LECTURE NOTES

For Environmental Health Students

Human and Other Liquid Waste Management

Ethiopia Public Health Training Initiative

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Preface

The protection and promotion of health, human comfort and well being through control of man's environment are responsibilities which modern conditions have forced upon us. The population increase has demanded diversified activities, which have accompanied diversified environmental problems. This diversity creates complication where control becomes more difficult. For us such complicated problems are choking us before we even come out of the rudimentary ones.

Human excreta and liquid waster problems are considered as the most important for Ethiopia. Deplorable unsanitary conditions are apparent in city slums, market areas and near restaurants and hotels. People's sanitary practices need to be curbed to the better. It is anticipated that the amount of waste matter will increase with population increase. A waste generated and left unattended, which is the normal practice, will choke the environment and us.

This lecture note, which is specifically prepared for the diploma level environmental health students, will address the problem of human waste disposal or management. Different appropriate latrine technologies and on-site wastewater containment and treatment facilities are listed; their construction methods and the advantages and disadvantages of each is included. Emphasis have been made on the new concept ecological sanitation or compost toilets as it seems timely to think of "zero waste" options especially now where population is increasing in small towns and larger cities. To think in terms of "Zero Waste" in the living environment will help in safeguarding the environment; the natural resources and the general ecosystem.

The challenge now is both in the "hardware", (the latrine technology that is appropriate and affordable) and the "software "issues which include hygiene education for behaviour change.

- How should sanitation programs be organized? (see page 112-117)
- How are we getting the beneficiaries accept the technology and install the system by themselves and continue to do so thereafter? * How would we be able to change the behaviour and practices? of individuals in communities?
- What type of technology is (see page 21)
  1. Acceptable ?
  2. Sustainable?
  3. Easily operable?
  4. Replicable?
  5. Replaceable or maintainable?
  6. Beneficial / not a liability?

These are some of the questions that must be clearly answered in order to have a viable and sustainable community based sanitation and hygiene behaviour change program.

In this lecture note a chapter on operation and maintenance of the sanitary installations is included. Each chapter has its own objectives, model questions, and assignment suggestion, which will help the teacher, do cognitive and summative evaluation of his students.

The sanitarian trained to carry out this task must be conversant with the psychology and social make up (custom, tradition) of the community to be served, and the preferred technology to be used for that particular soil, geography, economy and tradition.

What is important is that teachers of this course should help the student understand the problems and solutions so that a functional, confident and devoted professional is created.

Acknowledgments

The four Environmental Health schools in the country had acute shortage of teaching materials for their diploma level students. Reference materials that are prepared for foreign countries and by foreign authors have many irrelevant materials for conditions in Ethiopia. Materials that are incorporated in the books we purchase for reference materials for our students generally are based on developed country experience, technologies and policies.

It is with this understanding that we are assisted by Carter Center to prepare this lecture note specifically for diploma level environmental health students. We are very grateful for Professor Carlson without whom things would have not got the green light from Carter Center. We are also indebted for the senior consultants who had been with us and gave us valuable suggestion from the outset when decision to prepare the 'lecture notes' was raised in Jimma.

We are indebted to Ato Gebre Emanuel Teka for his valuable suggestions he made after reviewing this lecture note. His comments were so valuable that it has given our lecture notes much more shape and completeness.

Las but not least we are very grateful for Ms. Carla Gale, Ato Aklilu Mulugeta and Miss Meseret Tsegaw of the RTA office who committed themselves in facilitating several workshops for our group in Addis Ababa.

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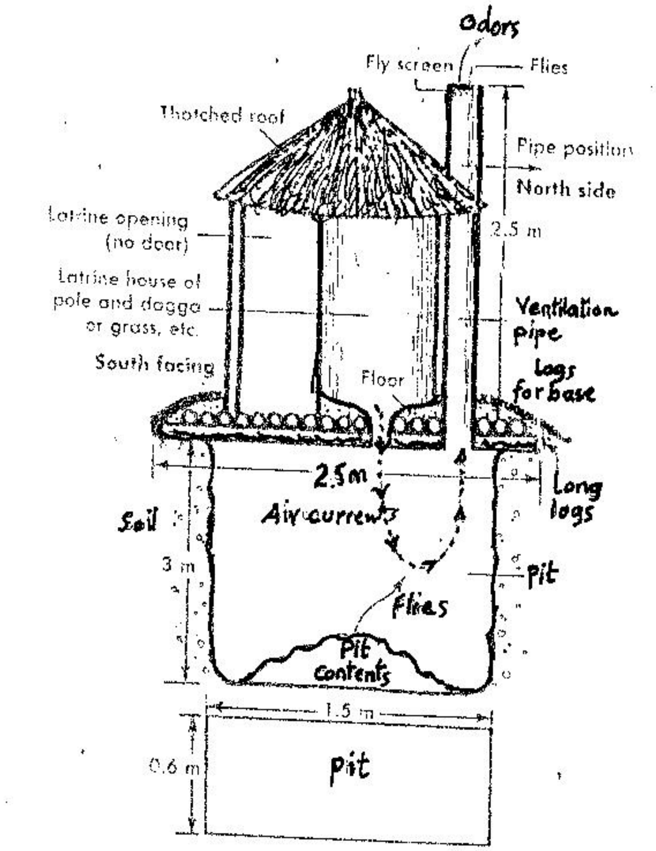

LACK OF SANITATION IS A PUBLIC HEALTH DISASTER, IT CONSIGNS NEARLY THREE BILLION PEOPLE-HALF OF HUMANITY TO LIFE IN ALMOST MEDIEVAL CONDITION, WITHOUT ACCESS TO LATRINE AND UNABLE TO PRACTICE SUCH BASIC HYGIENE AS WASHING THEIR HANDS IN SAFE WATER

UNICEF

CHAPTER ONE

Problems and the Need for Human Waste Management

Learning Objectives

At the end of this chapter the student will be able to:

1. Define the problems and need of sanitation (human waste management)
2. Classify sanitation systems
3. List the type of technologies based on their acceptability, sustainability, replicability etc.
4. Describe excreta related diseases by their category
5. Discuss the prevalence of excreta related diseases common in Ethiopia.
6. Describe ways of disease transmission from human feces to the healthy person.
7. Describe the life cycles of common parasites in Ethiopia and suggest control measures.

