERAGE PROJECT - MEXICO
International Bank for Reconstruction and Development. Report No. 885a-ME. U.S.A. 57 pp. 25 of main text, 32 of annexes. November 1975.
8 annexes, 11 tables, 3 graphs, 1 map.
MEXICO: WATER SUPPLY: SEWERAGE: LOW INCOME: EXCRETA DISPOSAL.

* This report covers the appraisal of a US $90 million equivalent Water Supply and Sewerage Project in eight medium size cities in Mexico.

The project will increase the water supply in the cities concerned. The sewerage service provided to low income groups will be an important factor in controlling diseases caused by land excreta disposal.

The executing agency is the Secutaria au Recursos Hidraulicos (SRH).

(See note on World Bank Appraisal Reports, p. 307)

158 Anon.

Regional Projects Department,
Latin America and the Caribbean
Regional Office,
International Bank For Reconstruction
and Development,
Washington, D.C. U.S.A.

APPRAISAL OF THE WATER SUPPLY AND SEWAGE PROJECT FOR NEW PROVIDENCE ISLAND - BAHAMAS
International Bank for Reconstruction and Development, Report No. 940a-BM. U.S.A. 68 pp. 18 of main text, 50 of annexes. June 1976.
15 annexes. 18 tables, 4 graphs, 1 map
BAHAMAS: WATER CONSERVATION: URBAN COMMUNITIES: SHIP SEWAGE: SEWAGE REHABILITATION: HARBOUR POLLUTION.

* The report covers the appraisal of a US $32 million equivalent project to improve the water supply and sanitary sewerage services for the Island of New Provident.

The primary goal is to increase the supply of water in 6.0 million gallons per day from well fields to be developed on Andros Island and transported by tankers to New Providence. The project also supports a water conservation program as well as the rehabilitation of the sewerage system and an interceptor for ship sewage.

The executing agency is the Water and Sewerage Corporation.

(See note on World Bank Appraisal Reports, p. 307).

159 Anon.

Regional Projects Department,
Latin America and Caribbean
Regional Office,
International Bank For
Reconstruction and Development,
Washington, D.C. U.S.A.

BOLIVIA - APPRAISAL OF THE URBAN AND RURAL COMMUNITIES WATER SUPPLY AND SEWERAGE PROJECT
International Bank for Reconstruction and Development. Report No. 1076b-BO. U.S.A. 70 pp. 28 of main text, 30 of annexes. October 1974.
8 annexes, 26 tables, 4 graphs, 3 maps.
BOLIVIA: WATER SUPPLY: SEWERAGE: RURAL COMMUNITIES:OPERATION: MAINTENANCE.

* The project is designed to improve and extend water supply in approximately 70 rural communities and two cities in Bolivia in addition to extending sewerage in Sucre, at a cost of approximately US $15.0 million.

The report provides practical criteria for the selection of communities to be bettered. The main benefits of the rural port will be the improvement of health and disease in immigration to the urban centers.

The studies and design will be prepared by local and foreign consultants for the urban component and by Corpaguas to the rural.

Executing agencies will be Corpaguas, Arpos, and Ecapas.

(See note on World Bank Appraisal Reports, p. 307).

160 Anon.

Regional Projects Department,
Latin American and the Caribbean
Regional Office,
International Bank For
Reconstruction and Development,
Washington, D.C. U.S.A.

BRAZIL - APPRAISAL OF MINAS GERAIS WATER SUPPLY AND SEWERAGE PROJECT II
International Bank for Reconstruction and Development. Report No. 1042c-BR.
U.S.A. 58 pp. 22 of main text, 36 of annexes. June 1976.
12 annexes, 14 tables, 4 graphs, 1 map.
BRAZIL: WATER SUPPLY: SEWERAGE: URBAN COMMUNITIES:
RURAL SECTOR: IRRIGATION.

* The report covers the appraisal of a $134 million program for water supply and sewerage projects in the state-of-Minas Gerais. The project is composed of about 108 water supply and sewerage subprojects to be constructed in comments ranging from 500 inhabitants to 1.6 million, benefiting half million new customers, improve quality of water to 140,000 people and provide sewerage service for about 400 people, thus reducing migration to major metropolitan areas.

The Companhia de Saneamento de Minas Gerais, S.A. (COPASA) is responsible for the design and construction of the project.

(See note on World Bank Appraisal Reports, p. 307)

161 Anon.

Regional Projects Department,
Western Africa Regional Office,
International Bank for
Reconstruction and Development,
Washington, D.C. U.S.A.

APPRAISAL OF THE ABIDJAN SEWERAGE AND DRAINAGE PROJECT IVORY COAST
International Bank for Reconstruction and Development. Report No. 5802-IVC.
U.S.A. 44 pp. 20 of main text, 24 of annexes. January 1975.
16 annexes, 22 tables, 1 graph, 2 maps
SEWERAGE: DRAINAGE: PUBLIC SHOWERS: TOILETS: STAFF TRAINING: FLOODING:
LOW INCOME POPULATION: IVORY COAST.

* A ten year project consisting of laying 19.1 Kms of sewers with construction of associated works, 3.6 kms of drains, a pilot scheme for the construction of public showers and toilets in low income areas, supply of vehicles, service equipment and training of staff. The cost of the project is at $17 million.

Main advantages are preventing further distribution of public health and environment, reducing pollution level and reducing incidence of flooding in low lying sectors.

The technical responsibility for the sewerage and drainage development relays on the Societe d'Equipment des ferrains Urbains (SETU).

(See note on World Bank Appraisal Reports, p. 307)

162 Anon.

Secrétariat des Missions
d'Urbanisme et d'Habitat
(SMUH),
Paris. France.

A BIBLIOGRAPHY ON SANITATION AND WATER SUPPLY IN DEVELOPING COUNTRIES
(BIBLIOGRAPHIE SUR L'ASSAINISSEMENT ET L'APPROVISIONNEMENT EN EAU DANS LES PAYS EN VOIE DE DÉVELOPPEMENT)
Secretariat des Missions d'Urbanisme et d'Habitat (SMUH). France. January 1977.
139 references.
SANITATION: SEWERS: DEVELOPING COUNTRIES: TROPICS: BIBLIOGRAPHY.

* A bibliography of 139 entries with short abstracts of primarily French language literature dealing with both sanitation and water supply.

(Original paper written in French)

163 Anon.

Service de l'Habitat et
de l'urbanisme,
Paris. France.

PRINCIPLES OF RURAL COMMUNITY SANITATION IN THE TROPICS
(PRINCIPES D ASSAINISSEMENT COLLECTIF EN MILIEU RURAL TROPICAL)
Bureau central d'études pour les équipements d'outre-mer. France. 64 pp. December, 1960.
SEWERS: TROPICAL: SEWAGE TREATMENT.

* This report describes the application of wastewater sewage to rural settlements in the tropics, and discusses methods for calculating pipe diameters, slopes, etc. Some basic principles for treatment are given.

(Original paper written in French)

164 Anon.

South Asia Projects Department,
Water Supply Division,
International Bank For Reconstruction
and Development,
Washington, D.C. U.S.A.

PAKISTAN - APPRAISAL OF THE LAHORE WATER SUPPLY, SEWERAGE AND DRAINAGE PROJECT, PHASE II
International Bank for Reconstruction and Development. Report No. 996A-PAK. U.S.A. 131 pp. 25 of main text, 110 of annexes. April 1976.
16 annexes, 27 tables, 3 graphs, 3 maps.

PAKISTAN: WATER SUPPLY: SEWERAGE: DRAINAGE: FLOOD PREVENTION: STABILIZATION POND: NIGHT SOIL COLLECTION.

* The report covers the appraisal of a project that forms part of a long range program for improving water supply, sewerage and drainage in Lahore. The project at a cost of US $4€.3 million equivalent will provide water supply to 600 thousand people, sewerage to additional 250 thousand and will alleviate flooding that takes place during the monsoon by means of the drainage works.

The water component includes the construction of 47 tube wells, 193 miles of transmission lines and filters. The sewerage and drainage components include about 300 miles of sewers, 21 of drainage channels, 4 pumping stations and one large waste stabilization pond.

The project will have definite environmental impacts in the Lahore area.

Camp Dresser & McKee, Ltd. and A.F. Fergusen & Co. were the consulting engineers for the project.

(See note on World Bank Appraisal Reports, p. 307)

○ 165 Anon. World Health Organization, Geneva, Switzerland.

COMMUNITY WATER SUPPLY AND EXCRETA DISPOSAL IN DEVELOPING COUNTRIES:REVIEW OF PROGRESS
World Health Statistics Report. Switzerland. 29(10). pp. 544-603. 1976.
10 tables, 16 figures.
DEVELOPING COUNTRIES: WATER SUPPLY: EXCRETA DISPOSAL: COSTS.
*This special WHO issue reviews the progress of community water supply and excreta disposal services in the developing countries in the period 1970 to 1975. It furnishes estimates of investments required to meet the WHO targets for 1980 and outlines courses of action to meet these goals.

Globally, there has been an increase in the percentage of urban population served by excreta disposal facilities from 71% (337 million people) to 75% (437 million people) in this five-year period. These were served either by connection to the public sewerage system or through household systems. There was, however, a drop in the percentages of population with house connections to the public sewerage systems from 27% in 1970 to 25% in 1975; that is to say, any increase in connection to the public sewerage system could not keep pace with the increase in urban population. The 1980 WHO targets expect that 95% of the urban population would have excreta disposal facilities and roughly US $ 16,000 million would be required to accomplish this goal.

The global percentage of rural people that had adequate excreta disposal facilities rose from 11% (134 million people) in 1970 to 15% (209 million people) in 1975. The 1980 WHO targets expect to increase this figure to 25% and that approximately US $ 2,000 million would be needed for this purpose.

166 Contractor, J.C.
Agrawal, M.C.

(Both) Department of Civil Engineering,
S.V. Regional College of Engineering and Technology,
Surat, India.

SIMPLIFIED TREATMENT FOR URBANIZED VILLAGE
Report on the Seminar on Sewage Treatment and disposal for small communities. India. Paper No. 11, 4 pp. March 13-14, 1971.
3 tables, 6 references.
SEWAGE TREATMENT: SEWER COSTS: SAND FILTERS: INDIA: URBAN.

*A review of the costs of sewers and sand filters used to collect and treat sewage from Umra and Piplod villages on the outskirts of Surat. Sewers and manholes cost 9 rupees per capita at Umra, population 2,500, and 12.6 rupees per capita at Piplod, population 450. Sand filtration sewage treatment cost at both villages was about 8 rupees per capita.

167 de Azevedo Netto, J.M.

COST OPTIMIZATION (MINIMIZATION) OF SEWER DESIGN - (OTIMIZACAO ECONOMICA DOS PROJETOS DE ESGOTOS)
Revista DAE. Brazil. 35(105). pp. 71-81. 1976.
4 figures, 9 tables.
ECONOMICS: SEWERAGE: SEWER DESIGN.

* A review of sewer design principles shows that substantial cost savings (40 - 50%) can be made by improved layouts for sewer networks, correct choice of pipe material and the use of small diameter inspection holes to replace more expensive manholes at many points in the network. (Original paper written in Portugese)

168 de Azevedo Netto, J.M.

Sistemas de Esgotos Sanitarios de Baixo Costo Otimizacao Economica dos Projetos de Esgotos. Sao Paulo, Brazil.

LOW COST SEWERAGE SYSTEMS - ECONOMIC OPTIMIZATION OF SEWERAGE PROJECTS
Symposium on Wastewater Treatment and Disposal. Argentina.37 pp. June 1976.
9 tables, 4 figures.
BRAZIL: SEWERAGE: CONSTRUCTION: ECONOMIC OPTIMIZATION: DESIGN: LOW COST TECHNOLOGY: PLANNING.

* Based on the analysis of several projects in Brazil, the paper examines each of the major components which influence the overall cost in sewerage systems: population served, design, hydraulic conditions, pipe diameter, type of joints, etc. The author states that the review of several typical cases revealed that innovative design criteria would have made it possible to attain savings up to 50%. The author also points out that in most cases, more conservative projections of population growth would have prevented overdesign of systems, making it possible to install smaller pipes, consequently, saving substantial amounts of money.

(Original paper written in Portugese)

169 Elong, P.M. — University of Cameroon, Cameroon.

STUDY OF DONALE'S WASTEWATER DISPOSAL SYSTEM
Planning, Housing. Information, Secrétariat des Missions d'Urbanisme et d'Habitat. France. No. 74. pp. 62-67. August 1973.
1 table.
CAMEROON: SEWERS: URBAN.
* A sewerage system in the city of Donale serves only a sixth of the area of the town and due to lack of maintenance, poor operation is reported; as a result the surface rainwater drainage system is utilized for waste disposal. Environmental pollution results also from lack of sewage treatment facilities.

170 Feachem, R. — Dept. of Civil Engineering, University of Birmingham, U.K.

APPROPRIATE SANITATION
New Scientist. U.K. pp. 68-69. Issue 8. January, 1976.
1 figure.
SANITATION: SEWERAGE: EXCRETA DISPOSAL:
COST: CONSTRUCTION: WATER USAGE: AQUA-PRIVY.
* The author shows that conventional sewerage is, in economic and social terms, an inappropriate solution for excreta transport in tropical cities. More research on alternative solutions such as aqua-privies is required and it is suggested that the World Health Organization should play a more active role in evaluating alternative sanitation technologies.

171 Hansen, J.A. — Dept. of Sanitary Engineering, Technical University of Denmark. Denmark.

Therkelsen, H. — Dept. of Civil Engineering, University of Washington, Seattle, U.S.A.

ALTERNATIVE SANITARY WASTE REMOVAL SYSTEMS FOR LOW-INCOME URBAN AREAS IN DEVELOPING COUNTRIES
Polyteknisk Forlag Publishers. Denmark. 143 pp. 1977.
16 chapters.
DEVELOPING COUNTRIES: HUMAN WASTES: COST -BENEFIT :
AQUA-PRIVY: PIPED DISPOSAL SYSTEMS: NON-PIPED DISPOSAL SYSTEMS: ECONOMICS
* An investigation of alternatives to traditional Western World sewerage (flushed toilet and piped network) for the removal of human wastes from high density, low-cost housing in developing countries. A hypothetical case based on background data from Lagos, Nigeria has been used for the analyses of cost-benefits of various systems and the systems applicability. It is concluded that at high densities, e.g. above 400 capita/ha, an aqua privy and piped liquid disposal systems are more favourable. At low densities, e.g. 125 capita/ha and less, the non-piped disposal systems appear preferable.

172 Kenneth, L.
Hutzler, N.
Boyle, W.C.

(All) Civil and Environmental Engineering Dept., University of Wisconsin, Madison. U.S.A.

HOUSEHOLD WASTEWATER CHARACTERIZATION
Journal of the Environmental Engineering Division, Proceedings of the American Society of Civil Engineers. U.S.A. 100(EE1), Paper No. 10372. pp. 201-213, February, 1974.
9 tables, 46 references.
WASTEWATER CHARACTERISTICS: HOUSEHOLD: RURAL: URBAN: TREATMENT.

* In order to effectively study alternatives to the treatment and disposal of wastewaters from individual homes, a study has been conducted to evaluate the qualitative and quantitative characteristics of wastes generated by both rural and urban households. A survey of a number of households, in concert with the analysis of current information available in the literature, provide data to establish guidelines characterizing individual wastewater events within the homes.

173 Koneigsberger, O.H.

INTERNATIONAL URBANIZATION SURVEY - REMOVAL AND TREATMENT OF SOLID AND LIQUID WASTES
Report of the Ford Foundation. U.S.A. pp. 98-142. 1972.
64 references.
URBAN: EXCRETA REMOVAL: DEVELOPING COUNTRIES.

* A general discussion of excreta disposal problems in rapidly urbanizing areas of developing countries.

174 Lemoine, L.

Comité interafricaine d'études hydrauliques. Upper Volta.

Michel, C.

Ecole Inter Etats des Ingenieurs de l'equipment rural. Upper Volta.

EXPERIMENTS IN APPLYING TRADITIONAL URBAN SANITATION FORMULAR TO TROPICAL AFRICA
(ESSAI D ADOPTION A L'AFRIQUE TROPICALE DES METHODES CLASSIQUES DE CALCUL DU DEBIT DES OUVRAGES D ASSAINISSEMENT URBAIN)
Serie hydrologies de comite interafricaine d'etudes hydrauliques. Upper Volta. 35 pp. May 1972.
3 references.
AFRICA: SEWERS: DESIGN.

* A study of adapting western mathematical methods for designing waterborne sewerage systems to tropical African conditions.

(Original paper written in French)

175 Marais, G.V.R.

Dept. of Civil Engineering,
University of Cape Town,
South Africa.

DESIGN CRITERIA FOR COMMUNITY WASTEWATER COLLECTION SYSTEMS FOR DEVELOPING COUNTRIES
World Health Organization. Switzerland. Publication No. CWSS/WP/73.6. 7 pp. 1973.
SEWAGE: EXCRETA: SEWERAGE: AQUA-PRIVY: LATRINES.

* A review of sanitation needs for low-income high-density housing schemes leads the author to conclude that the best solution in areas where there is a water supply, is an aqua-privy sanitation block connected to small-bore (100mm) flat-grade sewers discharging into a series of stabilization ponds. The water supply need not be an in-house or on-lot piped supply. The proposed system is most suitable for "site and service" housing schemes.

176 Marais, G.V.R.

University of Cape Town,
South Africa.

SANITATION AND LOW COST HOUSING
Water Quality: Management and Pollution Control Problems. U.K. pp. 115-125. Jenkins, S.H. (Ed.) Pergamon Press, Oxford. 1973.
1 figure, 4 references.
HOUSING SANITATION: PIT LATRINES: AQUA-PRIVY: AQUA-PRIVY SEWERAGE SYSTEM: STABILIZATION PONDS: TROPICS.

* The author claims that access to work, water supply and sanitation are more important than shelter when providing housing in the tropics and sub-tropics. The disadvantages of pit and bucket latrines, water-carried sanitation and communal facilities are described. An aqua-privy system in which sullage is discharged to the tank and effluent is passed to waste stabilization ponds is advocated.

○177 Oakley, H.R.
Goode, G.S.G.

(Both) J.D. and D.M. Watson,
High Wycombe, U.K.

THE PLANNING OF SEWAGE SYSTEMS IN DEVELOPING COUNTRIES
In: "Civil Engineering Problems Overseas". U.K. pp. 383-400. Published by Institution of Civil Engineers, 1971.
16 references, 7 tables.
SOUTH-EAST ASIA: MIDDLE EAST: SEWERAGE: PLANNING: COSTS: SEWAGE.

* This paper describes the planning of sewerage schemes in developing countries in South-East Asia and the Middle East. The influences of climate, water supply, availability of skilled labour and materials and the living and health standards of the community are discussed. Project appraisal, design criteria and the administrative requirements of sewerage schemes are discussed in general terms and in relation to specific cities in the Middle and Far East.

178 Pickford, J.

Loughborough University of Technology,
Loughborough, U.K.

SEWAGE TREATMENT IN DEVELOPING COUNTRIES
Water Pollution Control. U.K. 76(1), pp. 65-66, 1977.
1 table, 21 references.
WATER SUPPLY: SANITATION: SEWAGE TREATMENT.

* The shortage of water in many urban areas of developing countries makes watercarried sewerage unsuitable. Waste stabilization ponds are usually ideal, but a number of plants using conventional treatment processes have been built.

179 Siddiqi, R.H.

National Environmental Engineering Research Institute,
Nagpur, India.

CHARACTERISTIC OF DOMESTIC AND MUNICIPAL SEWAGE IN INDIA
Public Health Engineering Division, Institute of Engineers, India. 55(3), pp 85-88 June 1975.
5 tables, 4 figures, 11 references
INDIA: U.S.A.: DOMESTIC: MUNICIPAL: SEWAGE: BOD: COD: FLOW RATE.

* This paper deals with the characteristics of domestic and municipal sewage from some cities in India along with average values reported for U.S.A. Various parameters that are described include physico-chemical and biological characteristics, per capita daily contribution of sewage, BOD rate constants, and relationships between BOD and COD.

180 Singh, G.P.

THE SEWAGE SYSTEM OF THE CITY OF RANGOON.
Public Health Engineer. U.K. No. 9. 96 pp. May 1974.
BURMA: SEWERAGE: NIGHTSOIL.

* A brief account of the history and present extent of sewerage in Rangoon. Nightsoil is dumped into sewers, which discharge untreated sewage in the Irrawaddy river, or is buried.

●● 181 Vincent, L.J.
Algie, W.E.
Marais, G.V.R.

(All) African Housing Board,
Lusaka, Northern Rhodesia. (Zambia)

A SYSTEM OF SANITATION FOR LOW COST HIGH DENSITY HOUSING.
Symposium on Hygiene and Sanitation in Relation to Housing, CCTA/WHO. Niger. Publication No. 84. pp. 135-173. 1961.
18 figures, 7 references.
AQUA PRIVY: HOUSEHOLD: WASTEWATER: TREATMENT: STABILIZATION PONDS: SEWERS: FACILITY: DESIGN: INSTALLATION: MAINTENANCE: COSTS: RHODESIA.

* An aqua privy - sewerage system has been proposed and developed in Rhodesia for effective treatment and disposal of sewage from dwelling houses. The ideas that form the basis of the system are:

(i) to discharge all the wastewater from the household into the aqua privy tank and by this means retain the seal around the chute.

(ii) to dispense completely with soakaways by discharging the effluent from the aqua privy tank into sewers to stabilization ponds.

(iii) to use the aqua privy as a sedimention tank for all inorganic solids and to pre-treat the organic pollution solids to a more amenable form for transportation in the sewers.

The important features of the system include:

(a) The sanitation block which can be located astride the common boundry or corners of the plots it serves. It consists of two, three or four units, one unit per family. Each unit comprises a latrine cubicle with an aqua privy squat plate and chute, an ablution cubicle in which a shower can be installed and a washing trough under cover of the roof.

(b) The tank which receives all the wastewater located underneath the building. This wastewater maintains the seal around the chute of the aqua privy squatting plate, thus dispensing with the necessity of manually adding water to the tank.

(c) The water carriage system for transportation of overflow from the tank into the collecting sewer is drained into a series of stabilization ponds where it is purified. Since there are no sand, stones, and other large solids entering the sewer, design of the sewer can be economic because the minimum velocity of flow can be reduced to one foot per second and in consequence the grade of sewer layout can be very flat, and sewer diameter can also be reduced to a certain extent.

(d) The stabilization ponds for final purification of the tank effluent. Treatment can be accomplished to a high degree by employing a series of ponds, usually three in numbers. Since there are no stones or sand present, the inlet arrangement to ponds treating aqua privy effluent can be of the simplest character.

Design details of each of the above facilities are described in appendices. Installation cost of the ponds and ancillaries in Northern Rhodesia is reported to be between six pence and one shilling as compared to between 5 shillings and 1 pound for conventional small disposal works per gallon treated per day. Maintenance costs are also minimal as there are no pumps, cisterns or other mechanical equipment to give rise to high maintenance costs.

Experience with existing installations of this type of system has revealed random blockages in the sewer lines due to introduction of large size materials into the manholes. Some correction measures suggested include replacement of the manhole covers with medium duty type covers and transporting the effluent containing large materials directly to the ponds through a tanker service.

182 Wall, J.D. Howard Humphreys & Sons U.K.

THE PROPOSED MAIN DRAINAGE OF LAGOS
Proceedings of a Conference on Civil Engineering Problems Overseas, The Institution of Civil Engineers. U.K. pp. 133-140. 1958.
1 figure.
SEWERAGE: SEPTIC TANKS: NIGERIA: NIGHTSOIL: NIGHTSOIL TREATMENT.
*A report of a proposal for sewerage of Lagos, Nigeria. Collected nightsoil would be screen-washed and wash-water discharged to sewer. Previous unsuccessful attempts to disintegrate nightsoil are described. The 'Apapa method' of sewerage is proposed: effluent from septic tanks together with sullage would pass to shallow sewers laid at flat gradients, with considerable saving of capital cost.

3Bi. Off-Site Treatment: Ponds

183 Alagarsamy, S.R.
Bhalerao, B.B.

(Both) Central Public Health Engineering Research Institute, Nagpur, India.

LOW COST WASTE TREATMENT SYSTEM FOR CANTONMENT AND TOWNSHIPS
Proceedings of the Seminar on Distribution and Maintenance of Electric Supply and Public Health Engineering Services in Cantonments and Townships. India. pp. 129-135, held at the College of Military Engineering. 1973.
4 tables, 2 figures, 5 references
SEWAGE TREATMENT: STABILIZATION PONDS: AERATED LAGOONS: OXIDATION DITCHES: TRICKLING FILTERS: INDIA.

* A review of the design, operating efficiency and costs of waste stabilization ponds, mechanically aerated lagoons and oxidation ditches in comparison with trickling filters. The design of a sewage treatment plant to handle wastes from a population increasing from 1,000 to 10,000 over two years is discussed.

184 Anon.

Central Public Health Engineering Research Institute, Nagpur, India.

DESIGN OF OXIDATION DITCH FOR M/S HINDUSTAN PHOTO FILM MANUFACTURING CO. LTD., OOTACAMUND.
Special report (Consultancy) to M/s Hindustan Photo Film Manufacturing Co. Ltd. India. 16 pp. March 1974.
1 figure, 2 appendices, 2 drawings.
SEWAGE TREATMENT: OXIDATION DITCHES: LOW-COST TREATMENT: INDIA: URBAN.

* A report recommending oxidation ditch treatment for two communities of 1600 and 2100 people. Each treatment plant recommended included an oxidation ditch of 4 ft. depth, two cage rotors, one hopper-bottom settling tank and sludge drying beds. A layout drawing of the plant is given for each case and details of construction outlined. Specifications for mechanical equipment are included as appendices.

185 Anon.

Secretaria de Recursos
Hidraulicos,
Mexico City. Mexico.

DETERMINATION AND DEVELOPMENT OF CONSTRUCTION, OPERATION AND MAINTENANCE COSTS OF THE DIFFERENT PROCESSES FOR THE TREATMENT OF WASTEWATER
(DETERMINACION Y DESARROLLO DE COSTOS DE CONSTRUCCION, OPERACION Y MANTENIMIENTO DE LOS DIFERENTES PROCESOS DE TRATAMIENTO DE AGUAS RESIDUALES)

Secretaria de Recursos Hidraulicos, Subsecretaria de Planeacion Direccion General de Usos del Agua y Prevencion de la Contaminacion. Mexico. C. Proyectos INTUAL, S.A. Contrato No. SP-74-C-13. 2 Volumes. 520 pp. 1974.
65 annexes, 150 figures.
MEXICO: ANAEROBIC LAGOONS: CONSTRUCTION: COST EVALUATION: IMHOFF TANKS MAINTENANCE: OPERATION: PRETREATMENT: PRIMARY TREATMENT: SECONDARY TREATMENT: SEDIMENTATION TANKS: STABILIZATION PONDS:VACUUM FILTERS: WASTEWATER TREATMENT.

* The study determines the state of the art of wastewaters treatment in Mexico and includes for several processes, the construction, operation and maintenance costs. Through a nation-wide inventory of the existing facilities, a rehabilitation program is designed to fulfill the treatment needs of each region. The report points out the lack of proper management as the major cause for poor operating conditions of the systems. Treatment cost data and curves are presented in order to aid the calculation of new projects. Finally the report recommends construction of stabilization ponds for cities with populations up to three hundred thousand, providing land availability; and sedimentation tanks for those cities where land is scarce. Imhoff tanks are suggested as an immediate solution for cities with populations of less than one hundred thousand.

(Original paper written in Spanish)

186 Arceivala, S.J.
Alagarsamy, S.R.

(Both) Central Public Health Engineering Research Institute, Nagpur, India.

DESIGN AND CONSTRUCTION OF OXIDATION DITCHES UNDER INDIAN CONDITIONS

Proceedings of the Symposium on low cost waste treatment. India. pp. 172-184. Sastry, C.A. and Nandgaonkar, K.M. (Eds.), Central Public Health Engineering Research Institute. May 1972.
2 tables, 4 figures, 10 references, 1 appendix, discussion.
SEWAGE TREATMENT: OXIDATION DITCHES: RURAL: DESIGN: INDIA.

* A review of the design and construction of oxidation ditches for Indian conditions. Essential design criteria are listed and the possible range of values given in a table. A design example is worked in the appendix. A discussion is included.

187 Arceivala, S.J.
Alagarsamy, S.R.
Lakshminarayana, J.S.S.

(All) Central Public Health Engineering Research Institute, Nagpur, India.

DESIGN AND CONSTRUCTION OF AERATED LAGOONS IN INDIA
Proceedings of the Symposium on Low Cost Waste Treatment. Ind.a. pp. 131-138. Sastry, C.A. and Nandgaonkar, K.M. (Eds.), Central Public Health Engineering Research Institute. May 1972.
1 table, 3 figures, 6 references.
SEWAGE TREATMENT: AERATED LAGOONS: RURAL: DESIGN: INDIA.
*A review of the design procedure for aerated lagoons in India. Construction features are discussed and this form of treatment recommended as the best comoromise between conventional sewage treatment processes and stabilization ponds. A worked design example is included.

188 Arceivala, S.J.
Bhalerao, B.B.
Alagarsamy, S.R.

(All) Central Public Health Engineering Research Institute, Nagpur, India.

COST ESTIMATES FOR VARIOUS SEWAGE TREATMENT PROCESSES OF INDIA
Proceedings of the Symposium on Low Cost Waste Treatment. India. pp. 239-254. Sastry, C.A. and Nandgaonkar, K.M. (Eds.), Central Public Health Engineering Research Institute, India. May 1972.
7 tables, 11 figures, 5 references, 1 appendix.
SEWAGE TREATMENT: COSTS: INDIA.
* A comparison of estimated costs for construction and operation of waste stabilization ponds, mechanically aerated lagoons, oxidation ditches and conventional treatment using trickling filters. Five typical designs for populations between 5,000 and 200,000 were compared. Land costs were considered separately as being variable from place to place. Waste stabilization ponds were found to be cheapest if land was not more costly then 55,000 rupees/acre. The mechanically aerated lagoon was next cheapest and the oxidation ditch was less costly than trickling filtration up to a population level of 150,000 in India.

189 Arceivala, S.J.
Lakshminarayana, J.S.S.
Alagarsamy, S.R.
Sastry, C.A.

(All) Central Public Health Engineering Research Institute, Nagpur, India.

DESIGN, CONSTRUCTION, AND OPERATION OF WASTE STABILIZATION PONDS IN INDIA
Central Public Health Engineering Research Institute Publication. India. 128 pp. 1970.
20 figures, 16 tables
SEWAGE TREATMENT: LOW-COST TREATMENT: STABILIZATION PONDS; OXIDATION PONDS: ANAEROBIC LAGOONS:.INDIA: EFFLUENT RE-USE.
*A review of waste stabilization pond principles and their application in design for Indian conditions. Techniques of pond construction are detailed and pond operation and maintenance discussed. Health aspects of sewage treatment in stabilization ponds are covered and alternatives for effluent re-use in agriculture, for pisciculture, for algal reclamation and water recycle are introduced. A unique feature of this text is a collection of operating date from 38 stabilization ponds from different parts of the country and an evaluation of each pond for its treatment efficiency.

190 Bokil, S.D.
Agrawal, G.D.

(Both) Department of Civil Engineering,
Indian Institute of Technology, Kanpur, India.

PERFORMANCE OF HIGH RATE SHALLOW STABILIZATION PONDS
Indian Journal of Environmental Health. India.
18(2). pp. 87-98. 1976.
14 references
SEWAGE TREATMENT: STABILIZATION PONDS: ALGAE: LOADING RATES.
*A description of performance characteristics of high-rate shallow stabilization ponds treating domestic sewage. It is found that the overall BOD removal efficiency was about 85 per cent. Depending upon the rate of organic loading and the depth, even a pond as shallow as 35 cm had an anaerobic zone at the bottom. The algal cultures in the ponds showed an adaptability of growth which is in consonance with modern continuous culture theories. The per cent of the incoming total nitrogen converted to algae was about 25 per cent and about 30 per cent of the total nitrogen was lost from the system. There was complete absence of E. Coli at any depth and at any time.

191 Canter, L.W. — University of Oklahoma, Norman, Oklahoma, U.S.A.

Malina, J.F. — University of Texas, Austin, Texas, U.S.A.

SEWAGE TREATMENT IN DEVELOPING COUNTRIES
A report prepared by the University of Oklahoma, U.S.A. for US AID Contract No. AID/CM-ta-C-73-13. December 1976. 170 pp. 2 fitures, 18 tables, plus numerous references from various countries.
DEVELOPING COUNTRIES: SEWAGE TREATMENT: BIBLIOGRAPHY.

*The purpose of this study was to provide an overview of the state-of-the-art of sewage treatment in developing countries. Mention was made of processes utilized in developing countries from the context of available treatment system technology. No attempt was made to cover every process in detail. The paper was oriented to treatment applied for sewered wastewaters. Individual treatment systems were discussed in a report by van den Berg (Internal Report, AID Project, University of Oklahoma, 1974). Very little was located in the literature relative to "Alternative Disposal Methods." However, since this type of treatment has been finding wider application an overview of current topics of interest was included in Appendix II of this report. Topics included were algae removal by fish production, dutch ditch, advanced sewerless treatment, and wastewater reuse.

This paper was developed following a review of published references on wastewater treatment in developing countries. In addition, selected non-U.S. and some U.S. references for developed countries were also identified relative to wastewater treatment.

On the basis that ponds are the most used process in developing countries, a portion of this report presents the use and costs of ponds and increases in treatment costs associated with the use of more sophisticated wastewater treatment processes.

192 Chaudhuri N.
Basu A.

(Both) Jadavpur University, Calcutta. India.

ECOLOGICALLY BALANCED COMMUNITY WASTEWATER DISPOSAL SYSTEMS FOR DEVELOPING COUNTRIES
Journal of the Institution of Engineers. India. Volume 56. Part EN2, pp. 71-75, February 1976.
7 references, 6 tables, 5 figures.
WASTEWATER MANAGEMENT: INDIA: SEWAGE TREATMENT: STABILIZATION PONDS: FISH CULTURE: RECREATION.

*The authors argue that wastewater disposal in large metropolitan areas such as Calcutta, wastewater treatment and disposal must be based on ecologically sound principles of waste reclamation and re-use. They propose a waste stabilization pond system whereby all the nutrients in wastewater are conserved for reuse as irrigation water, manure and fish protein; in addition the wastewater treatment plant would be landscaped in an afforested green-belt area which would serve as a major recreational park for the area. It is estimated that 50 ha of land would be required for each unit flow of 10,000 m^3/day, i.e. about 6.7 m^2 of land per capita.

193 Drews, R.J.L.C.

National Institute for Water Research, CSIR, South Africa.

FIELD STUDIES OF LARGE-SCALE MATURATION PONDS WITH RESPECT TO THEIR PURIFICATION EFFICIENCY
Journal and Proceedings of the Institute of Sewage Purification. U.K. Part 3. pp. 280-294. 1966.
3 tables, 7 figures, 4 references.
SOUTH AFRICA: MATURATION PONDS: SEWAGE TREATMENT: TREATMENT EFFICIENCY: ORGANIC LOAD: TEMPERATURE: SOLAR RADIATION: BACTERIAL DIE-OFF.

* Large-scale maturation ponds situated in different climatic regions of South Africa have been studied with respect to their treatment efficiencies. It is concluded that the actual organic load applied per unit of pond capacity is a deciding factor so far as pond performance and effluent quality are concerned. Other parameters such as solar radiation and temperature also have effects on the pond performance as they supply heat and/or energy for photosynthesis and organic decomposition, respectively. No definite correlation between bacterial die-off in the ponds and the intensity of solar radiation and/or temperature has been found from this investigation.

194 Gloyna, E.F.

College of Engineering,
The University of Texas
at Austin,
Austin. U.S.A.

FACULTATIVE WASTE STABILIZATION POND DESIGN
Ponds as a Wastewater Treatment Alternative, Water Resources Symposium No. 9, Center for Research in Water Resources, College of Engineering, The University of Texas at Austin. U.S.A. pp. 143-157. Gloyna, E.F., Malina, J.F. Jr., Davis, E.M., (Eds.). 1976.
2 figures, 4 tables, 13 references.
FACULTATIVE PONDS: WASTEWATER: TEMPERATURE: LIGHT: DESIGN: ECONOMICS: EFFLUENT.

* Facultative ponds are capable of handling wastewaters varying in both quantity and quality. Climatic conditions, primarily temperature and secondarily light, are most important design parameters. A basis for design of facultative ponds is presented which includes empirical equations and diagrams. Based on both economics and the overall quality of the effluent, facultative pond systems frequently are reported to compare favourably with conventional high rate biological systems.

○ 195 Gloyna, E.F.

College of Engineering,
University of Texas,
Austin, U.S.A.

WASTE STABILIZATION PONDS
World Health Organization Monograph Series No. 60. Switzerland. 175 pp, 1971.
44 figures, 28 tables, 164 references.
TREATMENT: STABILIZATION PONDS: DESIGN: PUBLIC HEALTH: OPERATIONS: METHODOLOGY.

* A general reference written for sanitary engineers which includes basic theory of biological waste treatment, process design procedures and their alternatives, public health aspects, and common operational problems. A unique feature of the book is a worldwide survey of stabilization pond uses with a brief description of practices within various countries.

196 Haridass, G.
Sundaresan, B.B.

(Both) Public Health Engineering Dept., University of Madras, Guindy, India.

DESIGN CRITERIA FOR BATCH OPERATION OF OXIDATION DITCHES
Journal of Institution of Engineers, Public Health Engineering Division. India. Volume 54, Part PH 3. pp. 84-88, June 1974.
6 figures, 5 tables, 5 references.
OXIDATION DITCH: CAGE ROTOR: BOD: POWER CONSUMPTION: SEWAGE SUBMERGED DEPTH: ROTOR SPEED: DESIGN: CRITERIA: BATCH SYSTEM: EFFLUENT: INDIA.

* A pilot scale oxidation ditch with cage rotor has been operated under batch process at various submergences. Experimental data on BOD removal, DO in the mixed liquor, oxygenation capacity and power consumption indicate 13.5 cm submergence at 72 rpm to be the optimum. Design criteria for batch operation to counteract fluctuations in flow has been outlined and compared with a similar continuous system. A marked reduction in power consumption can be achieved without deleterious effect on effluent quality.

197 Harris, S.E.
Reynolds, J.H.
Hill, D.W.
Filip, D.S.
Middlebrooks, E.J.

(All) Utah Water Research Laboratory, College of Engineering Utah State University, Logan, U.S.A.

INTERMITTENT SAND FILTRATION FOR UPGRADING WASTE STABILIZATION POND EFFLUENTS
Journal of the Water Pollution Control Federation. U.S.A. 49(1) pp. 83-102, January, 1977.
12 figures, 9 tables, 7 references.
SAND: LAGOONS: TREATMENT: FILTRATION: HYDRAULICS: ALGAE: EFFLUENT.

* A pilot scale experiment on intermittent sand filters indicates that lagoon effluents can be economically polished to become high grade water. No serious operational problems are encountered during winter seasons, however, its effluent quality is observed to be slightly lower when compared to warm weather effluent quality. From the data obtained, the authors conclude that length of filter run is related to influent suspended solits concentration, hydraulic loading rates, and algal growth in standing water above the filter.

198 Hernandez, L.

INVESTIGATION OF AN OXIDATION POND
(INVESTIGACION SOBRE UNA LAGUNA DE OXIDACION)
XIII Interamerican Congress of Sanitary Engineering. Paraguy.
13 pp. August 1972.
8 references, 3 tables, 2 maps, 2 graphs.
VENEZUELA: LOADING RATES: ODORS: ORGANIC LOADS: OXIDATION PONDS: DETENTION TIME: TROPICAL CLIMATE.

* The paper summarizes technical data relevant to research done in an oxidation pond in Venezuela where it was demonstrated that loads of 240 Kg of BOD per day were feasible and that retention periods of nine and a half days did not reduce the efficiency of the pond in tropical climates neither it produced any other nuisances such as odors.

(Original paper written in Spanish)

199 Jayangoudar, I.S.
Kothandaraman, V.
Thergaonkar, V.P.
Shaik, G.

(All) Central Public Health Engineering Research Institute Field Centre, Ahmedabad, India.

RATIONAL PROCESS DESIGN STANDARDS FOR AEROBIC OXIDATION PONDS IN AHMEDABAD, INDIA
Journal of Water Pollution Control Federation. U.S.A.
42(8) pp. 1501-1514, August, 1970.
7 tables, 22 references.
DESIGN: CRITERIA: INDIA: OXIDATION PONDS: TREATMENT: LOADING: DETENTION TIME: POND DEPTH.

* A development of design criteria for oxidation ponds treating domestic wastewater in India. By utilizing data from pilot scale experiments conducted year-round, the authors recommend the following: organic loading (BOD_5)= 200-250 lb/acre-day, detention time = 6-7 days, and pond depth = 3-4 feet.

200 Kharkar, C.B.
Venkatesan, T.L.
Tiwari, A.R.

(All) Bhilai Steel Plant, Bhilai, India.

REVIEW OF PERFORMANCE OF THE STABILIZATION PONDS AT BHILAI
Proceedings of the Symposium on Low Cost Waste Treatment. India. pp. 70-77, Sastry, C.A. and Nandgaonkar, K.M. (Eds.), Central Public Health Engineering Research Institute, May 1972.
6 tables.
SEWAGE TREATMENT: STABILIZATION PONDS: PISCICULTURE: EFFLUENT RE-USE: SEWAGE IRRIGATION: INDIA.