Introduction

In many cities, towns and rural areas of Ethiopia today people live and raise their children in highly polluted environment. Urban and peri-urban areas are among the worst polluted and disease ridden habitats. Much of this pollution, which leads to high rates of disease, malnutrition and death, is caused by lack of adequate excreta disposal facilities and inadequate solid waste collection and disposal service. As communities expand and population increase, the situation will grow worse and the need for safe, sustainable and affordable sanitation technology or system will be even more critical.
The sanitation practices that are promoted in developing countries fall into one or two broad types: “Flush- and -Discharge “and“ drop-and -

store". For those who have no or will not have access to flush toilets the conventional alternative is a drop-and-store device; usually a pit latrine. Pit latrines are meant for containment and indefinite storage of human excreta. Drop-and-store is often regarded as an inferior and temporary solution compared with flush system. Although this technology can prevent pollution in some places it is not often feasible in urban crowded communities because of lack of space. It is not also a reliable technique in areas where digging deep pits in difficult soil formation and where the ground water is high which in this case are expensive above ground system has to be installed. Unless it is given due attention in cleaning and maintaining it may also be cause of odor and fly nuisance.

This chapter will enlighten the instructor and the students about the problem of human waste disposal. Based on the problem one will also appreciate the need for mitigation. At the end of this chapter appropriate evaluation questions are installed. The questions are addressed fully in the text and will have emphasis in the class.

The instructor of this subject is encouraged to use for these groups of students not only the theoretical part but also the exercises and practical works suggested as well.

Problems and Need

Sanitation is defined as the "safe management of human excreta and other waste product produced by the day to day activities of people". This definition includes the hardware and software components, as effective interventions need to stimulate both the constructions of **sanitary facilities** for waste management and their **hygienic use.** Fecal-oral diseases are among the most obvious endemic diseases throughout the developing countries and more so in Ethiopia. The effectiveness of sanitation as an intervention to the fecal-oral diseases varies because of the following reasons. (See table 1)

1. Bacterial infection such as cholera involve large infective doses, hence they are more susceptible to control through sanitation.
2. Polio or hepatitis require only a small dose to cause the disease
3. Many diseases such as salomellosis involve transmission cycles that can pass through animal hosts, which limits the benefits of controlling only human excreta if the disease can be transmitted through the feces of chickens in the household.

(Global environmental health initiatives)

However, sanitation improvement together with hygiene behavior change is known to substantially reduce the transmission of diseases that could spread through human excreta and other wastes. Table 1 illustrates the importance of each sector alone and in combination in the control of excreta related diseases. When hard ware and software are combined the effect is great.

Table 1: Major category of excreta related diseases and the control options

Category	Examples	Dominant transmission mechanism	Likely effect of sanitation hardware alone	likely effect of hygiene promotion alone	Both hardware and software
Fecal oral (non bacterial)	• Hepatitis A • Amoebic dysentery • rotavirus • giardiasis	• person to person contact, • domestic contamination	Negligible (as very low infective doses required)	Moderate	Great
Fecal oral (bacterial)	• Cholera • Salmonellosis • shigellosis • many forms of diarrhea	• person to person contact, • domestic contamination • water contamination • crop contamination	Slight to moderate	Moderate	Great
Soil transmitted helminths	• Hookworm • Roundworm • whipworm	• compound contamination, • communal deification areas • crop contamination	Great	Negligible	Great
Tapeworms	• Beef tapeworm • Port tapeworm	• compound contamination • field contamination • fodder contamination	Great	Negligible	Great
water-based helminthes	• Schistosomiasis	• water contamination	Moderate	Negligible	
excreta related insect vectors	• Filariasis • some fecal oral diseases	• insects breed or feed in sites of poor sanitation	Slight to moderate	Negligible	

Adapted from DFID, Guideline Manual On Water Supply and Sanitation Programs.

Esrey et al. has made very rigorous studies on the intervention advantage of water, sanitation, and hygiene taking diarrhea disease as an example. The result shows that the median value of studies made on water and sanitation is 30 % reduction; sanitation alone is 36%; hygiene alone is 33%; improvement of water quality alone 15%; water quality and quantity alone 17%. (Esrey et al 1991) This result shows that water, sanitation, and hygiene are the most important component especially if they are combined together during intervention. As shown improvement of water quality alone is not as effective as one think.

The problems in the world and especially in developing countries such as Ethiopia indicate the importance of excreta disposal as an important part of environmental sanitation. The inadequate and insanitary disposal of infected human waste leads to the contamination of the soil and sources of water supplies. Although there are many confounders for the transmission of communicable disease in poor communities (contaminated water, nutrition etc.), it is a known fact that feces are the culprits for many diseases.

In the world today, over 2.5 million children die of diarrhea that could have been prevented by good sanitation. In Ethiopia alone about 600 children are dying from diarrhoea every day. Children are usually the first to fall victim and die from diseases such as cholera, dysentery and other serious infections.

In addition, millions of school age children and adults suffer from parasitic infections where improvements in sanitation especially human excreta and solid waste management could have prevented. Human excreta are responsible for the transmission of other diseases such as schistosomiasis, typhoid, hookworm, round worm and other infectious diseases affecting children and adults. The risks of infection with severe diarrhoea increased 30 to 50 percent where stools were not safely disposed. (Esrey et al 1991.)

Infection with parasitic worms (helminthes) is common in Ethiopia. According to UNICEF's study children in developing countries commonly carry up to 1,000 hookworms and round worms at a time; one gram of faces can contain (UNICEF).

- 10,000 viruses
- 1,000,000 bacteria
- 1,000 parasitic cyst
- 100 parasitic eggs

The Facts in Ethiopia Indicates:

- About 80% of diseases are related to poor sanitation and unsafe water supply
- Diarrhea and parasitic infections are classified in the top 10 diseases causing high morbidity and mortality especially among the under five children
- 46 % of under five moralities is due to diarrhea (MOH, annual report 1987).
- A nation wide KAP study conducted in 1997 revealed that latrine coverage in the country is as low as 7%. Apart from human waste, solid waste in urban and rural areas is health threatening, as it is means of insect and rodent breeding, surface contamination and water pollution (MOH, KAP on water and sanitation).
- The level of health awareness is very low due, basically, of non existent coordinated hygiene education program

UNICEF has predicted that unless immediate action is taken, the number of people without adequate sanitation in the world will climb to more than 4.5 billion in just 20 years. Hardest hit will be us, the developing poor countries who are already with out adequate sanitation facilities.

Common excreta related diseases and their characteristics are shown in the following table.