* A review of the performance results from 1955 to 1968 of stabilization ponds at Bhilai in India. The ponds perform satisfactorily, are leased out for two-year periods for fish culture, and the effluent is used to irrigate agriculture land.

201 Kremer, M.

Mekoroth Water Co. Ltd.,
Tel Aviv. Israel.

DAN REGION SEWAGE RECLAMATION PROJECT
Water Research. U.K. 6(4-5). pp. 351-356. 1972.
1 table, 4 figures.
FACULTATIVE PONDS: RECIRCULATED PONDS: SEWAGE: DETENTION TIME: RECHARGE: POND STRATIFICATION: ALGAE: ISRAEL.

* Facultative recirculated ponds are employed to treat raw sewage from the Dan Region Association of Towns in Israel. Long detention time of the sewage permits accurate control and quality check prior to further treatment and recharge to ground water. Although pond stratification is overcome by stirring, this method encourages algal growth including an increase of 20-30% of organic load to the ponds.

202 Lee, S.J.

Environmental Engineering Division,
Asian Institute of Technology,
Bangkok, Thailand.

PERFORMANCE OF OXIDATION DITCHES IN THAILAND
Master of Engineering Thesis No. 829, Asian Institute of Technology. Thailand. 85 pp. 1975.
9 tables, 33 figures, 57 references, 4 appendices containing 6 tables and 6 figures.
WASTEWATER TREATMENT: OXIDATION DITCHES: THAILAND: FISH.

* A report on the performance study of two full-scale oxidation ditches treating a soft drink and a milk plant waste in Thailand. The milk plant waste plant was incorrectly designed and operated and performance was always unsatisfactory. The soft drink waste plant performed well at organic loadings between 0.07 and 0.12 kg COD/kg MLSS per day and gave an effluent with COD less than 50 mg/l. Fish were being bred in the ditch and no solids accumulation was noted during the study period. Laboratory studies of sludge settling are also reported.

203 Ling, H.C.

Environmental Engineering Division,
Asian Institute of Technology,
Bangkok. Thailand.

PLANNING FOR WATER SUPPLY, LIQUID AND SOLID WASTES HANDLING IN ASIAN TOWNS

Master of Engineering Thesis No. 592. Asian Institute of Technology. Thailand. 208 pp. 1973.
14 tables, 17 figures, 34 references, 11 appendices containing 21 tables and 14 figures.

APPROPRIATE TECHNOLOGY: WATER SUPPLY: WASTEWATER COLLECTION: TREATMENT: SOLID WASTES: URBAN: ASIA.

* A report on a study of alternatives for economically and effectively administering and operating water supply and liquid and solid wastes handling systems in Asia. Slow sand filters were found to be preferable for water supply, followed by groundwater and, last, rapid sand filters. Sanitary landfill was recommended for solid waste disposal but collection of food wastes for swine feeding looked attractive if administrative difficulties could be overcome. Combined wastewater systems were found to be most suitable and use of nightsoil as fertilizer was not considered economic. The town of Nong Khai in Northeast Thailand, with a population of 25,000 was used in a case study.

204 Malina, J.F., Jr.
Rios, R.A.

(Both) Environmental Health Engineering,
The University of Texas at Austin,
Austin, U.S.A.

ANAEROBIC PONDS

Ponds as a Wastewater Treatment Alternative, Water Resources Symposium No. 9, Center for Research in Water Resources, College of Engineering, the University of Texas at Austin. U.S.A. pp. 131-141. Gloyna, E.F..Malina, J.F. Jr., Davis E.M.,(Eds.). 1976.
4 figures, 13 references.

ANEAEROBIC PONDS: WASTEWATER: BOD: METHANE: POND DEPTH: DETENTION TIME: EFFLUENT.

* Anaerobic ponds are effective in the removal of 70 to 80 percent of wastewater BOD. The major mechanism of waste stabilization is the bacterial conversion to methane gas. Provision of sufficient depth is critical for the anaerobic zone, and the practical depth limitations are reported to be between 9 and 12 feet. These depths will also provide a surface aerobic polishing zone for pond effluents. Recommended detention times are 2 to 5 days. Another essential element for a maximum waste stabilization is a uniform distribution of the influent which should be near the bottom of the pond.

205 Malnatif, L.

Ministerio de Salud,
Oficina de Saneamiento Ambiental,
Lima, Peru.

EXPERIENCE IN PERU WITH OXIDATION PONDS
(EXPERIENCIA EN EL PERU CON LAGUNAS DE OXIDACION)
Simposio sobre tratamiento y Disposicion de Aguas Sanitarias. Argentina. 38 pp. June 1976.
10 tables, 2 figures.
PERU: AGRICULTURE: ARID CLIMATES: AQUACULTURE: FERTILIZER: HARVESTING: IRRIGATION: LANDFILL: OXIDATION PONDS: REUSE: SOLID WASTES: WASTEWATER.

* After twenty years of experience with oxidation ponds, Lima's semiarid climate has proven to be quite suitable for efficient treatment of wastewaters. The report summarizes the bacteriological and biological investigations done in Lima regarding the reuse of wastewater for irrigation and aquatic life purposes. It concludes that oxidation ponds are the most economical means for sewage treatment in coastal cities with tropical temperatures and sandy soils; these can even be recovered for agricultural uses.

(Original paper written in Spanish)

206 Mara, D.D.

Dept. of Civil Engineering
University of Dundee,
Dundee, Scotland.

PROPOSED DESIGN FOR OXIDATION PONDS IN HOT CLIMATES
Journal of the Environmental Engineering Division, American Society of Civil Engineers, U.S.A. 101(EE2) pp. 296-300, April, 1975.
20 references.
DESIGN: OXIDATION PONDS: WASTEWATER TREATMENT: MATHEMATICAL MODELS: BOD: BACTERIOLOGICAL QUALITY: EFFLUENT: TROPICS.

* The author proposes a design procedure of a series of 5-7 ponds operating in hot climates, each having retention time of 5 days which is supposed to reduce the BOD_5 of a strong wastewater from 1000 mg/l to less than 25 mg/l and reduce its faecal coliform count from 4×10^7/100 ml. to less than 100/100 ml. Although the described technique is a mixture of mathematical models and empirical design factors, it is claimed to be an extremely economical design which can achieve a high bacteriological quality without chlorination of the effluent.

○ 207 Mara, D.D.

Dept. of Civil Engineering,
University of Dundee,
Scotland.

SEWAGE TREATMENT IN HOT CLIMATES
John Wiley & Sons Ltd., U.K. 184 pp. June 1976.
SEWAGE: SEWERAGE: TREATMENT KINETICS: STABILIZATION POND: AERATED LAGOONS: OXIDATION DITCH: BIOFILTRATION: SEPTIC TANKS: AQUA-PRIVIES: EFFLUENT RE-USE: AQUACULTURE: IRRIGATION: NIGHTSOIL TREATMENT.

*Emphasizing appropriate designs for developing country situations, this chapter gives succinct description of facultative, maturation, anaerobic pretreatment and high rate ponds. The major advantages of pond systems are that they require less maintenance, mechanical equipment and energy than other processes achieving secondary treatment of wastewater. They are also far less subject to failure than other forms of mechanical or chemical processes. They are without doubt the most important method of sewage treatment in hot climates where sufficient land is normally available and where the climate is favourable for their operation.

The term faculative refers to the most commonly used type of pond which is aerobic in its surface layers but anaerobic at the bottom. A symbiosis exists between the bacteria decomposing organics using carbon dioxide and producing an organic nutrients and the microscopic plant life algae which use the inorganic nutrients and carbon dioxide to produce more cell material and the oxygen needed by the bacteria. Mixing is important to effective operation of the pond to breakup thermoclines which separate the anaerobic benthal layers producing nutrients from the upper layers requiring them for oxygen production. Solar radiation is the driving force behind treatment and algae the mechanism used to produce the oxygen through photosynthesis required for treatment of the wastewater.

Anaerobic ponds are often placed in series with but ahead of the facultative pond. Being heavily loaded are anaerobic throughout their depth and effect treatment through sedimentation of the settleable solids and their digestion in the benthal sludge layers. Although odours are often claimed to be the greatest drawback in employing this type of scheme the relationship between odour development and organic loading is now reasonably well understood so this problem can be overcome at the design stage. Tremendous economics of land that are achieved by use of anaerobic ponds will often dictate their inclusion in large schemes.

Such pond systems as described can achieve any required degree of purification at the lowest cost and with the minimum of maintenance by unskilled operators. Removal of pathogens within these ponds is considerably greater than in other methods of sewage treatment. They are well able to withstand both organic and hydraulic shock loads. They can effectively treat a wide variety of industrial and agricultural wastes and be designed so that the degree of treatment is easily altered. The methods used in construction is such that, should at some future date the land be required for some other purpose, it is easily reclaimed. Finally, the algae produced in the pond are a potential source of high protein food which can be exploited by fish farming.

Pond design layouts and parameters are discussed. Facultative pond design is suggested as best being based on the principles of first order kinetics in completely mixed reactors using temperature as the mean temperature of the coldest month which will provide the designer with the required ponds areas. The resulting design can then be checked against operational characteristics of ponds in other parts of the world operating under similar climatological conditions. Design equation for expected indicators of disease causing organisms in the effluent are also given. Example designs are provided and illustrate the techniques of calculation and implicit assumptions made.

○208 Mara, D.D.

Department of Civil Engineering,
University of Nairobi, Kenya.
Africa.

DESIGN MANUAL FOR SEWAGE LAGOONS IN THE TROPICS
East African Literature Bureau. Kenya, 1975.
viii + 27, 11 figures.
STABILIZATION PONDS: DESIGN: TROPICS.

* A small design manual for the construction of waste stabilization ponds (sewage lagoons) in tropical countries. The chosen method of design for facultative ponds is the modified Marais and Shaw procedure. Several designs are given for inlet and outlet structures and interpond connections.

209 Marais, G.V.R.

African Housing Board,
Ridgeway, Africa.

A DESIGN CHART FOR A SERIES OF OXIDATION PONDS TREATING RAW SEWAGE AND SOME REMARKS ON THE DEPTH OF THE FIRST POND
The Civil Engineer in South Africa. Africa. 5(9)
pp. 241 - 245, September 1963.
3 diagrams, 2 references.
STABILIZATION PONDS: SEWAGE TREATMENT: AFRICA.

* Based on previously published theory design charts are given from which the area required for a first-stage waste stabilization pond can be found for a fixed BOD contribution per person per day.

210 Marais, G.V.R. University of Cape Town, South Africa.

FAECAL BACTERIAL REMOVAL IN STABILIZATION PONDS
Journal of the Environmental Engineering Division, ASCE, U.S.A. 100(EEL), pp. 119 - 139. February, 1974.
6 references, 12 figures, 2 tables.
STABILIZATION PONDS: COLIFORM SURVIVAL: FAECAL BACTERIA.

* A review of the kinetics of faecal bacterial removal in waste stabilization ponds working from the earlier model of simple first order kinetics in completely mixed ponds, the author shows that maximum efficiency of bacterial removal in a series of ponds occurs when each pond in the series has the same retention time; an Arrhenius equation is presented to describe the highly sensitive variation of the first order rate constant for faecal bacterial removal with temperature. It is shown that in temperate climates with low winter temperatures little advantage is gained by having a series of small ponds rather than a single large pond; conversely in hot climates there is considerable advantage in series operation.

211 Marais, G. V. R. University of Cape Town, South Africa.

NEW FACTORS IN THE DESIGN, OPERATION AND PERFORMANCE OF WASTE-STABILIZATION PONDS
Bulletin of the World Health Organization. Switzerland, Volume 34, pp. 737-763, 1966.
30 references, 18 figures, 2 tables.
AFRICA: SEWAGE TREATMENT: ANAEROBIC PRETREATMENT: SEPTIC TANKS: STABILIZATION PONDS: AQUA-PRIVIES: PATHOGENS.

*The theory of waste stabilization pond design is reviewed and the operational performance of the full scale ponds discussed with particular reference to the removal of BOD and faecal bacteria and to the influence of wind action in preventing the onset of thermal stratification. When aqua-privies or septic tanks are used as anaerobic pretreatment units the surface area required for the pond system can be substantially reduced and there will be less likelihood of anaerobic conditions or rising sludge problems in hot weather. The use of the self-topping aqua-privy is recommended for use in low-cost high-density housing schemes. The health aspects of ponds systems are discussed in relation to pathogen survival and snail and mosquito breeding.

212 Martinez, C.F.

Departamento Nacional de
Higiene Urbana y Rural
Ministerio de Salud Publica,
Havana. Cuba.

OPERATION OF STABILIZATION PONDS IN CUBA
(FUNCIONAMIENTO DE LAGUNAS DE OXIDACION EN CUBA)
XIV Congreso Interamericano de Ingenieria Sanitaria. Mexico.
August 1974.
1 table.
CUBA: BOD: COLIFORM COUNT: SEDIMENTATION: STABILIZATION PONDS:
SUSPENDED SOLIDS: TROPICAL CLIMATE.

* A study on seventeen of the 260 stabilization ponds that exists in Cuba. BOD levels, suspended and sedimented solids and coliform content of the water was closely monitored under different loads. The author concludes that stabilization ponds are satisfactory for the treatment of domestic wastewater. BOD levels below 20 mg/l, coliform removal from 90% to 99% was obtained and the efficiency in sedimenting solid was 95%.

(Original paper written in Spanish)

213 McGarry, M.G.
Pescod, M.B.

(Both) Environmental
Engineering Division
Asian Institute of Technology,
Bangkok, Thailand.

STABILIZATION POND DESIGN CRITERIA FOR TROPICAL ASIA
Proceedings of the Second International Symposium for
Waste Treatment Lagoons. U.S.A. pp. 114-132, June 23-25, 1970.
6 tables, 15 figures, 38 references.
STABILIZATION PONDS: TROPICS: BOD: LOADING: DESIGN: FORMULAS:
TREATMENT EFFICIENCY: DETENTION TIME: POND DEPTH: ANAEROBIC:
PONDS: FACULTATIVE PONDS: TREATMENT.

*Based on experimental data of stabilization ponds from various locations in tropical climates the authors find that areal BOD loading is a more significant factor in controlling areal BOD removal than detention period and depth of both anaerobic and facultative ponds. Design formulas for maximum areal BOD loadings of both types of the pond systems are present which are reported to result in greatest areal BOD removal and decreasing pond area requirement.

214 Meiring, P.C.J.
Drews, R.J.L.C.
Van Eck, H.
Stander, G.J.

(All) National Institute for Water Research, Pretoria, S. Africa.

A GUIDE TO THE USE OF POND SYSTEMS IN SOUTH AFRICA FOR THE PURIFICATION OF RAW AND PARTIALLY TREATED SEWAGE
South African Council for Scientific and Industrial Research. S. Africa. Special Report WAT 34, 48 pp. 1968.
43 references, 6 tables, 5 figures.
SEWAGE: AFRICA: STABILIZATION PONDS: SEPTIC TANKS: HEALTH: AERATED LAGOONS: ALGAL REMOVAL: FLIES: PARASITES: PATHOGENS: FAECAL BACTERIA.

* The design and operation of waste stabilization pond in South Africa is described with particular reference to anaerobic pretreatment, removal of faecal bacteria in maturation ponds and the health impact of pond systems. Mechanically aerated lagoons are described and a flotation method for the removal of algae from pond effluents is given.

215 Middlebrooks, E.J.
Porcella, D.B.
Gearheart, R.A.
Marshall, G.R.
Reynolds, J.H.
Grenney, W.J.

(All) Water Research Laboratory, Utah State University, Logan, U.S.A.

TECHNIQUES FOR ALGAL REMOVAL FROM WASTEWATER STABILIZATION PONDS
Journal of the Water Pollution Control Federation. U.S.A. 46(12). pp. 2676-2695, December, 1974.
1 table, 2 figures, 129 references
ALGAE PONDS: EFFLUENT: CENTRIFUGATION: MICROSTRAINERS: COAGULATION: FLOCCULATION: OPERATIONS: MAINTENANCE: COSTS: BIOLOGICAL DISKS: AUTOFLOCCULATION: SOIL MANTLE: AIR FLOTATION: GRANULAR MEDIA FILTRATION: SAND FILTRATION.

* An extensive review of 14 techniques for algal removal from stabilization pond effluents. Although many problems still exist, centrifugation, microstrainers, and coagulation-flocculation are considered as the potential processes. These evaluations are based upon the criteria and available data, on their ease and dependability of operations, minimum maintenance and costs, and efficiencies of particulate removal.

216 Moshe, M.
Betzer, N.
Kott, Y.

(All) Water Commission, Ministry of Agriculture, Israel and Technion, Haifa, Israel.

EFFECT OF INDUSTRIAL WASTES ON OXIDATION POND PERFORMANCE
Water Research. U.K. Volume 6, pp. 1165-1171, 1972.
1 figure, 4 tables, 12 references.
ISRAEL: STABILIZATION PONDS: HEAVY METALS: INDUSTRIAL WASTEWATER.

* Cadmium, copper, nickel, zinc and hexavalent chromium ions were tested in a bench-bioassay experiment for toxicity limits and possible application to experimental oxidation ponds.
It was found that the metal ions mentioned above are toxic, inhibiting chlorella growth. However, when added at concentrations of 0.5-1.5 mg l^{-1} to influent of oxidation ponds the ponds continued to operate normally. Higher concentrations of 3 and 6 mg l^{-1} did not affect adversely pond performance - not even a concentration of 6 mg l^{-1} of each ion (a total metal ion concentration of 30 mg l^{-1}). A mixture of 60 mg l^{-1} metal ions brought about a decrease in algal numbers and caused a sharp drop in dissolved oxygen concentration. It is believed that since high pH causes metal ions to precipitate, oxidation ponds operating normally above pH 8-0 will tolerate metal ions in sewage containing industrial wastes for a long time before sludge accumulation will affect pond performance.

217 Nadgir, K.N.
Murthy, C.K.
Shetty, M.S.
Murthy, C.R.N.
Murty, K.R.

(All) The Institution of Military Engineers, India.

DISTRIBUTION AND MAINTENANCE OF ELECTRIC SUPPLY AND PUBLIC HEALTH ENGINEERING SERVICES IN CANTONMENTS AND TOWNSHIPS
Proceedings of the Seminar held at the College of Military Engineering. India. 439 pp. 1973.
18 papers on water supply, 12 papers on sewage disposal
18 papers on electrical services, 12 papers on maintenance and operation.
SEWAGE DISPOSAL: SEWAGE TREATMENT: STABILIZATION PONDS: OXIDATION DITCHES: INDIA: SEPTIC TANKS.

* Seminar proceedings including papers on water supply, sewage disposal, electrical services and maintenance and operation. Sewage treatment design, construction and maintenance are included. Waste stabilization ponds, oxidation ditches, aerated lagoons and septic tanks are among the waste treatment systems covered.

218 Oswald, W.J.

Sanitary Engineering and
Public Health Department,
University of California,
Berkeley. U.S.A.

WASTE POND FUNDAMENTALS
A syllabus in a course on waste ponds presented in conjunction with the International Bank for Reconstruction and Development Training Program. U.S.A. 65 pp. December 5, 1975.
18 figures, 12 tables, 12 references
THEORY: WASTEWATER: STABILIZATION PONDS: DESIGN: CRITERIA: U.S.A.: LOADING: POND DEPTH: DETENTION TIME.

* Theoretical aspects of waste stabilization in pond systems are discussed which include physical factors, biochemical and microbiological processes in the ponds. A summary of current design criteria of ponds in California and their performance data are presented and compared with each other according to the pond series numbers, loadings, depths, and detention times.

219 Parhad, N.M.
Rao, N.V.

(Both) National Environmental
Engineering Research Institute,
Nagpur, India.

DECREASE OF BACTERIAL CONTENT IN DIFFERENT TYPES OF STABILIZATION PONDS
Indian Journal of Environmental Health. India. 18(1) pp. 33-46, January 1976.
2 tables, 8 figures, 11 references
SEWAGE TREATMENT: STABILIZATION PONDS: OXIDATION PONDS: E.COLI: ENTEROCOCCI: INDIA.

* A report on studies of the efficiency of bacterial removal in three stabilization pond systems. Highest removal of coliforms, E. Coli and Enterococci were achieved in a pond system with three cells and the lowest in the single cell system.

220 Parker, C.D.

Water Science Laboratories,
Victoria, Australia.

EXPERIENCE WITH ANAEROBIC LAGOONS IN AUSTRALIA
Proceeding of the 2nd International Symposium for Waste Treatment Lagoons. U.S.A. pp. 334-347. June 23-25, 1970.
6 figures, 16 tables, 4 references.
WASTEWATER TREATMENT: ANAEROBIC LAGOONS: SEWAGE: AUSTRALIA: ODOUR: LOADING.

* The design, performance, and operation of anaerobic lagoons in Victoria, Australia are described. These lagoons treat either domestic sewage or domestic sewage plus industrial wastewaters from eight communities ranging from a population of 2,400,000 down to 3,500. A low level of odour generated from the ponds could be maintained if pond organic loadings are from 400 to 800 lb/acre-day during winter and summer, respectively.

221 Pescod, M. B.

Asian Institute of Technology,
Bangkok, Thailand.

SLUDGE HANDLING AND DISPOSAL IN TROPICAL DEVELOPING COUNTRIES
Journal Water Pollution Control Federation. U.S.A.
43(4), pp. 555-570. April 1971.
8 tables, 12 figures, 5 references.
SEWAGE SLUDGE: ANAEROBIC DIGESTION: SLUDGE LAGOONING: SAND BED DRYING: TROPICAL.

*A review of studies on the anaerobic digestion, lagooning and sand bed drying of nightsoil and sewage sludges. No heating is necessary for anaerobic digestion with average temperatures near 30°C and 10-day detention with loading up to 4.5 g V.S./day per litre of active digester volume. Air drying of sludges on sand beds will produce a cake with 25 per cent solids at bed loading rates between 67.5 and 475 kg. day solids/m^2 per year with optimum application depth of 20 cm. Lagooning efficiency can be improved if a decantation arrangement can be designed to remove separated supernatant and lagoon loading can be 50 kg. dry solids/m^2 per year during the dry season.

222 Sanchez, A.
Aliaga, P.

(Both) Seccion de Ingenieria Sanitaria,
Universidad de Chile,
Santiago de Chile, Chile.

MAIN RESULTS OF THE EXPERIENCES WITH OXIDATION PONDS IN CEXA, MELIPILLA, CHILE
(EXPERIENCIA EN LAGUNAS DE ESTABILIZACION CEXAS, MELIPILLA, CHILE RESULTADOS PRINCIPALES)
XIV Inter American Congress of Sanitary Engineering. Mexico.
30 pp. August 1974.
11 tables, 5 graphs, 3 references.
CHILE: ANAEROBIC LAGOONS: BOD: COLIFORM: DESIGN: DOMESTIC WASTEWATER: FACULTATIVE LAGOONS: MULTIPLE SYSTEMS: NITROGEN: SLUDGE ACCUMULATION: SLUDGE REMOVAL: STABILIZATION PONDS: TEMPERATURE: WASTEWATER.

* The performance of a system of three stabilization ponds operated in parallel and series is analyzed. BOD removal, coliform content, nutrients, suspended solids and sludge accumulation are monitored for different loads and depths. The report concludes that anaerobic-faculative systems are more advantageous than simpler schemes. The study also proves experimentally some new design criteria based on temperature as the main parameter.

(Original paper written in Spanish)

223 Sastry, C.A.
Mohanrao, G.J.

(Both) National Environmental Engineering Research Institute, Nagpur, India.

WASTE STABILIZATION POND DESIGN AND EXPERIENCES IN INDIA
Ponds as a Wastewater Treatment Alternative, Water Resources Symposium No. 9, Center for Research in Water Resources, College of Engineering, The University of Texas at Austin. U.S.A. pp. 399-313. Gloyna, E.F., Malina, J.F., Jr., Davis, E.M., (Eds.), 1976.
5 figures, 6 tables, 32 references.
STABILIZATION PONDS: FACULTATIVE PONDS: BOD: PATHOGEN: TREATMENT: DESIGN: POND SURFACE AREA: INDIA.
*The efficiency of stabilization ponds has been found to be somewhat comparable in BOD removal and superior in pathogen removal to that of conventional treatment (excluding disinfection). Many approaches that have been used in India for the design of waste stabilization ponds are discussed. Facultative ponds are favourable because it will reduce the area requirement.

224 Sauze, M.
Gervais, M.
Francette, M.

(All) Bureau Central d'études pour les équipements d'outre-mer, Paris. France.

STABILIZATION PONDS - A STATE OF THE ART
(LES ETANGS DE STABILISATION - SYTHESE DES PRINCIPALES CONNAISSANCES ACTUELLES)
Informations et documents, 1er trimestre, No. 1. B.C.E.O.M. France. pp. 21-53. 1971.
2 figures, 2 tables.
OXIDATION PONDS: FRANCE: ECONOMICS: SEWAGE TREATMENT.
* This report summarizes basic concepts on oxidation ponds, including data from experiments in southern France.

(Original paper written in French)

●● 225 Shaw, V.A.

National Institute for Water Research, Council for Scientific and Industrial Research, Pretoria, South Africa.

A SYSTEM FOR THE TREATMENT OF NIGHTSOIL AND CONSERVING TANK EFFLUENT IN STABILIZATION PONDS
CSIR Reprint RW 166. Originally published in Africaans in "Public Health (J'berg). S. Africa. Vol. 63, pp. 17-22, Originally presented at the 20th Annual Health Congress of the Institute of Public Health, U.K. 1963.
1 figure, 2 tables.
SOUTH AFRICA: NIGHTSOIL TREATMENT: CONSERVANCY TANK EFFLUENT: STABILIZATION PONDS.
*A report on a pilot plant waste stabilization pond study for the treatment of nightsoil and conservancy tank effluent. Recommendations are given for the design and construction of full-scale ponds.

226 Shaw, V.A.

National Institute for Water Research, Council for Scientific and Industrial Research, South Africa.

A SYSTEM FOR THE TREATMENT OF NIGHTSOIL AND CONSERVING TANK EFFLUENT IN STABILIZATION PONDS
CSIR, Reprint RW (166). South Africa. October 1962.
1 diagram, 2 tables.
NIGHTSOIL TREATMENT: STABILIZATION PONDS: SOUTH AFRICA.

* A small concrete-lined pond was loaded with nightsoil at a rate equivalent to 3,000 persons per hectare. Sufficient water was added to compensate for evaporation and there was no effluent. The pond was operated without nuisance and with little accumulation of sludge after thirteen ponds. Bacteriological and chemical analysis of pond water showed it to be similar to a primary pond treating sewage at the same area per person.

227 Slanetz, L.W.
Bartley, C.H.
Metcalf, T.G.
Nesman, R.

(All) Dept. of Microbiology University of New Hampshire, Durham, U.S.A.

SURVIVAL OF ENTERIC BACTERIA AND VIRUSES IN MUNICIPAL SEWAGE LAGOONS
Proceedings of the Second International Symposium for Waste Treatment Lagoons. U.S.A. pp. 132-141, June 23-25, 1970.
6 figures, 6 tables, 12 references.
BACTERIA: VIRUSES: OXIDATION PONDS: U.S.A.: DOMESTIC: TREATMENT: PUBLIC HEALTH.

* A study of the survival of enteric bacteria and viruses in oxidation pond systems used by three different communities in New Hampshire for the disposal of domestic wastes. About 95-99% reduction of fecal bacteria are observed when these ponds are operated as one or two ponds in series and their percentages of survival increase during the winter season. With systems of 3 or 4 ponds in series, excellent removal of bacteria are obtained, but enteric viruses could still be isolated from the effluents, thus creating a chance of health hazard if such effluents are discharged into the environment.

228 Sless, B.J. Technion, Haifa, Israel.

BIOLOGICAL AND CHEMICAL ASPECTS OF STABILIZATION POND DESIGN
Reviews on Environmental Health. Israel. 1(4) pp. 327-354, 1974.
29 references, 6 tables, 4 figures.
ALGAE: STABILIZATION PONDS: ISRAEL: SEWAGE TREATMENT.
*The results of monitoring 29 stabilization ponds in Israel and laboratory model and pilot scale ponds for physical, chemical and biological parameter variation, show that pond design criteria such as organic loading and retention time exert a much greater influence on algal species composition and concentrations than does temperature. It was found that a series of ponds did not provide superior BOD removal than a single large pond with a retention time equal to that in the series of ponds; in both cases BOD and nutrients reductions were about 70-80%. It is concluded that unless algal crops can be harvested economically, optimization of algal growth in conventional pond systems is unwarranted.

229 Stander, G.J.
Meiring, P.G.J. (Both) National Institute for Water Research, Pretoria. South Africa.

EMPLOYING OXIDATION PONDS FOR LOW COST SANITATION
Journal Water Pollution Control Federation. U.S.A. 37(7), pp. 1025-1033, July 1965.
1 figure, 4 tables, 11 references
AFRICA: SEWAGE: NIGHTSOIL: STABILIZATION PONDS: AQUA-PRIVIES: ECONOMICS.
*Sewerage and sewage treatment costs in southern Africa are reviewed and it is shown that it is possible to provide water-borne sewerage with treatment in stabilization ponds at a total cost similar to that of a pail conservancy system. The use of the self-topping aqua-privy in combination with small bore flat sewers is described and recommended for low income high density areas. The treatment and disposal of nightsoil in facultative ponds is recommended in preference to trenching or spreading on land.

230 Stander, G.J.
Meiring, P.G.J.
Drews, R.J.L.C.
Van Eck, H.

(All) South African Council for Scientific and Industrial Research,
National Institute for Water Research,
Pretoria, S. Africa.

A GUIDE TO POND SYSTEMS FOR WASTEWATER PURIFICATION
Developments in Water Quality Research, U.S.A. pp. 125-164. Shuval, H.I. (Ed.), 1970.
5 figures, 6 tables, 41 references.
WASTEWATER TREATMENT: STABILIZATION PONDS: THEORY: OPERATION: MAINTENANCE: CONSTRUCTION: PLANNING: POND LOADING: PUBLIC HEALTH.

* A description of waste stabilization ponds according to its theories, methods of operation and maintenance. Although waste stabilization ponds provide economic advantages and are simple to construct and operate, they require proper planning and application, and periodical review of pond loading. Public health aspects of waste stabilization ponds are also discussed.

231 Talboys, A.P.

Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente (CEPIS)
Lima, Peru.

STABILIZATION PONDS IN LATIN AMERICA
(LAGUNAS DE ESTABILIZACION EN LATIN AMERICA)
Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente (CEPIS). 628.34098 T16. Peru. 38 pp. July 1971.
60 references.
LATIN AMERICA: DOMESTIC: INDUSTRIAL WASTEWATER: OPERATION MANUALS: REUSE: SEWAGE: STABILIZATION PONDS: WASTEWATER TREATMENT.

* During 1970 and 1971 CEPIS undertook a survey to determine the Latin American experience with stabilization ponds. The results of it showed that at the time there were 181 ponds, most of them are multiple systems operating in series and for treatment of domestic wastes. Very few schemes for recycling the effluents were in operation, even in those countries where climatic conditions would favour it. The report also includes: 16 summaries on specific experiences in selected countries, the survey format, several manuals for the operation and maintenance of lagoons and a large bibliography of reports on the subject.

(Original paper written in Spanish)

232 Talboys, A.P.

STABILIZATION POND INSTALLATIONS IN LATIN AMERICA
CEPIS - Pan American Center for Sanitary Engineering and Environmental Sciences. Peru, July 1971.
SOUTH AMERICA: SEWAGE TREATMENT: STABILIZATION PONDS.
*This publication records the results of a survey of stabilization pond use in Latin America conducted by CEPIS in October 1970; 181 pond installations were reported in 20 Latin American and Carribean countries and details are given of these systems. An abstracted bibliography of important local publications from 1956 to 1971 on waste stabilization ponds is included.

233 Van Eck, H.
Simpson, D.E.

THE ANAEROBIC POND SYSTEM
Journal and Proceedings of the Institute of Sewage Purification. U.K. Part 3. pp. 251-260. 1966.
3 figures, 10 tables, 10 references.
ANAEROBIC-AEROBIC POND SYSTEM: ORGANIC LOADS: NUISANCE: SEWAGE TREATMENT.
* The anaerobic-aerobic ponds treating domestic sewage at Chatsworth in South Africa, incorporate recirculation from the aerobic pond to the anaerobic pond. It is shown that this system is capable of treating much higher organic loadings without smell nuisance than a single aerobic primary stabilization pond. At temperature above 25°C, BOD removals of over 30 per cent have been recorded, however, this efficiency decreases during the winter months and a thick scum is formed on the anaerobic pond surface. The sludge which accumulates in the anaerobic ponds is reported to be well digested and similar to sludge produced by a conventional sewage works.

234 Varadarajan, A.V.
Raman, A.
Venkataswamy, R.
Munichami, M.

(All) Sewage Reclamation Research Unit, Kodungaiyur, Madras, India.

STUDIES ON THE ANAEROBIC LAGOONING OF MUNICIPAL SEWAGE AT KODUNGAIYUR, MADRAS
Proceedings of the Symposium on Low Cost Waste Treatment. India. pp. 23-29. Sastry, C.A. and Nandgaonkar, K.M. (Eds.), Central Public Health Engineering Research Institute, May 1972.
2 tables, 5 references, discussion
SEWAGE TREATMENT: ANAEROBIC LAGOONS: EXCRETA DISPOSAL: INDIA: URBAN.

*A report of studies on anaerobic lagooning of Madras city sewage carried out between November 1967 and April 1969. Lagoons were 38m x 38m and were operated at depths of 2.4m and 2.1m. BOD removal ranged from 58 to 78 percent with a 4 to 5 day detention time and influent BOD between 276 and 560 mg/l. Performance was best during summer months. Organic loading changes from 1080 kg/ha-day to 1360 kg/ha-day did not affect performance significantly. Odour was not a serious problem with the Madras sewage containing about 50 mg/l sulphate but sludge accumulation was high and desludging would be necessary after about 3 years.

235 Watson, J.L.A.

Ministry of Health, Jerusalem, Israel.

OXIDATION PONDS AND USE OF EFFLUENT IN ISRAEL
Proceedings of the Institution of Civil Engineers. U.K. Volume 22, pp. 21-40, 1962.
ISRAEL: EFFLUENT REUSE: STABILIZATION PONDS: DESIGN: CONSTRUCTION: MAINTENANCE: SODIUM ABSORPTION RATIO.

*A description of the design and field performance of waste stabilization ponds in Israel. Recommendations are given for the design, construction, and maintenance of anaerobic and facultative ponds. Agricultural use of pond effluent for irrigation is discussed with particular reference to effluent quality in terms of its sodium absorption ratio.

236 Yanez, F.

Centro Panamericano de Ingenieria
Sanitaria y Ciencias del
Ambiente (CEPIS)
Lima, Peru.

STABILIZATION PONDS
(LAGUNAS DE ESTABILIZACION)
Curso Intensivo sobre diseno de Plantas de Tratamiento de Aguas Residuales para Paises en Desarrollo. Peru. 36 pp. November 1976.
29 references, 5 graphs, 2 figures.
LATIN AMERICA: AEROBIC LAGOONS: ANAEROBIC LAGOONS: CONSTRUCTION: DESIGN: DESIGN CRITERIA: DEVELOPING COUNTRIES: FACULTATIVE LAGOONS: LOADING: OPERATION: OXIDATION PONDS: TROPICAL CLIMATES.

* The author discusses the proper uses of oxidation ponds in the Latin American countries. Provides a description of the most popular and adaptable designs and outlines its restrictions according to the geographic characteriestics factors of the region. Several practical suggestions learned from a wide experience are presented. Special emphasis is given to the application of oxidation ponds in tropical climates where conditions allow for superficial loads 10 to 25 times greater than those permitted in countries with seasonal variations....

(Original paper written in Spanish)

237 Yao, K.M.

Institution of Public Health
Engineering, U.K.

MOSQUITO BREEDING IN OXIDATION PONDS
National Symposium on Wastewater Disposal. Pakistan. pp.56-61, April 17, 1975
10 references.
MOSQUITOS: OXIDATION PONDS: MALARIA: BREEDING.

* A report on a one year study of mosquito breeding in four oxidation ponds. It was observed that the key to mosquito breeding control is to keep the banks clear of weeds. In dirty water pools, malaria mosquitos were observed.

238 Yau, C.H.

Environmental Engineering
Division,
Asian Institute of Technology,
Bangkok, Thailand.

DESIGN PARAMETERS FOR OXIDATION DITCHES IN THE TROPICS
Master of Science Thesis No. 643, Asian Institute of Technology. Thailand. 56 pp. 1974.
12 tables, 19 figures, 41 references, 1 appendix containing 1 table and 5 figures.

SEWAGE TREATMENT: OXIDATION DITCH: DESIGN: TROPICS: ASIA.

* A report of pilot scale studies on oxidation ditch treatment of a soft-drink bottling plant waste to develop design criteria suitable for tropical countries. Effluent COD increased with increasing COD loading but removal efficiency remained above 96 per cent throughout the range of F/M of 0.07 to 0.78 with detention 48 hours. At F/M 0.38, neither the COD removal rate nor ash content of the sludge varied when detention time varied between 17.5 and 48 hours. Laboratory tests indicated that 0.6 g/l of calcium acetate and 0.5 g/l of sodium nitrate suppressed the growth of Sphaerotilus and eliminated bulking sludge problems in the ditch within 8 days.

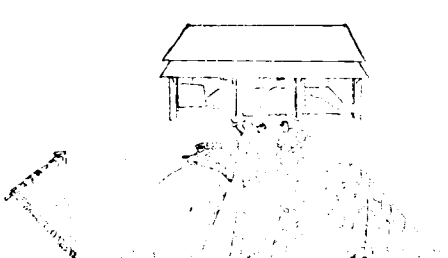
3Bii. Off-Site Treatment: Composting

239 Anon.

Dept. of Environmental Health,
Institute of Health,
Chinese Academy of Medical
Sciences, Peking.

SANITARY EFFECTS OF URBAN GARBAGE AND NIGHT SOIL COMPOSTING
Chinese Medical Journal. China. 1(6), pp. 406-412, November 1975.
8 tables
CHINA: COMPOSTING: NIGHT SOIL: URBAN: GARBAGE: HEALTH: FERTILIZER: REUSE.

*In Peking, noncompostable material is reclaimed for utilization and organic wastes are promptly transported out of the city and mixed with night soil for high-temperature composting. This not only helps improve sanitation, but provides agriculture with large quantities of high quality organic fertilizers. The composition of the garbage, processing conditions of composting physical and chemical indices, and the effect of composting on ascaris eggs and maggots are discussed.



●● 240 Anon.

Department of Hygiene,
District of Chien Ann Revolution
Committee, Province of Hopei,
China.

DISCUSSION ON THE IMPLEMENTATION OF UNIFIED MANAGEMENT AND HYGIENIC DISPOSAL OF EXCRETA AND URINE

In "Compilation of Data on Experience and Sanitary Management of Excreta and Urine in the Village". Unpublished report of the International Development Research Centre. Canada. Translated from Chinese by Lee Thim Loy. pp. 2-10. 1976.
3 tables, 3 figures.
COMPOSTING: EXCRETA: REFUSE: ANIMAL WASTES: CHINA: PATHOGENS.

*Two methods of composting human excreta, livestock manures and refuse with soil are described as being commonly used in China. These are said to raise the efficiency and increase the quantities of natural fertilizers, promote food production, reduce the pathogen content of the fertilizer and fly breeding areas and improve public health. The standardized techniques are two fold:

(1) the surface aerobic continuous method, and
(2) the large pit aerobic composting method.

The surface method is best for climates which do not reach freezing temperatures in the winter. The four materials are mixed in equal weights (the proportions vary considerably depending on the location and availability of raw materials) and laid on the ground 9' X 9' X ½'. Three inch diameter bamboo rods are placed on the pile at 3 ft. intervals in both directions. Bamboos are erected vertically where the horizontal bamboos cross. More compost is added to reach a pile depth of three feet. The pile is then covered with earth or preferably earth and horse manure mix. The timber are extracted when the earth is slightly dried. Generally it takes 20 to 30 days for the compost to be fully fermented in summer and winter respectively.

The large pit aerobic composting method employs a 5' X 4' pit in which 3" square channels are dug along its bottom (one lengthwise and two across the pits width). These are covered with stalks of millet or the like and 3" diam vertical bamboos erected at the ends and where the channels meet. The pit is filled with compost and covered with a layer of earth to prevent ingress of vermin and flies and with grass material to insulate the pit. The vertical bamboos are extracted, the channels then act to ventilate the compost during fermentation which takes thirty days. This method can be used in below freezing conditions. This article provides full details of mixing, pile preparation and maintenance. The optimum water content in the composting material depends on the evaporation rate but should be about 30% during winter when evaporation is low but rising to 50% in the summer. The temperature should reach 50°-60°C for at least 5-7 days.

Report is made of experiments on the die-off of pathogens in the compost. Above 95% kill of ascarid eggs in the compost was achieved throughout the trials.

(Original paper written in Chinese)

241

Bhaskaran, T.R.
Ghosh Roy, B.K.
Sampathkumaran, M.A.
Radhakrishnan, I.
Mukherjee, D.B.

(All) All India Institute of Hygiene and Public Health, Calcutta, India.