Table: 2 Excreta Related Disease and their Characteristics

Disease	Specific agent	Reservoir	Transmission	Incubation period
Hookworm (ancylostomiasis)	Necator americanus Ancylostoma duodonale Ancylostoma ceylanicum	Man	Fecal contamination of the soil; eggs hatch, infective larvae penetrates the bare skin, usually of the foot	Few weeks to several months
Ascariasis (roundworm)	Ascaris Lumbricoids	Man	Ingestion of infective eggs from contaminated soil, salads and other foods eaten raw, eating with contaminated hand	Two months
Tape worm	Taenia saginata	Man	Ingestion of raw or Partially cooked meat containing infected larvae passed through then feces.	8 to 14 weeks
Entrobiasis (pinworm, thread worm)	Entrobius vermicularies	Man	Direct transfer of infected eggs by hand from anus to the mouth; indirect through contaminated fomites	3 to 6 weeks
Poliomyelitis	Poliovirus type 1,2,3	Man	Direct contact with pharyngeal secretion or feces of infected person	Commonly 7 to 12 days; range from 3 to 21 days
Bilharziasis	Schistosoma haematobium, Schistosoma mansoni	Man	Exposing oneself to infected water during bathing or wading.	Months

Strongyloidiasis	Strongyloids stericolaris	Man, possibly dogs	Infective soil in moist soil contaminated with feces penetrate the skin usually of the foot	17 days
Viral diarrhea	Rotavirus	probably man	probably fecal-oral and possibly fecal-respiratory	Approximately 48 hours
Infectious hepatitis A	Hepatitis A virus	Man	Person to person by the fecal-oral route	From 15-50 days depending on dose
Cholera	Vibrio Cholerae	Man	Ingestion of water contaminated with feces or vomitus of patients, ingestion of food contaminated with dirty hand, fomites etc	from few hours to five days
Shigellosis (bacillary dysentery)	Shigella bacteria species	Man	Direct or indirect fecal-oral transmission from patient or carrier	one to seven days, usually one to three days
Typhoid and paratyphoid	Salmonella typhi	Man both patients and especially carriers	By food or water contaminated by feces or urine of a patient or carrier; fruits, vegetables harvested from sewage contaminated area	Usually ranges from 1-3 weeks depending on dose

Giardia lambliasis	Giardia lamblia	Man, possibly other wild or domestic animals	ingestion of cysts in feacally contaminated water or less often faecally contaminated food	5-25 days or longer; median is 7-10 days
Amoebiasis	Entamobeba Histolitica	Man	Epidemic outbreaks result mainly from ingestion of faecally contaminated water containing amebic cysts. Endemic spread involve hand to mouth transfer of feces, by contaminated raw vegetables,, by flies, soiled hand of food handlers	From few days to several months or years. Commonly 2-4 weeks
Tricuriasis	Tricuruis Tricuria	Man	Ingestion of developed eggs, which have been deposited with feces on to the ground.	Indefinite

Adapted from: Gebre-Emanuel Teka, human waste disposal Ethiopia, 1984; and US.PHS, Communicable disease control in man

Many studies in Ethiopia have indicated the prevalence of intestinal parasites and other infective agents among the population. Some examples of the prevalence in different parts of Ethiopia are depicted in table 3.

The infection transmitted through human excreta is because of basically inadequate sanitary systems, no use of sanitary systems or poor hygiene practices. The viruses, bacteria, protozoa and other parasitic worms may spread through ingestion of the eggs (ascaris), the larvae (strongyloides), direct contact (pinworm), through water and soil (amoebae) etc.

Feces contaminated food or drink transmits diseases such as poliomyelitis, hepatitis A, cholera, bacillary dysentery, giardiasis, typhoid, etc. The control of these infections depends on proper waste management, control of flies, and personal hygiene habits of hand washing with soap and water.

Tapeworm caused by eating raw beef, pork or fish are the types of diseases are also common diseases affecting people in Ethiopia and other parts of the world. In Ethiopia beef tapeworm is the most common. The infection spread from human to human because of the unsanitary practices in excreta management in the country.

Other diseases such as schistosomiasis are transmitted when people enter into an infected water source either to fetch water, bath, swim or fish. The water source is infected when infected person urinates or defecates near or inside the water body.

Hookworm is helminthes infection of the soil. The soil where people work or play could be infected when an infected feces is deposited on it. In countries such as Ethiopia where many people travel barefoot and are agrarian such unsanitary practices will ndoubtedly propagate the disease. It is a disease most common with children and adults in Ethiopia.

Therefore, with poor excreta disposal, the water we drink, wad, or swim; the food we eat; the soil we till or play on could be contaminated.

Table 3: Samples of prevalence for some common parasites and other excreta related infections

No	Region	Prevalence of Intestinal parasites and other infections %					
		Giardiasis	Ascariasis	Hook worm	Tricuris	Schistoso miasis	Rota virus
1	Addis Ababa	-	-	-	-	-	18
2	Bale	-	84	67	64	5-48	-
3	South Welo	1.1	18.3	2	4.4	24.9	-
4	Harar	-	4.7	-	-	-	-
5	Ethiopia	8.9	43.7	-	-	-	-
6	Keffa/Jimma	-	71.8	-	-	-	-
7	Western Abaya	-	-	4.1-75	-	53	-
8	Wolisso	-	-	72	-	-	-
9	Akaki	-	40.7	-	27.7	1.5	-

(Source: Ethiopian Journal of Health development; Vol. 12 No.3 1998; Vol. 11, No.3, 1997;Vol 13, No.1, 1999; Ethiopian Medical Journal, 27, PP 183. 24, PP 79.)

Ways fecal borne diseases are transmitted

As could be seen in the following life cycles man is the reservoir of most of the intestinal parasites, bacteria and viruses. In the transmission of these diseases from the infected person or carriers of disease to the healthy person the chain of events usually involved the following:

1. A causative or etiologic agent;
2. A reservoir or source of infection of the causative agents
3. A mode of escape from the reservoir;

4. A mode of transmission from the reservoir to the potential new host;
5. A mode of entry into the new host;
6. A susceptible host (E.G. Wagner and J.N.Lanoix)

Fig. 1 below illustrates how disease is spread from feces to a healthy person. The media between the agent and host are known as the five “Fs”-fluid, finger food, fomite and flies. Transmission of disease from excreta may assume different mode in different countries. In Ethiopia, due to the unhygienic habit of peoples behavior most of the diseases are transmitted in all the five “Fs’ mentioned above.

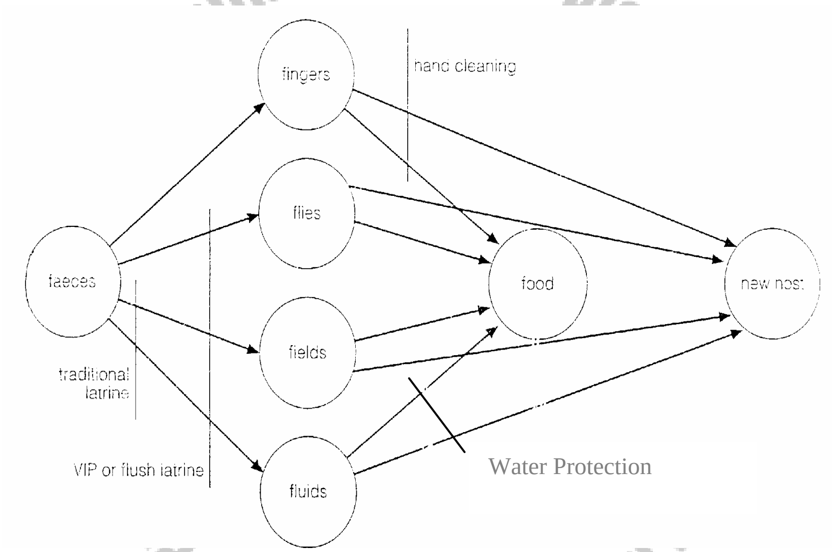

Fig. 1. Transmission routes of disease from excreta: adapted from Wagner& Lanoix Excreta Disposal for Rural Areas and Small Communities, 19…?

One of the first lines of defense against the transmission of diseases is the proper human excreta management or disposal and changes in hygiene behavior such as hand washing after visiting toilets (Christine Van Wijk et al 1993).

Life Cycles for Some Common Parasites

In Ethiopia there are all types of parasites infecting people especially small children. Soil based parasitic infestation is common, and it is not uncommon to find that people harbor two or more parasites. Investigation made in several schools in Ethiopia has indicated that some children were found harboring three and four parasites. (USPHS and GET 1982)

1. Ascaris Lumbricoids

Ascariasis is an infection of the small intestine. The male and female worms must be present in the intestine to continue the cycle and hence the transmission. Matured male and female parasites mate after which fertilized eggs passed through the feces. Once the eggs have been deposited on the ground it usually takes three weeks before they are matured enough to be infective. Humans through eating uncooked vegetables consume infective eggs, or other foods that have been contaminated after cooking or by placing contaminated hands and other objects in the mouth.

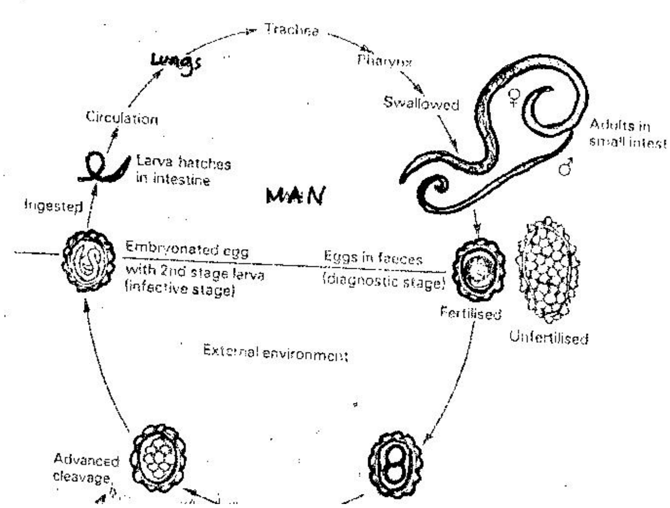

Fig. 2: Life Cycle of Ascariasis Lumbricoids (Roundworm)
(Source: On-site Waste Disposal Systems, PL 86-121 USPHS.)

2. Hookworm

Hookworm is also an infection of the small intestine. The male and female of this worm also mate and the fertilized eggs are passed out with the feces and mature on the ground. After maturation the eggs in the soil hatch and the newly emerged larvae undergo further development for another one to two weeks. Once mature enough to be infective they penetrate bare footed person and travel to the intestine via the blood stream, lungs, trachea, gullet and stomach. Once in the intestine they keep on sucking blood from the victim.

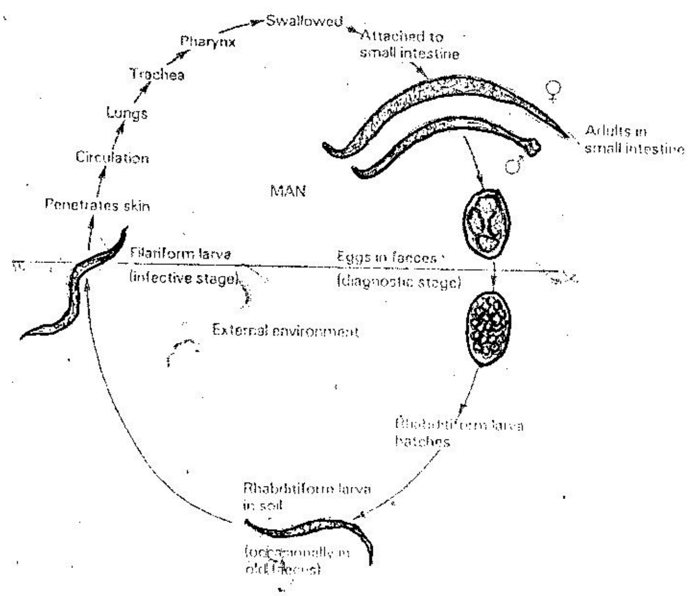

Fig. 3: The Life Cycle of Hookworm

(Source: On-site Waste Disposal Systems, PL 86-121 USPHS.)

3. Tapeworm

Beef tapeworm is one of the commonest parasites in Ethiopia. It is transmitted to the healthy person by ingesting raw meat that has been infected by the disease. The infected person will pass the feces with eggs on to the ground where cows graze. The eggs deposited with the feces in the grass are eaten up by the cow and hatch in the intestine after which larvae emerge. The larvae bore into the intestinal walls, enter the blood stream and become lodged in the muscle tissues where they develop a hard protective capsule. When a person eats raw meat the capsule is digested and a new tapeworm is set free in the intestine. They then appear as cysts in the active muscles of the animal

Starting from the day that the eggs are swallowed it takes two to three months for the parasite to produce ripe segments that lay eggs.

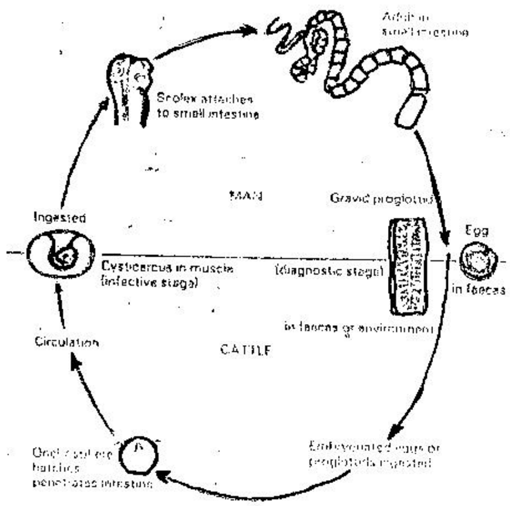

Fig.4: Life Cycle of Beef Tapeworm

(Source: On-site Waste Disposal Systems, PL 86-121 USPHS.)