STUDIES ON THE SURVIVAL OF PATHOGENS IN NIGHTSOIL COMPOST
Indian Journal of Agricultural Science. India. Volume 27. Part I. pp. 91-102. March 1957.
2 diagrams, 5 tables, 9 references.
NIGHTSOIL: COMPOSTING PRIVY: INDIA: PATHOGENS.

*The Bangalore method of composting in which refuse and human excreta are used for manufacture of compost has been advocated by the Central and State Governments in India for disposal of nightsoil and refuse in rural and municipal areas. The purpose of this investigation is to study the fate of pathogenic organisms of intestinal origin in the composting process and to determine conditions under which nightsoil compost could be free from the risk of infection. Data on the presence and viability of pathogens of the Salmonella and Shigella group of bacteria and the eggs of intestinal helminthic parasites such as ascaris, hook-worm and trichuris were obtained by analysing compost samples from 5 different parts of the country as well as from 8 experimental compost pits maintained under controlled conditions. For the latter case, city refuse and nightsoil were stacked in the pits in alternate layers of 6 inches and 2 inches, respectively. In some of the pits refuse and nightsoil were mixed together in equal proportions of weight prior to filling in the pits. The size of each pit is 6 ft. 3 in. wide at the base, 3 ft. 3 in. wide at the top, 2 ft. high and about 6 ft. 1 in. long. Sample collection was made by a 2 inch-auger and care was taken to see that representative samples were obtained from the pits at different stages.

Results of the analysis show that in the experimentally controlled compost pits both the number and viability of helminthic ova decrease rapidly within the first one month and they are completely eliminated in the course of 3 months. Bacteriologically, all the samples were uniformly negative. This rapid destruction of the pathogens is reported to be caused by rising temperature inside the pits (about 104 F) which was maintained under anaerobic conditions for a period of 10 - 15 days. However, the results of the samples collected from different States are found to be somewhat irregular, due to inadequate care and control in making of compost pits, and insanitary supervision during maturity period of the composting process. In a few cases, even six month old samples showed the presence of a few eggs some of which were viable.

Chemical analysis of the compost obtained with nightsoil and town refuse shows that the product forms a well-digested manure which has potential agricultural value, having about 1 percent nitrogen and C/N ratio of 6 to 8.

An important observation arised from these studies is that composting of nightsoil and refuse can be satisfactorily employed for hygienic disposal of human excreta provided that composting operations are carried out under controlled supervision. If the health departments of the States arrange for regular supervision of the composting operations so as to ensure that the compost pits are properly made up and are fully ripe before the material is taken out of the pits and used as manure, then there is very little hygienic risk involved in the use and handling of compost for agricultural purpose.

242 Gilles, E.C.

Health Department,
Nigeria.

COMPOSTING
Farm and Forest. Nigeria. No. 2. pp. 92-102. 1946.
2 tables, 2 graphs, 2 figures, 3 references.
NIGERIA: HUMAN WASTE: ANIMAL WASTE: COMPOSTING: FERTILIZERS: SOLID WASTES.

* Disposal of human and animal excreta and domestic refuse by means of composting in Kane, Northern Nigeria, has resulted in the satisfactory and economic conversion of waste matter into humus of manurial value. This paper describes the methods of composting; its requirements, operation and effects of weather/temperature. The use of the composting products as fertilizers has been very successful.

243 Golueke, C.G.

Sanitary Engineering
Research Laboratory,
University of California,
Berkeley, U.S.A.

COMPOSTING: A REVIEW OF RATIONALE, PRINCIPLES AND PUBLIC HEALTH
Compost Science. U.S.A. 17(3). pp. 11-15, Summer 1976.
COMPOSTING: TREATMENT: OPERATION: PUBLIC HEALTH: THEORY.

*Composting is a process of waste treatment that will yield many advantages. However, the compost operation has to be done properly or otherwise it will make the conditions worse. Principles of composting and its related public health aspects are discussed.

○ 244 Gotaas, H.B.

University of California,
Berkeley, U.S.A.

COMPOSTING-SANITARY DISPOSAL AND RECLAMATION OF ORGANIC WASTES
World Health Organization. Switzerland. Monograph No. 31. 205 pp. 1956.
94 references, 48 figures
COMPOSTING: RURAL: DESIGN: CONSTRUCTION: OPERATION: URBAN: COMMUNITY: EXCRETA.

* Composting is proposed as a sanitary method for re-using human wastes in agriculture while maintaining public standards. The fundamental theory of composting is described. A number of techniques are proposed which can be applied to cities, small towns, villages and individual farms, respectively.

245 Gray, K.R.
Sherman, K.
Biddlestone, A.J.

(all) Department of Chemical Engineering,
University of Birmingham, U.K.

A REVIEW OF COMPOSTING - PARTS I, II, III.
Process Biochemistry. U.K. Part I, June 1971. Part II, October 1971. Part III, October 1973. 17 pp.
168 references, 11 figures, 12 tables.
COMPOSTING: MUNICIPAL WASTES.
*This three-part review discusses the process of composting as a municipal wastes disposal process which can provide humus to maintain intensively cultivated soils in a state of adequate fertility. The microbiological and biochemical aspects of the fundamental composting process are described. The chemical and physical parameters are described and it is concluded that sufficient data now exists for accurate process design of composting plants. The historical development and various systems of composting practiced since 1930 are enumerated. The properties of the compost product are described as well as analytical methods involved in understanding the composting reaction.

246 Hills, L.D.

Henry Doubleday Research Association,
Bocking, Braintree,
Essex. U.K.

EUROPEAN METHODS OF COMPOSTING AND SLUDGE UTILIZATION
Compost Science. U.S.A. pp. 18-19. July-August, 1972.
WASTE TREATMENT: LAND RECLAMATION: FERTILIZERS: EXCRETA: URINE: KITCHEN WASTES: ORGANICS: EUROPE,
* Methods of composting and sludge utilization in Europe are described. Sludge is primarily used as fertilizer, fish food, and for land reclamation while composting is done by means of a "Clivus toilet". It is a family municipal compost plant which takes the excreta and urine and composts them with the kitchen waste to produce roughly a hundred pounds a year from a family of three, of a good high potash organic fertilizer.

247 Hovsenius, G.

National Environmental Protection Board,
Solna, Sweden.

COMPOSTING AND THE USE OF COMPOST IN SWEDEN
Journal of the Water Pollution Control Federation. U.S.A. 47(4). pp. 741-747. April 1975.
3 tables.
COMPOSTING: URBAN: ECONOMICS: OPERATION: SLUDGE: GARBAGE: RESEARCH: FERTILIZER: SWEDEN.
* A description of a Swedish research program in large scale composting of dewatered sewage sludge, domestic refuse and night-soil. Economic and technological parameters are discussed. The problems of using such compost in agriculture are referred to.

248 Hovsenius, G.

Statens Naturvardsverk
Fack
S-171 20 Solna, Sweden.

COMPOSTING OF HOUSEHOLD-WASTE TOGETHER WITH SLUDGE (KOMPOSTERING AV HUSHALLSAVFALL TILLSAMMANS MED SLAM)

AVFALL 76, chapter K3, The work is part of the documentation from the International Fair "AVFALL 76" (WASTE 76) in Jonkoping, Sweden. September 27 - October 1, 1976. Sweden. 15 pp. Issued 1976.
8 figures, 2 tables.
COMPOSTING: HOUSEHOLD-WASTE: SLUDGE: AERATION: HUMIDITY: HEAVY-METALS.

*A review is made of the composition of household-waste. The preconditions for a good composting are discussed. It is noted that the C/N-ratio is too high in household-waste. Through addition of sludge from purifying plants the ratio can be lowered to a suitable value. The addition has to be of that size that all the sludge produced in the area where the household-waste is collected can be used.

Other factors of importance for a good composting are water-content, aeration, transportation of CO_2 and the rate of fragmentation of the material. The principles for fragmentation with systems based on mills and on big drums are described.

Some results from the research concerning composting of household-waste and sludge that is carried out at Laxa, Sweden are given. Among other things a preliminary review is done of heavy-metals occuring in different types of waste. This content is compared with that in farmyard manure. The main parts of these metals come from material that could be separated by magnetic means. The problem with plastic waste is pointed at, but today there does not exist any good separation-method for plastic materials.

Different forms of composting are compared; reactor-composting, some kinds of open composting and aeration-methods. The placing of compost-material in rows of various sizes is found to give a very poor aeration. An artificial addition of oxygen is therefore concluded to be necessary for obtaining an efficient decomposition.

(Original paper written in Swedish)

249 Jalal, K.F.

A TECHNOLOGICAL EVALUATION OF COMPOSTING FOR COMMUNITY WASTE DISPOSAL IN ASIA
Compost Science. U.S.A. Volume 10. pp. 20-25, Spring/Summer 1969.
29 references, 3 figures.
DISPOSAL: COMPOST: AGRICULTURE: NUTRIENTS: RE-USE: RURAL: FERTILIZER.

* The various methods of low-cost waste disposal that have been practiced in Asia are discussed and criticized. A quantitative evaluation of the fertilizer value of compost is presented and specific recommendations made with regard to the method of composting.

250 Krogstad, O.
Gudding, R.

(Both) Dept. of Microbiology and Immunology and Dept. of Food Hygiene, The Veterinary College of Norway.

THE SURVIVAL OF SOME PATHOGENIC MICRO-ORGANISMS DURING REACTOR COMPOSTING
Acta Agriculturae Scandinavica 25. Sweden. pp. 281-204, December 8, 1975.
16 references.
COMPOSTING: PATHOGENS: SLUDGE: GARBAGE: ANALYSIS.

* A report on micro-organism survival after composting of urban solid wastes mixed with septic and dehydrated sludge. Previously innoculated salmonella typhimurium and serratia marcescens could not be detected in the waste after 3 days composting at 60°-65°C. Bacillus cereus was demonstrated in the compost after seven days composting, but when the temperature rose to 70°C. and was maintained during the composting period, this organism could not be detected in the compost.

251 Peel, C.

THE PUBLIC HEALTH AND ECONOMIC ASPECTS OF COMPOSTING NEIGHT SOIL INTO MUNICIPAL REFUSE IN TROPICAL AFRICA
Proceedings of the Conference on Planning for Water and Waste in Hot Countries, Loughborough University of Technology. U.K. pp. 25-36. September 1976.
1 diagram, 2 tables, 13 abbreviated references.
COMPOST: REFUSE: NIGHTSOIL.
The value of composting of nightsoil with refuse is related to agricultural needs and public health. Details are given of a composting plant at Kano, Nigeria, using the Indore composting system. The maximum temperature in the windrow was 69°C, sufficient for destruction of pathogens.

252 Unakul, S.

Southeast Asia Research Organization.
New Delhi, India.

RURAL SANITATION IN CHINA
Unpublished report. 26 pp. February 3, 1975.
18 references
CHINA: RURAL: DISPOSAL: COMPOSTING: PUBLIC HEALTH: ORGANIZATION.

* This report describes rural health services in China with emphasis given to organizational aspects.
The composting of animal and human waste for re-use in agriculture is described. Digested night-soil is mixed with animal manure, rice straw or grass and soil at special composting sites. Details of composting pits are given.

253 Wilson, G.B.
Walker, J.M.

(Both) Agricultural Research Service,
U.S. Dept. of Agriculture.

COMPOSTING SEWAGE SLUDGE: HOW?
Compost Science. U.S.A. 14(5). pp. 30-32, September/October, 1973.
8 figures
SLUDGE: COMPOSTING: OPERATION: U.S.A.: SEWAGE: AERATION.

* Preliminary full-scale tests indicate that sewage sludge can be windrow-composted if bulking materials such as woodchips or sawdust are added. Methods of compost operation are described. The authors conclude that the sludge can be composted outdoors in Maryland, despite some operational problems, mainly due to rainfall.

3Biii. Off-Site Treatment: Aquatic Weeds

○ 254 Anon.

National Academy of Sciences
Washington. D.C., U.S.A.

MAKING AQUATIC WEEDS USEFUL: SOME PERSPECTIVES FOR DEVELOPING COUNTRIES
Report of an Ad Hoc Panel of the Advisory Committee on Technology Innovation, Board on Science and Technology for International Development, Commission on International Relations. U.S.A. Chapter 13, pp. 115-126. 1976.
9 figures, 14 references
AQUATIC WEEDS: WASTEWATER: TREATMENT: DEVELOPING COUNTRIES: NUTRIENTS: REUSE: ANIMAL FEED: SOIL CONDITIONER: FISH HARVESTING: PUBLIC HEALTH: HUMAN FOOD.

* A state-of-the-art review of an aquatic weed-wastewater treatment system. Pilot scale experiments conducted in developed countries show that these plants are capable of extracting large portions of organic and inorganic constituents from water and incorporate them into their own structure, thus making them suitable for reuses as animal feeds or soil conditioner. Miscellaneous uses of aquatic weeds in developing countries are reported including fish harvesting and food production. The authors also discuss some public health limitations and research needs for improvement of this technique.

255 Bagnall, L.O.
Furman, T.D.S.
Hentges, J.F., Jr.
Nolan, W.J.
Shirley, R.L.

(All) Agricultural Engineering
University of Florida,
Gainesville, U.S.A.

FEED AND FIBER FROM EFFLUENT - GROWN WATER HYACINTH
Environmental Protection Technology Series EPA-660/2-74-041. U.S.A. pp. 116-141, June 1974.
7 figures, 7 tables, 26 references.
WATER HYACINTH: POND: DETENTION TIME: NITROGEN: PHOSPHORUS: ANIMAL FEED: REUSE.

*A water hyacinth covered pond with a detention time of over 10 hours removes 10% of the nitrogen and phosphorus from secondary treated sewage effluent. Removal is increased to 80% and 60%, respectively by increasing detention time to 5 days. Only 10% of the removed nutrients are found in the plant tissue. Cattle and sheep can readily eat processed water hyacinth in complete diets and remain in good health. Paper can be made from water hyacinth but production cost is uneconomically high. Compost may be the best use, having the highest value and lowest processing cost.

256 Cornwell, D.A.
Zoltek, J. Jr.
Patrinely, C.D.
Furman, T.D.S.,
Kim, J.I.

(All) Dept. of Environmental Engineering Sciences, University of Florida, Gainsville, U.S.A.

NUTRIENT REMOVAL BY WATER HYACINTHS
Journal of the Water Pollution Control Federation. U.S.A. 49(1), pp. 57-65, January, 1977.
4 tables, 5 figures, 15 references.
SEWAGE: EFFLUENT: BIOFILTERS: NUTRIENTS: AQUATIC WEEDS: U.S.A.

* A field experiment conducted in Florida on the use of water hyacinths (Eichhornia crassipes) to remove nutrients from secondary effluents. It is observed that water hyacinths can grow twice as fast in ponds containing secondary effluents, as they do in natural conditions. About 80% total nitrogen and 40% total phosphorus removals are obtained with the ponds having a depth of 0.34 meters and a detention time of 48 hours, while ponds with a greater depth and a lesser detention time do not provide satisfactory results. A direct correlation is found to exist between the percent nutrient removal and a loading parameter defined as surface area per unit flow.

257 Culley, D.D. Jr.
Epps, E.A.

(Both) School of Forestry and Wildlife Management, Louisiana State University, Baton Rouge, U.S.A.

USE OF DUCKWEED FOR WASTE TREATMENT AND ANIMAL FEED
Journal of Water Pollution Control Federation. U.S.A. 45(2). pp. 337-347. February 1973.
28 references, 5 tables, 1 figure.
DUCKWEED: WASTEWATER TREATMENT: POLLUTION CONTROL: ANIMAL FEEDS: WATER PURIFICATION.

* Aquatic plants provide a good animal feed, are immune to certain pests, grow well in water containing organic wastes, and purify the water in which they grow. The report presents analyses of several aquatic plants and compares them to conventional animal feeds. Based on laboratory scale experiments, yields of about 2 tons of duckweed (dry weight) per hectare per 3 weeks could be attained.

258 DeJong, J.

Federal Commission for the IJsselmeerpolders, Netherlands.

THE PURIFICATION OF WASTEWATER WITH THE AID OF RUSH OR REED PONDS
Biological Control of Water Pollution. U.S.A. pp.133-139. Tourbier, J., Pierson, R.W., Jr. (Eds.). 1976.
5 tables, 7 figures, 3 references.
NETHERLANDS: AQUATIC WEEDS: RUSH PONDS: TREATMENT: SEWAGE.

* A description of an actual project of sewage treatment utilizing aquatic weeds. On the basis of this work it is concluded that treatment of sewage with rush ponds is considerably cheaper than with activated sludge type plants.

259 Koltypin, Y.A.

Central Research Station for Agricultural Utilization of Sewage,
All Union Kostyakov Research Institute of Hydraulic Engineering and Land Development, U.S.S.R.

DECONTAMINATION OF SEWAGE IN PADDY FIELDS
Hygiene and Sanitation, U.S.A. 34(7). pp. 87-90. 1969.
2 tables.
DECONTAMINATION: SEWAGE: WASTEWATERS: PONDS: PADDY FIELDS: USSR: HELMINTH EGGS.

* An investigation of the decontamination of municipal sewage in biological ponds under the conditions of the Hissar Valley in the Tadzhik SSR, followed by additional processing and utilization in paddy fields. The settling ponds are reported to achieve the settling of up to 93% of the suspended solids and most of the helminth eggs. A high degree of decontamination is attested when the pond effluent is passed through paddy fields. Various potential utilizations of paddy fields for the decontamination of other wastewaters are discussed.

(Original paper written in Russian)

260 Miner, J.R.

Agricultural Engineering Dept., Iowa State University, Ames, Iowa, U.S.A.

Wooten, J.W.
Dodd, J.D.

(both) Dept. of Botany and Plant Pathology, Iowa State University, Ames, Iowa, U.S.A.

WATER HYACINTHS TO FURTHER TREAT ANAEROBIC LAGOON EFFLUENT
In "Livestock Waste Management and Pollution Abatement". The Proceedings of the International Symposium on Livestock Wastes, held in Columbus, Ohio, April 19-22, 1971, published by the American Society of Agricultural Engineers, St. Joseph, Michigan. pp. 170-173.
7 tables, 4 figures, 4 references.
WATER HYACINTHS: TREATMENT: SWINE-MANURE: ORGANICS: NUTRIENTS.

*A pilot experiment to evaluate the use of water hyacinths (Eichhornia crassipies) in a treatment system to transform anaerobic swine-manure lagoon effluent into water suitable for discharge to a surface water course. Four circular plastic swimming pools, 10 ft in diameter and 24 ft in depth, operated in series, are used as the treatment scheme utilizing water hyacinths. Results show that the effluent is free of color and sufficiently lowered in organic matter and nutrients to allow discharge into the natural water courses. Reduction of nitrogen concentration by water hyacinths also allow more intense application of the effluent to cropland without danger of groundwater pollution by excess nitrogen.

●● 261. Seidel, K.

Max Planck Institute,
Knefeld, West Germany.

MACROPHYTES AND WATER PURIFICATION
Biological Control of Water Pollution. U.S.A. pp. 109-121.
Tourbier J., Pierson, R.W. Jr., (Eds.) University of Pennsylvania Press. 1976.
6 tables, 10 figures, 6 references.
MACROPHYTES: WEST GERMANY: AQUATIC WEEDS: TREATMENT: SEWAGE: SLUDGE: BACTERIA.

*This paper describes a long term research program carried out in West Germany on treatment of wastewater utilizing aquatic weeds. Questions that the research have been oriented toward include:

a) Which types of plants could endure varying water conditions?
b) Could certain plants eliminate water contaminants?
c) Do plants have an influence on the condition of water, subsoil, and sludge?
d) Do plants themselves change when confronted with new/polluted environments?

It is found from this extensive study that most plants could grow well or much better in fecal or domestic sewage than in uncontaminated water. Anatomical and physiological changes inside the plant bodies are also observed when they are confronted with toxic chemicals present in the wastewater, i.e. formation of hydropods (water cells) on the epidermis, and irregular arrangement of the stomates of S. lacustris when cultivated in water containing phenol solutions.

The beneficial properties of aquatic weeds in elimination of inorganic and organic pollutants from wastewater are reported to be remarkable. Absorption capacities of heavy metals and other chemicals by various macrophytes have been investigated and results tabulated in tables from which the capacities are shown to increase from 4 to 40 times when a species (S. lacustris) is grown in sewage instead of a healthy non-polluted lake. Another experiment involves testing a wide range of plants for their compatibility with phenol and cyanide. A few plants of the Juncus species and Schoenoplectus species, especially S. lacustris are found to suit this purpose well as they could reduce from 10 to 100 mg/l of phenol to non-detectable levels within the designated period. However, a lag phase in plant adaptation to high phenol concentrates is particularly evident during cold weather months. Further analysis demonstrates that, at least in S. lacustris, phenol is cleared by the plant itself and afterward metabolized to amino acids for production of protein and the plant biomass.

Average percent reduction of fecal indicator and pathogenic bacteria after 2 hours contact with certain species of macrophytes are significantly high, i.e., 80% to 90%. The mode of organism inactivation is possibly by excretions from the plant roots. The pH of water is also affected by the action of certain plants as it is observed to be neutralized when passing through the plant roots.

The use of aquatic weeds for the purification and reclamation of sludge from coastal areas and from sewage has been encouraging. The plant roots could turn the otherwise dead silt at the sea coast into genuine soil having abundance in oxygen which is vital for marine lives. Stabilization of sewage sludge could also be effectively accomplished when the plants (Phragmites communis) are grown in the sludge bed. About 80 to 90 percent dry matter sludge is obtained from the actions of the plant roots while clear water from the sludge is drained off easily. Reduction of disease-causing-organisms present in the sludge are reported to be significant caused by excretions from the plant roots.

Guidelines for operation of the system utilizing aquatic weeds for wastewater treatment are described in details. They include providing oxygen to the plants by either means of small water falls or by drainage pipes into the sludge beds. Harvesting of the plants should be carried out periodically and care must be taken not to damage the planting beds.

Reuse of the plant stems as fodder has been found to be useful as they are rich in protein and minor elements. The plant stems can also be used as a compost material (with the resulting by-products of biogas and fertilizer) and as wicker, often in expensive furniture.

262 Wolverton, B.C.
McDonald, R.C.

(Both) National Space Technology Laboratories (NASA) Mississippi. U.S.A.

DON'T WASTE WATERWEEDS
New Scientist. U.K. pp. 318-320. August 12, 1976.
3 figures, 3 tables.
STABILIZATION PONDS; BIOGAS: METHANE: WATER HYACINTH: EXCRETA: SEWAGE: ANIMAL FEED.

* A description of a NASA demonstration plant for the secondary treatment of sewage or excreta by water hyacinth plants. The plants very efficiently convert sewage nutrients into new plant material which is then harvested and chopped up to produce either methane and a fertilizer residue or, after sun drying, a processed animal feed.

263 Wolverton, B.C.
McDonald, R.C.

(Both) National Space Technology Laboratories,
Bay St. Louis. U.S.A.

WATER HYACINTHS FOR UPGRADING SEWAGE LAGOONS TO MEET ADVANCED WASTEWATER TREATMENT STANDARDS, PART I
Report No. TM-X-72729. U.S. National Aeronautics and Space Administration. 9 pp. October 1975.
WATER HYACINTH: TERTIARY FILTRATION: SEWAGE LAGOON: SEWAGE TREATMENT: SUSPENDED SOLIDS: BOD: CHEMICAL SUBSTANCES: UPGRADING.

* Water Hyacinths, (Eichhornia crassipes) have been found to function well as an efficient and inexpensive final filtration system in a secondary domestic sewage lagoon during a three month test period. These plants reduced the suspended solids, biochemical oxygen demand substances, and other chemical parameters to levels below the standards set by EPA. The desired quality of final sewage effluent can be controlled by the water hyacinth surface area, harvesting rates, and the detention time of sewage in the lagoons.

264 Wolverton, B.C.
McDonald, R.C.

(Both) National Space Technology Laboratories,
Bay St. Louis. U.S.A.

WATER HYACINTHS FOR UPGRADING SEWAGE LAGOONS TO MEET ADVANCED WASTEWATER TREATMENT STANDARDS, PART II
Report No. TM-X-72730, U.S. National Aeronautics and Space Administration. 22 pp. October 1976.
WATER HYACINTH: U.S.A.: SEWAGE TREATMENT: LAGOONS: BOD : SUSPENDED SOLIDS.

* Field experiments using water hyacinths as biological filtration agents have been conducted by NASA in the Mississippi Gulf Coast Region. The plants were installed in one single cell and one multiple cell sewage lagoon systems. Water hyacinths have demonstrated the ability to maintain both BOD_5 and suspended solids levels within the EPA prescribed limits of 30 mg/l. Excellent results year round are obtained with a multiple cell sewage lagoon system consisting of two aerated and one water hyacinth covered cells connected in series.

265 Wolverton, B.C.
McDonald, R.C.

(Both) National Space Technology Lab.
Bay St. Louis, U.S.A.

WATER HYACINTHS (EICHHORNIA CRASSIPES) FOR REMOVING CHEMICAL AND PHOTOGRAPHIC POLLUTANTS FROM LABORATORY WASTEWATERS
Report No. TM-X-72731, U.S. National Aeronautics and Space Administration. 10 pp. October 1976.
WASTEWATER TREATMENT: WATER HYACINTH: HEAVY METALS: ORGANIC COMPOUNDS: LAGOON: BIO-ACCUMULATION.

* Experiments have been conducted by NASA to investigate the ability of water hyacinth (Eichhornia crassipes) as a biological filtration agent to remove toxic heavy metals and organic compounds from laboratory waste discharges. Water hyacinths were installed in a specially designed zig-zag lagoon into which the laboratory wastes were diverted. Results of a 1-year study showed that the water hyacinths were efficient at removing heavy metals as well as many organic substances. Heavy metals were most concentrated in the plant roots, but were also detected in the stems and leaves. Means of utilizing harvested plants are discussed.

●● 266 Wolverton, B.C.
McDonald, R.C.
Gordon, J.

(All) National Space Technology Laboratories,
Bay St. Louis. U.S.A.

BIO-CONVERSION OF WATER HYACINTHS INTO METHANE GAS, PART I
Report No. TM-X-72725, U.S. National Aeronautics and Space Administration. 13 pp. July 1975.
BIO-GAS: ANAEROBIC DECOMPOSITION: WATER HYACINTHS: METHANE: NICKEL: CADMIUM.

* Biogas production from the anaerobic decomposition of water hyacinths (Eichhornia crassipes) has been investigated by NASA. The experiments demonstrated the ability of water hyacinths to produce an average of 13.9 ml of methane gas per gram of plant wet weight. Pollution of water hyacinths by nickel and cadmium almost double the rate of methane production as compared to the non-contaminated plants incubated at the same temperature (36°C). The methane content of biogas evolved from the anaerobic decomposition of Ni-Cd contaminated plants was 91 per cent as compared to 69.2 per cent methane content of biogas collected from the fermentation of non-contaminated plants.

3Biv. Off-Site Treatment: Other Methods

267 Adams, E.G. University of Oklahoma,
Norman, Oklahoma, U.S.A.

COST EFFECTIVENESS OF THE SOCIO-CULTURAL AND HEALTH BENEFITS OF SEWERLESS ALTERNATIVES FOR DOMESTIC WASTE DISPOSAL IN DEVELOPING COUNTRIES

A report submitted to the Office of Health, USAID. U.S.A.
March 1976. 105 pp.
12 figures, numerous references.
COST-EFFECTIVENESS: DEVELOPING COUNTRIES: WASTE DISPOSAL SYSTEMS.

*Cost-effective analysis of sewerless alternatives versus conventional treatment systems for domestic waste disposal in developing countries have been carried out. The above analysis utilizing decision-weighting models are considered necessary for placing some value upon the importance of varied considerations and summing these values for each alternative when considering projects where real data or data sources are inadequate. Methodology of the decision weighting and selection of criteria and subcriteria for each specific case are addressed in details. Results of a comprehensive survey of waste disposal systems, both conventional and unconventional, and hardware manufacturers on available systems are included.

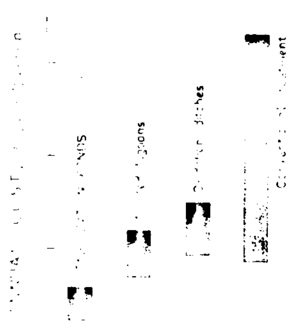


Figure [illegible] Annual costs of sewage [illegible] in India. From data given by CPHERI[illegible]

263 Anon.

Danmarks Geologiske Undersogelse
Thoravej 31
2400 Kobenhavn NV, Denmark

INFILTRATION OF HOUSEHOLD WASTEWATER AT FREDERIKS (NEDSIVNING AF HUSSPILDEVAND I BASSINANLAEG VED FREDERIKS)

Miljostyrelsen Kampmannsgade 1 ISBN 87-503-2052-1, 1604 Kobenhavn V Denmark. 31 pp. Issued August 1976.
1 figure, 3 tables, 20 appendices, 4 literature references.
WASTEWATER: INFILTRATION: GROUNDWATER POLLUTION: CHLORIDE: PHOSPHORUS: NITROGEN.

*Geohydrological investigations in the small community of Frederiks are carried out in connection with an infiltration-plant for wastewater.

The plant has been in use since 1965 and treats water from households and a dairy. The amount of wastewater in 1975 was measured to 287 m^3/day. The infiltration capacity was determined to 60 mm/day over an area of 4000 m^2.

Observations are made regarding both the spread of wastewater in the soil downstream of the plant and how the chemical/physical composition of the water is changed during its transport in the soil.

The water-bearing material consists of water transported glacial sand and gravel. The infiltration of wastewater raises the groundwater level about 10 - 20 cm around the plant, which affects the groundwater-flow in a way that makes the field of wastewater-flow many times wider than the infiltration basin.

Comparisons of the chemical composition of the water in the basins and the groundwater are made at various distances from the plant. The analysis show a high reduction of phosphorus - and also nitrogen - content in the water, increasing with the distance from the plant. The concentration of chloride, on the other hand, does not decrease in the same way and therefore it is suggested that Cl^- is used as an indicator of wastewater pollution in groundwater.

(Original paper written in Danish)

269 Anon.

James M. Montgomery,
Consulting Engineers, Inc.
Pasadena, California. U.S.A.

WATER SUPPLY AND SEWERAGE FACILITIES FOR TAIZ, YEMAN ARAB REPUBLIC "Wasterwater System", Unpublished Report to United States Department of State Agency for International Development Contract No. AID/ASIA-C-1081. Volume 1. Chapter 9. 23 pp. April 30, 1975.
1 figure
SEWERS: YEMAN ARAB REPUBLIC: TRICKLING FILTERS: SEPTIC TANKS: AERATED LAGOONS: OXIDATION PONDS: ECONOMICS.

* Proposed wastewater collection is conventional waterborne. Considering the extremely limited supply of water available it was decided to reclaim sewage water by recharge into the ground water basin. Five systems are evaluated: neighbourhood septic tanks, raw sewage lagoons, mechanically aerated lagoons, Imhoff tanks and trickling filters. Trickling filters are chosen as the optimum system with low maintenance. Sewage flows through primary sedimentation tanks, two stages of trickling filters, secondary tanks and through percolation beds.

270 Anon.

MANUAL FOR COMMUNITY PROMOTION FOR THE NATIONAL PROGRAM FOR BASIC RURAL SANITATION (MANUAL DE PROCEDIMIENTOS EN PROMOCION COMUNITARIA PARA EL PROGRAMA NACIONAL DE SANEAMIENTO BASICO RURAL)
Instituto Nacional para Programas Especiales de Salud
Division de Saneamiento Basico Rural Seccion de Promocion
Botota, D.E. Colombia - January 1975. 120 pp.
2 tables, 26 annexes.
LATIN AMERICA: RURAL SANITATION SYSTEM: EXCRETA DISPOSAL: COMMUNITY DEVELOPMENT: WATER SUPPLY.

*The Colombian National Program for Basic Rural Sanitation is carried out in five consecutive and clearly defined stages:

a) Study of the community;
b) Preparation and approval of the project;
c) Motivation promotion and organization of the community;
d) Construction of the works; and
e) Administration and supervision of the works.

The paper presents the methods and activities to complete each phase. Twenty six well prepared annexes, provide all the complementary information to undertake each step. Examples of how to determine labor input, followed by payments for the works etc. is also included.

(Original paper written in Spanish)

271 Anon.

Swedish National Environmental
Protection Board,
Sweden.

SNEP PUBLICATION 1974:15
SMALL SCALE WASTEWATER TREATMENT PLANTS, WASTEWATER-TREATMENT FOR SINGLE HOUSES
(SNV PUBLIKATION 1974:15
SMA AVLOPPSANLAGGNINGAR, RENING AV SPILLVATTEN FRAN ENSTAKA FASTIGHETER)
Swedish National Environmental Protection Board. Sweden.
No. 1974:15 in the series "SNV Publikationer". ISBN 91-38-02022-X.
17 pp. 1974.
6 figures, 3 appendices, no references.
WASTEWATER: INFILTRATION: SAND-FILTER TRENCHES: ON-SITE TREATMENT: SINGLE-HOUSE: RURAL: SMALL-SCALE PURIFYING PLANTS: TREATMENT: GUIDE-LINES: CONSTRUCTION.

*The publication is issued by the Swedish National Environmental Protection Board to serve as guide-lines for treatment of wastewater from single houses used all year around, which can not easily be connected to conventional wastewater purifying plants.

Three methods for treatment are suggested and described:
1) Infiltration in natural soil;
2) Treatment in sand-filter trenches;
3) Treatment in single-house purifying plants.

Advices are given about the design of infiltration plants, suitable dimensions of pipes and wells and the geological preconditions necessary for infiltration.

A method for testing the suitability of different natural soils for infiltration is given.

The construction of simple artificial sand-filter trenches is shortly described, for the case where natural infiltration is unsuitable.

The first step of purification when both these methods are used must be to de-sludge the wastewater. A method for this is described.

A short description of principles and working-methods of single-house purifying plants is given.

(Original paper written in Swedish)

●● 272 Anon.

Taiwan Institute of
Environmental Sanitation PHA,
Taipei, Taiwan.

THE STUDY OF MICROBIAL TREATMENT OF NIGHTSOIL
A report prepared by Taiwan Institute of Environmental Sanitation PHA, Taipei, under Contract with the University of Oklahoma Project on Lower Cost Methods of Water and Waste Treatment in Developing Countries (USAID Contract No. AID/CM-ta-C-73-13). February 1976. 31 pp.
7 tables, plus an Appendix.
NIGHTSOIL TREATMENT: TAIWAN: BACTERIA; ALGAE.

*In Taiwan there are few sanitary sewerage systems in the cities or towns, and treatment of large amounts of nightsoil has become a very serious problem. The Taiwan Provincial Institute of Environmental Sanitation has run studies on the treatment of nightsoil, using anaerobic digestion for nightsoil treatment and activated sludge for the supernatant. The problem of the bulky sludge remained. Therefore an experiment was devised using a combined microbial method for nightsoil treatment.

A genus of photosynthetic bacteria (purple non-sulfuric bacteria), and chlorella were used to decompose the organic matter in nightsoil to make it stable. The multiplied photosynthetic bacteria and chlorella contain protein and can be collected for animal feed.

Aerobic digestion was used for the pretreatment of the nightsoil. The digested liquid was then used to culture the photosynthetic bacteria (PSB). After collection of the PSB, the remaining liquid was diluted and used to culture chlorella. The conditions which produced the most chlorella and the best BOD removal, were found to be the use of a culture liquid BOD of 400-420 mg/l, a depth of tank of 30 cm, and a culture duration of three days. (If it were possible to devise a method to use a greater depth of tank, the land area required and thus the cost of the process could be reduced).

Following culture of the chlorella, the liquid was centrifuged to collect chlorella; then it was chlorinated and discharged. The PSB obtained on a dry basis, was 0.4 gram/l of culture liquid, or 0.404 kg (dry basis) for one ton of nightsoil. Under continuous operation conditions, chlorella obtained was 0.831 kg (dry basis) for one ton of nightsoil.

273 Chen, C.S.

Environmental Engineering
Division,
Asian Institute of Technology,
Bangkok, Thailand.

DEVELOPMENT OF TROPICAL DESIGN CRITERIA FOR BIOLOGICAL DISC FILTRATION
Master of Engineering Thesis No. 590, Asian Institute of Technology. Thailand. 104 pp. 1973.
31 tables, 24 figures, 30 references, 2 appendices containing 18 figures.
SEWAGE TREATMENT: BIOLOGICAL DISC FILTRATION: ROTATING BIOLOGICAL CONTACTORS: ASIA: DESIGN.

* A report on research studies of performance of a rotating biological disc filter unit incorporating an anaerobic compartment for solids digestion. For disc areal loadings between 16 g COD/m^2d and 30 g COD/m^2d and influent COD levels ranging from 300 mg/l to 4000 mg/l, COD removal was 60-85 per cent. Disc areal COD loading was found to have the greatest effect on total COD and nitrogen removal efficiencies.

274 Devroey, E.

SANITATION IN THE TROPICAL COLONIES AND SEWERAGE WITH TREATMENT PLANTS IN ELIZABETHVILLE (BELGIAN CONGO)
(LES INSTALLATIONS SANITAINES DANS LES COLONIES TROPICALES ET LE RESEAU D EGOUTS AVEC STATIONS EPU RATIONS D ELISABETHVILLE (CONGO BELGE))
Revue Universelle des Mines. Belgium. 15(12). pp. 3-8. December 1939.
4 figures.
BELGIAN CONGO: BORED-HOLE LATRINE: SEPTIC TANK: SEWERS: TREATMENT: SMOKING-PIT LATRINES: PERCOLATING FILTERS.

* A description of rural and urban sanitation, particularly as applied in the Belgian Congo. Bored-hole latrines are used in the rural areas, as are also smoking-pit latrines and earth closets. The septic tank linked with a percolating or biological filter is the most common treatment in higher density settlements, and serves up to 100 persons. A sewerage network has been built in Elizabethville in 1923, and treatment is affected by a combination of settling chambers, coagulation chambers and septic tanks with percolating filters.

(Original paper written in French)

275 Enayatullah

Environmental Engineering
Division,
Asian Institute of Technology,
Bangkok. Thailand.

PERFORMANCE OF A ROTATING DRUM FILTER IN TREATMENT OF WASTEWATERS IN THE TROPICS
Master of Engineering Thesis No. 825. Asian Institute of Technology. Thailand. 97 pp. 1975.
7 tables, 44 figures, 53 references, 2 appendices containing 6 tables and 11 figures.
WASTEWATER TREATMENT: ROTATING BIOLOGICAL CONTACTOR: ROTATING BIOLOGICAL DRUM: TROPICS: ASIA: AERATED LAGOONS: DRUM AERATOR.

* A report on performance testing of a 60 cm diameter floating rotating biological drum treating two industrial wastewaters with average BOD concentrations of 4,200 and 790 mg/l. For the two wastes mentioned, 82 and 98 per cent efficiencies of soluble BOD removal were achieved at BOD loadings of 143 and 29.5 g/day per m^2 of surface area of drum packing corresponding to volumetric BOD loadings of 14 and 2.92 kg/day per m^3 of drum. It was recommended that filter contact chamber volume should be only large enough to accommodate the drum, otherwise mixing was poor. An additional study is reported comparing a 30 cm diameter packed drum with a 12 cm diameter turbine aerator used on pilot scale lagoons treating domestic sewage.

276 Gien, I.
Vosloo, P.B.B.
Stander, G.J.

DIGESTION OF NIGHT SOIL BY AN ELUTRIATION TECHNIQUE
Public Health. South Africa. pp. 31-35, January 1957.
1 diagram, 1 table, 1 reference.
NIGHTSOIL: ANAEROBIC DIGESTION: ELUTRIATION.

* Laboratory tests on digestion of nightsoil with dilution are reported. Results showed that satisfactory digestion occurs when at least eight volumes of diluting water are added, the effluent then being suitable for aerobic treatment. At lower dilutions ammonia concentrations appear to inhibit digestion; the pH did not rise above 7.8.

277 Hindhaugh, G.M.A. Ward, Ashcroft & Parkman, Liverpool, U.K.

NIGHT-SOIL TREATMENT
Consulting Engineer. U.K. 37(9) pp. 47-49, September 1973.
1 map, 1 diagram, 2 photographs.
NIGHTSOIL TREATMENT: NIGERIA: SEPTIC TANK: SLUDGE: AEROBIC TREATMENT: NIGHTSOIL DIGESTION: AERATED LAGOON.
*The paper described a nearly-completed plant to treat 190 m^3/d nightsoil and septic tank sludge by screening, dilution, disintegration and aeration in two lagoons. The lagoons were constructed on reclaimed land, were lined with synthetic rubber sheeting and were each provided with four 56-kW floating aerators. Effluent would be discharged through a 120 metre long 400mm diameter pipe to Lagos harbour.

278 Ikeda, I. Sewage Works Bureau, Yokohama, Japan.

EXPERIMENTAL STUDY ON TREATMENT OF NIGHTSOIL BY THE WET AIR OXIDATION PROCESS
Water Research. U.K. Volume 6. pp. 967-979, 1972.
7 diagrams, 3 photographs, 3 references.
NIGHTSOIL TREATMENT: JAPAN: WET AIR OXIDATION.
*The importance of nightsoil treatment in Japan is described. A pilot wet-air-oxidation plant with a capacity of 2.7 tonnes/day dry solids was tested at Yokohama, Japan, at temperatures around 200°C and flow rates around 50 m^3/d. Treated sludge was stable, easily separated and dried. Supernatant could be treated by activated-sludge.