The concern for human excreta disposal is not only on disease transmission but also on the social and economical effect of the country. For example when sanitation is poor, disease breeds and medical costs increase. One study made by UNICEF indicated that people living in areas without adequate sanitation or hygiene education spend six times more on medical treatment than do people with adequate sanitation service and proper hygiene behavior and practice. In Ethiopia

Children of below five years of age spent 46% of their life on illnesses due to excreta borne disease especially diarrhea (MOH, 1998).

Sanitation related illnesses also depletes national economies:

- When people miss school or can not work;
- When tourism are affected;
- When agricultural products are suspected to be contaminated;
- When highly infectious disease such as cholera outbreak is reported.

(UNICEF – ref)

It is therefore necessary to safely dispose human excreta in a manner that it will not contaminate the soil, water and food. In addition creating awareness on the part of the public on hand washing after visiting toilets; proper maintenance of the latrine so that flies will be discouraged and utilization will be maximized.

4. Stongyloides Stercoralis

Strongyloides is a helminthic infection of the duodenum and upper jejunum. It is a worm infection that occurred throughout the tropical and temperate areas.

It is more common in warm and wet areas where the eggs of the infective organism survive easily. The eggs are introduced in the environment when infected person defecates indiscriminately everywhere.

Obviously, this parasitic infection is common in Ethiopia because of the poor sanitation condition of our neighborhood. The infection is common among children who play in dirty and infected environment.

Life Cycle of Strongyloides Stericoralis

Infective larvae, which are, called filariform and that which has developed in feces or moist soil in the environment enters by penetrating the skin. Once in the body of the person it enters into the venous circulation and is carried to the lungs. It travels through complicated routes trespassing capillary walls, entering alveoli, ascending to the trachea and descends the digestive tract to reach its final destination- the small intestine. In the small intestine development of the adult female parasite takes place. The adult female lives embedded in the mucosal epithelium of the intestine where eggs are deposited. The eggs hatch and ultimately are liberated through feces and develop into infective parasite of the same person or other new host or live freely in the soil.

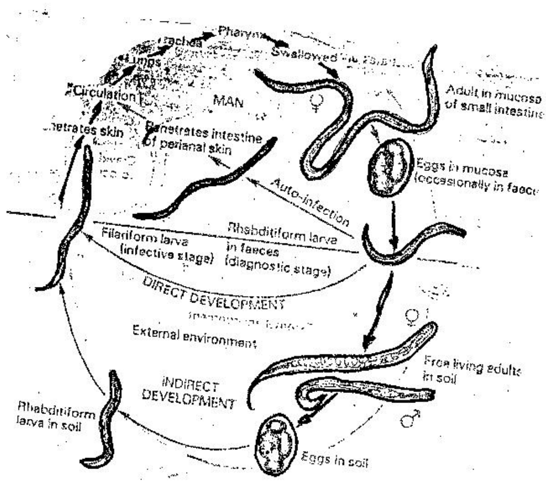

Fig.5: Life Cycle of Strongyloides

(Source: On-site Waste Disposal Systems, PL 86-121 USPHS.)

5. Trichuris Trichiura

Tricuris is a nematode infection of the large intestine. Triuris is also called the human whip worm. It occurs throughout the world, especially in worm moist regions. It is also a disease that is common in areas where sanitation is very poor and where people commonly defecate in the open.

Life Cycle of Tricuris

Eggs passed in feces will be deposited in the soil. The eggs are not immediately infective but will mature in the soil in approximately 2-3 weeks. The infective embroynated eggs are ingested with food when people with contaminated hand eat with out washing properly or not washing at all. The larvae that have hatched in the intestine will attach itself to the mucosa of the cecumand proximal colon and develop into mature worms. Eggs appear in the feces 90 days after infection of the eggs and the cycle continues so long as the unsanitary disposal of feces continues in that community.

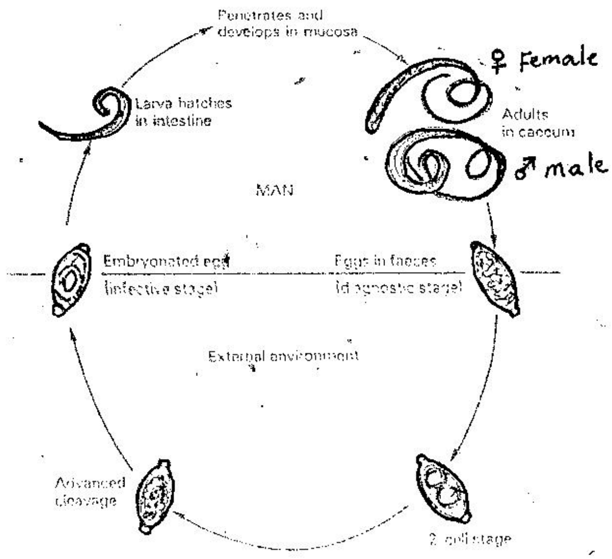

Fig. 6: Life Cycle of Trichuris Trichuria
(Source: On-site Waste Disposal Systems, PL 86-121 USPHS.)

6. Enterobius Vermicularis

This is also an intestinal infection transmitted through feces. Like many other parastic worms enetrobiasis, as the disease is called, has a worldwide occurrence. The disease is much common with children and adults whose children are infected.

Life Cycle of Enterbius Vermicularis

The eggs from the infected person are deposited in the soil where soil borne transmission is possible especially where there are heavily

Penetraes and develops in mucosa

contaminated households. It is also transmitted directly by hand from anus to mouth of the same or new host, or indirectly through clothing, bedding, food or other articles contaminated with eggs of the parasite.

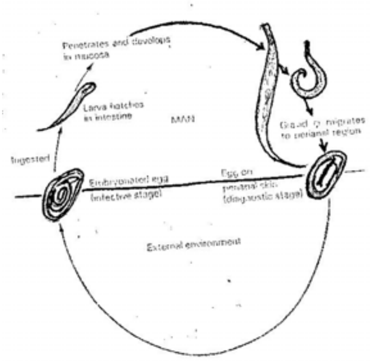

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Fig.7. Life Cycle of Enterobious Vermicularis
(Source: On-site Waste Disposal Systems, PL 86-121 USPHS.)

Review Question / Assignment

1. What do you understand about the problems and needs of human waste disposal
2. What are the ways faecal borne diseases are transmitted
3. Differentiate between hookworm and ascaris transmission
4. What are the criteria for selecting a sanitation technology
5. Differentiate between faecal oral, non bacterial and faecal oral bacterial diseases

Note to the Teacher:

1. Assign groups of students to go to different health facilities (hospitals, health centers, or health stations) in the area to review statistics or collect information on sanitation related diseases reported in the last 10 years.
2. Take stool samples from volunteers or from randomly selected students to see if there is parasitic infection even among the students themselves.

This will help you generate discussion and also to reinforce the theory you have been taking about “why we need sanitation facilities”?

CHAPTER TWO

Human Waste Management

Learning Objectives

At the end of this chapter the student will be able to:

1. Describe the barriers for the development of the sanitation sector
2. Describe other countries experiences with respect to the development of the sector
3. Describe the principles of breaking the barriers
4. Define the importance of equity, health promotion, and environmental Protection as one challenge of sanitation systems

Introduction

Human waste management is one of the most important public health program. It is considered by WHO as one of the basic steps to be taken to safeguard our environment. As has been mentioned in Chapter one lack of proper waste disposal is one of the most pressing public health problems in Ethiopia where availability of safe excreta disposal is very limited.

A country wide KAP study on environmental sanitation by the Ministry of Health, Department of Environmental Health revealed that the national coverage is only 26 % (7 % for rural and 71 % for urban areas (MOH, programs and planning Department, 1991 E.C.) This indicates that, the majority of the Ethiopian population is defecating in areas other than a proper excreta disposal facility. The inadequate and insanitary disposal of infected human waste leads to the contamination of soil, ground and surface water, affords an opportunity for domestic and other type of flies to lay their eggs to breed and carry infection. Besides it causes nuisance, attracts animals and rodents and other vermin, which will spread the feces within the environment.

Why is this sector not developed? Why don't our population use latrines? Professionals in the field ask these and other questions. Some of the reasons why are indicated below. If we can modify or overcome some of this barriers or obstacles we may do better in our waste management program.

1. Barriers for the Development of the Sanitation Sector

Sanitation has been neglected through out the developing world as a means of disease prevention. It was always thought that sanitation is an individual matter. For example, governments in developing countries such as Ethiopia are very keen and devoted to do as much as possible on the improvement of water supplies both for the rural and urban communities but not for sanitation. Some of the barriers for its development in Ethiopia are the following.

1.1 Lack of Sanitation Policy and Government Commitment.

Government or other agencies that are responsible in creating supportive environment for sanitation have ignored the sector thus far. They strive for short -run outputs such as constructing water supply in spite of that many prominent researchers indicated that water in quality or quantity is not enough to improve health unless sanitation and hygiene behavior change is also included in the program.

The present Ethiopian government has now issued policies that will encourage or stimulate states (*kilils*) to undertake sanitation as one of the viable disease prevention measures. The overall policy of the federal government at present is prevention than cure as much as possible.

Promoting sanitation facilities and hygiene education has never been prestigious even among professional groups who usually avoid working on excreta management, but rather, engage themselves in water development, food and drinking establishment inspection and other administrative work.

1.2 It is not a Priority Issue in Government, NGOs or Communities.

For example among 150 NGOs under the umbrella of CRDA operating in a health field in the country, 62% have water supply program, 77 % have overall health activities (curative, family planning etc) but only 8-10% have sanitation program. (CRDA, membership water and sanitation survey, 1991-1994)

1.3 Lack of Proper, Coordinated Hygiene and Sanitation Messages

Hygiene or health education messages in the form of posters, charts, leaflets, or dramas have not been designed, issued and used by health workers. Even if there are attempts they fail to acknowledge the diversity of needs and the cultural, economic, and social context. Critical issues of behavior are either ignored or are not thought of all together. An attempt to locate health and hygiene education messages developed by different organization including MOH in the form of posters or leaflets in the past have never yielded results.

1.4 Lack of organized program for sanitation

Lack of organized, sanitation and hygiene promotion in the country is one factor for its low development. Even during the decade program latrines were built and given to people without their consent, understanding, and wish. Government has practiced such unorganized, untaught of top down approach during the villegization program in the 1980s; and by NGOs in many areas of Ethiopia.

1.5 Level of poverty

Poverty have major share in that, people concentrate more on finding food, water or firewood during the day than engaging themselves on latrine construction and /or attending health forums. There have been many instances that people openly protest against latrine construction stating that “what would we contain in the latrine when we do not have food to eat”.

1.6 Lack of Uniform, Low Level, Cheap and Affordable Varieties of Technologies for the Sector.

It is also frequently planned for the promotion of sanitation technologies without considerations for the consumer preferences. What are thought to be appropriate by the promoters (usually top down) are far beyond the financial reach of those in need. In Ethiopia, the traditional pit latrine and to some extent the VIP latrine technologies are the only technologies used.

1.7 Lack of Demand

There is virtually ***no demand*** for sanitation especially by the rural people and the urban poor. If that could be achieved many of the problems would have been resolved. People may want sanitation management, privacy and security but not if it costs money beyond their ability to pay.

1.8 Women and Children are not Included During Sector Development.

Women are potential agents in hygiene education and children are the most vulnerable victims of poor sanitation. Yet, it is men who are asked to make the decisions about sanitation. Women also often want privacy and security but are unable to express this need. No one is giving due attention to children's feces, even though they are a major source of pathogens.

1.9 Cultural Taboo and Beliefs.

In some part of Ethiopia handling of excreta is considered as taboo, or disgusting. It is not also normally discussed in public. On the other hand handling children's feces is not considered dirty as a result of which it is very difficult to convince mothers that it is even worse as far as transmission of disease is concerned. Some cultures in the south will not use the same latrine with their in-laws. To counter taboo and cultural constraints hygiene education and sanitation promotion should link the value of urine and excreta with ecology or agriculture production or their livelihood.

1.10 Sector Financing Scheme is Non-existent

In many countries sanitation service is commercialized in that private investors manufacture, install and maintain systems. Private sector involvement saves time, spaced out financial system, and offer perfect system. If simple technologies are developed and private investors who will manufacture and sell latrine parts are involved, the chance of developing the sector will be better than the present condition.

Because of the above constraints or barriers we were unable to progress in the improvement of sanitation. In the future the sanitarian must be able to overcome these barriers. To be successful it will be important to examine the barriers closely with respect to the particular community and tackle them.

2. Principles for Breaking the Barriers

The ultimate aim of a sanitation (waste management) program is to have a system that fulfill the principles of equity, disease prevention and protect the environment. The sanitarian and other involved in the sector program must examine the problem or barriers on the context of the local situation. Generally, to evaluate existing programs the following principles are necessary to be recognized.