279 Jahn, S.A. Dept. of Physiology, University of Khartoum, Sudan.

SUDANESE NATIVE METHODS FOR THE PURIFICATION OF NILE WATER DURING THE FLOOD SEASON
Biological Control of Water Pollution. U.S.A. pp.95-106 Tourbier J., Pierson, R.W. Jr., (Eds.), University of Pennsylvania Press. 1976.
4 tables, 3 diagrams, 14 references.
SUDAN: SANITATION: ENVIRONMENTAL HAZARDS: WATER TREATMENT.
*The waters of the Nile have been traditionally purified using clay soil as a floculant, and also a number of local plants for the same purpose. Bacteriological studies were done to determine the effectiveness of these methods. All samples of untreated water were found to be fecally contaminated. There is evidence that treatment with clay soil reduces E. Coli to a certain extent.

230 Martinez, J.M.

FORCED AERATION PONDS, DESIGN AND EXECUTION CRITERIA. NEED FOR NEW STANDARDS FOR EFFLUENT CONTROL
(LAGUNAS DE OXIDACION CON AEREACION FORZADA, CRITERIOS DE CALCULO, DISENO Y EJECUCION. NECESIDAD DE UN NUEVO STANDARD PARA CONTROL DEL EFLUENTE)
XII Inter American Congress of Sanitary Engineering. Venezuela.
27 pp. August 1970.
36 pictures.
ARGENTINA: ACTIVATED SLUDGE: BOD: COST EFFECTIVENESS: DESIGN CRITERIA: EFFLUENTS: FORCED AERATION: OXIDATION PONDS: DETENTION TIME: WASTEWATER TREATMENT.

* The author proposes forced aeration as a viable solution to avoid most of the inconveniences presented by oxidation ponds. Two projects in Argentina are given as examples of the results achieved by introducing forced aeration. Transformation of animal organic matter into live vegetables is suggested as a cost effective measure for treatment as opposed to the traditional depuration of effluents by retention periods. Finally the paper demonstrates that control of BOD levels alone does not constitute sufficient criteria to approve or disapprove industrial wastewater treated in forced oxidation ponds.

(Original paper written in Spanish)

231 Matsumoto, J.
Endo, I.

(Both) Dept. of Civil Engineering,
Faculty of Technology,
Tohoku University, Sendai,
Japan.

ANAEROBIC DIGESTION OF NIGHT SOIL
Second International Conference on Water Pollution Research.
Japan. Paper No. 2, 13 pp. August 24-28, 1964.
1 table, 9 figures, 7 references.
NIGHTSOIL: ANAEROBIC: DIGESTER TEMPERATURE: DIGESTION DETENTION TIME.

* A laboratory experiment on anaerobic digestion of night soil at temperature from 30^{0}-60^{0} C and detention time from 3 to 30 days. An effective temperature range was found to be between 33^{0}-37^{0} C with the optimum temperature at 33^{0} C. It was concluded that night soil digester should not have less than 20-day detention time at any temperature to avoid digester failure.

282 Mijares, C.R.

WATER DESINFECTION IN TROPICAL AREAS (LA DESINFECCION DEL AGUA EN AREAS TROPICALES)
Boletin de la Academia de Ciencias Fisicas, Matematicas y Naturales No 87 Caracas, Venezuela, 1970. (Separata)
19 pp.
7 tables, 2 graphs, 21 references.
LATIN AMERICA: VENEZUELA: TREATMENT: TROPICAL CLIMATES: BACTERIA: VIRUS: PROTOZOA: PARASITES: SALMONELLAS: SHIGELLAS: ENTEROVIRUS: PHYSICAL TREATMENT: CHEMICAL TREATMENTS: BIOLOGICAL TREATMENT

*Relatively little research has been done to investigate the wide variety of parasite pathogens actively present in the tropical zones. Protozoa, nematodes, pathogen trematodes, etc., are amongst the organism frequently found residing in the bodies of people living in the tropics.

The paper familiarizes the sanitary engineer with the effectiveness of the various treatment processes - physical, chemical and biological - in destroying such micro-organisms.

(Original paper written in Spanish)

283 Muga, E.

SOCIO-ECONOMIC CONDITIONS WHICH PERTAIN TO COST OF CONSTRUCTION AND OPERATION OF WATER AND SEWAGE TREATMENT FACILITIES AND QUANTITY OF WATER CONSUMPTION IN KENYA.
A report prepared for the USAID project on Lower Cost Methods of Water and Wastewater Treatment in Less Developed Countries. U.S.A. 1976.
KENYA: SEWAGE TREATMENT: SOCIO-ECONOMICS.

*This report entailed a detailed analysis of the socio-economic conditions which pertain to cost of construction and operation of water and sewage treatment facilities and quantity of water consumption in Kenya. It was stated that rational planning for the supply of adequate water and wastewater facilities, their operation, and maintenance, and the total cost of construction of such facilities consider many factors, derived as a result of this study.

Because of the African traditional way of life many people are not in favor of shared water and wastewater facilities. However, communal water points may be necessary where there are those who cannot pay for their water. Where it is not possible to construct more sophisticated water supply and wastewater facilities due to lack of funds, it might be advisable to use pit latrines which would be cheaper to construct and maintain.

284 Pescod, M.B.
Nair, J.V.

(Both) Environmental Engineering Division,
Asian Institute of Technology,
Bangkok, Thailand.

BIOLOGICAL DISC FILTRATION FOR TROPICAL WASTE TREATMENT: EXPERIMENTAL STUDIES
Water Research. U.K. 6. pp. 1509 - 1523, 1972.
1 table, 12 figures, 10 references.
SEWAGE TREATMENT: BIOLOGICAL DISC FILTER: ROTATING BIOLOGICAL CONTRACTOR: TROPICAL COUNTRIES.

* A report of experimental studies on organic wastewater treatment under tropical conditions using biological disc filtration units incorporating an anaerobic digestion compartment. Up to 95 per cent COD removal was achieved in treating a waste with COD near 1,000 mg/l at an aerobic volumetric loading of 4 kg. COD/m^3 day, giving 6 hours detention. An anaerobic compartment with the same capacity as the aerobic section gave a high degree of digestion of biological solids sloughing off the rotating discs.

●●285 Pillai, S.G.
Mohanrao, G.J.
Prabhakaro Rao, V.S.
Sastry, C.A.
Subrahmanyam, P.V.R.
Natarajan, C.V.

(All) Department of Biochemistry, Indian Institute of Science, Bangalore, India.

NATURAL PURIFICATION OF FLOWING SEWAGE
Current Science. India. 29. pp. 461-465, December 1960.
4 photographs, 4 tables, 7 references.
INDIA: NATURAL PURIFICATION: SEWAGE DISPOSAL.

*The object of this paper is to describe conditions, particularly at Bangalore, India, under which some 16 million gallons of sewage flows daily down on the outskirts of the town and purify itself naturally without any treatment. Bangalore is an inland town situated on the Deccan Plateau at a height of about 3,000 feet above sea-level. Its temperature is ranged from 46°F to 102°F in the winter and summer, respectively. Population number of Bangalore during the investigation period is reported to be 1.4 million and the daily water consumption is about 17 million gallons.

Most areas of Bangalore are provided with underground sewerage systems. The bulk of the sewage is taken to three outfalls from which the sewage is allowed to flow down in three natural channels having varying gradients, viz., 1:50, 1:100 and 1:800. It has been observed that the turbid, foul liquid flowing in these channels becomes clear and is oxidized to an appreciable extent after its flow over a distance generally of 1 to 5 miles, depending on the channel gradients. The purified effluent is then used by the villagers in the vicinity for irrigating the land, raising crops, and washing purposes. No pathogenic organisms have been found at the point where the liquid is used for washing but the presence of total bacteria at densities 3,000 to 10,000 numbers /ml is reported.

A close study of the natural treatment process has revealed that the important factors influencing purification of the flowing sewage include:

(i) adequate agitation or turbulence of the sewage and other conditions in the channel, which facilitate the dissolution of oxygen to the extent of about 3.5 mg/l. This evidence is supported by the fact that for the channel having the gradient of 1:50 distance from the outfall at which sewage is completely purified is 1.29 miles, while for the channels having the gradients of 1:100 and 1:800 the required flow distances are over 4 miles.

(ii) the consequent development in large numbers of ciliated protozoa in the clarification zone of the channels. These organisms provide flocculating activity and clarification of the sewage. Apart from that, they bring about nitrification which results in removal of ammonia and amino acids from the sewage. The quality of the final effluents from these channels are reported to be similar to that from the activated sludge process.

Observations have also been made at other locations in India on the flowing sewage. The authors made conclusions from these investigations that the extent of agitation of the sewage during its flow is a basic factor in the process of natural purification as it influences the initial oxygenation of the sewage, development of the protozoa and the consequent changes leading to purification. When, however, sewage flowed down in a more or less contour channel, it could not be oxygenated or purified to any appreciable extent even after its flow over a distance of 5 miles.

286 Reid, G.W.

Bureau of Water and Environmental Resources Research, University of Oklahoma,
Norman, Oklahoma, U.S.A.

FINAL REPORT: LOWER COST METHODS OF WATER AND WASTEWATER TREATMENT IN LESS DEVELOPED COUNTRIES (LDC).
A report submitted to the Office of Health, USAID under Contract No. AID/CM-ta-C-73-13, March 1, 1977. 28 pp.
7 figures, 5 tables, 6 references, 6 annexes.
DEVELOPING COUNTRIES: SEWAGE TREATMENT: MATHEMATICAL MODELS.

* The specific products of this research project are: a predictive or selection model supported with cost and demand analysis, computer and manual user guides, and an in-country supportable analytical kit. In addition a data classification and collection system was developed along with in-depth State-of-the-Arts involving historic, unpublished and published sources. Selected studies were made of the "high make" technologies, at Global sites,

of both water and wastewater treatment in terms of not only economic performance but consumer acceptance. The models were tested for consumer acceptance and the field analytical kit was also tested for complete in-country capability to monitor water and wastewater treatment devices.

287 Reid, G.W. — University of Oklahoma, Norman, Oklahoma, U.S.A.

Discenza, R. — University of Maine, Orono, Maine, U.S.A.

PREDICTION METHODOLOGY FOR SUITABLE WATER AND WASTEWATER PROCESSES
A report prepared by the Office of Research Administration, University of Oklahoma, U.S.A. for the USAID. U.S.A. October 1976. pp.

COMPUTER MODELS: DEVELOPING COUNTRIES: WASTEWATER TREATMENT PROCESSES.
*A predictive model was developed to help planners select suitable water and wastewater treatment processes appropriate to the material and manpower resource capabilities of particular countries at particular times. This model was computerized and a manual approach was developed.

The model brings together a number of critical inputs relating to the effective installation and use of various water and wastewater treatment methods, processes, and combinations of processes. The output of the model is a list of the plausible alternatives for water and/or wastewater treatment in developing country communities. This output allows planners or project engineers to look at all the plausible processes and their related construction costs, plus the operation, maintenance, and manpower requirements associated with each of the various processes. This technique will eliminate the problem of overlooking good processes for water and wastewater treatment.

288 Reid, G.W. — Bureau of Water and Environmental Resources Research, University of Oklahoma, Norman, Oklahoma, U.S.A.

Discenza, R. — University of Maine, Orono, Maine, U.S.A.

PREDICTION METHODOLOGY FOR SUITABLE WATER & WASTEWATER PROCESSES SUPPLEMENT I MANUAL COMPUTATION METHOD
A report prepared by the Office of Research Administration, University of Oklahoma, U.S.A. for the US AID. U.S.A.
21 pp. October 1975.
4 tables.
DEVELOPING COUNTRIES: WASTEWATER TREATMENT: COMPUTER MODELS.
*The selection of the most appropriate water and wastewater treatment method for developing countries by using the predictive model is not limited to situations where an electronic computer is available. A manual computation method has also been devised consisting of twelve steps including first the assigning of weights to the data which will determine the socio-technical level of the community under consideration. Next determination is made from information from the data form, of the availability of the

operation equipment, process materials, operation and maintenance supplies, and chemical supplies, and comparison is made with the basic processes and their manpower and resource requirements. Comparisons are also made either of the water quality of the community or the volume of receiving water, with the criteria given for a list of various combinations of processes. Feasible processes for the community have been identified at this point. Costs for the various feasible combinations of processes can be determined from data for the various water treatment costs contained in Appendix D of the Model and the current population of the community. The final step is selection of the lowest total cost or the lowest maintenance cost combination of processes.

289 Reid, G.W.
Muiga, M.I.

(Both) Bureau of Water and Environmental Resources Research, The University of Oklahoma, Norman, Oklahoma, U.S.A.

A MATHEMATICAL MODEL FOR PREDICTING WATER DEMAND, WASTE WATER DISPOSAL AND COST OF WATER AND WASTE WATER TREATMENT SYSTEMS IN DEVELOPING COUNTRIES

A report prepared by the Office of Research Administration, the University of Oklahoma, U.S.A. for the US AID. U.S.A. January 1976. 1140 pp.

15 tables, 5 figures, 54 references, 4 appendices.

DEVELOPING COUNTRIES: MATHEMATICAL MODELS: WASTEWATER DISPOSAL.

*This study uses mathematical modelling techniques to develop predictive equations for water supply and wastewater disposal models in developing countries utilizing socio-economic, environmental and technological indicators. Predictive equations are developed for three regions (Africa, Asia, and Latin America) for water demand, wastewater amounts, and construction and operation and maintenance costs of slow sand filter, rapid sand filter, stabilization lagoon, aerated lagoon, activated sludge and trickling filter processes. The primary objective of this study was to provide engineers, planners and appropriate public officials in developing countries with an innovative technique for more effective development of in-country water resources.

Data analysis indicated that water demand is a function of population, income and a technological indicator (percentage of households connected to water supply) while wastewater disposal was found to be a function of water demand, and two technological indicators (percentage of homes connected to public sewerage systems and percentage of household systems). The predictive equations for water treatment costs were found to be a function of a technological indicator (percentage cost of imported water supply materials), population, and the design capacity. The variables which gave the best correlation for waste water treatment costs were population, design capacity and the percentage of imported wastewater disposal materials.

290 Reyes, W.L.
Kruse, C.W.
Batson, M.S.C.

(All) School of Hygiene and Public Health, The Johns Hopkins University, Maryland, U.S.A.

THE EFFECT OF AEROBIC AND ANAEROBIC DIGESTION ON EGGS OF ASCARIS LUMBRICOIDES VAR. SUUM IN NIGHT-SOIL

American Journal of Tropical Medicine and Hygiene. U.S.A. 12(1). pp. 46-55. 1963.
2 tables, 4 figures, 10 references.

NIGHTSOIL: AEROBIC DIGESTION: ANAEROBIC DIGESTION: ASCARIS: PUBLIC HEALTH.

*Aerobic and anaerobic batch digestions of nightsoil seeded with eggs of pig ascaris as a test organism have been investigated at various temperatures to determine whether the eggs are preserved, cultured, or destroyed. The authors report that in neither system is the destruction of eggs complete at the end of nightsoil stabilization, unless temperatures are held at or above 38°C for the anaerobic and 45°C for the aerobic digestion. At these temperatures, nightsoil is well-digested and drainable in about 30 days of anaerobic and 20 days of aerobic digestion. Simple heating of raw nightsoil at 55°C for 20 minutes can also provide public health safety but this process has some practical objections because the undigested nightsoil has offensive odours and poor dewatering characteristics.

291 Ruderman, P.
Pflucker, J.
Espinoza, R.
Brown, J. C.

(All) Organizacion Panamericana de la Salud, Universidad Nacional de Ingenieria, Facultad de Ingenieria Sanitaria, Lima, Peru.

COURSE ON FINANCING OF SANITARY WORKS (CURSO SOBRE FINANCIACION DE OBRAS SANITARIAS)

Course of Financing of Sanitary Works, Universidad Nacional de Ingenieria, Facultad de Ingenieria Sanitaria, Lima, Peru. July 1968.
26 tables, 21 graphs, 4 references, 4 papers.

LATIN AMERICA: SANITATION: RURAL DEVELOPMENT: FINANCING: COST-BENEFIT.

*The course is designed to make the sanitary engineer aware of the input once played by Sanitation in the overall development process of Latin America.

The four papers presented touched on different aspects of economics, finances and engineering specifically applied to sanitation. Through the use of several practice examples, the course teaches how to evaluate cost and benefits, how to design functional tariff structures that allow systems to be self sufficient and how to maximize the benefits from the scarce resources available.

(Original paper written in Spanish)

292 Secretaria de Planeacion

Secretaria de Recursos Hidraulicos, Mexico.

LOW COST SYSTEMS FOR WASTE WATER TREATMENT
(SISTEMAS ECONOMICOS DE TRATAMIENTO)
Direccion General de Usos del Agua Y Prevencion de la Contaminacion
Direccion del Centro de Investigaciones y Entrenamiento
Contrato No. SP-73-C-16, Clave UAPC 73-16. Mexico. 1974.
13 chapters, 37 tables, 42 figures.
MEXICO: CONVENTIONAL METHODS: ECONOMIC ASPECTS: EXTENDED AERATION: IMHOFF TANKS: PRIMARY TREATMENT: SECONDARY TREATMENT: SEPTIC TANKS: STABILIZATION LAGOONS: WASTEWATER TREATMENT.

* Laboratory modeling and field investigations were designed to evaluate technically and economically, seven of the most widely used alternatives for wastewater treatment in Mexico, giving special interest to stabilization ponds, and its application to cities whose populations range was between 500 and 50,000 inhabitants.

The study concludes that stabilization ponds proved to be the best alternative, given the social, technical and environmental condition of the country and highlighted the need to develop design manuals for sewage treatment in small communities.

(Original paper written in Spanish)

293 Sieberg, D.

COMPARATIVE STUDY OF THE CONSTRUCTION, OPERATION AND MAINTENANCE COSTS FOR WASTEWATER TREATMENT PLANTS IN COMMUNITIES FROM 1000 TO 150,000 INHABITANTS
(ESTUDIO COMPARATIVO DE COSTOS DE CONSTRUCION, OPERACION Y MANTENIMIENTO PARA DIFERENTES TIPOS DE PLANTAS DE TRATAMIENTO DE AGUAS RESIDUALES PARA POBLACIONES DE 1000 A 150,000)
XIII Congreso Interamericano de Ingenieria Sanitaria. Paraguay. August 1972.
42 tables, 13 figures, 3 graphs.
WASTEWATER TREATMENT PLANTS: ACTIVATED SLUDGE: CONSTRUCTION: COSTS: DESIGN PARAMETERS: EXTENDED AERATION: LAGOONS: MAINTENANCE: OPERATION: OXIDATION PONDS: PERCOLATING FILTERS.

* The paper is oriented to aiding the engineer in the selection of the different alternatives for wastewater treatment. It analyzes the major factors that enter into the decision-making process. A comparative study on the costs and alternatives for small communities is presented taking into consideration manpower, resource availability, soil characteristics, land availability, etc.

(Original paper written in Spanish)

294 Yanez, F.

Centro Panamericano de
Ingenieria Sanitaria y Ciencias
del Ambiente (CEPIS),
Lima. Peru.

CONSIDERATIONS IN THE SELECTION AND APPLICATION OF WASTEWATER TREATMENT TECHNOLOGIES
(CONSIDERACIONES EN LA SELECCION Y APLICACION DE TECNOLOGIAS DE TRATAMIENTO)

Simposio sobre tratamiento y Disposicion de Aguas Sanitarias
Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente Buenos Aires, Argentina. 31 pp. June 1976.
28 references, 10 figures, 6 tables.
WASTEWATER: ACTIVATED SLUDGE: AERATION TANKS: DISSOLVED OXYGEN: LOW COST TECHNOLOGY: LOW PRESSURE AERATION: SEDIMENTATION SETTLEMENT TANKS: STABILIZATION: TREATMENT.

* The paper evaluates several alternatives for wastewater treatment, emphasizing those of lower costs in developing countries. Working levels and engineering needs for each alternative are discussed. Financial considerations for selecting a given technology are presented for each case.

(Original paper written in Spanish)

4A. Reuse: Irrigation

295 Aquirre, J.

Centro de Investigacion y Entranamiento para el Control de la Calidad de Agua. Mexico.

WASTEWATER REUSE FOR AGRICULTURE AND INDUSTRY (REUTILIZACION DE AGUAS RESIDUALES PARA PROPOSITOS AGRICOLAS E INDUSTRIALES)
Secretaria de Recursos Hidraulicos. Mexico. 16 pp. October 1974. 6 tables.
MEXICO: BACTERIA: BORIUM: DOMESTIC REUSE: INDUSTRIAL REUSE: IRRIGATION: PRODUCTIVITY: SALINITY: SOILS: WASTEWATER REUSE: WATER QUALITY.

* Urban and industrial development in Mexico has not taken place in those areas where water is abundant; therefore, reuse of waters has become a first priority in the development of new hydric resources. Agriculture demands 90% of the recycled water. The report analyses the possible effects in human metabiolism of the crops that have been irrigated with wastewaters and provides standards for water quality.

(Original paper written in Spanish)

296 Amirov, R.O.
Salamov, D.A.

(both) Department of Hygiene, Aliev Azerbaidzhan Graduate Medical Institute, Baku, USSR.

SANITARY-HELMINTHOLOGICAL EVALUATION OF SEWAGE FARMS UNDER CLIMATIC CONDITIONS OF THE APSHERON PENNISULA
Hygiene and Sanitation. USA. (Gigienai Sanitariia. USSR) 32(6). pp. 437-439. 1967.
USSR: DOMESTIC SEWAGE: IRRIGATED AGRICULTURE: HOT CLIMATES: VEGETABLES: FLOODING IRRIGATION: FURROW IRRIGATION: HELMINTH EGGS: THERMAL PROCESSING.

*Domestic sewage from Baku district, USSR, has been utilized in irrigated agriculture in conditions of the Apsheron Penninsula which are sandy and sandy-loamy soils, having a hot climate in the summer. The results show that vegetables grown on soil irrigated by flooding with sewage are contaminated with helminth eggs. However, in the case of furrow irrigation the vegetables carry no viable helminth eggs. The contamination of vegetables is lower in summer and higher in autumn and winter. The authors recommend that irrigation should be limited only to food plants which undergo thermal processing before being eaten and only by furrow irrigation.

297 Anon.

Central Public Health
Engineering Research Institute,
Nagpur. India.

SEWAGE FARMING - A COURSE MANUAL
A course given by Central Public Health Engineering Research Institute. India. November 1973.
10 chapters, 19 tables, 2 figures.
SEWAGE FARMING: EFFLUENT RE-USE: PUBLIC HEALTH: SEWAGE IRRIGATION: INDIA.

* A manual for a two and a half day course given for three years to compost development officers, public health engineers, farm superintendents, etc. Provides an introduction to scientific farming and describes Indian practice. Important sections in the manual include descriptions of factors affecting plant life, sewage as an irrigant, principles of farm management, problems of salinity and alkalinity, sewage farming in India, public health aspects of sewage farming and desirable management practices. A final short chapter gives a simple design for a sewage farm in Nagpur.

298 Anon.

Committee on Natural Resources,
Planning Commission,
Government of India.

UTILIZATION OF URBAN WASTES
Unpublished Report. 26 pp. August 1963.
An appendix of four tables.
SEWAGE: SULLAGE: INDIA: IRRIGATION.

* Sewage/sullage from most cities in India is disposed of by (i) irrigation on the land with or without treatment, and (ii) discharge into the nearest river or stream either throughout the year where no sewage irrigation farms exist or at least for some part of the year where there are sewage farms. The government is encouraging further uses of sewage in irrigation and has laid out several plans in the coming years. Data tabulation of selected towns in India that are utilizing sewage/sullage for irrigation is included.

299 Anon.

Instituto Nacional de Planificacion (INP),
Banco Interamericano de Desarrollo (BID),
Universidad Nacional de Ingenieria.
Lima, Peru.

INVESTMENT PROJECT...UTILIZATION OF LIMA'S WASTEWATERS FOR LAND IRRIGATION
(PROYECTO DE INVERSION...USO DE AGUAS SERVIDAS DE LIMA PARA RIEGO DOCUMENTO DE TRABAJO)
Programa de Capacitacion en Preparacion y Evaluacion de Proyectos de Inversion. Peru. 394 pp. May 1974.
59 tables, 11 graphs, 9 annexes, 3 maps.
PERU: BILOGICAL FILTERS: CLIMATOLOGY: ECONOMIC ASPECTS: GROUNDWATERS: IRRIGATION: IRRIGATION SYSTEMS: SURFACE WATERS: WATER REUSE.

* Two alternatives are presented for the treatment of Lima's wastewaters: stabilization ponds and biological filters. Both are designed to reduce the sea pollution from the dumping of wastes into the Pacific Ocean. Economic analysis favours the second choice since there exists the potential for recovering through irrigation 6900 hectareas in the vicinity of the city. An additional benefit derived from the biological treatment is the reduction in nitrogened fertilizers that would be needed to upgrade the lands.

(Original document written in Spanish)

300 Anon.

Water Quality Control Branch,
Robert S. Kerr Environmental Research Laboratory,
Ada, Oklahoma. U.S.A.

LAND APPLICATION OF SEWAGE EFFLUENTS AND SLUDGE...SELECTED ABSTRACTS
U.S. Environmental Protection Agency, Technology Series. U.S.A. Report No. EPA-660/2-74-042. 248 pp. June 1974.
MUNICIPAL WASTEWATER: TREATMENT: SLUDGE: DISPOSAL: REUSE: IRRIGATION: RECLAMATION: GROUNDWATER: RECHARGE: PUBLIC HEALTH: AGRICULTURE: ECONOMICS.

* This report includes 563 selected annotated abstracts which have been compiled as part of several EPA contracts on land application of sewage effluents and sludge. The literature, which dates from 1930 to 1973, contains various topics of waste disposal on land such as: land reclamation, aquaculture and agricultural reuses, public health aspects and groundwater recharge.

301 Anon.

World Health Organization,
Serie de Informes Tecnicos,
Informe No. 517.
Switzerland.

REUSE OF WASTEWATERS...METHODS AND CRITERIA FOR SANITARY PROTECTION OF WASTEWATERS
(APROVECHAMIENTO DE EFLUENTES...METODOS Y MEDIDAS DE PROTECCION SANITARIA EN EL TRATAMIENTO DE AGUAS SERVIDAS)
World Health Organization. Switzerland. 69 pp. 1973.
Two volumes, 60 references, 5 tables, 4 figures, 2 annexes
WASTEWATER: REUSE: AGRICULTURE: EFFLUENT QUALITY: HEALTH HAZARDS: INDUSTRY: RECREATION: VIRUSES.

* The state of the art in wastewater treatment technologies is registered in the report as well as the risks involved in the reuse of the effluents for agricultural, industrial, and domestic purposes. Quality and supervision criteria for recycled waters are set forth. The paper is complemented with an extensive bibliography on the subject and with the results of a survey on wastewater reuse in thirty countries throughout the world.

(Original paper written in Spanish)

302 Applegate, C.H.
Gray, D.V.

(Both) Environmental Health Division,
General Electric Company,
St. Petersbury. U.S.A.

LAND SPREADING EFFLUENT FROM A SECONDARY FACILITY
Water and Sewage Works Journal. U.S.A. 122(7). pp. 85-87. July 1975.
1 table, 2 figures.
SEWAGE: INDUSTRIAL WASTEWATERS: TREATMENT: RETENTION LAKE: SPRAY IRRIGATION: REUSES: U.S.A.

* The system described in this article is used for treatment of combined sewage and industrial wastewaters. It comprises of extended aeration activated sludge treatment of sewage and pH ajustment of the industrial wastes, the combined effluents are directed to an aerated lake. They are then sprayed over a ten-acre field containing a network of subsurface drainage pipes. The percolated effluent is pumped to a secondary retention lake prior to discharging to a salt water bayou. Data are presented, showing both the efficiency of the system in pollutant removal and the quality of the effluent as compared to the Florida state standards, U.S.A. Some considerations for reuse of the secondary lake water are discussed.

303 Babov, D.M.
Nadvornyi, N.N.
Keimakh, A.S.

(All) Department of Hygiene,
Odessa Medical Institute,
U.S.S.R.

THE MICROFLORA OF VEGETABLES AND OTHER CROPS GROWN ON SEWAGE FARMS
Hygiene and Sanitation. U.S.A. 32(3). pp. 273-275. 1967.
1 reference.
BACTERIAL CONTAMINATION: SEWAGE FARMS: USSR: IRRIGATION: PATHOGENS.

* A study of bacterial contamination of crops grown on sewage farms. Although irrigation with sewage may result in the contamination of vegetables and other crops by enteric bacteria, under the conditions of the southern Ukraine, USSR, pathogenic microorganisms are rarely detected two weeks after the cessation of irrigation because of the imitation of active self-purification processes.

(Original paper written in Russian)

304 Bajaj, K.L.
Singh, J.
Verma, A.K.
Bhatia, I.S.

(All) Dept. of Chemistry and Biochemistry,
Punjab Agricultural University, Ludhiana,
India.

EVALUATION OF THE SEWAGE WATER OF THE PUNJAB STATE FOR IRRIGATION
Journal of Research. India. 11(1). pp. 80-83. 1974.
2 tables, 14 references.
SEWAGE: INDIA: SODIUM-ADSORPTION-RATIO (SAR); NUTRIENTS: SALINITY: IRRIGATION.

* Sewage water from different cities of the Punjab State, India has been analyzed for its suitability for irrigation. Based on the conductivity and sodium adsorption ratio (SAR) values, four types of sewage water are classified ranging from low-salinity water to very-high-salinity water. The sewage waters are found to contain considerable amounts of nutrients such as N, P, and K.

305 Baubinas, A.K.

Nauchno-Issledovatelskii Institut Epidemiologii Mikrobiologii i Gigieny, Vilnius. USSR.

BACTERIAL CONTAMINATION OF PERENNIAL GRASSES IN OVERHEAD IRRIGATION WITH SEWAGE
Gigiena i Sanitariya. USSR. pp. 97-99. 1975.
BACTERIAL CONTAMINATION: USSR: E.COLI: ENTEROCOCCI: PATHOGENS: OVERHEAD IRRIGATION: SEWAGE: SEWAGE FARMS.

* The bacterial contamination of perennial grasses by E. Coli enterococci and pathogenic organisms during and after overhead irrigation with sewage at sewage farms in USSR has been studied. The bacteria in the sewage during overhead irrigation can be carried far by air currents, leading to massive contamination of the grass. The microorganisms on the plants exposed to direct solar rays generally die-off within one week. Grazing of cattle 14 days after irrigation is reported to be safe.

(Original paper written in Russian)

306 Bell, R.G.

Agriculture Canada, Canada.

PERSISTENCE OF FECAL COLIFORM INDICATOR BACTERIA ON ALFALFA IRRIGATED WITH MUNICIPAL SEWAGE LAGOON EFFLUENT
Journal of Environmental Quality. U.S.A. 5(1). pp. 39-42. January-March 1976.
3 tables.
COLIFORM BACTERIA: SEWAGE EFFLUENT: IRRIGATION: LIVESTOCK.

* Fecal coliforms on alfalfa plants irrigated with sewage lagoon effluent are completely destroyed by exposure to 10 hours of bright sunlight. No decrease is observed in the absence of bright sunlight under cool, damp, overcast conditions. The author concludes that it requires at least two sunny days between cessation of effluent irrigation and consumption of forage to adequately protect the livestock.

307 Bishnoi, O.P.

DILUTION OF SEWAGE FOR IRRIGATION
Journal of the Institution of Engineers. India. Volume 47. PH1. pp. 11-17. October 1966.
4 tables, 2 references.
DOMESTIC SEWAGE: IRRIGATION: FOOD SUPPLY: SEWAGE DILUTION: NUTRIENTS: FERTILIZERS.

* Domestic sewage can be profitably used as irrigation of land to increase food supply. From the point of view of manurial content, sewage can be diluted to provide the same percentage of nutrients as would be obtained from the required dose of chemical fertilizer for a given crop. However, the dilution for different crops needs to be worked out. Some problems which may be involved in sewage utilization for agricultural purposes are discussed.

308 Bouwer, H.
Lance, J.C.
Riggs, M.S.

U.S. Water Conservation Laboratory, Phoenix. U.S.A.

HIGH RATE LAND TREATMENT II...WATER QUALITY AND ECONOMIC ASPECTS OF THE FLUSHING MEADOWS PROJECT
Journal of the Water Pollution Control Federation. 46(5). pp. 844-859. May 1974.
9 figures, 3 tables, 15 references.
USA: SEWAGE EFFLUENT: RENOVATION: GROUNDWATER RECHARGE: RAPID INFILTRATION BASINS: FILTRATION: WATER CHARACTERISTICS: FAECAL BACTERIA: IRRIGATION: RECREATION: COST.

* A report of a five-year experimental work on renovating secondary sewage effluent by groundwater recharge with rapid infiltration basins in the sandy and gravelly materials of the Salt River bed in Arizona. The filtration of the secondary effluent through the sands and gravels resulted in essentially complete removal of suspended solids and BOD. Most fecal bacteria were removed in the first 2 ft. (0.6m) of the soil and none were encountered after 300 ft. (91 m) of horizontal travel of the renovated water. Other characteristics of the renovated water analyzed were found to be within the ranges suitable for unrestricted irrigation and recreation. The cost of this renovation system has been estimated at about U.S. $4.3/1,000 m^3. This is reported to be much less than the the cost of equivalent inplant tertiary treatment to produce a renovated water of similar quality.

309 Bouwer, H.
Rice, R.C.
Escarcega, E.D.

(All) U.S. Water Conservation Laboratory, Phoenix. U.S.A.

HIGH-RATE LAND TREATMENT I. INFILTRATION AND HYDRAULIC ASPECTS OF THE FLUSHING MEADOWS PROJECT
Journal of the Water Pollution Control Federation. U.S.A. 46(5). pp. 834-843. May 1974.
5 figures, 5 tables, 11 references.
RENOVATION: EFFLUENT: RECHARGE: GROUNDWATER: INFILTRATION: U.S.A.: AQUIFERS.

* An experimental project for renovating secondary sewage effluent by groundwater recharge with infiltration basins located in Phoenix, Arizona. One acre of basin area is found to be capable of receiving 1350 m^3/day of effluent. A mature stand of grass can receive higher infiltration rates than a bare soil. The hydraulic conductivity of the aquifer is not measurably affected by the effluent recharge.

310 Bruvold, W.H.
Ward, P.C.

(Both) School of Public Health,
University of California,
Berkeley, U.S.A.

USING RECLAIMED WASTEWATER -- PUBLIC OPINION
Journal of Water Pollution Control Federation. U.S.A. 44(9). pp. 1690-1696. September 1972.
4 tables, 10 references.
U.S.A.: PUBLIC OPINION: PUBLIC ACCEPTANCE: RECLAMATION: WASTEWATER: LAWN IRRIGATION: SOCIAL: REUSE.
* A survey in ten cities in California of public opinion on the use of reclaimed wastewater. Although the results do not indicate major opposition to such resue, the authors suggest a way to foster more public acceptance by starting with uses of least opposition, such as lawn irrigation, and then moving upwards step by step, as acceptability increases and as reclamation techniques improve.

311 Crites, R.W.
Pound, C.E.

LAND TREATMENT OF MUNICIPAL WASTEWATER
Environmental Science and Technology. U.S.A. 10(6). pp. 548-551. June 1976.
2 photos, 2 tables.
SEWAGE DISPOSAL: RECHARGE: U.S.A.: AUSTRALIA
* A description of slow rate, rapid infiltration and overland-flow land disposal systems for municipal wastewater. Soil treatment mechanisms are explained. Examples of the different disposal systems in communities in the U.S.A. and Australia are included.

312 Day, A.D.
Taher, F.A.
Katterman, F.R.

(All) University of Arizona, Arizona. U.S.A.

INFLUENCE OF TREATED MUNICIPAL WASTEWATER ON GROWTH FIBER, ACID-SOLUBLE NUCLEOTIDES, PROTEIN AND AMINO ACID CONTENT IN WHEAT GRAIN
Journal of Environmental Quality. U.S.A. 4(2). pp. 167-169. April-June 1975.
2 tables.
SEWAGE: IRRIGATION: LAND APPLICATION: WHEAT: NUTRIENTS.
* The effects of treated municipal sewage on growth fiber, acid-soluble nucleotides, protein, and amino acid content in grain from wheat are examined. The authors conclude that the treated municipal sewage can be an effective source of irrigation water and plant nutrients for the production of good quality grain grown in sandy loam soil.

313 Dowdy, R.H.
Larson, W.E.

(Both) ARS and University of Minnesota. U.S.A.

THE AVAILABILITY OF SLUDGE-BORNE METALS TO VARIOUS VEGETABLE CROPS
Journal of Environmental Quality. U.S.A. 4(2). pp. 278-282. April-June 1975.
1 figure, 5 tables, 29 references.
SEWAGE: HEAVY METALS: SLUDGE: BIO-ACCUMULATION: VEGETABLES.

* The extent to which sludge-borne metals accumulate in the edible tissue of seven vegetable crops grown on a sludge-amended sandy soil is determined under field conditions. Generally, metal contents of vegetative tissue are higher than those of the fruiting, root and tuber tissue. Soil with an application of 450 ton/ha sludge does not provide an increase of metal accumulations in crop tissue more than two or three-fold. Lettuce is an accumulator, but potatoes and carrots are excellent non-accumulators of metals.

314 Dugan, G.L.
Young, R.H.F.
Lau, L.S.
Ekern, P.C.
Loh, P.C.S.

(All) Dept. of Civil Engineering, University of Hawaii, Honolulu. U.S.A.

LAND DISPOSAL OF WASTEWATER IN HAWAII
Journal of Water Pollution Control Federation. U.S.A. 47(8). pp. 2067-2087. August, 1975.
7 tables, 4 figures, 11 references.
EFFLUENT: LAND APPLICATION: IRRIGATION: NUTRIENTS: SOLIDS: SALTS: VIRUSES: MANAGEMENT: UTILIZATION: U.S.A.

* A feasibility study of applying secondary treated wastewater effluent to selected irrigated pond areas in the State of Hawaii. Both pilot and field experiments have been carried out and favourable results are obtained with respect to nutrients, solids and salts removal. Another extensive study also reveals that the test soils are highly effective in adsorbing viruses from the applied effluent. The authors discuss some management measures in irrigation system which are essential in order to achieve the goal of wastewater utilization.

315 Dunlop, S.G.

Department of Microbiology,
University of Colorado Medical
Center,
Boulder. U.S.A.

SURVIVAL OF PATHOGENS AND RELATED DISEASE HAZARDS
Proceedings of Municipal Sewage Effluent for Irrigation, Louisiana Polytechnic Institute Symposium, the Lousiana Polytech Department of Agricultural Engineering. U.S.A. Wilson, C.W. and Beckett, F.E. (Eds.). pp. 107-121. July 30, 1968.
1 table, 62 references.
HEALTH HAZARDS: IRRIGATION: TREATED EFFLUENT: SEWAGE: EPIDEMICS: PATHOGENS: SURVIVAL TIMES.

* A survey of health hazards which may result from irrigation with reclaimed municipal wastewater. No disease outbreak has been traced to irrigation with properly treated and disinfected sewage, but many epidemics have been caused by irrigation with improperly treated wastes. Survival times of various pathogenic organisms in soils, plants, and waters are tabulated and discussed.

316 Fedotov, V.E.
Gorkopenko, F.G.

USE OF SEWAGE FOR IRRIGATION
(ISPOLZOVAIYE STOCHNYKH VOD DLYA OROSHENIA)
NWWA Translation from Gidrotekhnika i Melioratsya. Transcript No. 9. pp. 1, 4-6. September 1972.
IRRIGATION: USSR: SEWAGE: CROP YIELDS: SETTLING PONDS: INDUSTRIAL WASTEWATER.

* The experiences of a collective farm with irrigation by means of sewage from a community located in a dry area in USSR are given. Yields of crops irrigated with sewage have been found to be higher than the yields of those irrigated with usual irrigation water (river water). Irrigation of treated wastewater from a series of settling ponds is found to be better than those with the untreated sewage since the materials in the untreated sewage clogged the soil causing rotting of the crops in the fields. An addition of industrial wastewater to sewage is found to adversely affect crop yield.

(Original paper written in Russian)

317 Feinmesser, A.

Water Commission,
Israel.

SURVEY OF SEWAGE UTILIZATION FOR AGRICULTURAL PURPOSES IN ISRAEL
Advances in Water Pollution Research, Proceedings of the 5th International Water Pollution Research Conference. Pergamon Press. U.K. Volume 1. pp. I-33/1-7. 1971
4 tables.
SEWAGE: ISRAEL: AGRICULTURAL RE-USE: IRRIGATION: TREATMENT: STABILIZATION PONDS.

* A summary of sewage treatment and effluent reuse practices in Israel. The most common form of sewage treatment is waste stabilization ponds (anaerobic and facultative). Approximately one third of all treated urban sewage is re-used, principally for irrigation of crops (63%) and fruit trees (30%) and in fish culture (7%).

318 Fogg, C.E.

Soil Conservation Service,
U.S. Department of Agriculture,
Washington. D.C. U.S.A.