2.1 Sanitation is the First Barrier

Many researches conducted in many developing countries has proved that sanitation is the first barrier to many feacaly transmitted diseases, and its effectiveness improves when integrated with improved water supply and behavior change.

2.2 Promote Behavior and Facilities Together

Sanitation combines behavior and facilities, which should be promoted together to maximize health and socioeconomic benefits.

2.3 Give Sanitation its Own Priority

From an implementation perspective, sanitation should be treated as a priority issuing its own right and not simply as an add-on to more attractive water supply programs. Sanitation requires its own resources and its own time-frame to achieve optimal results. However, it would have been beneficial from public health point of view to integrate sanitation with other health development program

2.4 General Political Will

Political will at all levels is necessary for sanitation programs to be effective. Communities are more motivated to change when they know political will to promote and support such changes exist.

2.5 Use a "System Approach"

Communities are bicultural systems. In a sanitary environment, the key parts of that system- (waste, the natural environment with its unique physical, chemical, and biological process local cultural beliefs and practices, the sanitation technology, and the management practices applied to the technology) interact effectively.

2.6 Create Demand

Sanitation program should be based on generation of demand, with all its implications for education and participation, rather than providing free or subsidized infrastructure.

2.7 Government Role

Government should be responsible to protect public health. The policy should create demand services, facilitate and enhance partnership among the private sector, NGOs, community-based organizations, local authorities, and households and remove obstacles in the path of achieving improved sanitation.

2.8 Be Gender Sensitive

Sanitation program should equally address the needs, preferences, and behavior of children, women and men. This is basically because a sanitation program is implemented in a community with traditional patterns of living. The program has to be built on existing practice. The women in the house perform most of hygiene and sanitation practices. If changes to more healthy practices by every one in the house are to be made the best people to promote those changes are the ones with the vested interest, one of those being the women. If the women's views and concerns are not expressed and integrated into the program design, it is unlikely that the program will earn their commitment.

2.9 Build on Existing Practices

Sanitation improvement should be approached incrementally, based on local beliefs and practices and work towards small, lasting improvements that are sustainable at each step. Upgrading of the existing practices is based on the understanding that existing sanitation practices and facilities are reflections of local social and cultural preferences and local economic and environmental conditions

2.10 Empower People

User-ownership of sanitation decisions is vital to sustainability. Empowerment is often a necessary step towards achieving a sense of ownership and responsibility for sanitation improvements.

2.11 Use Promotional Methods

Proven methods of public health education and participation, especially social marketing, social mobilization, promotion through schools and children can be used to advance and sustain sanitation improvements.

2.12 Prioritize High Risk Groups

Sanitation services should be prioritized for high risk, under-served groups in countries where universal coverage systems are unlikely in the foreseeable future. Hygiene promotion should be targeted at every one.

2.13 Understand Consumers

Latrines are consumer products and their design and promotion should follow good marketing principles, including a range of options, design attractive to consumers, affordable prices, and design appropriate to local environmental conditions.

2.14 Continually Promote

As in all other public health programs aimed at preventing diseases, promoting sanitation should be a continuous activity. This is necessary to sustain past achievements and to ensure that future generations do not become complacent as disease decrease.

2.15 Take a Learning Approach

Continually monitor and evaluate and feed back the lessons learned into projects and programs.

3. Future Challenges in the Development of Proper Sanitation Management

Sanitation program requires new strategies and methods, sanitation program must ensure equitable access to everyone, that human health is promoted and environmental resources be protected and conserved while moving towards the goal of disease prevention and achieving sustainability. Working for sanitation in the future is not only to promote health and prevent disease but also from the need of ecologically sustainable environment.

An approach to sanitation challenge is concerned with ***creation of equity***, ***the protection of the environment the user and the general public.*** Its goal is to create socially, economically and ecologically sustainable system.

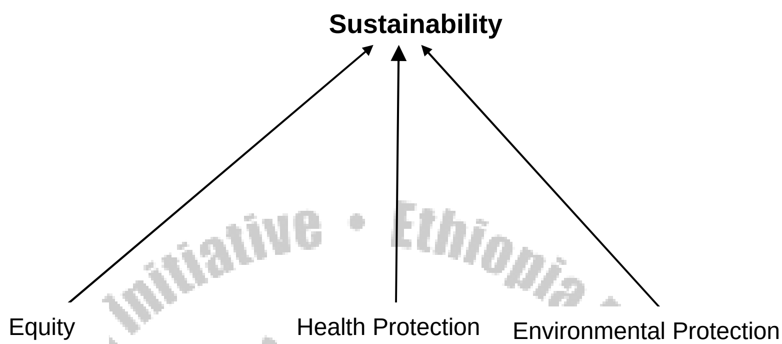


Fig. 8: After WSSCC working group on promotion of sanitation

1. Equity

It is mandatory that all segment of the community have access to a reasonable, safe and appropriate sanitation facility adapted to the needs and means (technological, economic etc) of the community.

2. Health Promotion

The Waste Management System should be such that which will prevent disease associated with excreta as well as interrupting the cycle of disease transmission. This implies that:

- The importance of social and behavioral dimensions in achieving health benefits is given priority
- Future sanitation technologies have the demonstrated capacity to prevent the transmission of pathogens

Protection of the Environment

The sanitation system must neither pollute the ecosystem nor deplete scarce resources rather should augment to the natural resources. This implies that:

- Sanitation systems should not lead to water or land degradation

- Sanitation should, if possible, be designed to recycle to the maximum the renewable resources as far as possible

Review Question / Assignment

1. Mention at least three barriers you consider are important for the development of the sector and explain why you consider them to be so important.
2. Among several principles of breaking the barrier which one do you think are important for Ethiopia? Why?
3. What are the three approaches we will follow to overcome the challenge of sanitation?
4. In some countries, localities are exemplified to achieve the highest sanitation coverage with out any subsidy. Do you think that can be achieved in Ethiopia? If yes, how? If No, Why?
5. Describe the philosophy behind the approaches to be taken for sanitation challenges

CHAPTER THREE

Sanitation Technologies

Learning Objectives

At the end of this chapter the student will be able to:

1. Describe factors that are important in the selection of sanitation technologies.
2. Consider site selection as an important undertaking before constructing the system.
3. Classify the available technologies for sanitation into four major categories
4. Describe each available technology and their construction methods
5. Design the capacity of pits according to the number of people and years of service desired.
6. Draw and label parts of different latrine technologies
7. Describe the difference between the traditional latrines such as pit privy and other latest technologies such as VIP, ECOSAN etc.