LAND APPLICATION OF SEWAGE EFFLUENTS
Proceedings of the 28th Symposium of the Soil Conservation Society of America. pp. 148-152. 1973.
4 tables
SEWAGE EFFLUENTS: SPRAY IRRIGATION: OVERLAND RUNOFF: RAPID INFILTRATION: NITROGEN: PHOSPHORUS: POTASSIUM: MAGNESIUM: SULPHUR: CROP UPTAKE.

* Spray irrigation is reported to be a satisfactory method for final treatment of sewage effluents. This paper describes some typical characteristics of sewage effluents and a guide to renovative capacity of soils recommended for spray irrigation, overland runoff, and rapid infiltration systems. A list of representative amounts per acre of nitrogen, phosphorus, potassium, magnesium and sulphur that may be used by various crops each year is also included.

319 Furr, A.
Stoewsand, G.S.
Bache, C.A.
Lisk, D.J.

(All) Virginia Polytechnic Institute,
Virginia. U.S.A.

STUDY OF GUINEA PIGS FED SWISS CHARD GROWN ON MUNICIPAL SLUDGE-AMENDED SOIL
Archives Environmental Health. U.S.A. 31(2). pp. 87-91. March-April 1976.
3 tables.
HEAVY METALS: SEWAGE: LAND: SLUDGE: ANIMALS: PLANTS: TOXIC SUBSTANCES.

* The effects on Guinea pigs of ingestion of Swiss chard, field-grown on soil amended with 100 dry ton/acre of municipal sewage sludge from Washington, D.C., are examined. Elevated concentrations of several elements found in the Swiss chard also appear at higher levels in certain animal tissues. The elements include antimony in adrenal, cadmium in kidney, manganese in liver tissues, and tin in several tissues. The animals show no observable toxicological effects.

320 Gagnon, J.D.

Environment Canada,
Quebec 10. Canada.

ENVIRONMENTAL ASPECTS OF SEWAGE-DERIVED FERTILIZERS
U.S. Forest Service Technical Report No. NE3. U.S.A.
pp. 101-107. 1973.
1 table, 1 figure, 10 references.
SLUDGE: FERTILIZER: PLANTATION: GROWTH RESPONSE:
ENVIRONMENTAL HAZARDS.

* A 4-year study on the application of digested sludge as fertilizers to a 10-year old white spruce plantation established on sandy soil. There is a 30% increase in height-growth response as compared to the control trees having no sludge addition. Environmental hazards resulting from this application are reported to be minimal.

321 Gerba, C.P.
Wallis, C.
Melnick, J.L.

(All) Baylor College,
Houston. U.S.A.

FATE OF WASTEWATER BACTERIA AND VIRUSES IN SOIL
Journal Irrigation and Drainage Division, American Society of Civil Engineers. U.S.A. 101(3). pp. 157-174. September 1975.
5 tables, 63 references.
BACTERIA: VIRUSES: SOIL: PATHOGENS: PERCOLATION: STRAINING:
SEDIMENTATION: ADSORPTION.

* Bacterial survival in soil is affected by moisture content, temperature, organic matter, and antagonism by soil microflora. In most instances survival of pathogens is less than two to three months. Removal of bacteria from sewage during percolation through soil is accomplished largely at the soil surface by straining, sedimentation, and adsorption. Removal of viruses by soil occurs largely by adsorption. The fate of wastewater bacteria and viruses in soil is reviewed.

322 Gilbert, R.G.
Rice, R.C.
Bouwer, H.
Gerba, C.P.
Wallis, C.
Melnick, J.C.

(All) U.S. Drug Administration,
Arizona. U.S.A.

WASTEWATER RENOVATION AND REUSE,..VIRUS REMOVAL BY SOIL FILTRATION
Science. U.S.A. 192(4243). pp. 1004-1005. June 4, 1976.
1 table.
VIRUSES: SEWAGE DISPOSAL: RECHARGE: WASTEWATER: REUSE.

* Secondary sewage effluent and renovated water from four wells in operation since 1967 were tested about every two months in 1974 for viruses during flooding periods. Viruses were not detected in any renovated water samples. Human viral pathogens did not move through soil into groundwater, but were apparently absorbed and degraded by the soil.

323 Giordano, P.M.
Mortvedt, J.J.
Mays, D.A.

(All) Tennessee Valley Authority (TVA). U.S.A.

EFFECT OF MUNICIPAL WASTES ON CROP YIELDS AND UPTAKE OF HEAVY METALS
Journal of Environmental Quality. U.S.A. 4(3). pp. 394-399. July-September 1975.
7 tables.
CROP: HEAVY METALS: GARBAGE COMPOST: SEWAGE SLUDGE: BIO-ACCUMULATION.
* Crop uptake of several heavy metals contained in garbage compost and sewage sludge applied at relatively high rates is determined. Application of rather high rates of garbage compost and sewage sludge results in increased yields of corn, although tissue concentrations of several heavy metals are higher. In contrast, lower yeilds of beans are obtained with this same application, possibly due to the greater sensitivity of beans to high rates of available zinc.

●● 324 Goldberg, S.D.

Irrigation Department, The Hebrew University of Jerusalem. Israel.

NEW TECHNIQUES IN THE REUSE OF EFFLUENTS
A report prepared for the World Bank, Washington, D.C. U.S.A.
7 pp. November 1976.
2 tables, 5 references.
SEWAGE EFFLUENTS: VEGETABLE CROP CULTIVATION: DRIP IRRIGATION: DISINFECTION: FUMIGATION: EPIDEMICAL HAZARDS.
*An experiment is described in which raw sewage was used to irrigate cucumbers and egg-plants. These crops were selected as being most vulnerable to contamination by the sewage. Drip irrigation of sewage was practiced by:

1) laying the drip irrigation pipes on the ground;
2) covering the ground with plastic and burying the edges;
3) fumigating the soil under the plastic; and
4) punching holes in the plastic through which the vegetables were planted.

This method was compared to cultivation of the cucumbers with drip irrigation but without any plastic cover protection. It was shown that both methods using drip irrigation exhibited lower bacteriological contamination than similar cucumbers purchased on the open market which had been grown using conventional irrigation techniques.

In a second phase of experimentation an "artificial epidemic" was created in which mutated bacteria and Sabin's weak poliomyelitis type viruses were introduced into the sewage irrigation waters in very high concentrations.

It was concluded that, with high levels of significance, the protected treatment(with plastic and fumigation) yielded a safe crop of cucumbers in contrast to highly contaminated cucumbers from non-protected treatment.

325 Hinesly, T.D.

U.S. Corps of Engineers,
Washington. D.C., U.S.A.

WATER RENOVATION FOR UNRESTRICTED RE-USE
Water Spectrum. U.S.A. 5(2). pp. 1-8. 1973.
10 photos, 1 chart
WASTEWATER RECYCLING: SPRAY IRRIGATION: WASTEWATER TREATMENT: SOIL EROSION: HEALTH HAZARDS.

* The author states that a wastewater recycling through spray irrigation has the greatest applicability to different soil types and cultural practices of all methods of wastewater treatment. The physical, chemical and biological actions that take place during land treatment processes are described, giving communities a scientific basis for determining which choice is best. Through effective management practices, erosion and health hazards will not be a serious problem.

326 Katzenelson, E.
Telch, B.

(Both) Hebrew University,
Israel.

DISPERSION OF ENTERIC BACTERIA BY SPRAY IRRIGATION
Journal of Water Pollution Control Federation. U.S.A.
48(4). pp. 710-716. April 1976.
2 figures, 4 tables, 21 references.
SALMONELLA: ISRAEL: SPRAY IRRIGATION: SEWAGE: COLIFORM BACTERIA.

* Data are obtained about the number and types of enteric bacteria dispersed into the air during spray irrigation with sewage in two communities in Israel. Coliform bacteria are found in the air at 350 m. downwind from the irrigation line. In one case, a salmonella bacterium is isolated 60 m. from the irrigation source.

327 Kotia, R.R.

Compost Development Office,
Krishibhuvan, Paldi,
Ahmedabad. India.

SEWAGE FARMING IN GUJARAT
Report on the Seminar on Sewage Treatment and Disposal for small communities. India. Paper No. 15. 7 pp. March 13-14, 1971.
3 tables in Appendix.
SEWAGE FARMING: AGRICULTUREAL RE-USE: SEWAGE IRRIGATION: INDIA.

* A review of sewage farming in Gujarat State in India. Sewage distribution and farm management are discussed. Problems in sewage farming are outlined and solutions recommended. Sewage dosage rates used at different locations are given in a table and application rates for different soil types suggested in another table.

328 Kott, H.
Fishelson, L.

(Both) Dept. of Food Engineering and Biotechnology, Technion-Israel Institute of Technology, Haifa, Israel.

SURVIVAL OF ENTEROVIRUSES ON VEGETABLES IRRIGATED WITH CHLORINATED OXIDATION POND EFFLUENTS
Israel Journal of Technology. Israel. 12(5-6). pp. 290-297. 1974.
5 figures, 3 tables, 19 references.
ISRAEL: OXIDATION POND: EFFLUENT: VIRUSES: AGRICULTURE: CHLORINATION: SOLAR RADIATION: INACTIVATION.

* An investigation conducted in Israel on the survival of Poliovirus 1 LSC on the surface of vegetables contaminated by virus infected and chlorinated oxidation pond effluents. A factor is found in oxidation pond effluents which, affected by solar radiation (over a minimum of 0.35 cal/cm^2 -- minute), accelerates the rate of inactivation of viruses on the vegetable surface. The maximum percentage of viruses remaining is observed to be 1.63% when exposed to sunlight for 6 hours as compared to 8.45% when the vegetables are kept in darkness.

329 Kott, Y.

Environmental Engineering Laboratory, Technion, Israel Institute of Technology, Haifa, Israel.

HAZARDS ASSOCIATED WITH THE USE OF CHLORINATED OXIDATION POND EFFLUENTS FOR IRRIGATION
Water Research. U.K. 7(6). pp. 853-862. June 1973.
7 tables, 17 references.
ISRAEL: IRRIGATION: OXIDATION POND: CHLORINE: PUBLIC HEALTH: EFFLUENT: ALGAE: CONTACT TIME.

* A possibility of overcoming the health hazards, which may arise due to irrigation with oxidation pond effluents in Israel has been investigated. The use of chlorine is found to be practical because algal cells in the pond effluent do not exert chlorine demand during a 2-hour contact time. For maximum safety, the author suggests an application of 15 mg/l chlorine dose for a 2-hour contact.

330 Krishnamoorthi, K.P.
Abdulappa, M.K.
Anwikar, A.K.

(All) Central Public Health Engineering Research Institute, Nagpur, India.

INTESTINAL PARASITIC INFECTIONS ASSOCIATED WITH SEWAGE FARM WORKERS WITH SPECIAL REFERENCE TO HELMINTHS AND PROTOZOA
Proceedings of Symposium on Environmental Pollution, Central Public Health Engineering Research Institute. India. pp. 347-355. January 17-19, 1973.
9 tables, 3 references.
SEWAGE FARMING: INTESTINAL PARASITES: INDIA: PATHOGENS: PUBLIC HEALTH: EXCRETA DISPOSAL: AGRICULTURAL RE-USE.

* A report on the findings of stool examinations of workers at five large sewage farms at Jaipur, Madras, Hyderabad, Trivandrum and Poona in India. 466 samples from sewage farm workers are compared with 432 samples from a control population for the presence of Ancylostoma duodenale (hook worm), Ascaris lumbricoidos (round worm), Trichuris trichura (whip worm), Enterobius vermicularis (pin worm), Hymenolepis nana (dwarf tapeworm) Entamoeba histolytica and Giardia intestinalis. The incidence and multiplicity of infection was found to be much greater in sewage farm workers.

331 Kutera, K.

TREATMENT AND DISPOSAL OF WASTEWATERS OF SETTLEMENTS IN RURAL, AGRICULTURAL, NON-URBAN AREAS.
7th Conference on Water Pollution Research. Paris, France. 12 pp. September 13, 1974.
8 figures, 16 references in Polish.
RURAL:WASTE WATER DISPOSAL: IRRIGATION.

*Describes a year-round system for spreading and/or irrigation of household wastewaters from small rural communities. Discusses ice formation, winter irrigation, as well as types and kinds of soils.

332 Larkin, E.P.
Tierney, J.T.
Sullivan, R.

(All) Virology Branch, Division of Microbiology, Bureau of Foods, Cincinnati. U.S.A.

PERSISTENCE OF VIRUS ON SEWAGE-IRRIGATED VEGETABLES
Journal of the Environmental Engineering Division, American Society of Civil Engineers. U.S.A. 102(EE1). Proceeding Paper 11935. pp. 29-35. February 1976.
3 tables, 23 references.
DISEASES: SPRAY IRRIGATION: SLUDGE: VEGETABLES: VIRUSES: LAND DISPOSAL.

* A number of municipalities are contemplating land disposal of sewage effluents. However, the present treatment systems do not completely remove viruses from such wastes. A pilot-scale spray-irrigation project of vegetables irrigated with virus-innoculated sewage sludge and effluent has demonstrated that poliovirus 1 persist on vegetable surfaces for as long as 36 days, indicating potential contamination of vegetables when spray-irrigation systems are used.

333 Law, J.P.

Water Quality Control
Research Program,
Robert S. Kerr Water
Research Center,
Ada. Oklahoma. U.S.A.

AGRICULTURAL UTILIZATION OF SEWAGE EFFLUENT AND SLUDGE,, AN ANNOTATED BIBLIOGRAPHY
Federal Water Pollution Control Administration, U.S. Dept. of the Interior. U.S.A. Paper No. CWR-2. 89 pp. January 1968.
REUSES: AGRICULTURE: SEWAGE EFFLUENTS: POLLUTANT LOADS: PUBLIC HEALTH: SLUDGE: NUTRIENTS: IRRIGATION.
* This report brings together about 300 annotated references on agricultural reuses of sewage effluents and sludge which have been in practice in Europe and the U.S.A. Such uses aid crop production, but also make use of water that would have been wasted, and decrease the pollutant load on the receiving streams. A chapter on public health aspects of wastewater utilization is included.

334 McGarry, M.G.

Asian Institute of
Technology,
Bangkok, Thailand.

SEWAGE AS A NATURAL RESOURCE... ECONOMIC DISPOSAL OF DOMESTIC WASTEWATERS
Proceedings of a Symposium on the Role of the Engineer in Environmental Pollution Control. Malaysia. 4 pp. March 1972. 4 figures, 6 references.
NIGHT SOIL: COLLECTION: AGRICULTURE: FISH PONDS: REUSE: ALGAE POND: PASTEURIZATION: PATHOGENS.
* Traditional collection and reuse of night soil in agriculture and fish ponds are discussed. The author points out the economic value of night soil and proposes a schematic treatment system which includes pasteurization and algae growth pond to destroy the pathogenic organisms and maximize those productions, respectively.

335 Novoderzhkina, Y.G.
Kigel, T.V.
Makarenko, E.V.

(all) Rostov-Na-Donu Gosudarstvenni Meditisinskii Institut, USSR.

HARMLESS OF GRAIN GROWN ON SEWAGE FARMS
Voprosy pitania. USSR. Volume 2. pp. 86-88. 1974.
WHEAT GRAINS: SEWAGE FARMING: HEALTH EFFECTS: ANIMAL FEEDS.
*Experiments have been conducted for 1½ years on rats and rabbits to study the effect of wheat grain grown on sewage farms irrigated with conditionally pure sewage containing Ca, Mg, Na, K, sulfates, chlorides, toluene, petroleum products, caprolactum and formaldehyde from a chemical plant. The general health of the animals, condition of hair, motor activity, change of body weight and relative weight of organs, rectal temperature, enzyme spectrum of the blood and liver tissue, protein and carbohydrate metabolism and pigment-producing function of the liver were determined. Feeding grains grown on sewage farms apparently does not cause any changes in the laboratory animals. (Copyright 1975, Biological Abstracts no. 24/5/0000001-0000200).

(Original paper written in Russian)

336 Parker, C.O.

Water Science Laboratories. Victoria, Australia.

LOW COST METHODS OF WASTEWATER TREATMENT
Water Quality, Management and Pollution Control Problems, Pergamon Press, Oxford. U.K. pp. 141-148. 1973.
17 references.
SEWAGE TREATMENT: OXIDATION DITCHES: SEWAGE IRRIGATION: STABILIZATION PONDS: AERATED LAGOONS.
* Irrigation of raw sewage as a method of treatment is described and some details of the 11,000 ha irrigation area at Melbourne are given. The loading of waste stabilization ponds is discussed. Aeration lagoons and (Pasveer) oxidation ditches are discussed.

337 Pescod, M.B.
Okun, D.A.

WATER SUPPLY AND WASTEWATER DISPOSAL IN DEVELOPING COUNTRIES
Proceedings of a Water Supply and Sanitation Seminar held in Bangkok, Asian Institute of Technology. Thailand. 309 pp. January 1971.
39 papers, Summary, List of Participants.
WATER SUPPLY: WASTEWATER DISPOSAL: SANITATION: DEVELOPING COUNTRIES: WATER RESOURCES: WATER RECLAMATION: PROTEIN PRODUCTION.
* A collection of papers on the water supply and sanitation situation in Asia; planning of water projects; water resources development; water quality management; wastewater management; system operation and management; and new developments. Papers on wastewater solids utilization and disposal and on water reclamation and protein production through sewage treatment present data on studies carried out in Thailand.

338 Reed, S.C.
Buzzell, T.

(Both) U.S. Army Cold Regions Research and Engineering Laboratory, Hanover. U.S.A.

LAND TREATMENT OF WASTEWATERS FOR RURAL COMMUNITIES
Proceedings of a Conference on Water Pollution Control in Low Density Areas. U.S.A. Jewell, W.J. and Swan, R. (Eds.). Paper No. 3. pp. 23-40. September 26-28, 1973.
13 references.
WASTEWATER: DISPOSAL: LAND TREATMENT: RAPID INFILTRATION: OVERLAND FLOW: SPRAY IRRIGATION: DESIGN CRITERIA.

* Under proper conditions, wastewater disposal by land can offer a higher level of treatment at lower costs, than existing advanced waste treatment technologies. Three methods of land treatment such as rapid infiltration, overland flow, and spray irrigation are discussed according to their design criteria and suitabilities.

339 Romanenko, N.A.

Martsinovskii Institute of Medical Parasitology and Tropical Medicine, Moscow. U.S.S.R.

ON HELMINTH EGGS IN CROPS GROWN ON SEWAGE FARMS
Hygiene and Sanitation. U.S.A. 35(11). pp. 257-259. 1970.
1 table.
HELMINTH EGGS: SEWAGE FARMS: SPRINKLING IRRIGATION: FLOODING IRRIGATION: SUBSURFACE IRRIGATION.

* The contamination with helminth eggs of agricultural crops from sewage farms using 3 irrigation methods: sprinkling, flooding, and subsurface, have been investigated. Subsurface irrigation through clay pipes laid at 60 cm depth is reported to be the best method as the root crops (fodder beet) are free of helminth eggs even when irrigated with unclarified effluent. Helminth eggs, including viable ones, are discovered on beets irrigated by sprinkling and flooding through furrows.

(Original paper written in Russian)

340 Romanenko, N.A.
Abaev, A.N.
Dolivo-Dobrovolskii, L.B.
Smirnova, Z.M.

POSSIBILITY OF USING SOLAR RADIATION FOR DEHELMINTHIZATION OF SEWAGE SEDIMENTS
Meditsinskaia Paiazitologiia i Parazitarnye Bolezni. USSR. 44(2). pp. 227-229. 1975.
2 figures.
USSR: SOLAR: DEHELMINTHIZATION: SEWAGE: SEDIMENTS: HEATING: EXPOSURE TIME.

* The results of studies under laboratory and pilot conditions indicate a feasibility of using solar radiation for dehelminthization of sewage sediments in the Tajik area, U.S.S.R. The optimum operating conditions are found to be as follows: temperature of sediment heating = 60°C, exposure time = 20 minutes, and the thickness of the sediment layer should not be more than 25 centimeters.

(Original paper written in Russian)

341 Secretaria de Planeacion
Secretaria de Recursos Hidraulicos (SRH)
Mexico City. Mexico.

WATER REUSE IN AGRICULTURE, INDUSTRY, COMMUNITY AND AQUIFER RECHARGE
(REUSO DEL AGUA EN LA AGRICULTURA, LA INDUSTRIA, LOS MUNICIPIOS Y EN LA RECARGA DE ACUIFEROS)
Direccion General de Usos del Agua y Prevencion de la Contaminacion, Contrato No. SP-73-C-15. Mexico.
Clave UAPC 73 - 15. January 1974.
37 tables, 12 figures, 12 blueprints, 5 references.
MEXICO: AQUIFER RECHARGE: AGRICULTURE: BORIUM: CROPS: CROP PRODUCTIVITY: SOIL ANALYSIS: WATER REUSE.

* Mexican arid lands have forced the government to take a deep insight into the potential for water reuse not only in agriculture but in industry and aquifer recharge as well. The effectiveness of the reuse of wastewaters for agriculture is studied through a comparative analysis of the productivity of the soils and chemical residuals that affect them. Experiments were carried out and closely monitored where lands were irrigated with potable water, wastewater and mixed waters. The reports concludes that a) productivity is a function of the soil; b) that there are several basic crops that grow better when irrigated with wastewaters and c) that wastewaters should not be applied to those lands where drainage is deficient, the texture is too fine or to crops not tolerant to saline components.

(Original paper written in Spanish)

342 Sepp, E.

Bureau of Sanitary Engineering,
California State Dept. of
Public Health,
Berkeley, California. U.S.A.

DISPOSAL OF DOMESTIC WASTEWATER BY HILLSIDE SPRAYS
Journal of the Environmental Engineering Division, Proceedings of the American Society of Civil Engineers. U.S.A. 99(EE2). Paper No. 9673. pp. 109-121. April 1973.
1 figure, 23 references.
WASTEWATER: SPRAYS: U.S.A.: INFILTRATION: LAND CONFINEMENT: PUBLIC HEALTH: DISPOSAL: RECHARGE.

* Spray irrigation of hillsides is considered a suitable method for wastewater disposal in areas where the soils have good infiltration capacity and the terrain does not permit construction of large ponds. It is a method of land confinement which is being used by 100 small systems located in foothills and mountain areas in California. The use of adequate reliability features for the protection of public health is also discussed.

343 Shende, G.B.

Central Public Health Engineering
Research Institute,
Nagpur, India.

SEWAGE UTILIZATION IN AGRICULTURE
Indian Farming. India. 23(11). pp. 25-27. February 1974.
INDIA: AGRICULTURAL REUSES: SEWAGE FARMING: FARM PRODUCTION: PUBLIC HEALTH.

* Reclamation and reuse of sewage for agricultural uses is a practical proposition for India. A scientific approach to sewage farming should be taken for the purposes of maximizing the farm production without jeopardizing the soil productivity, public health and environment. Some recommendations for proper practices of sewage farming are discussed. Research on utilization of sewage in agriculture in different regions having different agro-climatic conditions is encouraged.

344 Shtarkas, E.M.
Krasil'shchikov, D.G.

(Both) Research Institute of Epidemiology, Microbiology and Hygiene of the Ministry of Health of the Lithuanian. USSR.

ON THE SANITARY ZONE AROUND SEWAGE FARMS IRRIGATED BY SPRINKLING
Hygiene and Sanitation. U.S.A. 35(7-9). pp. 330-331. July-September 1970.
SEWAGE: SPRINKLING IRRIGATION: BACTERIAL CONTAMINATION: USSR: SANITARY ZONE.

* Sprinkling with sewage is widely used in sewage farms outside the USSR. However, data on the possible spread of microflora as a result of sprinkling with sewage are scant and contradictory. Results of this study indicate that sprinkling irrigation of sewage produces bacterial contamination of the air, its degree depending upon the wind velocity. The findings suggest the need for a sanitary zone of at least 1,000 m. around sewage farms using sprinkling. Further experiments are needed to determine the feasibility of the extensive use of this technique under various meteorological conditions.

(Original paper written in Russian)

345 Shuval, H.I.

Hebrew University of Jerusalem, Israel.

DISINFECTION OF WASTEWATER FOR AGRICULTURAL UTILIZATION
7th International Conference on Water Pollution Research. France. Paper No. 7C(ii). 10 pp. September 9-13, 1974. 5 figures, 12 references.
PATHOGENS: SEWAGE: REUSE: AGRICULTURE: CHLORINE: CONTACT TIME: COLIFORM BACTERIA: POLIOVIRUS: ISRAEL.

* The presence of pathogenic organisms in sewage makes it necessary to disinfect the treated effluent prior to its reuse in agriculture. The author has conducted laboratory experiments and finds dosages of chlorine required to achieve coliform counts of about 100 per 100 ml. are from 10 to 20 mg/l at a contact time of one hour. As much as 10 times the amount of chlorine dose is required to accomplish an equivalent degree of inactivation of poliovirus.

346 Sidle, R.C.
Hook, J.E.
Kardos, L.T.

(all) Pennsylvania State University, University Park, Pennsylvania, USA.

ACCUMULATION OF HEAVY METALS IN SOILS FROM EXTENDED WASTEWATER IRRIGATION.
Journal of Water Pollution Control Federation. USA.
49(2). pp. 311-318. February 1977.
9 Tables, 21 References.
HEAVY METALS: USA: IRRIGATION: SECONDARY EFFLUENT: WASTEWATER: SLUDGE: HEAVY METAL ACCUMULATION.
*An investigation of both the accumulation and distribution of heavy metals in the soil profile in two sites in Pennsylvania, a reed canarygrass area and a corn rotation area, which have been irrigated with treated municipal wastewater and sludge-injected wastewater for approximately 7 years. The rate of wastewater application is about 50 mm/week at 40 to 45 weeks/year and concentrations of the heavy metals in the applied wastewater are less than 1 mg/l. It is concluded from the study that no serious soil contamination of heavy metals in either study area is observed, and copper is the only heavy metal that accumulated at a significant rate over time in the 0 to 30 cm depth in the treated corn areas. However, annual monitoring of heavy metals, especially cadmium, zinc, and copper in the surface foot of the soil and in the vegetation would be desirable to avoid any future possibility of their entry into the food chain at unacceptable levels.

347 Sivanappan, T.R.K.

Soil and Water Conservation Engineering,
College of Agricultural Engineering,
Tamil Nadu Agricultural University,
Coimbatore. India.

METHODS OF WASTEWATER APPLICATION FOR AGRICULTURE
Unpublished Paper on Refresher Course on Waste Recycling: Utilization for Agriculture, Public Health Engineering Dept., College of Engineering. India. pp. 10-1 to 10-15. March 10-14, 1975.
1 table.
WASTEWATER: IRRIGATION: INDIA: PHYSICAL CHARACTERISTICS: CHEMICAL CHARACTERISTICS: CRITERIA: SURFACE IRRIGATION: SUBSURFACE IRRIGATION: SPRAYING.
* A general review of methods of wastewater irrigation being practiced in India and elsewhere. The author describes four physical-chemical characteristics of wastewater which are essential criteria for judging its suitability for irrigation as well as three main categories of wastewater application to irrigation such as surface, subsurface and overhead techniques.

348 Stone, R.

Ralph Stone and Co. Inc.
Los Angeles, U.S.A.

WATER RECLAMATION...TECHNOLOGY AND PUBLIC ACCEPTANCE
Journal of Environmental Engineering Division, American Society of Civil Engineers. U.S.A. 102(EE3). Proceeding Paper 12193. pp. 581-594. June 1976.
4 tables, 7 figures, 3 references.
REUSES: RECLAMATION: WASTEWATER: U.S.A.: PUBLIC ATTITUDES: SOCIO-ECONOMIC: TECHNOLOGY.

* An investigation into the socio-economic and technical practicability of wastewater reclamation for domestic, agricultural, irrigational, recreational and industrial resues. Attitudes of the public have been obtained mainly from ten southern California communities. Results of the survey indicate the general order of reuse preference as: non-body contact to body contact to consumptive uses. A cost-benefit model is presented that can determine the overall socio-economic feasibility of reclaiming wastewater for a variety of alternative uses, taking into account differing local constraints likely to be encountered.

349 Sutherland, J.C.

Williams & Works, Inc.,
Grand Rapids, Michigan,
U.S.A.

Cooley, J.H.
Neary, D.G.
Urie, D.H.

(All) USDA,
Cadillac, Michigan,
U.S.A.

IRRIGATION OF TREES AND CROPS WITH SEWAGE STABILIZATION POND EFFLUENT IN SOUTHERN MICHIGAN
U.S. EPA Publication, Series EPA 660/2-74-041. pp. 295-313. June 1974.
9 tables, 8 references.
USA: BORON: IRRIGATION: POND EFFLUENTS: FOREST AGRICULTURE.

* Results on the use of sewage pond effluents for irrigation of hardwood and conifer plantings in southern Michigan, U.S.A., are reported. Irrigated red pine has shown increases in length and dry weight of needles by as much as 36 and 56 per cent, respectively, over that of unirrigated controls. However, nutrient analysis of the red pine foliage has indicated elevated levels of boron which may lead to toxicity conditions in future years. Considerable increases in survival and height growth of hardwoods are also observed when irrigated with the pond effluents.

350 Thomas, R.E.
Jackson, K.
Penrod, L.

(All) Robert S. Kerr Environmental Research Centre, Ada, Oklahoma. U.S.A.

FEASIBILITY OF OVERLAND FLOW FOR TREATMENT OF RAW DOMESTIC WASTEWATER

Publication No. EPA-660/2-74-087. U.S.A. 31 pp. July 1974.
5 figures, 4 tables, 6 references.
TREATMENT: OVERLAND FLOW: LAND USE: U.S.A.: LOADING.

* A pilot-scale field study conducted in Oklahoma to evaluate the capability of overland flow to provide complete treatment of raw comminuted wastewater on a year-round basis in a mild climatic zone. The results of this 18-month study indicate that such a system can perform satisfactorily when loaded at an average loading of 10 cm/week with the applicator operating at a pressure of 1.0 kg/sq. cm. to avoid the formation of aerosols.

351 Trout, T.J.
Smith, J.L.
McWhorter, D.B.

(All) Agricultural Engineering Dept., Colorado State University, Fort Collins. U.S.A.

ENVIRONMENTAL EFFECTS OF LAND APPLICATION OF ANAEROBICALLY DIGESTED MUNICIPAL SEWAGE SLUDGE

Transactions of the American Society of Agricultural Engineers. U.S.A. 19(2). pp. 266-270. 1976.
4 tables, 4 figures, 12 references.
ANAEROBIC SLUDGE: AGRICULTURE: LAND APPLICATION: ENVIRONMENTAL HAZARDS: PATHOGENS: METALS: LOADINGS: pH: NITRATES: POLLUTION: MANAGEMENT: LEACHING: U.S.A.

* Anaerobically digested sludge from the city of Boulder, Colorado has been applied to agricultural land for the purpose of environmental hazard evaluation. Pathogenic dangers and metal contamination of groundwater and plants are found to be insignificant at the sludge loadings up to 65,000 kg/ha on neutral pH soils but serious threat from nitrate pollution occurs. The author proposes some management techniques involving timing and balancing of nitrogen applications with crop uptake and other factors to overcome the problem of nitrate leaching.

352 Viraraghavan, T. Ministry of Health, India.

SEWAGE TREATMENT WITH SPECIAL REFERENCE TO USE ON LAND FOR IRRIGATION
Journal of the Institution of Engineers. India. Volume 50. Part PH1. October 25-28, 1969.
2 tables, 14 references, 1 appendix.
INDIA: SEWAGE TREATMENT: IRRIGATION: HEALTH: STABILIZATION PONDS.

* The public health aspects of both restricted and unrestricted irrigation with raw and treated sewage are discussed. It is concluded that treatment in waste stabilization ponds should be encouraged prior to restricted irrigation in order to minimize risks to public health; this has the added advantage that when the effluent is not required for irrigation it can be discharged more safely into a surface watercourse.

353 Watermeyer, J.M. Department of Conservation and Extension, Rhodesia.

USE OF SEWAGE EFFLUENT FOR IRRIGATION
Rhodesian Agricultural Journal. Technical Bulletin No. 15. pp. 37-44. 1972.
3 figures, 5 references.
RHODESIA: SEWAGE IRRIGATION: SECONDARY TREATMENT: SECONDARY EFFLUENT: ECONOMICS: PUBLIC HEALTH.

* The author has reviewed literature on the subject of sewage irrigation in Rhodesia and the experience gained elsewhere in the world. Except where high and excessively long pumping-lifts are involved, disposal of sewage effluents through irrigation either by the municipalities themselves or by selling or subsidizing the sale of effluents to nearby farmers is considered economical. Since there is no evidence of disease outbreaks or epidemics that can be directly attributed to irrigation with sewage effluent that has been subjected to secondary treatment, it can be assumed that secondary effluent is safe for irrigation use, provided that the health regulations are strictly adhered to.

354 Wellings, F.M.
Lewis, A.L.
Mountain, C.W.

(All) Epidemiology Research Centre,
Tampa. U.S.A.

THE FATE OF VIRUS IN FLORIDA SOILS FOLLOWING SECONDARY EFFLUENT SPRAY IRRIGATION
Proceedings of a National Conference on "Individual Onsite Wastewater Systems". U.S.A. pp. 117-124. September 18-20, 1974.
7 references.
WASTEWATER: EFFLUENT: VIRUS: SPRAY IRRIGATION: AQUIFER: CONTAMINATION.

* The studies reported here confirm the findings of others which show that secondary wastewater treatment processes, including chlorination, do not provide a virus-free effluent. More importantly, those viruses do survive aeration and sunlight during spraying and percolation through 10-20 feet of sandy soil. Their survival periods can vary from a few days to a few months, depending on the surrounding environment. Attention is drawn to a potential danger of aquifer contamination over time from wastewater spray irrigation.

355 Wellings, F.M.
Lewis, A.L.
Mountain, C.W.

(All) Epidemiology Research Centre,
State of Florida Department of Health and Rehabilitative Services,
Tampa. U.S.A.

PATHOGENIC VIRUSES MAY THWART LAND DISPOSAL
Water and Wastes Engineering Journal. U.S.A. 12(3). pp. 70-74. March 1975.
LAND DISPOSAL: SEWAGE: PATHOGENIC VIRUSES: SPRAY IRRIGATION: GROUNDWATER: SOIL: U.S.A.

* Land disposal of sewage may possibly cause hazardous build-up of pathogenic viruses in soil and in groundwater. Experiments conducted in Florida, U.S.A., indicate that viruses can and do survive percolation through the soil. At an application rate of sewage of 58,500 gallons per day contianing seeded viruses of about 12 million plaques-forming units per day, a burst of virus is demonstrated in groundwater at both 10 and 20 feet depths. The authors conclude that secondary wastewater spray irrigation of sandy soils should be recognized as one of the hazards of wastewater spray irrigation.

4B. Reuse: Aquaculture

356 Allen, G.H.

Division of Natural Resources,
Humboldt State College,
Arcata, U.S.A.

A PRELIMINARY BIBLIOGRAPHY ON THE UTILIZATION OF SEWAGE IN FISH CULTURE
FAO Fisheries Circular No. 308. Italy. 15 pp. March 1969.
U.S.A.: GERMANY: SEWAGE: SEWAGE EFFLUENTS: UTILIZATION: FISH CULTURE: BIBLIOGRAPHY.

* A compilation of papers dealing with the direct utilization of sewage or effluents from sewage treatment plants in fish culture. Included are 224 references dating from 1898-1966 and are derived primarily from the yearly reviews of the Journal of Water Pollution Control Federation (U.S.A.) and various institutions and authors in Germany.

○ 357 Allen, G.H.

School of Natural Resources,
Humboldt State College,
Arcata. U.S.A.

THE CONSTRUCTIVE USE OF SEWAGE, WITH PARTICULAR REFERENCE TO FISH CULTURE
Food and Agricultural Organization of the United Nations. Italy. FIR: MP/70/R-13. 26 pp. December 1970.
10 figures, 1 appendix, 122 references.
AQUACULTURE: FISH CULTURE: FISH YIELD: FISHPOND BIOLOGY: PUBLIC OPPOSITION.

* A review of literature on the use of sewage in aquaculture especially as related to Germany, United States, Israel, and India. The review brings some highlights in the history of sewage fishculture in these countries, stresses the increased fish production in these ponds (though actual yields are not given), and discusses the biology of sewage fish pond systems, while pointing to the need for further research. In conclusion the author states that there is good reason to believe that there will be an increase, worldwide, in the use of waste water for fish and shellfish culture and recommends that an appropriate international agency, or private foundation, should be solicited for funding an international program of research and training in utilization of wastewater in integrated agriculture-aquaculture systems.

●● 353 Allen, G.H.
Busch, A.
Morton, W.

(All) Fisheries Department,
School of Natural Resources,
Humboldt State College,
Arcata. U.S.A.

PRELIMINARY BACTERIOLOGICAL EXPERIENCES WITH WASTE WATER - FERTILIZED MARINE FISH PONDS, HUMBOLDT BAY, CALIFORNIA
FAO Technical Conference on Aquaculture. Japan. 12 pp.
May 26 - June 2, 1976.
5 tables, 30 references.
WASTEWATER: MARINE AQUACULTURE SYSTEM: SALMON: FISH DISEASES: ENTEROBACTERIAECAE.

* The results from studies undertaken during 1971 - 1975 with wastewater - fertilized marine fishponds at Arcata, Humboldt Bay, California, are described with respect to:

i) Salmonid fish diseases (especially Vibrio anguillarum)

ii) The pathobiology of cultured Salmonids

iii) The bacterial levels in these fishpond waters Vibrio anguillarum was isolated as the causative agent of an epizootic in fingerling coho salmon in closed recirculating aquaria originally charged with wastewater - sea water.

Almost one half of the micro-organisms recovered from gastro-intestinal tract washings were members of family enterobacteriaecae indicating a contamination of public health. Results from kidney, liver and spleen samples indicate that none of the potential pathogens had become systemic under the fish culture conditions.

●●359 Allen, G.H.

Fisheries Department,
Humboldt State College,
Arcata, U.S.A.

Hepher, B.

Fish and Aquaculture Research
Station,
Dor, Israel.

RECYCLING OF WASTES THROUGH AQUACULTURE AND CONSTRAINTS TO WIDER APPLICATION

FAO Technical Conference on Aquaculture Paper No. FIR: AQ/Conf./76/R.19. Japan. 18 pp. May 26 - June 2, 1976. 5 tables, 94 references.

AQUACULTURE: FISH CULTURE: FISH YIELDS: FISH FOOD: NUTRIENT REMOVAL: DISINFECTION: DISSOLVED OXYGEN: PUBLIC ACCEPTANCE.

*Allen and Hepher give a broad coverage of the literature related to fish culture in wastewater fed systems while emphasizing the inherent value in combining a wastes treatment system with a food production system which results in an improved quality of treated wastewater. Both fresh and saltwater regimes are reviewed. Wastewater/aquaculture processes are considered as falling into four groupings:

1) Use of treated effluent in fish culture ponds;
2) Dilution of wastewaters which have received only primary treatment in fish culture ponds;
3) Dilution of treated effluent in fish ponds; and
4) Use of sewage with minimal pre-treatment or dilution.

Feeding wastewater to fish ponds has given 70% increases in yields of fish despite 40% reduction in supplemental feeds. Absolute productivity figures from Israel have been in the order of 3500 kg/ha over an 8 month growth period. These results exceed commercial production rates in ponds using supplemental feed and inorganic fertilizers. Wastewater fertilized ponds produce high fish yields because of the increase in natural foods produced by these wastes including the growth of phyto - and ZOO - plankton of nitrogen, phosphorous and trace elements consequent to bacterial breakdown of waste materials in the pond.

Wastewater treatment incorporating aquaculture and use of the treated wastewater for irrigation in agriculture has been practiced in Germany for decades. Conventional stabilization used in the United States ponds tend to produce an effluent which is high in algae content which have become regarded as a pollutant in themselves. Algae eating fish such as the Chinese carp can extend the biological chain and act to "harvest" the algae before discharge of reuse of the pond's effluent. These fish can be used to remove elements which would otherwise become bound up in the ponds' benthal deposits or plant life such as phosphorous and the nitrogens. Sewage/fish-culture systems can also produce higher quality effluents in terms of reduced pathogens or disease causing organisms. A study in Oklahoma showed virtually no human pathogens in cultured fish drastic reductions in coliforms. The authors warn, however that although the current literature indicates negative findings on human bacterial diseases being transmitted through fish, these results must be confirmed through more intensive studies.

There are constraints to the production of fish in sewage fed ponds. Among the most important is the possibility of excessive organic loading on the pond which results in reduced dissolved oxygen with consequent fish kill. Substances found in various wastewaters can be deleterious to fish; each wastewater must be evaluated on its own merits. Fish caught in natural waters frequently possess off-tastes and odours when caught in areas subject to discharges of raw wastes (particularly those containing hydro-carbons). Personal observations by several workers indicate that, on the contrary, fish grown in well treated domestic wastes are equal to or even superior in taste or odour to non-wastewater cultivated fish. The high pH and high oxygen levels in wastewater fish ponds could actually be producing quite disease-free environmental conditions as opposed to the psychological expectation that such systems must encourage fish parasites, diseases, and pathologies. In general, the literature on wastewater-cultured fish has not reported heavy losses from fish diseases, something which would be inconsistent with the high production rates reported.

Recent studies of human pathogens in salmonids reared in U.S. wastewater fish ponds showed bacteria causing human infections only in the gut. As in all water supply and wastewater processing systems, the fate of viral particles infectious to man, requires a major commitment to low cost standard methods development for identifying and quantifying virus. Probably the most critical need for data to obtain public acceptance of wastewater-grown fish is its content of human pathogens. Depuration, such as is often used in cleaning bivalves before marketing, is the primary precautionary measure against transmission of human diseases in wastewater-reared fish (Hickling, 1962; Hepher, 1975). Undoubtedly some systematic study of the length of time human pathogens might stay in the intestinal tract of a fish placed in an environment clear of human pathogens would provide the type of data required. Obviously, initial development of re-utilization schemes not involving direct consumption of the product by human beings would allow time to develop background data on the entire zoonoses problem. It appears that where the fish pond acts as an improved oxidation pond, a high-quality effluent for such crops, plus a crop of fish provided by a fish pond in the system, seems an eminently practical system for widespread consideration. Such integrated systems do exist throughout the world on informal or unauthorized bases. They probably do work without excessive public health risks.

360 Allen, G.H.
Carpenter, R.L.

(Both) Fisheries Department, School of Natural Resources, Humboldt State College, Arcata. U.S.A.

THE CULTIVATION OF FISH IN MUNICIPAL WASTEWATER LAGOONS AS AN AVAILABLE PROTEIN SOURCE FOR HUMAN BEINGS WITH EMPHASIS ON SALMONIDS
Wastewater renovation and reuse. Marcel Dekker Inc. U.S.A. D'Itri, F. (Ed.). ISBN 0-8247-6505-2. pp. 479-528. 1977.
8 figures, 11 tables, 54 references, Discussion by Balfour Hepher.
WASTEWATER: AQUACULTURE SYSTEMS: U.S.A.: SALMONIDS: FISH DISEASES.

* Two pilot projects employing wastewater to produce fish are presented. One project - Quail Creek, near Oklahoma City, Oklahoma is testing the use of a fish polyculture system in six municipal lagoons operated in series. The second project - Humboldt Bay, Arcata, north - coastal, California is testing empirically the feasibility of rearing juvenile salmonids on natural food chains. In addition some of the non technical considerations surrounding wastewater aquaculture in one of these regions (California) is presented.

361 Bose, P.C.

Corporation of Calcutta, India.

Nair, K.

Department of Fisheries, Bengal, India.

Fowler, G.J.

A SYMPOSIUM ON THE UTILIZATION OF SEWAGE FOR FISH CULTURE
Proceedings of the National Institute of Science of India. 10(4). pp. 411-467. 1944.
INDIA: SEWAGE: FISH: FISH CULTURE: AQUACULTURE: CARP.

* Four papers on the utilization of Calcutta's sewage for fish culture. The primary sewage treatment plant at Calcutta and the effect of the discharge of settled sewage on the fish life in local rivers are described. The utilization of sewage in local fisheries is discussed with particular reference to the various types of fish able to grow in sewage fertilized waters and the alternate use of fish ponds for fish culture and rice cultivation. The symposium high-lighted the large profitability of sewage-fed fish culture both from the point of view of protein production and wastewater treatment.

362 Carpenter, R.L.
Coleman, M.S.
Jarman, R.

(All) Oklahoma State Department of Health, U.S.A.

AQUACULTURE AS AN ALTERNATIVE WASTEWATER TREATMENT SYSTEM
Biological Control of Water Pollution, University of Pennsylvania Press. U.S.A. Tourbier, J. and Pierson, R.W. (Eds.). pp. 215-224. 1976.
1 table, 5 figures, 22 references.
AQUACULTURE: STABILIZATION PONDS: U.S.A.: EFFLUENT: NUTRIENTS: BACTERIA: FISH: PUBLIC HEALTH: DOMESTIC: WASTEWATER: REUSE.

* A report of a full scale aquaculture pond, serially operated system, treating domestic wastewater in Oklahoma, U.S.A. The system is reported to provide a high grade effluent being low in nutrients and bacteria counts while yields of fish biomass are observed to be moderate. The authors propose future studies in order to maximize the fish production and examine its potential effects on public health.

363 Chan, W.L.

Fisheries Research Division, Agriculture and Fisheries Department, Hong Kong.

A GENERAL ACCOUNT OF FISH CULTURE TRIALS IN THE OXIDATION PONDS OF THE PILOT SEWAGE TREATMENT PLANT AT SHEK WU HUI, HONG KONG
Unpublished report. 13 pp. September 1976.
1 figure, 8 tables.
FISH CULTURE: FISH YIELD: TILAPIA: CATFISH: GRASS CARP: SILVER CARP: BIGHEAD CARP: COMMON CARP: HONG KONG.

* A report on an experiment carried out in Hong Kong in which fish were stocked into 6 ponds of 0.2 ha/each receiving treated effluent from the near-by Shek Wu Hui experimental sewage treatment plant. The fish cultured were Tilapia mossambica, the catfish Clarias fuscus, grass carp ctenopharyngodon idella, bighead carp Aristichthys nobilis, silver carp Hypophtholmichthys molitris and common carp Cyprinus carpio. Due to low stocking densities the average net yield of carps was 1.6 tons per ha. The survival of the catfish was low.

364 Ghosh, A.
Rao, L.H.
Banerjee, S.C.

(All) Central Inland Fisheries Research Institute, Barrackpore. India.

STUDIES ON THE HYDROBIOLOGICAL CONDITIONS OF A SEWAGE-FED POND WITH A NOTE ON THEIR ROLE IN FISH CULTURE
Journal of Inland Fisheries Societies. India. Volume 6. pp. 51-61. 1974.
2 figures, 2 tables, 15 references.
STABILIZATION POND: SEWAGE: FISH CULTURE: EFFLUENT.
* Hydrobiological conditions of a sewage-fed pond in relation to fish culture are presented and discussed. It is observed that the fluctuation in biota and other chemical factors of the pond are mainly governed by the characteristics of the applied sewage effluent. A 0.67 ha sewage-fed pond stocked with rohu, calta, mrigal and silver carp at a stocking density of 50,000/ha have a gross production of 7,676 kg/ha in seven months.

365 Hepher, B.
Schroeder, G.L.

(Both) Fish and Aquaculture Research Station, Dor, Israel.

WASTEWATER UTILIZATION IN INTEGRATED AQUACULTURE AND AGRICULTURE SYSTEMS
United States Environmental Protection Agency. U.S.A. Series EPA 660/2-74-041, pp. 9-15. June 1974.
1 figure, 7 references.
STABILIZATION PONDS: AQUACULTURE: AGRICULTURE: REUSE: DISSOLVED OXYGEN: NUTRIENTS: BACTERIA: TOXIC SUBSTANCES: EFFLUENTS:
* The authors describe some benefits gained from utilizing aquaculture ponds receiving waste effluent from a treatment plant, instead of direct reuse of the effluent in agriculture. Apart from fish yields, water from the fish ponds is observed to have higher dissolved oxygen (D.O.) with less nutrient content and bacteria count than the system without fish. Two factors that may affect the fish stocks such as D.O. depletion and the presence of toxic substances are also discussed.

366 Jhingran, V.G.

Central Inland Fisheries
Research Institute,
Barrackpore, West Bengal,
India.

A CRITICAL APPRAISAL OF THE WATER POLLUTION PROBLEM IN INDIA IN RELATION TO AQUACULTURE
Proceedings FAO Indo-Pacific Fisheries Council.
New Zealand. 15th Session, Section II. pp. 45-50.
1974.
1 table, 16 references.
FISH CULTURE: AQUACULTURE: INDIA: POLLUTION.
*The major sites of freshwater pollution lie along the important river systems of India. The present status of sewage fed fish culture in India is reviewed. It is estimated that there are more than 132 sewage fed fisheries in India, covering an area of about 12,000 hectares. In experimental investigations conducted in a West Bengal State fisheries sewage fed farm near Calcutta yields up to 3.2 tons per hectare per annum has been attained. More than 50 wastewater stabilization ponds are used for fish culture and appreciable fish production has been reported from some of them. Pollutants that pose a major threat to aquaculture are listed and discussed.

367 Kerfoot, W.B.
Redmann, G.A.

(Both) Woods Hole Oceanographic
Institution,
Boston. U.S.A.

PERMISSIBLE LEVELS OF HEAVY METALS IN SECONDARY EFFLUENT FOR USE IN A COMBINED SEWAGE TREATMENT-MARINE AQUACULTURE SYSTEM II. DEVELOPMENT OF GUIDELINES BY METHOD OF ADDITION.
Wastewater use in the production of food and fiber-
Proceedings: U.S. Environmental Protection Technology Series.
U.S.A. EPA-660/2-74-041. pp. 79-101. June 1974.
7 figures, 2 tables, 23 references.
MARINE AQUACULTURE: HEAVY METALS: OYSTERS.
*An attempt to develop guidelines for the permissible concentrations of six metals: zinc, copper, lead, cadmium, chromium and nickel in a combined sewage treatment-marine aquaculture system. this was done experimentally by enriching effluent added to algae culture used in a model aquaculture system with these metals and studying their accumulation in the algae and oysters and the toxicity effects of the metals. Suggested permissible concentrations were (ppm): Copper- .2, Cadmium - .01, nickel-.05, chromium- .5, lead -1.0, zinc - 1.0.

363 Krishnamoorthi, K.P.
Abdulappa, M.K.
Sarka, R.
Siddiqi, R.H.

(All) Central Public Health Engineering Research Institute, Nagpur. India.

PRODUCTIVITY OF SEWAGE FERTILIZED FISH PONDS
Water Research. U.K. 9(3). pp. 269-274. 1975.
8 figures, 7 references.
INDIA: FISH HARVESTING: STABILIZATION PONDS: EFFLUENT: DOMESTIC WASTEWATER: ALGAE: ENERGY.
* A pilot scale experiment, conducted in India, of fish culture ponds receiving effluent from a stabilization pond treating domestic wastewater. Fish yields are observed to be better where diluted effluent is used than without dilution, and a similar trend is also noted for primary productivity (or algal growth). An energy balance shows that 3.86% of incident solar energy is fixed through primary production and 0.1% can be harvested in the form of fish.

369 Mortimer, C.H.

Freshwater Biological Association, Ambleside, Cumbria. U.K.

FERTILIZERS IN FISHPONDS
Colonial Office Fishery Publications No. 5, Her Majesty's Stationery Office. U.K. 1954.
Section 10: Utilization of Sewage in Fishponds pp. 28-29, abstracts of literature on this subject pp. 46,48,57-58,83-85, 98, 106, 108, 118-119 and 133.
SEWAGE TREATMENT: FISH CULTURE: FERTILIZERS: BIBLIOGRAPHY.
* A selected annotated bibliography of the literature on sewage fertilization of fish ponds, 1899-1954.

370 Mortimer, M.H.E.
Ruth, D.J.
Mulnwa, L.

(All) Game and Fisheries Dept., Northern Rhodesia (Zambia).

DUCKS, VEGETABLES AND FISH.....
Rhodesia Agriculture. pp. 82-87. May/June 1963.
ZAMBIA: IRRIGATION: FISH CULTURE: ANIMAL WASTES: DUCKS.
* A simple irrigated small holding pond, 0.8 ha in size, centred on fish, duck and vegetable production is described. The fish pond, fertilized with duck faeces, yielded 1120 kg of fish per ha per annum.

371 Muthuswamy, S.
Govindan, S.
Sundaresan, B.B.

(All) Public Health Engineering Dept.,
College of Engineering,
Madras. India.

PRODUCTIVITY OF CYPRINUS CARPIO IN STABILIZATION POND EFFLUENTS
Indian Journal of Environmental Health. India. 16(4). pp. 370-379. 1974.
7 figures, 10 references.
STABILIZATION PONDS: FISH FARMING: EFFLUENT RE-USE: CYPRINUS CARPIO: FISH PONDS: RURAL SANITATION: INDIA.

* A report on a 6 month study of growth of Cyprinus Carpio in fish ponds fed with sewage stabilization pond effluent in Madras. The test fish attained maturity in about 4 months from fingerling stock and a maximum weight of 620 g was achieved in 6 months. Maximum gross primary production was 43.3 g O_2/m^2 day and the rate of fish survival was very high, giving fish production of 7700 kg/hectare year.

372 Prowse, G.A.

Tropical Fish Culture Research Institute,
Malacca, Malaysia.

A REVIEW OF THE METHODS OF FERTILIZING WARM-WATER FISH PONDS IN ASIA AND THE FAR EAST
Proceedings of FAO World Symposium on Warm-Water Pond Fish Culture. Italy. pp. 7-12. March 18-25, 1966.
FISH POND: FERTILIZER: CHINA: HONG KONG: TAIWAN: MALAYSIA: NIGHT SOIL: SEWAGE: PHILIPPINES: INDIA.

* Traditional methods of fish-pond fertilization are reviewed. In China, Hong Kong, Taiwan and Malaysia, Chinese carp are raised in conjunction with pigs and ducks. Cut plants and night soil are often added. In India where other carps are cultured, cut plants, oil seed cake and sewage are used as fertilizers. Experiments on artificial fertilizers have been carried out in Taiwan, Philippines and India, and have been based on N-K-P mixtures.

373 Radebaugh, G.H.
Agersborg, H.P.K.

(Both) Urbana-Champaign Sanitary District,
Illinois. U.S.A.

THE ECONOMIC VALUE OF TREATED SEWAGE EFFLUENT IN WILDLIFE CONSERVATION, WITH SPECIAL REFERENCE TO FISH AND WATER FOWL
Transactions of the American Fisheries Society. U.S.A.
Volume 64. pp. 443-456. 1934.
19 references, 4 tables.
SEWAGE TREATMENT: FISH CULTURE: CONSERVATION: WATERFOWL: MUSSELS: U.S.A.

* A report on the use of undiluted humus tank effluent for the culture of fish and molluscs in Urbana-Champaign, Illinois. The fish included carp, bullheads, catfish and mudcats; carp was the most successful. Mussels were suggested as 'indicators' of the fitness of the lagoon to rear marketable fish and waterfowl.

374 Ryther, J.H.

Woods Hole Oceanographic Institution,
Massachusetts. U.S.A.

PRELIMINARY RESULTS WITH A PILOT PLANT WATER RECYCLING-MARINE AQUACULTURE SYSTEM.
Wastewater Renovation and Reuse, Marcel Dekker Inc. Institute of Water Research, Michigan State University. U.S.A. D'Itri, F. (Ed.). pp. 89-132. 1977.
1 figure, 5 tables, 7 references, Discussion by Malcolm S. Gordon.
WASTE RECYCLING: MARINE AQUACULTURE: UNICELLULAR ALGAE: DIATOMS: SEAWEED: NITROGEN REMOVAL: OYSTERS: FLOUNDERS: LOBSTERS.

* The paper gives the results of a one year period testing of a combined waste recycling-marine aquaculture system which has been developed on a pilot plant scale at Woods Hole Oceanographic Institution. Successful cultures of unicellular algae, mostly diatoms, and seaweeds have been sustained over long periods of time (months) with only minor problems. Algae yields and nitrogen removal capacity vary seasonally by 3-4 fold and are controlled by solar radiation but not by temperature. Bivalve mullusc culture was unsuccessful during the first year of operation. Good growth of flounders and lobsters was obtained, but carrying capacity of the system and potential yields has not yet been determined.

375 Schillinger, Von A.

ON THE WASTEWATER TREATMENT IN FISHPONDS
(VON DER ABWASSEREINIGUNG IN FISCHTEICHEN)
Gesundheits-Ingenieur, Zeitschrift fur die gesamte Stadtehygiene. Germany. 58(14). pp. 192-193. April 1935.
WASTEWATER: FISH PONDS: TREATMENT CAPACITY: DILUTION: GERMANY: ECONOMICS.

* The paper describes briefly the wastewater-fishpond system near Munich. It points out the advantages of the system, especially the smaller area required for treatment as compared to land application, as also the constraints, especially the need for dilution waters. In general, at normal temperature 1 hectare of fish pond can treat primary sewage effluents from 2000 persons. The paper discusses the economics of the treatment system.

(Original paper written in German)

376 Schroeder, G.L.

NIGHTTIME MATERIAL BALANCE FOR OXYGEN IN FISH PONDS RECEIVING ORGANIC WASTES
Bamidgeh. Israel. 27(3). pp. 65-74. 1975.
3 figures, 1 table, 1 appendix, 7 references.
DISSOLVED OXYGEN: AERATION: BIOLOGICAL OXYGEN DEMAND (BOD): AQUACULTURE: ORGANIC WASTES: OXYGEN TRANSFER.

* Factors using oxygen in fish ponds receiving organic wastes are discussed. Biological oxygen demand (BOD) of the pond water and suspended material was the largest consumer of oxygen for the cases studied. Transfer of oxygen across the pond surface was calculated. A system for re-aerating pond water is described.

377 Tapiador, D.D.

FAO Regional Fisheries for Asia and the Far East, Bangkok, Thailand.

A PRELIMINARY REVIEW ON THE POSSIBILITY OF COMMERCIAL FISH MEAL PRODUCTION FROM SEWAGE FISH FARMING
Draft Paper prepared for the FAO Technical Conference on Fisheries Products. Japan. 3 pp. December 4-11, 1973.
SEWAGE: FISH FARMING: FISH MEAL: COMMERCIAL MANUFACTURE.

* A preliminary review is made of sewage fish farming and its possible use as a new non-traditional source of commercial fish meal manufacture. The author concludes that the aforementioned possibility exists and that interested Member Governments or international or regional organizations with the financial resources should immediately undertake a pilot project in this field.

378 Vinberg, G.G.
Lyakhnovich, V.P.

FERTILIZATION OF PONDS... CHAPTER IV. ORGANIC FERTILIZATION OF PONDS - 5. FERTILIZATION BY WASTEWATER. (UDOBRENIE PRUDOV...GLAVA IV. ORGANICHESKOYE UDOBRENIE PRUDOV - 5. UDOBRENIE STOCHNIMI VODNAMY)
Isdatelstvo "Pyshchevaya Promishlenoste". USSR. pp. 167-172. 1965.
22 references.
FISHPONDS: FERTILIZATION: FISH YIELD: WASTEWATER DILUTION: STAGNANT PONDS: FLOW-THROUGH PONDS: DAIRY WASTES: SUGAR INDUSTRY WASTEWATER: CARP.

* The chapter discusses the advantages and problems related to the use of wastewater in fish ponds and reports previous experiments carried out on this aspect such as those on the wastewater receiving fish pond at Munich, Germany, fish culture in wastewater treating ponds at Lyubarchi, near Moscow, USSR. The use of treated sewage in fish ponds near Kielce, Poland; and studies carried out in Czechoslovakia on the use of dairy and sugar factory wastes in fish ponds.

(Original paper written in Russian)

379 Wolny, P. Institut Rybactwa Srodladowego Drss Zabieniec, Poland.

THE USE OF PURIFIED TOWN SEWAGE IN FISH REARING
Selected translations from Roczniki Nauk Rolniczych, The Scientific Publications, Foreign Cooperation Center of the Central Institute for Scientific, Technical and Economic Information. Poland. TT65-50503. pp. 36-51. 1966.
1 figure, 8 tables, 3 diagrams, 16 references.
FISH REARING: AQUACULTURE: MUNICIPAL SEWAGE: CARP: POLAND: FISH PONDS: DISSOLVED OXYGEN: FISH NATURAL FOOD.

* A study on the use of treated wastewater in fishponds was conducted during 1958-1961, at Kielce, Poland, near the sewage disposal works. Stagnant and flow-through fishponds were stocked with carp fingerling. The composition of the sewage and pond water are reported maximum yield obtained in the wastewater fish pond was 1317.7 kg/ha, a record yield for Poland. In contrast the flow-through ponds had an adverse effect on fingerlings growth. There was no need for dilution of the treated sewage prior to introduction into the pond. The treated sewage is suitable also for wintering ponds. The presence of carp in the stagnant ponds enhances photosynthesis, improves oxygen conditions, accelerates the cycling of materials in the pond and accelerates sewage purification.

4C. Reuse: Algae

380 Anon.

ALGAE AND BRINE SHRIMP TREAT SEWAGE AND HELP PRODUCE CROPS AND SEAFOOD
NOAA News release. U.S.A. 7 pp. July 1974.
ALGAE: BIOLOGICAL TREATMENT: SHRIMP.
* Brine shrimp used with certain algae that thrive in raw sewage can biologically treat effluent and provide food for raising fish at the same time. Brine shrimps are used to keep the organism in a continuous state of exponential growth. Component chemicals highly nutritious to algal growth, especially phosphate, are reduced to levels similar to those of conventional secondary or possible tertiary-treated sewage.

○ 381 Anon. Commonwealth Bureau of Animal Nutrition, Bucksburn, Aberdeen.

FUNGI AND UNICELLULAR ALGAE AS FOODS
Annotated Bibliography No. 6 of the Commonwealth Bureau of Animal Nutrition, Supplement covering the period 1968 - 1970. 15 pp.
ALGAE: FUNGI: FOODS: BIBLIOGRAPHY.
*This is a worldwide literature search and annotated bibliography on the use of fungi and unicellular algae as foods for man and animals. About 70 reports deal with fungi and 13 reports with algae.

382 Anon.

Technion-Israel Institue of Technology and Sherman Environmental Engineering Research Center with the Fish and Aquaculture Research Station, Ministry of Agriculture, Israel.

FISH FEEDING EXPERIMENTS WITH ALGAE
A progress summary of a project "Combined Systems for Algal Wastewater Treatment and Reclamation and Protein Production, October 1975 - May 1976". 3 pp.
ISRAEL: ALGAL DIGESTIBILITY: CARP: GROWTH RESPONSE: ALGAL DEWATERING.

*A series of algal digestibility experiments on carp has been conducted and results obtained indicate that the drum dried algae were better digestible than the sun dried algae while milling increased the digestibility of the drum dried algae. On growth experiments, it is shown that algae of the Euglena species could successfully replace part of the fish meal diet. Further tests in field conditions of this growth experiments are being carried out in Israel.

383 Dugan, G.L.
Golueke, C.G.
Oswald, W.J.

(All) Sanitary Engineering Research Laboratory, University of California, Richmond, U.S.A.

PHOTOSYNTHETIC RECLAMATION OF AGRICULTURAL SOLID AND LIQUID WASTES
Solid Waste Research and Development, II, Engineering Foundation Research Conference. U.S.A. 34 pp. July 22-26, 1968.
4 tables, 5 figures, 28 references.
RECLAMATION: ANIMAL WASTES: ALGAE: ANAEROBIC: DESIGN: DIGESTERS.

*A research report on the design of a reclamation facility for converting animal wastes into useful materials, such as algae. The study involves a practical method of handling chicken manure, an anaerobic digestion of the manure, and an algal production in ponds receiving effluents from the digesters and other operations. Drawings of a pilot scale poultry house which is representative of a practical egg-production operation are included.

○ 384 Golueke, C.G.
Oswald, W.J.

(Both) Sanitary Engineering Research Laboratory, University of California, Richmond. U.S.A.

HARVESTING AND PROCESSING SEWAGE-GROWN PLANKTONIC ALGAE
Journal of the Water Pollution Control Federation. U.S.A. 37(4). pp. 471-498, April 1965.
7 figures, 7 tables, 12 references.
ALGAE: SEWAGE: ECONOMICS.
*An extensive investigation in the laboratory and the field concerning the harvesting of algae from sewage. Three steps involved in the harvesting are: initial concentration, dewatering (secondary concentration) and final drying. A number of methods have been tried. Economics of the algal-production process are also analyzed in detail.

385 Golueke, C.G.
Oswald, W.J.

(Both) University of California, Berkely. U.S.A.

AN ALGAL REGENERATIVE SYSTEM FOR SIMPLE-FAMILY FARMS AND VILLAGES
Compost Science. U.S.A. 14(3). pp. 12-15. May/June 1973.
2 figures
RURAL: HOUSEHOLD: BIOGAS: ALGAL: DESIGNS.
*A design proposal for a rural house in which the principal components are an anaerobic digestor for animal and human wastes, combined with an algal regenerative system situated in a roof pond. The algae product is used as animal feed. Vapours from the algal pond pass through a solar still and provide portable water.

○ 386 Grisanti, N.E.
Oswald, W.J.

(Both) Public Health and Civil Engineering Dept., University of California, Berkeley, U.S.A.

PROTEIN FROM ALGAE
Session on Processes for New Protein Foods, American Institute of Chemical Engineers National Meeting. U.S.A.
25 pp. April 14, 1976.
4 tables, 42 references.
ALGAE: WASTEWATER: PROTEIN: ANIMAL FEED: HUMAN FOOD: PUBLIC HEALTH.
*Many investigations are being conducted for the purpose of maximizing algal production from wastewaters. Although algae is considered a good source of protein for man and animals, some qualitative problems still exist, such as; a lack of balance of complement amino acids, the cell walls are indigestible by non-ruminant animals, and some public health aspects. However, the authors report that these problems are being overcome and the future of algae as a protein supplement for animal feed appears promising.

387 Hintz, H.F.
Heitman, H. Jr.
Weir, W.C.
Torell, D.T.
Meyer, J.H.

(All) Dept. of Animal Husbandry,
University of California,
Davis. U.S.A.

NUTRITIVE VALUE OF ALGAE GROWN ON SEWAGE
Journal of Animal Science. U.S.A. 25(3). pp. 675-681, August 1966.
10 tables, 19 references.
U.S.A.: ALGAE: SEWAGE: PROTEIN: ANIMAL FEEDS: NUTRITION

* An experiment conducted in California to determine the nutritive values of sewage-grown-algae fed to pigs, cattle, and sheep. Several feeding trials indicate that these algae are capable of supplying adequate proteins and other essential elements to the animals, however, they have to be pelleted with other more desirable feeds, such as barley or alfalfa, to avoid an unpleasant taste.

388 Lee, E.S.

Environmental Engineering Division,
Asian Institute of Technology,
Bangkok, Thailand.

ECONOMICS OF ALGAL PROTEIN PRODUCTION, HARVESTING AND PROCESSING, FROM HIGH-RATE OXIDATION PONDS
Master of Engineering Thesis No. 974. Asian Institute of Technology. Thailand. 126 pp, 1976.
16 tables, 46 figures, 35 references, 8 appendices containing 82 tables and 1 figure.
WASTEWATER TREATMENT: OXIDATION PONDS: EFFLUENT RE-USE: PROTEIN RECOVERY: ALGAE CONCENTRATION: ECONOMICS: ASIA.

* A report on an updated evaluation of the economics of algal production in high-rate oxidation ponds and their harvesting. Sewage was fed to a pilot scale pond operated without chemical addition and with addition of 2 mg/l Purifloc-C31 or 0.4 me/l of ferric chloride to effect autoflocculation. The raw effluent from the pond was subjected to sedimentation (autoflocculation) flotation and centrifugation as alternatives for algal harvesting. Algal paste drying was by open air pan drying and sand bed drying. Pelletization of the algae both as sole constituent and in combination with tapioca was studied in an attempt to produce a more marketable product. It was concluded that autoflocculation without chemicals for 7 hours was the most economic algal harvesting method. For an autoflocculation plant with a capacity of 15,750 m^3/day of oxidation pond effluent containing 200 mg/l algae the estimated cost of the algal product is U.S. 12 cents and an annual profit of U.S. $111,200 if the product is sold at the same price as fish meal.

389 McGarry, M.G.

Asian Institute of
Technology,
Bangkok, Thailand.

UNICELLULAR PROTEIN PRODUCTION USING DOMESTIC WASTEWATER
Thai Journal of Agricultural Science. Thailand. Volume 4. pp 213-223. October 1971.
3 tables, 2 figures, 9 references.
ALGAE PONDS: DOMESTIC SEWAGE: ALGAL CONCENTRATION: ALGAL DEWATERING: ALGAL DRYING: DIETARY PROTEINS.

* Unicellular algae has been grown on a pilot plant scale in open ponds receiving domestic sewage. An overall process of algal harvesting, concentration, dewatering and drying is described. Preliminary experiments reveal that the algae may be used as a dietary source of protein for chickens, swine and cattle.

390 McGarry, M.G.
Lin, C.D.
Merto, J.L.

(All) Division of Environmental Engineering,
Asian Institute of Technology,
Bangkok, Thailand.

PHOTOSYNTHETIC YIELDS AND BYPRODUCT RECOVERY FROM SEWAGE OXIDATION PONDS
Advances in Water Pollution Research. U.K. pp. 521-535. Jenkins, S.H. (Ed.). 1973.
6 figures, 17 references.
OXIDATION PONDS: ALGAE: SEWAGE TREATMENT: EFFLUENT.

* This paper describes sewage treatment and algal growth under tropical conditions as affected by pond mixing, solar radiation and diurnal variations in pond loading. Research into processing the algal byproduct is also discussed.

391 McGarry, M.G.
Ng, K.S.
Leung, N.H.
Lee, T.L.

(All) Asian Institute of Technology,
Bangkok, Thailand.

WASTEWATER RECLAMATION UNDER TROPICAL CONDITIONS
Process Biochemistry. U.K. 9(7). pp. 14-24. September 1974.
4 figures, 18 references.
SEWAGE TREATMENT: EFFLUENT RE-USE: ALGAE HARVESTING: WATER RECLAMATION: ASIA.

* A report on studies aimed at reclaiming a potable water from domestic wastewater using techniques appropriate to tropical and savanna developing countries. High rate treatment oxidation ponds, dissolved air flotation with alum coagulation, roughing filtration through coarse sand, photosynthetic nitrogen stripping ponds, powdered activated carbon adsorption, dual media filtration and chlorination were necessary to remove nitrogen and low level organic constituents and produce a physically, chemically and bacteriologically suitable water.

392 McGarry, M.G.
Tongkasame, C.

(Both) Asian Institute of Technology, Bangkok. Thailand.

WATER RECLAMATION AND ALGAE HARVESTING
Journal of the Water Pollution Control Federation, U.S.A. 43(5). pp. 824-835, May 1971.
3 tables, 9 figures, 8 references.
HIGH-RATE PONDS: ALGAE: TREATMENT: ALGAL HARVESTING: THAILAND: RECLAIMED WATER: RECYCLING: TROPICS.

* The high-rate oxidation pond is considered as a potential method of waste treatment in tropical regions. Products of the process are reclaimed water and edible protein harvested from the pond in the form of algae that may be incorporated directly into stock feeds. This paper describes data findings that are obtained from laboratory and pilot scale experiments conducted in Thailand. The reports are concerned with the following: operating conditions of the ponds, methods of algal harvesting, and an urban model development for recycling of the reclaimed water.

393 Neil, J.H.

Environment Canada

THE HARVEST OF BIOLOGICAL PRODUCTION AS A MEANS OF IMPROVING EFFLUENTS FROM SEWAGE LAGOONS
Environment Canada Research Report No. 38. Canada.
40 pp. 1976.
9 tables, 38 references.
SEWAGE: LAGOONS: ALGAE: AQUATIC WEEDS: NUTRIENTS: CANADA.

*The feasibility of removing phosphorus, nitrogen, and organic matter through harvest of algae, duckweed, daphnia, or midge larvae has been examined. Data from five Ontario sewage lagoons and from the literature are analyzed. Sufficient nutrients can be removed by this method. Effective harvesting would greatly enhance effluent quality.

○ 394 Oswald, W.J.

Sanitary Engineering Research Laboratory,
College of Engineering and School of Public Health,
University of California,
Berkeley, U.S.A.

THE HIGH-RATE POND IN WASTE DISPOSAL
Developments in Industrial Microbiology, American Institute of Biological Sciences. U.S.A. 4. pp. 112-119, 1963.
2 tables, 4 figures.
HIGH-RATE PONDS: ALGAE: SEWAGE: DISPOSAL: RECLAMATION: NUTRIENTS: POND DEPTH: DETENTION TIME: PROTEIN.

* High-rate algal laden ponds are used as systems for waste disposal, nutrient reclamation, and water reclamation. From laboratory and pilot plant experiments, the optimum depth and detention time of ponds are found to be 8-10 inches and 3-4 days, respectively. The optimum period of mixing is 2-3 hours per day. Algae produced in the ponds is reported to be high-vitamin, high-protein animal feed concentrate and its production is estimated to be one ton per million gallons of sewage.

395 Sastry, C.A.
Rao, A.V.
Rao, M.N.

REUSE OF STABILIZATION POND EFFLUENTS FOR HARVESTING OF ALGAE
Proceedings of a Seminar on Water Resources Development organized by the Institution of Engineers (India) Durgapur Sub-Centre, in collaboration with Central Mechanical Engineering Research Institute, and Regional Engineering College. Durgapur. India. pp. 243, 22-23 September, 1973.
9 tables, 6 references.
STABILIZATION PONDS: ALGAE RECOVERY: WASTEWATER TREATMENT: INDIA: ALGAE HARVESTING: ALUM FLOCCULATION.

*A report of jar test studies of algal flocculation from effluent of Shahpura oxidation ponds, Bhopal. An alum dose of 200 to 240 mg/l was required to remove 90-97% of the algae after sedimentation for 30 min. pH 8.0-9.0 and flocculation time 20 - 25 min. were optimum. Nirmali seed at a dosage of 8 mg/l in combination with 180 mg/l alum effected 98-99% algae removal. The harvested algae contained 49.4 per cent protein.

396 Shelef, G.
Schwarz, M.
Schechter, H.

(All) The Environmental Health Laboratories,
Dept. of Medical Ecology,
The Hebrew University,
Jerusalem, Israel.

PREDICTION OF PHOTOSYNTHETIC BIOMASS PRODUCTION IN ACCELERATED ALGAL-BACTERIAL WASTEWATER TREATMENT SYSTEM
Proceedings of the Sixth International Water Pollution Research Conference. Israel. No. 9. pp. A/5/9/1 - A/5/9/10 June 18-23, 1972.
6 figures, 2 tables, 23 references.
ALGAE: SEWAGE: STABILIZATION POND: DETENTION TIME: MODEL: SOLAR: GROWTH KINETICS.

* The rate of algal production and the concentration of algae in a sewage stabilization pond with respect to detention time, can be formulated and predicted according to the incident solar irradiance levels. The model is developed using algal growth kinetics and continuous mixed culture theories from which the predicted values are shown to be comparable to actual data.

397 Songer, J.G.
Smith, R.F.
Trieff, N.M.

(All) Department of Preventive Medicine and Community Health, University of Texas Medical Branch. U.S.A.

SEWAGE TREATMENT BY CONTROLLED EUTRIPHICATION...BACTERIAL STUDY

Applied Microbiology. U.S.A. 28(3). pp. 359-361. September 1974.
1 figure, 1 table, 6 references.

MARINE AQUACULTURE: MARINE ALGAE: BRINE SHRIMP: FECAL COLIFORMS: SALMONELLA: SHIGELLA: ENTEROCOCCI.

* A system has been developed on a laboratory scale involving the use of marine algae Tetraselmis chuni for controlled eutrification of raw sewage. Algae grown from raw sewage are fed to brine shrimp, Artemia salina. Net products of the system are reported as: (a) brine shrimp for use as food or shrimp food, and (b) a purified effluent. The authors studied bacterial pathogen flow through the system. Significant reductions in fecal coliforms and entrococci were noted from raw sewage to effluent. Salmonella and Shigella were not detected at any stage, nor was isolated from the effluent only, reflecting the halophilic nature of the organism. Brine shrimp were tested and found to have extremely low numbers of the above organisms.

398 Tenore, K.R.
Dunstan, W.M.

(Both) Department of Biology, Woods Hole Oceanographic Institution, Woods Hole. U.S.A.

GROWTH COMPARISONS OF OYSTERS, MUSSELS AND SCALLOPS CULTIVATED ON ALGAE GROWN WITH ARTIFICIAL MEDIUM AND TREATED SEWAGE EFFLUENT

Chesapeake Science, U.S.A. 14(1). pp. 64-66. March 1973.
2 tables, 13 references.

MARINE AQUACULTURE: SHELLFISH: OYSTER: MUSSEL: SCALLOP: ALGAE: SEWAGE EFFLUENT.

* Describes the experiments carried out at the Woods Hole Oceanographic Institution on the culture of shellfish, American oyster (Crassostrea virginica), the blue mussel (Mytilus edulis), and the bay scallop (Aequipecten irradiens), on algae grown in artificial medium and in secondary treated sewage effluent (10% dilution) in 9 liter trays. No significant differences were observed in shell growth, dry meat weight and mortality.

399 Vincent, W.A.

Battelle Institute,
Geneva, Switzerland.

ALGAE FOR FOOD AND FEED
Process Biochemistry. U.K. 3 pp. June 1969.
5 tables, 14 references.
ALGAE: HUMAN FOOD: ANIMAL FEED: PROTEIN PRODUCTION: NUTRITION: TECHNICAL: SOCIAL: ECONOMICS.

*A possibility of using algae for human food and animal feed is discussed. The author reports maximum protein production is obtained with algae as compared to other kinds of plants and animals, but he differentiates their nutritive values, such as, the hard-cell-wall and thin-cell-wall algal species which are suitable for ruminant and non-ruminant animals, resnectively. The promise of algal culture is not yet fulfilled, the reasons being technical, nutritional and socio-economics.

400 Wachs, A.M.
Shelef, G.
Sandbank, E.

(All) Technion-Israel
Institute of Technology,
Haifa, Israel.

ALGAE OF STABILIZATION POND - THEIR SEPARATION AND UTILIZATION
Unpublished Final Report, Project No. 013-366, 67 pp.
April 1971.
9 figures, 28 tables, 28 references.
ISRAEL: ALGAE: EFFLUENT: ALUM FLOCCULATION: AIR FLOTATION: FISH FEEDING: STABILIZATION POND.

*An investigation conducted in Israel to find a practical and economical method of algal separation from pond effluent and to produce algal by-product that can be used as animal feedstuff. Data from several experiments indicate that improved effluent quality during algal harvesting can be obtained with a combination of alum flocculation and air flotation. Preliminary fish feeding with alum-separated algae proves very encouraging with algae rations of up to 30% of the total feed.

4D. Reuse: Fertilization

401 Anon.

Department of Agriculture,
Stock and Fisheries,
Papua New Guinea.

WORKSHOP ON WASTE RECYCLING SYSTEMS
Proceedings of a Workshop held at the University of Papua New Guinea. 127 pp. 1974.
PAPUA NEW GUINEA: RECYCLING: METHANE: BIOGAS: ANAEROBIC DIGESTION: ALGAE: STABILIZATION PONDS: FISH CULTURE: ANIMAL FEED: LAND TREATMENT: EXCRETA.

* Seventeen papers and three summary papers on waste recycling systems and their application in Papua New Guinea. The first section (5 papers) covers anaerobic digestion of human and animal wastes and digester designs for maximum gas yield. The second section (7 papers) deals with the growth of algae and fish in stabilization ponds, the use of algae and dried animal excreta as livestock feeds, fertilization of sweet potato crops with wet pig manure and integrated rural development (biogas generation in a modified septic tank, waste stabilization ponds and fish and duck ponds to treat septic tank effluent, and vegetable gardens). The third section (5 papers) is concerned with socio economic aspects of human and animal waste recycling systems, principally with the economics and management of biogas generation systems.

●● 402 McGarry, M.G.

International Development
Research Centre,
Ottawa, Canada.

THE TABOO RESOURCE...THE USE OF HUMAN EXCRETA IN CHINESE AGRICULTURE
The Ecologist. U.K. 6(4). pp. 150-154. June 1976.
2 tables, 11 references.
EXCRETA: AGRICULTURE: CHINA: FERTILIZER: PUBLIC HEALTH: DISEASE: COMMUNITY: HOUSEHOLD.

* A review of popular practices in the use of human excreta as fertilizer in China from 1949-1974. Night soil is compared in nutrient value with other fertilizers, and the total contribution of human fertilizer to Chinese agricultural development is estimated. Health education campaigns have reduced the spread of intestinal diseases due to this practice.

○ 403 Peterson, J.R. — The Metropolitan Sanitary District of Greater Chicago, Chicago, U.S.A.

McCalla, T.M. — University of Nebraska, Lincoln. U.S.A.

Smith, G.E. — University of Missouri, Columbia. U.S.A.

HUMAN AND ANIMAL WASTES AS FERTILIZERS

Fertilizer Technology and Use, 2nd Edition, published by Soil Science Society of America, Inc. U.S.A. pp. 557-596. 1971.

8 figures, 27 tables, 42 references.

SEWAGE SLUDGE: MUNICIPAL WASTEWATER: U.S.A.: FERTILIZER: ODOUR: PATHOGENS: DIGESTED SLUDGE: ANIMAL WASTES.

*The solid waste from municipal wastewater treatment plants in the U.S.A. amounts to 45 million metric tons/year. This material contains from 2.6 to 5.6% N, 2.8 to 3.4% P, 35 to 47% organic matter, and a large assortment of other chemical elements. If properly digested, the sludge has little odor and is relatively free of pathogens. Sludge is generally considered as a slow-release fertilizer. The use of digested sludge to ameliorate spoils has been proven. Three years' use of digested sludge on corn land has resulted in increased grain yields and no visual toxic symptoms to the plants. The incorporation of the first year's sludge and plant residues resulted in a decrease in metal concentrations in the leachate water. Application of excessive amounts of digested sludge on cropland results in soil nitrate accumulations and possible groundwater contamination. The lagooning of digested sludge reduces the N content to about 2.6%. This allows an increase in the safe application rate to the soil and provides additional decay time for possible pathogens in the sludge.

Almost 1.8 billion metric tons of animal waste are generated in the U.S.A. annually by livestock and poultry. This waste, primarily feces and urine, although highly variable in composition, contains about 3 kg N, 2 kg P, and 3 kg K/metric ton of wet weight; it also contains numerous trace elements needed by plants and organic matter that improves many soils. The maximum amount of manure that can safely be applied to land is determined by composition of manure, frequency of application, soil, rainfall or quality of irrigation water, and type of crop. Much research has been done with application of manure in quantities ranging from 4.5 up to 45 metric tons/ha. These results can be used only to a limited extent in predicting maximum loading of land with animal waste for optimum crop production and maintaining environmental quality. Disease organisms of animals and humans in wastes must be watched carefully. Most disease organisms are generally destroyed in the holding of waste. Weed infestations may be a problem with the application of animal waste to soil. Tremendous quantities of plant nutrients are in the human and animal wastes produced in this country. In the conservation of resources, workable methods of applying maximum amounts of wastes to land with the least cost and still maintaining environmental quality would be highly desirable.

404 Sastry, C.A.

National Environmental
Engineering Research
Institute,
Zonal Laboratory,
Madras. India.

PUBLIC HEALTH CONSIDERATIONS OF WASTE RECYCLING
Unpublished Paper on Refresher Course on Waste Recycling: Utilization for Agriculture, Public Health Engineering Dept., College of Engineering. India. pp. 8-1 to 8-18. March 10-14, 1975.
3 tables.
PUBLIC HEALTH: SEWAGE: IRRIGATION: INDIA: INFECTION: PATHOGENS: DECONTAMINATION.

* A review of public health hazards associated with the use of raw and undiluted sewage for crop irrigation. Data from India clearly indicates higher infection incidences in sewage farm workers than in the control population. The author suggests a two-week interval between sewage irrigation and harvesting in order to yield vegetables free from enteric pathogens. Another effective method of decontamination is by immersing the vegetable in warm water at 60°C for 10-30 minutes.

405 Sebastian, F.B.

Envirotech Corporation,
Menlo Park,
California.

WASTE TREATMENT IN CHINA.,.ANCIENT TRADITIONS AND HIGH TECHNOLOGY
Ambio. Norway. 1(6). pp. 209-216. December 1972.
4 figures, 17 references.
CHINA: TREATMENT: NIGHTSOIL: AGRICULTURE: FERTILIZER: FISH PONDS: INDUSTRIAL WASTEWATER: HEALTH: ECONOMICS: COLLECTION.

* A report of some methods of treating wastes as practiced in China. While old traditions of night soil collection and recycling to agriculture and fish ponds are still followed, western technology is applied in industrial waste treatment. The author also discusses some health and economic aspects which are related to pollution control.

406 Shuval, H.I.

Environmental Health Laboratory,
The Hebrew University-
Hadassah Medical School,
Jerusalem, Israel.

PUBLIC HEALTH CONSIDERATIONS IN WASTEWATER AND EXCRETA RE-USE FOR AGRICULTURE
"Water, Wastes and Health in Hot Climates". A Wiley-Interscience Publication. U.K. Feachem, R., McGarry, M., Mara, D. (Eds.). ISBN 0 471 99410 3. Chapter 19. pp. 365-381. 1977.
1 photograph, 1 table, 2 figures, 32 references.
HUMAN EXCRETA: NIGHTSOIL: HEALTH: DISEASE: CROPS: SEWAGE FARMING.

* The use of human excreta or nightsoil for crop fertilization has been widely practised for years in many regions of the world. While the improvement in soil productivity is of vital importance, the health risks caused by disease transmission to farm workers or to consumers of vegetable crops eaten raw must be carefully considered. There are various species of pathogenic micro-organisms present in human excreta or municipal wastewater and most conventional treatment processes can only partially remove such pathogens. Some of these organisms have also been reported to survive a long period of time in the fields and crops irrigated with sewage. The author recommends a balance approach such as combining a low-cost waste treatment methods capable of providing reasonable reductions in pathogen levels with restricted irrigation to crops that present a low level of health risk.

407 Williams, G.B.

SEWAGE DISPOSAL IN INDIA AND THE FAR EAST
Thacker, Spink & Co. India. x + 230 pp. 1924.
Chap. 4 "Simple methods of sewage disposal",
Chap. 7 "Septic tanks"
Chap. 10 "Sewage irrigation"
Chap. 14 "Domestic sewage disposal"
INDIA: SEWAGE TREATMENT: EXCRETA: NIGHTSOIL: IRRIGATION: SEPTIC TANKS: AQUA-PRIVIES: DISINFECTION.

*Indian practice of sewage and nightsoil treatment, prior to 1924, is described. Dumping depots, connected to the sewerage system, are recommended for nightsoil bucket collection schemes in partially sewered cities. Aqua-privies, improved latrines and septic tanks for both town and household wastes are described. The use of sewage effluent for agricultural irrigation is discussed with particular reference to the sewage irrigation works at Dacca.

4E. Reuse: Biogas

408 Anon. Central Public Health Engineering Research Institute, Nagpur. India.

NIGHTSOIL DIGESTION SCHEME FOR DELHI CANTONMENT BOARD
Special Report (Consultancy) to Delhi Cantonment Board. India.
6 pp. May 1974.
1 drawing.
EXCRETA DISPOSAL: NIGHTSOIL DISPOSAL: DRY CONSERVANCY SYSTEM: ANAEROBIC DIGESTION: BIO-GAS: OXIDATION PONDS: SLUDGE DRYING: INDIA: URBAN.

*A consultancy report recommending an anaerobic digestion, oxidation pond, sludge drying bed system for treating nightsoil from 30,000 people in the Delhi Cantonment Board Area. The area is served by a dry conservancy system but 6,000 gallons/day of nightsoil containing some urine and ablution water is designed for. To handle a future population of 40,000 a 24 m diameter, 4.5 m liquid depth digester is designed for batch feeding every ½ hour with homogenized nightsoil. Overflow is displaced to two oxidation ponds, 55m x 1.5m, in series and digested sludge is to be drawn from the digester every 5-6 days and dried on four 10 m x 6 m drying beds. About 850 m^3/day of digester gas is expected to be generated, containing 550 m^3/day methane, with estimated fuel value of 140,000 rupees/year. Dried sludge cake, at a rate of about 1.5 tonnes/day with moisture content 50 percent, is expected to be sold as fertilizer for 25,000 rupees/year. A scale drawing of the installation is included in the report.

409 Anon.

Economic and Social Commission for Asia and the Pacific. New York, U.S.A.

REPORT OF THE PREPARATORY MISSION ON BIO-GAS TECHNOLOGY AND UTILIZATION (RAS 74 041 A 01 01)
Proceedings of ESCAP Workshop on Bio-Gas Technology and Utilization. Philippines. 146 pp. May 8, 1975.
7 tables, 14 figures, 74 references.
ANAEROBIC DIGESTION: NIGHTSOIL DIGESTION: BIO-GAS: DESIGN: ASIA.

* A report on bio-gas technology and utilization based on information gathered in India, Japan, Pakistan, the Philippines, Republic of Korea and Thailand. It principally relates to the treatment of animal and agricultural wastes with gas production through anaerobic digestion. Designs from the various countries are given and technological, economic and social aspects discussed. The need for an integrated approach utilizing the liquid effluent for growing algae and raising of fish and duck together with gas use in cooking and lighting.

410 Anon.

J.D. & D.M. Watson, Singapore.

TREATABILITY OF NIGHTSOIL
Master Plan report prepared for the Ministry of the Environment, Government of Singapore. Bukit Timah Area: Sewerage and Sewage Treatment. Singapore. Volume 2. Appendix L. pp. L1-L3. March 1974.
2 figures.
SINGAPORE: NIGHTSOIL TREATMENT: SEWAGE SLUDGE.

* Experiments carried out in Singapore show that maximum gas production was obtained when 1 part of nightsoil was digested with 4 parts of crude primary sewage sludge. Consolidation (thickening) of the nightsoil prior to digestion was advised in order to remove some of the water used to wash out the nightsoil buckets, this water being passed to the main sewage treatment works for full treatment.

●●411 Anon.

Revolution Committee,
District of Mien Chu,
Province of Szechuan, China.

EXCRETA REMOVAL FROM THE MIDDLE LAYER OF A FULLY ENCLOSED TYPE BIOGAS PLANT (TANK)
In "Compilation of Data on Experience and Sanitary Management of Excreta and Urine in the Village". Unpublished report of the International Development Research Centre. Canada. Translated from Chinese by Lee Thim Loy. pp. 55-65. November 1976.
12 tables, 18 figures.
CHINA: BIOGAS: RURAL: CONSTRUCTION: OPERATION: PATHOGENS: RURAL: DIGESTERS.

*This article is the most descriptive of several compiled to illustrate rural practices of excreta and manure treatment and reuse at the village level in China. The biogas plant is extensively described as comprising six parts:

(1) the inlet chamber which daily receives human excreta (10%), animal faeces (30%) crop stalks(10%) and water (50%);
(2) the rectangular or circular fermentation tank used to store the wastes during fermentation;
(3) the fixed top gas storage tank providing space for gas accumulation;
(4) the outlet chamber receiving digested wastes from the fermentation tank at its mid-depth;
(5) the slurry displacement tank located on top of the fisced gas storage tank which is used to store excess slurry as the gas accumulates; and
(6) the gas vent pipe and ancilliary equipment.

This biogas plant design which is extensively used in China offers an outstanding advantage of employing a fixed gas storage tank. Unlike other designs used primarily in Korea and India the gas tank is made of concrete and fixed in place. As biogas is produced by digestion of the wastes it accumulates under the inverted gas holder forcing the liquid level in the fermentation tank downwards. The equivalent volume of slurry is displaced moving through the outlet chamber and on top of the fixed gas storage tank where it is stored in what is called the slurry displacement tank. As gas is used in the household the displaced slurry returns to the outlet chamber.

Full details of design, construction, testing, operation and repair are given. Safety requirements, and in particular safety values are described. The designs of earthenware biogas cooker and lamp are also given.

The biogas plant's capacity to destroy bacterial pathogens and parasitic worms was investigated. Samples were drawn from the influent, the tank bottom and bottom and top of the outlet chamber. Total parasite eggs (including Schistosoma, Ascaris and hookworm) were counted by which it was determined that there was a 94% egg removal in the effluent compared to the influent. It is emphasized however that the effluent still contained over 1,500 parasite eggs per 100 millilitre; this being due to the fact that there were over 23,000 eggs/100 ml in the influent. The hookworm die-off was both rapid and effective.

The reduction in levels of disease-causing organisms is due both to the physical separation of the organism by its settling to the bottom of the tank and to its natural die-off in the tank under adverse growth conditions. Certainly, the major contributing factor to their reduction in the case of the hardier parasite eggs is that of physical separation. In one experiment an improvement of the plant's effluent storage chamber and point of effluent removal from the tank clearly indicated an improvement in total parasite egg reduction from 80% to 98%.

(Original paper written in Chinese)

412 Committee for the Assessment of the Cost-Benefit Effects of Cow-Dung Gas Plants — Indian Council of Agricultural Research, New Delhi, India.

THE ECONOMICS OF COW-DUNG GAS PLANTS
A Report by the Indian Council of Agricultural Research. India.
66 pp. First printed April 1966.
18 tables, 2 figures, 28 references.
COW-DUNG: BIOGAS: INDIA: COST-BENEFIT: PUBLIC ACCEPTANCE: CAPITAL INVESTMENT: RURAL.

* A survey of 133 cow-dung biogas plants at various rural locations in India for the purpose of cost-benefit assessment and identifying necessary measures to gain more public acceptance of the system. It is concluded that there will be a return of approximately 2.5 to 5 rupees for every rupee invested in a 100 cu. ft. gas plant, and as benefits increase with the size of the plant, pay-back for capital investment is possible in about a 4 to 6 year period. Some of the major problems inhibiting widespread adoption of the system are also discussed.

413 Florida, N.

SMALL-SCALE BIO-GAS PLANTS
Unpublished Report. Appropriate Technology Series.
45 pp. December 1973.
7 references, 17 figures, 7 tables.
INDIA: BIOGAS: RURAL: ECONOMICS.
* A general discussion based on observations of Indian experiences in rural biogas installations. The general conclusions are that biogas plants are rather too expensive for widespread use, the corrosion and cost of the steel gas cap remains an unresolved problem, and the dehydration of sludge during monsoon periods is problematic. Standardization of digestor designs and public education is called for.

○ 414 Fry, L.J.

PRACTICAL BUILDING OF METHANE POWER PLANTS FOR RURAL ENERGY INDEPENDENCE
Standard Printing. U.S.A. 96 pp. 1974.
73 references, 53 figures.
RURAL: METHANE: BIOGAS: SOUTH AFRICA: OPERATIONS: DESIGN: CONSTRUCTION.
* This book describes early work done by the author in developing practical batch-loaded and displacement methane digestors on a South African farm. Raw materials, digester design and operation, sludge re-use, and gas and gas usage are described.

415 Hanumanulu, V. National Environmental Engineering Research Institute, Nagpur, India.

COMMUNITY WASTE TREATMENT AND UTILIZATION FOR RURAL AREAS
Unpublished Manuscript. 21 pp. 1977.
7 tables, 5 figures, 9 references.
WASTEWATER TREATMENT: BIO-GAS: NIGHTSOIL DISPOSAL: INDIA: DESIGN: ECONOMICS.
*A review of possible application of the bio-gas system for digestion of nightsoil from communities of 100 - 2,000. The design of a system including homogenizer, nightsoil digester, two stabilization ponds for liquid effluent and sludge drying beds for digested sludge is given. Capital and operating costs for such a system are presented for different populations in the range mentioned. A community latrine and nightsoil digestion scheme is outlined and estimated to cost about 90,000 rupees in India for a population of 1000.

416 McGarry, M.G.

International Development
Research Centre,
Ottawa, Canada.

DOMESTIC WASTES AS AN ECONOMIC RESOURCE....BIOGAS AND FISH CULTURE
"Water, Wastes and Health in Hot Climates", A Wiley-Interscience Publication. U.K. Feachem, R., McGarry, M., Mara, D. (Eds.).
ISBN 0 471 99410 3. Chapter 18, pp. 347-364. 1977.
1 photograph, 4 figures, 24 references.
DOMESTIC WASTES: TREATMENT: REUSE: BIOGAS: FISH CULTURE: COST-BENEFITS: PUBLIC HEALTH: ASIA.

* The treatment and reuse of domestic wastes through biogas and fish culture have been employed by several countries in Asia. This chapter describes general processes of the biogas and fish culture, including their methods of construction, operation and maintenance. Cost-benefits analyses of the biogas plant are favourable as the end-product gas can be used for heating and cooking while its effluent slurry is suitable for uses as fertilizers. Increases in fish production in fish ponds receiving sewage are evident. Some public health aspects of these two systems are discussed.

417 Moulik, T.K.
Srivastava, U.K.

(Both) Centre for Management
in Agriculture,
Indian Institute of Management,
Ahmedabad, India.

BIO-GAS PLANTS AT THE VILLAGE LEVEL - PROBLEMS AND PROSPECTS IN GUJARAT
Unpublished Report, Centre for Management in Agriculture, Indian Institute of Management. India. 149 pp. November 1975.
27 tables, 5 figures, 19 references.
RURAL: BIOGAS: SOCIO ECONOMIC: OPERATIONS: INVESTMENTS: INDIA: ECONOMIES OF SCALE: COMMUNITY: HOUSEHOLDS.

* An investigation of 199 rural biogas plants in Gujarat, India with reference to socio-economic and operational problems. Investments in biogas plants of all sizes are found to be economically viable, but economies of scale are obtained with the larger sized plants for richer households. The authors propose community gas plants as a means of solving these problems and suggest strong cooperation from major organizations in order to make the program a success.

418 Mudri, S.S.

Central Public Health
Engineering Research
Institute,
Field Unit,
Poona, India.

SOME OBSERVATIONS ON THE ANAEROBIC DIGESTION OF NIGHTSOIL
Environmental Health. India. 9(2). pp. 133-136. 1967.
2 tables, 1 figure, 3 references.
NIGHTSOIL: EXCRETA DISPOSAL: ANAEROBIC DIGESTION: BIO-GAS: INDIA: RURAL.

* A report of a study of performance of a nightsoil digester at St. Joseph Technical School, Nagpur, serving four latrines. Digester influent and effluent analyses are tabulated showing a highly variable performance, from 29 - 93 per cent reduction in volatile solids for a detention time of 60 days. Gas production was 1.2 $ft.^3/lb.$ of wet nightsoil and this was used as fuel for cooking in the kitchen of the school hostel.

419 Nagar, B.R.

Indian Agricultural Research
Institute,
New Delhi, India.

BIOGAS PLANTS BASED ON NIGHTSOIL AND/OR ANIMAL DUNG
World Health Organization International Reference Centre for Waste Disposal News. Switzerland. No. 8. 4 pp. June 1975.
1 figure.
BIOGAS: CONSTRUCTION: OPERATION: MAINTENANCE: GAS PRODUCTION: DIGESTER: COW-DUNG: NIGHTSOIL: RURAL.

* A description of an Indian biogas plant, principles, construction, operation/maintenance, and uses of the gas. About 5 livestock units or 60 persons are required to provide sufficient raw materials for a plant having 2 cu. meter gas holder. Methods of stimulating gas production in winter are also suggested such as the addition of cattle urine, powdered leaves and/or wheat straw, to the digester.

420 Oswald, W.J.

Public Health and Civil
Engineering Dept.,
University of California,
Berkeley. U.S.A.

GAS PRODUCTION FROM MICROALGAE
Presented at the Institute of Gas Technology Symposium, "Clean Fuels from Biomass, Sewage, Urban Refuse and Agricultural Waste". U.S.A. 14 pp. January 29, 1976.
3 figures, 2 tables, 7 references.
METHANE PRODUCTION: ALGAE: DIGESTER: ECONOMICS: SOLID WASTES.

* A description of a methodology of methane production from integrated solid wastes and algal biogas facility, in which dry wastes could be used to generate power, release CO_2 for algae, and heat the algal digesters. Economic analyses of the system reveal its feasibility and the author discusses some crucial research areas which need to be carried out for the maximization of algal harvesting.

421 Pfeffer, J.T.

Dept. of Civil Engineering,
University of Illinois,
Urbana. U.S.A.

RECLAMATION OF ENERGY FROM ORGANIC WASTE
Report No. EPA-670/2-74-016. U.S. Environmental Protection Agency, National Environmental Research Centre, Office of Research & Development. 142 pp. March 1974.
45 tables, 27 figures, 48 references.
METHANE: ANAEROBIC FERMENTATION: SHREDDED REFUSE: SEWAGE: SLUDGE: TEMPERATURES: NUTRIENTS: OPERATION: COSTS: U.S.A.

* A study of methane production from an anaerobic fermentation of a mixture of organic shredded refuse and raw sewage sludge. The experiments were carried out in the laboratory at temperatures ranging from 30^{0} to 60^{0} C and parameters evaluated included the quality and quantity of gas produced, the rate of gas production, per cent solids reduction, nutritional requirements, and operating problems. These results together with other published cost data indicate that methane can be produced and sold at a price that is competitive with the current energy costs in the United States.

422 Prasad, C.R.
Prasad, K.K.
Reddy, A.K.N.

BIO-GAS PLANTS...PROSPECTS, PROBLEMS AND TASKS
Economic and Political Weekly. India. pp. 1347-1364. August 1974.
4 tables, 5 figures, 63 references.
BIOGAS: ELECTRICITY: FERTILIZER: PRODUCTION: MANURE: SOCIO-ECONOMIC: RESEARCH: RURAL: METHANE.

* Biogas plants are reported to be capable of fulfilling a demand for small scale electricity and fertilizer. For a village of 500 persons and 250 cattle, the biogas-energy production is claimed to be the equivalent of 667 kilowatt-hour per day with the organic manure by-product of about 295 tons per year. However, the author points out some socio-economic problems and further tasks for research and development which need to be carried out to gain more public acceptance of the system.

423 Pyle, D.L.

Dept. of Chemical Engineering
and Chemical Technology,
Imperial College,
London. U.K.

TECHNICAL OPTIONS IN ANAEROBIC DIGESTION - A BACKGROUND PAPER
Unpublished Report prepared for the International Development Research Centre. Canada. 146 pp. November 1976.
84 references
BIOGAS: ECONOMICS: ANALYSIS: DIGESTERS: MATHEMATICAL MODELS· METHANE.

* This is a general review of the state-of-the-art in biogas technology based on existing literature. Possible directions for future research are in reducing the capital cost of the plant; it is emphasized that in the biogas field at this time, good engineering is more important than "research". The implications of alternatives (fuel sources, designs, loading rates, etc.) in assessing biogas technology is emphasized.

424 Pyle, D.L.
Fraenkel, P.

(Both) Intermediate
Technology Development Group,
London. U.K.

METHANE
Proceedings of a one-day seminar. Intermediate Technology Publications Ltd. U.K. 51 pp. 1975.
METHANE: BIOGAS: ANAEROBIC DIGESTION: SEWAGE SLUDGE: AGRICULTURAL WASTES: EXCRETA.

*12 short papers covering three main areas of discussion: (1) theoretical and practical aspects of methane generation and early methane generator designs; (2) problems faced in the research, development and marketing of methane generators; and (3) the potential application of methane generation in rural communities with particular reference to developing countries.

425 Ramaprasad, T.N.C.
Srinivasan, M.V.
Shanta, S.

(All) National Environmental
Engineering Research
Institute,
Nagpur, India.

AN INTEGRATED SYSTEM OF TREATMENT AND DISPOSAL OF NIGHTSOIL WITH AN EMPHASIS ON BY PRODUCT UTILIZATION
Paper presented at the seminar on utilization of farm wastes for rural industrial growth, National Dairy Research Institute. India. 12 pp. December 31, 1975.
2 tables, 11 references.
EXCRETA DISPOSAL: NIGHTSOIL DIGESTION: ANAEROBIC DIGESTION: BIO-GAS: INDIA: OXIDATION PONDS: HOOKWORM: ASCARIS.

*A report on experimental digester studies with nightsoil and cow dung and pilot plant digestion of nightsoil of Nagpur Central Prison. Laboratory oxidation pond studies on digester supernatant are reported. Results of a laboratory study of survival of hookworm and ascaris ova in nightsoil digestion are presented.

426 Sathianathan, M.A. Association of Voluntary Agencies for Rural Development, New Delhi. India.

BIO-GAS - ACHIEVEMENTS AND CHALLENGE
Published by Association of Voluntary Agencies for Rural Development. India. 192 pp. First edition June 1975.
16 chapters, 201 references.
INDIA: BIOGAS: HISTORICAL ASPECT: PERFORMANCE: ECONOMICS.
*This book contains various aspects of biogas as being in practice in India. It includes a historical survey of biogas from 1951 to present, and a detailed explanation of the formation, production and use of the biogas. The performance of a number of biogas plants in the country is surveyed from which an economical analysis reveals that capital cost on these plants can be paid back within a short period. The study also reports that community plants in villages can provide power to at least two small industries in each village. A number of research and development problems concerning the future of biogas are discussed.

427 Singh, R.B.

BIOGAS PLANT - DESIGNS WITH SPECIFICATIONS
Gobar Gas Research Station. India. 49 pp. 1973.
49 drawings.
INDIA: BIOGAS: DESIGNS.
* A collection of blueprints for 21 biogas plants of various sizes, ranging from a 100 cubic feet per day family size to a 4000 cubic feet per day plant.

○ 428 Singh, R. B.

BIO-GAS PLANT- GENERATING METHANE FROM ORGANIC WASTES
Gober Gas Research Station. India. 104 pp. 1974.
19 references, 23 drawings.
BIOGAS: METHANE: DESIGN: CONSTRUCTION: OPERATION: INDIA: ANIMAL WASTES: ENERGY: TREATMENT: RURAL.
*A practical handbook for the design, construction and operation of small-scale rural biogas plants based on the author's experiences. A short history of the development of biogas is followed by a detailed discussion of operation techniques: loading, ingredients, temperature control. The construction procedures for a number of specific designs, ranging from family size to community scale, are described.

429 Singh, R.B.

Indian Council of Agricultural Research, New Delhi. India.

THE BIO-GAS PLANT - GENERATING METHANE FROM ORGANIC WASTES
Compost Science. U.S.A. Volume 13. pp. 20-25. January/February 1972.
2 tables, 3 figures.
INDIA: BIOGAS: DESIGN: OPERATION: MAINTENANCE: DIGESTERS: GAS COLLECTION.
*A description, based on the author's experiences in India, of how to design, operate and maintain a biogas plant. Both single and double-stage digesters for small scale (less than 500 cu.ft. of gas produced per day) and large scale plants are discussed including methods of gas collection.

430 Singh, R.B.

Indian Council of Agricultural Research, New Delhi. India.

BUILDING A BIO-GAS PLANT
Compost Science. U.S.A. Volume 13. pp. 12-16. March/April 1972.
1 figure, 1 table.
CONSTRUCTION: BIOGAS: OPERATION: TECHNOLOGY.
*Construction techniques of five types of biogas plants in many areas of the world are described. The author claims successful operation of all the systems and intends to provide the reader an idea of different levels of technology and scales of the plants which he can choose from.

431 Srinivasan, H.R.

Khadi and Village Industries Commission, Bombay. India.

GOBAR-GAS PLANTS PROMISES AND PROBLEMS
Indian Farming. India. XXIII(11). pp. 29-33. February 1974.
NIGHTSOIL DISPOSAL: ANAEROBIC DIGESTION: GOBAR GAS: BIO-GAS: INDIA: RURAL SANITATION.
* A brief review of the application of anaerobic digestion of village wastes in gobar gas plants, their social effects and economic impact. Some problems of this system are discussed and possible solutions suggested. Future plans of the Khadi and V.I. Commission for installing gas plants are mentioned.

432 Subrahmanyam, P.V.R.

National Environmental Engineering Research Institute, Nagpur, India.

DIGESTION OF NIGHT SOIL AND ASPECTS OF PUBLIC HEALTH
Paper presented at Workshop on Biogas Systems, The Management Development Institute. India. 21 pp. 1977.
5 tables, 3 figures, 19 references.
RURAL SANITATION: NIGHTSOIL DIGESTION: BIO-GAS: ANAEROBIC TREATMENT: INDIA.

*A progress report on the NEERI research on anaerobic digestion of faeces from the Nagpur prison. Laboratory and pilot plant studies are reviewed. The pilot plant has been in operation for 1½ years and at an organic loading of 2.6 kg. V.S./m^3 day the V.S. destruction was more than 50 percent and the gas generated was 0.448 m^3/kg. V.S. added. The gas contained 60-65 percent methane and 0.05 - 0.1 percent H_2S. Details of the digester and layout of the unit with stabilization ponds and sludge drying beds to serve a community of 1000 are given.

●● 433 Subramanian, S.K.

Management Development Institute, New Delhi. India.

BIOGAS IN ASIA
Unpublished Report. International Development Research Centre. Canada. 97 pp. November 1976.
INDIA: BIOGAS: RURAL: HOUSEHOLD: COMMUNITY: ECONOMICS: SOCIAL: CONSTRUCTION: OPERATION: AGRICULTURE: METHANE: FUEL: CUSTOMS: KOREA: PHILIPPINES: THAILAND: INDONESIA: JAPAN.

*Biogas plants have found their greatest popularity in Asia where the number of installed plants have increased remarkably over the past two decades. This report was written as a background paper for a meeting on the social and economic evaluation of the biogas plant, held in Sri Lanka and sponsored by the International Development Research Centre. It covers the historical development of biogas plants in India and present practices involving their use in India, S. Korea, the Philippines, Thailand, Indonesia and Japan. The report also discusses dominant social and economic issues related to the biogas plant in each country; problems of data collection and gaps in information; and finally the various technical approaches being used within the region.

There are over 36,000 plants in India, nearly 27,000 in Korea, 100 in the Philippines, and 225 in Thailand. Success in their continued operation is varied and affected by numerous inter-related factors. In India, most plants are fed by cow-dung although a significant percentage (particularly in the State of Harayana) are connected to toilets for direct feeding of human excreta. The gas is used essentially for cooking; the fertilizer slurry effluent is most often introduced into drying beds for later application to the land or into composting pits which utilize other forms of agriculture

waste and refuse. Adverse climatical conditions during the Korean winter limits the biogas units' effective use to the warmer months. Most are operated only with cattle and pig dung although toilets are attached to the digester in some cases. The digesters are insulated with rice husks to improve winter gas production rates; the gas collector dome is PVC and thus less expensive than the conventional Indian dome made of painted steel. The effluent slurry is most often used on the land without prior dessication.

Although India has standardized its biogas plant design through its implementing agency (The Khadi Village and Industry Commission) there are many variations being used in Asia including horizontal and vertical units made of both flexible and rigid materials and operated under continuous, intermittant and batch loading conditions. The report briefly describes the numerous attempts to use different locally available materials, to build plants in different ways to different designs, to find locally suitable methods of using the gas outputs or to experiment with using the effluent slurry. Subramanian notes that in contrast to the impression given by official publications on the subject a wide diversity in designs and practices exist in Asia and warns that the emphasis on informity may seriously reduce the potential usefullness of the technology.

Several international agencies have recently become interested in the biogas plant as an "appropriate technology". In particular ESCAP and UNEP have become actively involved in projects while UNIDO, UNDP, UNICEF, WHO, The World Bank and IDRC are interested; the latter two particularly in the plant's technical, social and economic evaluation.

Demand or motivational aspects are reviewed. Dominant motivation for adopting biogas plants vary between and even within countries. The gas as used for cooking does, however appear to be the primary benefit with the manurial value of the slurry often being given only marginal emphasis. The more hidden benefits related to public health and deforestation are recognized only by the governments which provide grants or soft loans (but decreasingly so) to individuals interested in installing biogas units. The author stresses that the perceived manurial value of the slurry may be more substantial than is commonly assumed. Not only do some people value the manure which was previously burnt, others value the composting of other waste materials with the digester's slurry. The perception of these advantages other than the availability of gas household use, could increase in the future.

Again, as perceived, benefits vary from country to country, so do problems with propagation and operation of the units. In particular, extension services vitally need for maintenance and repair are often lacking; likewise credit facilities are commonly cumbersome. One fact which is common to most situations where the plant is individually owned is that the biogas plant is adopted by and benefits the wealthier farmer as the landless labourer or tenant has neither the required capital

to construct nor animals to feed the system. Water and land also pose problems where they are not readily available, in particular, the land required for slurry drying or composting has a high opportunity cost in urban or peri-urban situations.

Use of night-soil or human excreta in the biogas plants is resisted for religious and psychological reasons in many locations. However, over 30% of the units in Harayana are attached to toilets, in the opinion of many, the psychological inhibitions are bound to die in the course of time. Serious strong resistance would likely be encountered in Thailand and the Philippines but in Indonesia such would not likely be the case as human waste is already used to feed back-yard fish ponds.

Although institutional plants connected to agro-industries or schools are operating successfully in many parts of Asia, successful communal plants are rare, and indeed non-existant in India Communal plants as may be attached to co-operative movements require strong, honest and dedicated leadership in overcoming the inherent problems of distribution of construction costs, operating responsibilities, contributions of wastes and use of the gas and slurry products.

Evaluating the biogas plant is complex and site specific in particular great variations and a dearth of basic information exists with respect to the capital costs of the biogas unit, costs of land, the dung produced by animals, seasonal fluctuations on demands, availabilities and values of resource, inputs and products, product yields and etc. With respect to the plants design and operation wide variations exist in loading but the normal practice in India is to load 1.6 to 2 kg volabile solids per cubic metre of digester volume per day (kg/m -day). The general concept of maximum loadings is 2 to 3 kg/m -day within the mesophilic temperature range and 5 to 6 kg/m -day within the thermophilic. Considerably higher loadings are reported from research findings in Japan. Detention periods are normally 50 days in India but this can be reduced to 20 - 40 days as practiced in the Philippines. Variance of opinion exists on the minimum number of animals which are required to feed the smallest viable plant. Although a minimum number of five cattle are stipulated to support even a 60 cubic foot plant, such units have been found to operate successfully on a two cattle, a buffalo and a calf or even one animal and an attached toilet. The dung produced by animals varies widely with the breed of animal. For example, a cow in Kerala may yield 4 kg of dung a day, whereas a well fed buffalo in Harayana may produce up to 30 kg daily. As a result of over-standardization and application of criteria over widely varying conditions the potential of biogas systems may be constrained. The author emphasized the need for site-specific socio-economic evaluations, development of less expensive gas holder and digester designs, gas burners with higher efficiences, improved modes of by-products use, increased efficiences of digestion, the compiling of the biogas system with other non-conventional energy sources and its use in agro-industrial wastes treatment.

434 Subramanian, S.K.
Ganesh, S.

BIOGAS TECHNOLOGY - PERFORMANCE AND PROSPECTS IN INDIA
Unpublished report NCST/SG/GG-74. National Committee on Science and Technology. India. 28 pp. December 1974.
22 references.
INDIA: BIOGAS: RURAL: ECONOMICS.
*A short discussion based on observations of Indian experiences with biogas plants in rural areas. It is felt that the two main problems retarding wider use of biogas are the lack of organization in installation and maintenance procedures, and the actual cost of the plant.

435 Tennakore, L.
Jayawardena, J.
Wijesekera, B.

BIOGAS - WHY AND HOW?
Industrial Development Board of Ceylon.
IDB - 684. 13 pp. July 1976.
3 diagrams
SRI LANKA: BIOGAS: DESIGN.
*A short discussion of biogas technology is followed by a description of a biogas generator design developed in Sri Lanka, the Lakgen, which eliminates the metal floating gas cylinder and replaces it with an all-masonry unit.

436 Trevelyan, W.E. Tropical Products Institute, London. U.K.

THE METHANE FERMENTATION,,,A DISCUSSION PAPER
Tropical Science. U.K. 17(4). pp. 193-209. 1975.
66 references.
METHANE: ANAEROBIC FERMENTATION: THEORY.
* The current status of scientific and technological studies of the anaerobic (methanogenic) fermentation is summarized. The process of the formation of methane through anaerobic fermentation is not as well understood as other major industrial fermentations, because of the difficulty in isolating and culturing pure strains of the highly oxygen-sensitive methanogenic bacteria, and of lack of knowledge of the bio-chemical pathways leading to the formation of methane.

5. Greywater

437 Anon.

HUMAN EFFECTS RELATING TO DIRECT AND INDIRECT RE-USE OF WASTEWATER FOR HUMAN CONSUMPTION
Technical Paper Series No. 7, WHO, International Reference Centre for Community Water Supply. Netherlands. 164 pp. September 1975.
4 appendices
PUBLIC HEALTH: WASTEWATER: REUSE: STANDARDS: CONTAMINANTS.
* The report presents the current knowledge relating to refractory water contaminants and their possible impact on health in relation to direct or indirect wastewater re-use for human consumption. A detailed survey of maximum reported concentrations of organic and inorganic compounds in water as well as microbiological contaminants in water is presented in appendices.

438 Anon. Office of Science and Technology, Agency for International Development, Washington. U.S.A.

WATER QUALITY STANDARDS AND INTERNATIONAL DEVELOPMENT
Report No. TA/OST-71-4. U.S. Agency for International Development. 34 pp. October 1971.
15 references.
WATER QUALITY: CRITERIA: STANDARDS: DRINKING WATER: WATER SUPPLY.
* This report summarizes progress to date in establishing water quality standards in the United States and in developing countries. Its purpose is to assist those broadly concerned with environmental policies in developing countries to better understand past efforts and future needs in this field.

439 Edling, M.
Ekstrand, G.

Avdelningarna for
Vattenforsorjnings - och
Avloppsteknik samt Vattenkemi
KTH, S-100 44 Stockholm,
Sweden.

INFILTRATION OF GREYWATER (INFILTRATION AV BDT-VATTEN)

A report issued December 1975. 30 pp.
13 figures and diagrams, 3 appendices, 11 literature references.
GREYWATER: WASTEWATER: INFILTRATION: BED-MATERIAL.

*Infiltration-tests were made with greywater in the laboratory and in an existing filter-bed for greywater. The laboratory-tests were aimed at checking if the bed-material itself has any purifying effect or if it only is spreading the water over the infiltration area, if the kind of material in the bed is of importance, if a mixture with organic material gives a different purification and if the thickness of the bed has any importance.

Three materials (fine - and coarse gravel and leca) were tested but no difference in purifying effect due to the different materials was noted. The bed gave an efficient spreading of the water over the infiltration area, but the purification obtained was low (partly due to the short period of investigation).

To control the importance of thickness and humus-content in the bed, greywater was infiltrated in a mixture, to various proportions, of gravel and peat, with varying height. The reduction of phosphorus and COD took place mostly in the upper 20 cm of the material.

An analysis of Clivus filterbed for greywater gave rather varying results. Its effect is very dependent on the flow through the bed. As there is no equalizing of the flows, the filter is washed out at heavy flows, while it works efficiently during low flows. As an improvement of the filter it is suggested that it is made cylindrical instead of conical and that the aeration is made more efficient through a construction that makes the water fall freely through a part of the filter-bed.

(Original paper written in Swedish)

440 Fogel, M.
Lindstrom, C.R.

THE TREATMENT OF HOUSEHOLD WASHWATER IN HOMES EQUIPPED WITH THE CLIVUS MULTRUM ORGANIC WASTE TREATMENT SYSTEM
An Unpublished Report of Clivus Multrum U.S.A., Inc.
7 pp. June 1976.
13 references
HOUSEHOLD: SULLAGE: TREATMENT: WASHWATER: FILTRATION: LEACHING CHAMBER: SEEPAGE BEDS: AEROBIC.
*The nature of grey-water is compared with that of combined wastewater.

It is noted that an elimination of the black-water, that is the result when using Clivus Multrum lowers the wastewater amount with about 40%. In addition the BOD , nitrogen - and phosphorus - concentrations are lowered considerably.

The bacteria-content remains high even after a separation, though most of the disease-causing organisms are eliminated.

Different methods for treatment of greywater are discussed. The methods are based on existing infiltration - and resorption - techniques, but some changes and simplifications are suggested due to the low pollution-load in grey-water compared with combined wastewater.

It is also noted that the methods are quite new and not yet fully tested.

441 Frankel, R.J.
Sevilla, A.S.

(Both) Asian Institute of Technology,
Bangkok, Thailand.

AN ASIAN TECHNOLOGICAL APPROACH TO WATER REUSE SERIES FILTRATION USING LOCAL FILTER MEDIA
Sixth International Conference, Advances in Water Pollution Research. Israel. pp. 723-731. June 8-23 1972.
5 figures, 1 table.
SULLAGE: TREATMENT: FILTRATION: WATER: MATERIALS: RICE HUSKS: COCONUT FIBER: CONSTRUCTION: OPERATION.
* A new approach to the filtration of water and wastes utilizes locally available materials, principally burnt rice husks and shredded coconut fibre, as media. These materials are cheap enough to discard, thus eliminating backwashing. The results of one year of testing are reported.

442 Htun, M.N.
Aftab, M.P.
Ramachandran, P.N.

(All) Asian Institute of Technology, Bangkok, Thailand.

SOME APPLICATIONS OF SOLAR ENERGY IN THAILAND
Research Report to the John F. Kennedy Foundation of Thailand, Asian Institute of Technology. 78 pp. June 1976.
3 tables, 38 figures, 24 references.
SOLAR ENERGY: SOLAR STILL: SOLAR DRYING: SOLAR COOKING: VILLAGE TECHNOLOGY: THAILAND.

* A report on research studies of solar drying, solar distillation and solar cooking. Good quality water can be produced at a rate of 2.04 l/m^2d at the mean solar radiation level of 5.1 KW/m^2 and, with mirrors, the rate can be increased to 4.95 l/m^2d. Addition of activated carbon to the feed at 12 g/l increased the efficiency by 48.6 per cent to an overall efficiency level of 27.5 per cent. Burnt rice husk suspended in the feed was less efficient than activated carbon but overall efficiency increased to 33 per cent when a static bed of burnt rice husk was used. Using a static bed of burnt rice husk and constructing the still so as to collect rainwater, when weather permits, the cost of producing one litre of potable water is calculated to be 11 Baht (U.S. 52 cents). The solar dryer reduced the moisture content of tapioca chips from 71 per cent to 14 per cent within 8 hours at a loading of 15 g/m^2 and costing 10 Baht (U.S. 45 cents) per kg. of chips.

443 Huisman, L.
Wood, W.E.

(Both) World Health Organization, Geneva. Switzerland.

SLOW SAND FILTRATION
World Health Organization. Switzerland. 122 pp. 1974.
52 figures, selected bibliography.
SAND: FILTRATION: WATER TREATMENT: SULLAGE: PURIFICATION: CONSTRUCTION: OPERATION.

*A detailed review of the technology of slow sand filtration as a method of water treatment. This traditional method is still the cheapest and simplest option for developing countries, as it makes use of locally available skills and materials. The construction and design of slow sand filters is described as well as operating techniques and the theory of biological filtration. The application of slow sand filtration to the artificial recharging of groundwater sources is described.

444

Hypes, W.D.
Batten, C.E.
Wilkens, J.R.

(All) NASA Langley Research Center,
Hampton, U.S.A.

PROCESSING OF COMBINED DOMESTIC BATH AND LAUNDRY WASTE WATERS FOR REUSE AS COMMODE FLUSHING WATER.
Report No. NASA TND-7937. U.S.A. 66 pp. October 1975.
4 references, 18 tables, 9 figures.
REUSE: WASTEWATER: FILTRATION: GREYWATER: CHARCOAL FILTER: DESSICATION: CHLORINE: PUBLIC HEALTH.

*An experimental investigation of processes and system configurations for reclaiming combined bath and laundry waste waters (grey water) for reuse as commode flush water has been conducted. Filtration by single pass (no control of pressure and flow rate), 90-minute recycle, and 120-minute recycle flows through a diatomaceous earth cake filter has been investigated as a means for improving physical/chemical characteristics of the grey water. A 90-minute recycle flow is reported to be effective in removing particulates down to 1 micro-meter in maximum dimension and in improving other physical characteristics to the extent that the filtered water is subjectively acceptable for reuse. A further improvement in physical and selected chemical characteristics of the treated water can be obtained by activated charcoal adsorption following the 90-minute recycle flow which has resulted in noticeable reductions in color, turbidity, and sudsing.

Heating of the wastewaters to temperatures of 135°F and 145°F for periods of 15, 30 and 45 minutes and chlorination at available chlorine concentrations of 1, 15, 20, and 25 mg/l to reduce/eliminate coliform organism counts, have been investigated. A temperature of 145°F for 30 minutes and chlorine concentrations of 20 mg/l in the collection tank followed by 10 mg/l in the storage tank are determined to be adequate for public health safety.

The volume of bath and laundry waters available from a typical American family of four is found to be greater than the volume of water required for commode flushing when the water conserving, shallow-trap commode is used. Losses due to collection-tank overflow and tank drainage to remove accumulated particulates will reduce the volume of wastewater available and could possibly result in the need for a small volume of makeup tap water. The amount of energy required to operate this typical reusing system is reported to be relatively low. A system using diatomaceous earth filtration and chlorine sterilization to process the waters for reuse requires an average of 0.695 kWh/day.

445 Kabbash, A.

GREYWATER TREATMENT
Unpublished Report, Renewable Resources Project. Macdonald College of McGill University. Canada. 29pp. March 1977.
9 references, 7 diagrams.
FILTRATION: GREYWATER: WASHWATER: REUSE: TREATMENT.
* A filtration system is designed to treat household washwater (greywater) which is then tested and evaluated. Possible methods of discarding the greywater (e.g. infiltration) or the possibility of reuse (e.g. for toilet flushing) are discussed. Similar research projects are briefly outlined.

446 Katzenstein, L.B.
Braswell, J.A.

(Both) Naval Coastal Systems Laboratory, Panama City. U.S.A.

VIRUS ELIMINATION IN WATER AND WASTEWATER
Unpublished Report. 34 pp. January 1976.
128 references.
TREATMENT: WASTEWATER: SEDIMENTATION: OZONATION: DISINFECTANTS: VIRUSES: MICROORGANISM CONTROL.
* The effectiveness of various techniques for disinfecting sewage and drinking water are discussed. Special emphasis is given to the elimination of viruses. Basic concepts of water and wastewater treatment are reviewed. Information is presented on economically feasible methods for improving virus removal.

447 Olsson, E.
Karlgren, L.
Tullander, V.

(All) The National Swedish Institute for Building Research, Stockholm. Sweden.

HOUSEHOLD WASTEWATER
Report 24: 1968, UDC 628-31 by the National Swedish Institute for Building Research, Stockholm. 162 pp. 1968.
36 figures, 98 tables, 58 references.
GREYWATER: CHARACTERISTICS: SWEDEN: BOD_5: PHOSPHORUS: NITROGEN BACTERIA: RATES OF DECOMPOSITION.

*The purpose of this investigation is to obtain information about the quantity and characteristics of waste water from dwelling houses. The study emphasizes grey water, i.e. wastewater from bathrooms, kitchens and laundry and the results obtained are compared with the pollution in wastewater from toilets (i.e. black water). About 25 flats in a suburb of Stockholm, Sweden, have been used as the subject of this experiment.

It is established from this extensive study that the flow as well as the pollution, with respect to both volume and nature, is the same from day to day without any noticeable differences between different days of the week. On the other hand, the variations within the day itself are so great and so unsystematic that the analysis results from separate parts of the day do not provide any useful representative figures of the quantities of pollution. Average flow of the grey water is reported to be 121.5 liter/capita-day and of black water is 8.5 liter/capita-day.

Analysis of the composition of the grey water reveal that the kitchens contribute nearly 70% of BOD , while approximately 60% of the quantities of phosphorus originates from the laundry. The quantities of nitrogen are split up in such a way that the kitchens supply 51%, the bathroom 31% and the laundry 18%. The amount of BOD_5 emanated from the grey water is averaged to be 25 grams/capita-day while for black water is 20 grams/capita-day. The ranges of coliform bacteria densities are reported to be 1.7×10^9-83.0×10^9 and 3.8×10^9 - 62.2×10^9 bacteria numbers/capita-day for grey water and black water, respectively.

The rates of organic decomposition of the grey water are found to be about 65% per 24 hours which are relatively fast as against 20% per 24 hours for black water and municipal wastewater. Furthermore, the secondary (indirect) aspect of pollution from the grey water is calculated to yield theoretically about 7.5 more biochemical oxygen demand than the primary (direct) oxygen/demand via phosphorus synthesigation into plankton cells. These results suggest that special attention must be paid to the grey water and that proper treatment of the grey water should be carried out prior to its discharge to the environment.

448 Shannon, E.E.

Wastewater Technology Centre,
Environmental Protection Service,
Environment Canada.

Verghese, K.I.

Chemical Development Department,
Aluminium Company of Canada Ltd.
Arvida. Quebec. Canada.

UTILIZATION OF ALUMIZED RED MUD SOLIDS (ARMS) FOR PHOSPHORUS REMOVAL
Water Pollution Control Directorate, Technology Development Report EPS 4-WP-75-2. Environment Canada. 15 pp. August 1975.
3 figures, 5 tables, 4 references.
ALUMIZED RED MUD SOLIDS: COAGULATION: PHOSPHORUS REMOVAL: SEWAGE TREATMENT: HEAVY METALS.

* Alumized red mud solids (ARMS) is a new material with coagulant properties which is derived from the waste product (red mud) of the Bayer process for producing aluminium. Pilot plant experiments utilizing ARMS to treat a municipal wastewater are described. BOD, suspended solids and total phosphorus removal efficiencies are reported and compared to results from a similar aluminium sulphate (alum) experiment. The fate of heavy metals impurities in the ARMS has also been investigated. It is concluded that ARMS can be used in full scale phosphorus removal systems, resulting in chemical operating costs as much as 50 per cent lower than comparable alum systems.

●● 449 Siegrist, R.
Witt, M.
Boyle, W.C.

(All) Civil and Environmental Engineering Dept.
University of Wisconsin,
Madison, U.S.A.

CHARACTERISTICS OF RURAL HOUSEHOLD WASTEWATER
Journal of the Environmental Engineering Division, American Society of Civil Engineers. U.S.A. 102(EE3), Proceeding Paper 12200, pp. 533-548. June 1976.
17 tables, 3 figures, 15 references.
RURAL: HOUSEHOLD: WASTEWATER: U.S.A.: CHARACTERISTICS MASS POLLUTANTS: WATER USAGE.

* Field studies have been conducted for 434 days at 11 homes in Wisconsin to study their water usage characteristics, flow per use, and flow per capita per day. Daily and weekly flow patterns are also developed. Wastewater quality characterization is carried out consequently from which the concentration and mass of pollutants per event occurrence, and the mass of pollutants per capita per day are determined.

450 Sivakumar, M.

Environmental Engineering Division,
Asian Institute of Technology,
Bangkok. Thailand.

HORIZONTAL FLOW PREFILTRATION OF TROPICAL SURFACE WATER
Master of Engineering Thesis No. 993, Asian Institute of Technology. Thailand. 75 pp. 1976.
17 tables, 38 figures, 32 references, 4 appendices containing 12 tables, 2 figures and computer programmes.
WATER TREATMENT: BANK FILTRATION: HORIZONTAL FLOW FILTRATION: ASIA.

* A report on studies of horizontal flow prefiltration through crushed stone for turbid surface water treatment. Multiple regression of data indicated that influent turbidity, depth of media, length of media and flow rate were significant parameters in affecting turbidity removal. For raw water turbidity about 35 JTU the optimum filtration rate was 0.34 m^3/m^2h and, with 150 JTU raw water, the optimum rate of filtration was 0.19 m^3/m^2h. A cost model for a pilot size horizontal flow prefilter unit was developed and solved using Lagrange's function. This type of filter is very effective in removing suspended solids from turbid surface waters.

451 Thanh, N.C.
Pescod, M.B.

(Both) Environmental Engineering Division,
Asian Institute of Technology,
Bangkok. Thailand.

APPLICATION OF SLOW FILTRATION FOR SURFACE WATER TREATMENT IN TROPICAL DEVELOPING COUNTRIES
Research Report No. 65 to WHO International Reference Centre for Community Water Supply. Asian Institute of Technology. Thailand. 75 pp. July 1976.
6 tables, 15 figures, 11 references, 4 appendices containing 8 tables and 4 figures.
WATER TREATMENT: SLOW FILTRATION: SERIES FILTRATION: LOCAL MATERIALS: BURNT RICE HUSK: COCONUT FIBRE: SAND: THAILAND.

* A report on a one-year performance evaluation of a slow sand/burnt rice husk filter in combination with a coconut fibre roughing filter and dual media filters containing coconut fibre overlying burnt rice husk and burnt rice husk overlying sand in the same filter box. With the series filter combination of coconut husk and burnt rice husk a filter run of 2-3 months can be expected with a raw water turbidity 100 JTU and filtration rate 0.2m^3/m^2-h. The dual media combination of the same materials gave a 2 1/2 month run with 100 JTU influent turbidity at the same filtration rate, but a 7 month run with 50 JTU influent and 0.1m^3/m^2-h filtration rate. A series filter system was estimated to cost 25% more to install than the dual media filter, but both would have running costs of 5 Baht/month per person (U.S. 25 cents). The burnt rice husk and sand dual media filter was expected to be most appropriate for village use.

452 Yen, T.C.

Environmental Engineering Division,
Asian Institute of Technology,
Bangkok, Thailand.

STUDY OF POTENTIAL EFFECTIVENESS OF VARIOUS LOCAL MATERIALS IN FILTERING INDUSTRIAL AND DOMESTIC WASTES
Master of Engineering Thesis No. 567. Asian Institute of Technology. Thailand. 156 pp. 1973.
26 tables, 18 figures, 5 appendices containing 42 figures, references.

WASTEWATER TREATMENT: LOCAL MATERIALS: COCONUT FIBRE: DUAL MEDIA FILTER.

* A report on laboratory scale filtration using a series of units with local materials as media in the treatment of industrial and domestic wastes. 50 cm of shredded coconut husk and 30 cm^3 of burnt rice husk operated at a filtration rate of 1.24 m^3/m^2-h was feasible as a tertiary treatment process, giving 40% BOD removal with oxidation pond effluent. 80 cm^3 of shredded coconut fibre at a filtration rate of 2.5 m^3/m^2-h was 40% efficient with the same waste and effective as secondary or tertiary treatment of domestic waste. 55% BOD removal was achieved using a dual media filter comprised of 50 cm pea gravel and 30 cm sugar cane bayasse ash at a filtration rate of 1.25 m^3/m^2-h.

6. Water-Saving

453 Anon. De Bell and Richardson, Inc. Enfield. U.S.A.

FINAL REPORT ON WASHWATER WASTE PRETREATMENT SYSTEM STUDY
U.S. National Aeronautics and Space Administration. U.S.A. Contract NAS 9-14518. 59 pp. March 1976.
29 tables.
WATER: WATER-SAVING: WATER REDUCTION: LOW-FOAM SOAPS: WASHING APPARATUS.
* An evaluation of numerous chemical agents as antifoams for synthetic washwater. A low-foaming liquid soap for sponge bathing and hand washing is described.

454 Anon. Environmental Control Technology Corporation, Ann Arbor. U.S.A.

EVALUATION AND PERFORMANCE RESULTS OF THE FLUSHMATE TANK
A report published by Water Control Products/N.A., Incorporated. U.S.A. 36 pp. November 1975.
4 tables, 9 figures, 5 references.
LOWW FLUSH CISTERN: TOILET BOWL DESIGN: WATER SUPPLY: WATER SAVING: TOILET PERFORMANCE.
* Basic operating characteristics of the Flushmate Tank with three leading water closets have been investigated. Water supply and discharge characteristics of both Flushmate and gravity tank operated water closets have been measured and compared. Fixture performance tests and backflow prevention tests have also been conducted on both Flushmate and gravity tank fixtures.

The results of the testing programme have shown:

1. Flushmate operated water closets place a substantially lower water demand on the water supply system (52% less water usage).

2. Peak discharge flow rates were influenced primarily by bowl design, and Flushmate and gravity tank operated fixtures had similar discharge peak flow rates, however, the Flushmate discharge time was 49% shorter.

3. Flushmate operated units were good performance water closets.

455 Anon. Information Office,
McGill University,
Montreal. Canada.

SHOWER WITH ONE LITRE OF WATER
Research McGill. Canada. pp. 5-7. May 1976.
WASHING APPARATUS: WATER: WATER CONSERVATION: ATOMIZED SPRAYS.
*This article describes work done in developing a shower which operates for 10 minutes using only 1 litre of water. A composting toilet which allows for the hygenic disposal of wastes without an elaborate plumbing system is also described.

456 Anon.

SAVING WATER IN THE HOME
Building Research Establishment News. U.K.
Volume 38. pp. 4-5. Winter 1976.
2 figures.
HOUSEHOLD: WATER REDUCTION: WASTEWATER: REUSE: ATOMISED SPRAYS: LOW-FLUSH TOILET: DESIGN.
* Research on water-saving devices for British homes is described. A retrofitted device reduces flush-water consumption in toilets by 40%. Bathroom wastewater is recycled to be used for toilet flushing. Atomised water is proposed for washing. It is estimated that savings of up to 50% could be achieved by various combinations of these devices.

457 Anon. Ultraflo Corporation,
Sandusky. U.S.A.

HOW ULTRAFLO SYSTEMS CONSERVE ENERGY AND WATER
Ultraflo Ecology Bulletin. U.S.A. 10 pp. 1973.
7 tables.
DOMESTIC: ENERGY SAVING: WATER CONSERVATION: WASTEWATER: WATER CONSUMPTION: ECONOMY: ONE LINE SYSTEM: PUSHBUTTON FAUCET: HEATED WATER.
*Based on electronic monitored programs in actual households, data compiled on water use and user habits demonstrated with the Ultraflo pushbutton, one line system that there was a saving of 12 to 20% of total water consumed compared to households with conventional two line systems. The Ultraflo system eliminates waste or heated water normally left standing in lines between uses.

458 Anon.

Washington Suburban Sanitary Commission,
Hyattsville. U.S.A.

ITS UP TO YOU
A CUSTOMER HANDBOOK ON WATER-SAVING AND WASTEWATER REDUCTION
The Washington Suburban Sanitary Commission. U.S.A. 24 pp. May 1976.
30 illustrations, 1 table.
WATER SAVING: WASTEWATER REDUCTION: DISHWASHING: CLOTHES WASHING: BATHING: PLUMBING MAINTENANCE: PRESSURE REDUCTION:
* FLOW RESTRICTION: TOILET FLUSHING: DOMESTIC.
Three reasons for water saving are given: (1) the fact that water resources are limited, (2) water costs are rising because of increased processing required to meet today's health standards for water, and cost of wastewater disposal; and (3) to reduce the load on collection and treatment systems potentially dangerous for pollution.

Many helpful hints for more effective use of conventional plumbing fixtures are offered. Mention is also made of water saving devices which attach to existing fixtures as well as alternative fixture equipment. Water use figures are stated to point up actual quantities of normal use and waste. Hints are given for water saving outside the house, and a table of plant watering guide is shown.

○ 459 Bailey, J.R.
Benoit, R.J.
Dodson, J.L.
Robb, J.M.
Wallman, H.

(All) General Dynamics,
Groton, U.S.A.

A STUDY OF FLOW REDUCTION AND TREATMENT OF WASTEWATER FROM HOUSEHOLDS
Water Pollution Control Research Series 11050 FKE 12/69, Department of the Interior. Federal Water Quality Administration. U.S.A. 154 pp. December 1969.
108 references, 18 figures, 14 tables.
WATER SAVING: DEVICES: HOUSEHOLD: WASTEWATER: FLOW REDUCTION.
* This study identifies practical means of waste flow reduction for American households. Commercially available devices for water saving are described and literature on advanced water and waste treatment is reviewed. A consumer survey was conducted and showed that water used in household functions such as bathing and toilet flushing can be substantially reduced by the use of more efficient appliances and plumbing devices.

460 Bailey, J. R.
Wallman, H.

(Both) Electric Boat Division,
General Dynamics,
Groton, U.S.A.

FLOW REDUCTION OF WASTE WATER FROM HOUSEHOLDS
Water and Sewage Works. U.S.A. 118(3). pp. 68-70.
March 1971.
3 tables, 4 figures, 8 references.
WATER SAVING: DUAL FLUSH TOILET: VACUUM TOILET: FLOW REDUCTION: PUBLIC ACCEPTANCE: DEVICES.

*Water saving devices such as the dual flush toilet tank system and the vacuum toilet system are currently available. These systems are reported to provide, at no overall cost penalty to the homeowner, a water savings (and waste flow reduction) of 30 to 50 per cent. A limited survey indicates that the use of such water saving devices would be readily accepted by homeowners.

461 Bender, T.

Department of Architecture,
University of Minnesota,
Minneapolis, Minnesota. U.S.A.

LIVING LIGHTLY...ENERGY CONSERVATION IN HOUSING
A report published by Department of Architecture, University of Minnisota. U.S.A. pp. 12-15. October 1973.
5 references, 7 illustrations.
WATER CONSERVATION: ENERGY CONSERVATION: FLUSH TOILET: BATHING: CLOTHES WASHING: DISHWASHING: PEDAL VALVES: MIST SHOWER: COMPOST TOILET: WATER HEATERS: DOMESTIC.

*The conservation of water is related to energy conservation. Water requires energy for treatment, which in turn affects the physical environment. Water savings are possible by its reuse in toilets, water reduction devices, toilet redesign, use of compost toilets, and use of foot operated faucet valves on sinks and wash basins and locating them close to water heaters. Design of clothes washers and even clothing material can affect the amount of water used. Heated water is a great energy consumer. Use of solar water heaters, proper water heater location, and insulation can all save heat.

462 Borjesson, E.
Bobeda, C.

(Both) Corporacion de Obras Sanitarias de Asuncion, Paraguay.

NEW CONCEPT IN WATER SERVICE FOR DEVELOPING COUNTRIES
Journal - American Water Works Association. U.S.A. 56(7). 11 pp. July 1964.
5 figures, 5 tables.
WATER CONSERVATION: DOMESTIC: SPRING-LOADED FAUCET: PLUMBING: WATER SUPPLY: WATER CONSUMPTION: PUBLIC HEALTH: ONE-PIPE SYSTEM: PUSH-BUTTON FAUCET: DEVELOPING COUNTRIES: WATER SAVING.
*This is a report about a system which effectively accomplishes an improvement in public health and social conditions in three areas in developing countries. The problem was to provide a permanent healthful water supply in adequate amounts to individual dwellings in all urban areas at a price that the customer could afford and that would also pay for the service. The solution was installation of a one-pipe water supply line serving a group of domociles, each provided with a "Fordilla" spring-loaded faucet. This device restricts the overuse and waste of water much as the hand pump does. Details of water distribution and costs and use data are presented, as well as public acceptance of the system.

463 Bostion, H.E.
Cohen, S.
Wallman, H.

(All) U.S. Environmental Protection Agency.

SAVING WATER IN THE HOME
Water Conditioning. U.S.A. 16(10). pp. 16-21. November 1974.
3 diagrams, 2 tables, 18 references.
WATER CONSERVATION: WASTEWATER REUSE: DOMESTIC.
* A report of two studies conducted by General Dynamics and by the Washington Suburban Sanitary Commission of equipment available for saving water in the home. This equipment includes reduced-flow toilets, flow-limiting shower heads, and faucet aerators. It is concluded that there is justification for installing such devices to save water.

○ 464 Cohen, S.
Wallman, H.

DEMONSTRATION OF WASTE FLOW REDUCTION FROM HOUSEHOLDS
U.S. Environmental Protection Agency. U.S.A. Report No. EPA-670/2-74-071. 102 pp. September 1974.
12 references, 1 aopendix, 29 tables, 28 figures.
WATER CONSERVATION: DOMESTIC: RECLAMATION: SEWAGE: TREATMENT: FILTRATION: DISINFECTION: COST ANALYSIS: PLUMBING: TOILET FLUSHING: FLOW RATE.

* A two-year demonstration program was conducted to evaluate water savings, costs, performance and acceptability of various water-saving devices. Reduced flow toilets, and flow limiting shower heads were installed in eight single-family dwellings. In three of the homes bath and laundry water was filtered, disinfected, and reused for toilet flushing and/or lawn sprinkling. The experimental portion of the program ran from May 1971 to May 1973.

Water requirements for toilet flushing were substantially reduced in an economically attractive and aesthetically acceptable manner. Shallow-trap and duel flush toilets resulted in average decreases in toilet water usage of 25% and 23%, respectively. Flow restricting shower heads proved to be relatively ineffective, however this result may have been due to use patterns unique to this study. Wash water recycle systems provided satisfactory operation throughout the test period. The average savings for toilet flushing reuse ranged between 23% and 26% of total water usage. The incorporation of lawn sprinkling as a supplemental reuse made further reduced waste flow from homes by 16% to 18%. For single-family dwellings, recycle systems could effect marginal cost savings in high water and sewer use rate areas. They are definitely warrented when septic systems with poor drainage (due to soil or topography) are encountered.

(U.S. NTIS PB-236 904)

465 Fowell, A.
Bransdorfer, A.
Fletcher, P.
Orend, R.
Pavel, H.
Williams, G.

RESIDENTIAL WATER USE AND THE POTENTIAL FOR CONSERVATION
Water and Water-related Conservation in Buildings, USN CCIB/CIB International Symposium on Water Supply and Drainage, National Academy of Sciences. U.S.A. pp. 5-9. September 28-30, 1976.
19 references, 4 tables, 1 figure.
RESIDENTIAL WATER: U.S.A.: EUROPE: WATER CLOSET: FLOW RATES: PLUMBING: WATER SAVING: ENERGY CONSERVATION: WATER HEATERS: FLOW RESTRICTORS: RESEARCH: GREYWATER.

* Differences in U.S. and European domestic water consumption are attributed to personal habits, water consuming appliances, and mainly water closet design. Fixture and fitting minimum flow rates based on function have not been researched in the U.S., but two criteria for estimating potential for water saving in appliances and fixtures are given.

Energy savings can result from improved efficiency of water heaters, from reduced consumption of hot water, and by use of flow restrictors in showers and basin faucets. Research is needed to provide a comprehensive study of energy use in water supply and wastewater treatment systems; and from the point of view of: economic impact in contrast to technology of conservation, safe economic quantities of water required for acceptable performance of fixtures, safety and practicality of greywater use. Without thorough evaluation of water saving water closets and add-on devices, the result may be a hazard to health and double flushing of toilets.

In sum, research should establish energy impact of water conservation by energy-benefit analysis as well as impact of water saving measures.

466 Fuller, B
Marks, R.

THE DYMAXION WORLD OF BUCKMINSTER FULLER
Anchor Books, Anchor Press/Doubleday. U.S.A. pp. 99-100. 1973.
5 illustrations
BATHING: ATOMIZED WATER: PLUMBING: WATER CONSERVATION: WASHING: SHOWERING: DOMESTIC: HYGIENE.

* The author considers the Dymaxion bathroom as an interim sanitary facility. Fog gun combines water and air at high pressure to release skin cells and dirt. Illustrations show laboratory set-up and three magnified photographs of skin surface, and students researching fog gun use in bathing. With such fog guns tons of plumbing would be saved as well as bathroom enclosing walls.

467 Gay, D.E.

SPRAY FAUCETS SAVE WATER AND ENERGY
Building Systems Design. U.K. 71(4). pp. 35-36.
June/July 1974.
1 table, 1 figure.
SPRAY FAUCET: WATER SAVING: ENERGY SAVING: ENGLAND.
*A spray faucet system is reported to provide savings for both water and energy. Investigations conducted in London show that an average time taken for washing with spray faucets is less than 60 seconds, compared with 90 seconds for the traditional method. Future uses of this system are expected to increase.

468 Goldstein, S.N.
Moberg, W.J. Jr.

WASTEWATER TREATMENT SYSTEMS FOR RURAL COMMUNITIES
Commission on Rural Water, National Demonstration Water Project.
U.S.A. pp. 294-307. 1973.
1 table, 9 diagrams.
WATER CONSUMPTION: WATER REDUCTION: HOUSEHOLD: WASTEWATER: PLUMBING: FLOW REDUCTION: LOW FLUSH TOILET: RURAL: COMMUNITIES: EQUIPMENT: SURVEY: FLOW REDUCTION.
* Reducing water consumption in households by careful use by individuals, by reducing the amount of water that flows through plumbing fixtures, and by recycling water used in certain functions reduces wastewater, treatment facilities, allows more users to be served by water systems of lesser capacity.

Survey of available equipment includes illustration, identifies manufacturer, shows performance, characteristics, and includes comments.

469 Guarneri, C.
Reed, A.
Renman, R.

(All) Grumman Aerospace Corporation, Bethpage. U.S.A.

STUDY OF WATER RECOVERY AND SOLID WASTE PROCESSING FOR AEROSPACE AND DOMESTIC APPLICATIONS
NASA Contract NAS 9-12503, Manned Spacecraft Center. U.S.A.
Volume I, 31 pp., Final Report Summary.
Volume II, 192 pp., Final Report.

Volume I	Volume II
8 figures	49 figures
3 tables	23 tables
	46 references
	3 appendices

WATER RECOVERY: SOLID WASTES: COMMUNITY: WATER CONSERVATION: COSTS: EQUIPMENT: DESIGN: VACUUM TOILET: WATER: TREATMENT: DOMESTIC.

* Land development in many parts of the country is discouraged by inadequate water resources or by incompatabilities between water supply and waste treatment plans. Many established areas cannot satisfactorily keep pace with rapidly expanding urban populations for the same reasons. In addition, the cost of additional water supply and waste management in such areas can be extremely high. Practical alternatives to conventional water and waste treatment systems are required in newly constructed or redeveloped communities where such difficulties exist. This report evaluates the manner in which current and advanced technology can be applied to develop practical solutions to existing and emerging water supply and waste disposal problems.

An overview of water resource factors as they affect new community planning, and requirements imposed on residential waste treatment systems are presented. The results of equipment surveys contain information describing: commercially available devices and appliances designed to conserve water; devices and techniques for monitoring water quality and controlling back contamination; and advanced water and waste processing equipment system concepts are developed and compared on the basis of current and projected costs. Economic evaluations are based on community populations of from 2,000 to 250,000. The most promising system concept is defined in sufficient depth to initiate detailed design.

(U.S. NTIS N73-19158 & N73-19159)

470 Hershaft, A.

Environmental Studies,
Enviro Control, Inc.,
Rockville. U.S.A.

WASTEWATER FLOW REDUCTION IN THE HOME
Environmental Systems. U.S.A. 4(3). pp. 217-239.
Fall 1974.
5 tables, 4 figures, 51 references.
RESIDENTIAL: WASTEWATER: FLOW REDUCTION: HOUSEHOLD: WATER USAGE: WATER SUPPLY: DEVICES: PRACTICES.

* Methods of residential wastewater flow reduction, devices and practices, are presented and discussed in detail. The author indicates a trend of future shortage of high quality water supply and suggests cooperation from institutions and government agencies in order to effectively carry out a program to reduce household water usage.

471 Hershaft, A.
Von Hasseln, R.
Roop, R.

WATER MANAGEMENT ALTERNATIVES ON LONG ISLAND
A report published by Booz, Allen and Hamilton, Incorporated and Environmental Technology Seminar, Incorporated. U.S.A. pp. 39-44. October 1974.
2 tables, 2 figures, 7 references.
FLOW REDUCTION: DEVICES: WATER-SAVING TOILETS: RECYCLING: WATER CONSUMPTION: WASTEWATER: TREATMENT: DOMESTIC: U.S.A.: LOW FLUSH TOILET.

* Water reduction can be acheived through introduction of flow reduction and recycling devices that complement described conservation practices. Some more common owner installed flow reduction devices are listed in a table as to type, operation, effectiveness, cost and name of manufacturer. Recycling domestic water assumes that water quality need only be sufficient for the intended purpose. A promising approach to water reduction is water saving toilets, which are described as to their nature, operation, effectiveness, cost, and manufacturer of the more common designs. If flow reduction practices suggested by the Washington Suburban Sanitary Commission could shift water consumption to off-peak hours, they would be particularly effective in decreasing required water and wastewater treatment plant capacity.

472 Irons, F.

HAND SPRAYERS AND DUSTERS
U.S. Department of Agriculture, Home and Garden Bulletin No. 63. U.S.A. 12 pp. 1970.
Out of Print, 1 table, 17 illustrations.
SPRAYS: HOUSEHOLD: COMPRESSED-AIR SPRAYER: BUCKET PUMP: NOZZLES.

* The pamphlet describes various hand-operated pesticide spraying and dusting devices for use in the home, in the garden, and on farms. Intermittant sprayers discharge the spray material only with each forward stroke of the pump. Continuous sprayers develop and maintain a constant pressure, and develop a continuous spray discharge of uniform pattern while the pump is being operated. Useful information such as operating pressure, tank sizes and spray patterns is given as well as information on maintenance and pesticide handling.

473 Mani, J.S.V.
Srinivas, V.
Subba Rao, V.
Rao, N.

(All) Andhra University, Waltair. India.

ATOMIZATION BY PRESSURE NOZZLES
Indian Institute of Chemical Engineering Journal. India. Part I, pp. 111-118, Part II, pp. 151-159, Part III, pp. 10-13. 1955-1956.

Part I	Part II	Part III
1 table	3 tables	2 tables
9 figures	8 figures	5 figures
9 references	5 references	4 references

PRESSURE NOZZLES: FLOW-RATE: DROP-SIZE: SPRAY: ATOMIZATION: WATER SAVING: PLUMBING: INDIA.

* An investigation on atomization of liquids by nozzles using a swirl-disk nozzle was conducted in India. The following characteristics: total flow-rate, volume-rate distribution, drop-size distribution and cone angles were determined. Correlation for the effect of pressure on total flow-rate, volume-rate, distribution, drop-size distribution, cone-angle and capacity were also attempted.

The effect of tangential and vertical velocity components on "atomization" in a swirl thread nozzle using water was examined as well as the effect of surface tension of liquids on "atomization", using aqueous isoamyl alcohol.

●●474 Morse, A.D.

School of Architecture,
McGill University,
Montreal, Canada.

THE USE OF ATOMIZATION FOR WASHING AND SHOWERING TO CONSERVE WATER

Master of Architecture Thesis, School of Architecture, McGill University. Canada. 124 pp. August 1976.
71 illustrations, 27 tables, 50 references.
WATER-SAVING DEVICES: ATOMIZATION: NOZZLES: SHOWERING: HYGIENE: DESIGN: PLUMBINGLESS BATHROOM: DOMESTIC.

*A number of devices to reduce domestic water consumption are available on the American market. These include spring-loaded self-closing faucets, pressure-reducing shower-heads and flow-reducing valves.

These devices are based on pressurized water-pressure in the house. There is also a need for devices that allow bathing with extremely small quantities of water, where the latter is not available within the home.

In order to reduce the amount of water needed for individual bathing, and, in turn, to reduce household consumption of water as well as production of wastewater, atomizer nozzles have been tested for washing and showering purposes.

Atomization is the mechanical subdivision of a bulk liquid (e.g. water) into a fine droplet spray. This is accomplished by passing water under pressure, through a nozzle. A test of a number of nozzles indicates best performance with industrial hydraulic nozzles having flow rates of 0.13 - 0.33 liters/minute at 1.3 atmospheres, which have enough impact to remove soap suds from the skin.

A prototype shower was built utilizing a 2.5 liter water tank in which pressure could be manually induced with a bicycle pump. A series of showering tests indicated a 5-8 minute shower utilized 2 liters of water. Some problems were encountered with rinsing excess soap-suds and hair-washing.

The atomized shower was pleasant to use and showed a water reduction of over 90% compared to a conventional shower.

In order to measure cleansing ability, a bacterial count was taken before and after atomized showering with biosidal soap. Sample results taken after 48 hours incubation showed a reduction in bacteria of 95%.

475 Murawczyk, C.
Ihrig, D.
Mayeux, J.
Weber, R.

(All) Martin Marietta Corporation,
Denver. U.S.A.

WATER RECOVERY AND SOLID WASTE PROCESSING FOR AEROSPACE AND DOMESTIC APPLICATIONS
NASA Contract NAS9-12504, Manned Spacecraft Center. U.S.A.
41 pp. January 1973.
2 figures, 3 tables.
WATER CONSUMPTION: AEROSPACE TECHNOLOGY: WASTEWATER REUSE: WATER QUALITY: WATER MANAGEMENT: POTABLE WATER: WATER RECOVERY: SOLID WASTES.

* The final report describes (a) compiling information needed to establish the current water supply and wastewater processing requirements for dwellings and (b) developing a preliminary design for a wastewater to potable water management system. Data generated as a result of item (a) above was used in the formulation of design criteria for the preliminary design of the wastewater to potable water recycling system. The system as defined herein was sized for a group of 500 dwelling units.

(U.S. NTIS N73-19161)

476 Ortega, A.
Rybczynski, W.

(Both) Minimum Cost Housing Group,
School of Architecture,
McGill University,
Montreal, Canada.

STOP THE FIVE GALLON FLUSH! A SURVEY OF ALTERNATIVE WASTE DISPOSAL SYSTEMS
School of Architecture, McGill University. Canada. 82 pp.
April 1976.
73 illustrations, 18 references.
WASTE DISPOSAL SYSTEMS: HOUSEHOLD: WATER CONSERVATION: HUMAN WASTE: LOW-COST TOILETS: COMPOSTING TOILETS: MOULDERING TOILETS: SANITATION: INTERMEDIATE TECHNOLOGY: BATHROOM: FLUSHING: DOMESTIC: DESIGN.

*The book is a survey of alternative domestic water conserving waste disposal systems. Part I reviews the known methods for the disposal of household waste, noting the advantages and disadvantages with special interest in self-contained systems and ones that use little or no water. Part II is a catalogue of data emphasizing low cost systems being manufactured in various countries, not purporting, however to be a consumer's guide. Classification of waste disposal systems is by processes that occur to the human waste: manual removal, mechanical removal, destruction, infiltration, and decomposition. Part III describes the operation of composting toilets, and ends with a low cost design by the authors for use in temperate climates, which can be made for $100 or less. A useful summary chart gives concise data on all toilets listed herein.

477 Rosener, A.
Parker, D.
Brzeczek, M.
Ott, G.
Harris, S.
Lenda, J.

(All) Martin Marietta Corp., Colorado. U.S.A.

TECHNOLOGY DEVELOPMENT FOR A ZERO-GRAVITY WHOLE BODY SHOWER
Contract No. NAS1-9819, National Aeronautics and Space Administration. U.S.A. 268 pp.
116 illustrations, 41 tables, 4 references.
SHOWER: AEROSPACE TECHNOLOGY: WATER CONSERVATION: DESIGN CRITERIA: HYGIENE: STERILIZATION: WATER COLLECTION: BACTERIA: NOZZLE: FLOW RATES.

* Initially, the program consisted of theoretical and experimental investigations to establish design parameters. These design parameters were used to establish the test hardware for further experimental investigations in both one-gravity and zero-gravity environments. This report describes these efforts and the resulting conclusions concerning shower feasibility, shower design concepts, liquid-gas separation techniques, and their related zero-gravity design criteria.

During Task 1, an analysis of zero-gravity air-water behaviour, stall configuration, and related habitability parameters was made before the test hardware was constructed. The Task 2 effort investigated and refined these concepts to establish the minimum impact on the contract baseline mission model.

Based on Task 1 and Task 2 test results, basic design criteria were established for two zero-gravity whole body shower concepts. The amount of water required to bathe the whole body, including the head, averages approximately ½ gallon, which is due to the use of a hand-controlled nozzle, the nozzle design, operating procedures, and the tendency of the water to cling to the body.

478 Rosener, A.
Parker, D.
Harris, S.

(All) Martin Marietta Corp., Denver. U.S.A.

Hall, J.

NASA Langley Research Centre, Hampton. U.S.A.

SPACE SHOWER HABITABILITY TECHNOLOGY
American Institute of Aeronautics and Astronautics Conference. U.S.A.
Paper No. 71-873. 8 pp. August 9-11, 1971.
10 figures, 6 tables.
SPACE SHOWER: BATHING: WATER CONSERVATION: WATER COLLECTION: WATER TEMPERATURE: WATER QUALITY: CLEANSER QUALITY: BACTERIAL REMOVAL: SHOWER: NOZZLE.

*A zero-gravity, whole body shower design has been developed that provides crewmen with bathing facilities similar to those used on Earth. In the absence of gravity, surface tension is the primary force which governs water behaviour. Shower stalls and associated hardware must be designed to effectively collect water for subsequent processing. The shower habitability parameters must be integrated with this technology to ensure crew compatability and comfort. Test results are presented concerning these habitability parameters and how they are effective in providing a shower to cleanse the hair and body and provide a psychological lift.

479 Schumacher, E.
Lenda, J.

(Both) Martin Marietta Corporation, Denver. U.S.A.

DESIGN, FABRICATION AND ACCEPTANCE TESTING OF A ZERO-GRAVITY WHOLE BODY SHOWER
American Institute of Aeronautics and Astronautics, Intersociety Conference on Environmental systems. U.S.A.
Paper No. A74-39144. 11 pp. July 29- August 1, 1974.
5 tables, 7 figures.
SPACE SHOWER: BATHING: WATER CONSERVATION: DESIGN: WATER COLLECTION: NOISE LEVELS: MICROBIAL COUNT: SHOWER ASSEMBLY.

* This paper describes the three task effort to design, fabricate, and acceptance test of a zero-gravity whole body shower for the Space Station Prototype. Conceptual designs for various subsystems of the shower were established as part of Task 1. Task 2 involved the formulation of preliminary and final designs for the shower. The design has separate modules for the showering area, electrical and mechanical components. Task 3 included the fabrication and test of the shower assembly.

480 Sharpe, W.

Pennsylvania State University, Institute for Research on Land and Water Resources and the Cooperative Extension Service, University Park. U.S.A.

WATER CONSERVATION AND WASTEFLOW REDUCTION IN THE HOME

The Pennsylvania State University, College of Agriculture Extension Service and the Institute for Research on Land and Water Resources. U.S.A. Special Circular 184. 9 pp. 1977.

6 references, 9 figures, 7 tables.

WATER CONSERVATION: WASTEFLOW REDUCTION: WATER-SAVING DEVICES: TWO-CYCLE TOILETS: VACUUM TOILETS: INCINERATOR TOILETS: WASTEWATER RECYCLING: WASTE-WATER TREATMENT: SEWAGE-DISPOSAL.

* step by step explanation of treatment of water supply and waste-water is given. What is shown are ways for the homeowner to save water and energy without changing a normal style of living. The less water we use the smaller the volume of waste water produced, and the less it costs for treatment. There is a description of water-using appliances and of water saving devices for taps, toilets, and showers; as well as a table showing water and cost savings by reusing wash water in toilets. Two-cycle, vacuum and incinerator toilets are also discussed.

481 Sibley, A.

Building Research Station, Garston, U.K.

WATER SUPPLY INSTALLATIONS AND APPLIANCES

Royal Society of Health Journal. U.K. 79(1). pp. 39-41. January/February, 1959.

7 references, 2 figures.

WATER SAVING DEVICES: WATER CONSERVATION: SPRAY TAPS.

* A report on some techniques for domestic water conservation. A new efficient type of ball valve for toilet flushing cisterns has been designed. Spray taps reduce water consumption in communal washrooms. The need for investigating the efficiency of flush toilets relative to water used is pointed out.

482 Sobolev, A. (Both) Building Research Station,
Lloyd, C.J. Garston. U.K.

TRIALS OF DUAL FLUSH CISTERNS
Journal of the Institution of Water Engineers. U.K.
18(1). pp. 53-58. February, 1964.
1 figure, 2 tables.
WATER-SAVING: DEVICES: LOW-FLUSH CISTERNS: WATER: WATERBORNE: WATER CONSERVATION.
*This paper describes the construction of a dual-flush cistern, and the way it saves water. Details of trials carried out, to determine the saving likely to be achieved are given.

●●483 Vincent, L.J. (Both) Zambia Housing Board,
Keppie, G. Lusaka, Zambia.

REDUCTION OF WATER WASTE BY THE USE OF CONSTANT-FLOW VALVES
AID-UNC/IPSED Series Item No. 2. U.S.A. 4 pp.
September 1966.
3 figures.
CONSTANT-FLOW VALVE: ZAMBIA: WATER REDUCTION: COSTS: WATER SUPPLY: HOUSEHOLD.
*Installation of inexpensive constant-flow valves rated at 9.1 l/min. in the supply lines to individual houses in Kitwe, Zambia reduces the water use by 25 to 30 per cent. No complaints regarding inadequate supply have been received. Cost of the constant flow valve is approximately U.S.$1.5 to 2.

IV. Keyword Index

☐WORLD BANK APPRAISAL REPORTS

World Bank Appraisal Reports have been included in the Bibliography as they contain information useful to particular country studies. These are not public reports but are available on a selected basis, with the approval of the government concerned.

V. Author Index

VI. Author's Corporate Affiliation Index