Introduction

Technologies for whatever use are a reflection of the educational and economic level of the country or society. Waste disposal or management technologies in developing countries are quite different than the technologies used in Ethiopia. One of the earliest technologies used in the USA for example was pit latrine. In 1943 Tisdale and Atkins mentioned the importance of pit privy for USA especially in areas where water carriage systems are impracticable. A close cooperation between Public Health Service officials with State Health Departments in rural sanitation campaigns for 30 years was promoting pit privy. Now, Pit Privy is not a technology of choice in the USA but it will remain ours for many years to come.

What is important in Ethiopia is a technology that is affordable by the people and one that is already known and accepted not of its superior performance but because of simplicity. The type of excreta disposal systems suggested in this note is therefore technologies that are simple and affordable and which are built on the existing and known types. The more advanced and expensive ones will also be mentioned for general knowledge but not necessarily to be applied in Ethiopian communities.

The collection and disposal (management) of human excreta, urine and other house refuse is a very important part of the work of an environmental health worker (sanitarian). Waste management is the first problem that must be tackled in every district or locality because the success of any other health measures introduced will largely depend on the efficiency of waste management.

1. Types of Technologies & the Construction Methods

Waste management requires viable, appropriate and affordable technologies. There are so many types of waste disposal technologies available in the world today. The technologies are different in the size, construction and lining of the pits, whether they use water or not, the type of superstructure and venting systems. It has become evident that in selecting a technology many interrelated factors and many local variables influence the types and construction methods of any sanitation system. These factors are:

1. Social, cultural, beliefs, values and practices
2. Religious customs
3. Population density and settlement pattern
4. Climatological conditions
5. Topography and soil conditions
6. Geological formations
7. Abundance or scarcity of water
8. Energy
9. Economic standards

10. Political and social organizations
11. Educational level of communities
12. Level of health awareness
13. Safety to users.
14. Availability of resources, and infrastructure that may support sanitation system (Skilled human power, construction materials, on-going water or Hygiene programs etc)

The selection of the technologies should suit to the local condition especially cost. It is a proven fact that water flash toilets are the best installation but they are expensive. On the other hand local community members may decide to use only the field for deification, which is not costing money at all. A technology should come in between these two extremities as solution to the problem. The solution should be that technology that will give the most in health protection and at the same time will be within the economic possibilities of the people to construct and maintain. Sanitarians should always take this philosophy into consideration not only for pit latrines but also to any other technologies that they suggest improving the health of the community. Installed technologies should be maintainable by the owners or by any local artisan, if not they may be used only once and are not sustainable.

There are, at present many different types of excreta disposal or management systems. From a purely technical point it has been agreed that an excreta disposal or management system should satisfy the following seven requirement as adapted from Ehlers and Steel.

1. The surface soil should not be contaminated because of the technology used
2. There should be no contamination of ground water that may enter springs or wells
3. There should be no contamination of surface water
4. Excreta should not be accessible to flies or animals

5. There should be no handling of fresh excreta; or, when this is indispensable, it should be kept to a strict minimum.
6. There should be freedom from odors or unsightly conditions
7. The method used should be simple and inexpensive in construction and operation.
8. Should serve at least 4 to five years to be cost effective

However, the available technologies are grouped according to the technology involved and their overall function.

1. Drop-and-Store Systems

1.1 Pit latrines/pit privy
1.2 VIP latrines
1.3 Compost latrines
1.4 Aqua Privy
1.5 Bucket latrine
1.6 Trench latrine
1.7 Overhung latrine
1.8 Borehole latrine

2. Drop-Flush-and-Discharge Systems

2.1 Water carriage
2.2 Pour-flush latrine

3. Individual containment and Treatment Systems

3.1 Cesspools
3.2 Septic tanks
3.3 Soak pits
3.4 Seepage pits

4. Community Treatment Systems

4.1 Primary treatment of sewage
4.2 Secondary treatment of sewage

I Drop-and-Store System

1. Pit Latrine

This system is known as traditional pit latrine, pit privy or out-house. Pit privy is the cheapest type of excreta disposal system known. It is also considered the most common sanitation system in the world. It is based on containment and indefinite storage of human excreta. It is now given another name based on its function- **" DROP-AND-STORE**. Drop and store requires for a hole to be dug in the ground. As its name indicates the excreta is deposited in this hole for until it is full after which the content will be pumped out or filled up by soil to remain underground forever.

Pit Latrine among other things require:

- A reasonable amount of open space,
- Soil condition that can be dug easily,
- A low ground water level
- Site that is never flooded.

Construction of pit latrines by the people in Ethiopia was usually found to be defective or inappropriate. Because:

- There is always some problem with the site selected
- The technique is simply digging a hole in the ground. Some times the pit collapse because the mouth was wider than the pit bottom.
- The size and volume of the pit is not considered either for prevention of ground water contamination or service life.
- Once the latrine is dug, log of woods of various size are put over the hole with a small hole left to give access for dropping the excreta.
- Over the log twigs and branches are put basically to support the dirt, which is going to be put on top to serve as floor.
- Superstructure is usually optional.
- There is no pit cover in most cases; even if available proper and constant use is not guaranteed

- Urine is impregnated in the soil and it smells badly after few weeks of use.
- Flies are attracted and start to breed in it.
- When it is filled it is abandoned and left uncovered.
- Depending on the type of soil it some times collapse
- Generally, pit latrine construction serves only for privacy or easy access but not for disease prevention and health improvement in mind.

A pit latrine should be properly constructed not only to isolate faeces but also to give :

- Comfort (no smell, give privacy);
- Prevent accident, pollution and fly breeding;
- Not spoiling the living environment.

1.1 Site Selection

Sitting the pit latrine is the first most important measures to take. A bad location could in the future be source of ground water or surface water pollution, soil and food contamination, and may create odor or unsightly condition.

A pit privy should be located down slope from water sources such as wells, springs or surface water. There may not be danger if the pit did not penetrate through the underground water formation. But, shallow wells in Ethiopia are usually less than 20 meters, which means the water bearing to such wells is the soil water. In this case there will be a chance that the pit latrine, which normally has a depth of 3 to 5 meters, could contaminate the well. If ground water does not enter the pit and the soil is uniformly compact, there should be no danger to a well at very short distance of at least 15 meters.

It should also be located at least 10 meters away from kitchen and the living house. Flies that may have access to the pit may travel to the kitchen to contaminate the food. The odor that may emanate from the pit may also be nuisance for people inside the house.

1.2 Size Determination

How quickly the pit fills depends on many factors including the size, number of people using it, how much other material (water, refuse) is added to it and what type of annal cleaning material is used. In the African situation 0.025to 0,040 m^3 of waste will accumulate each year per user. Volume of pit could be calculated using the above figure and putting the family size and the number of year's services desired.

If one have only a small plot and yet want to dig a latrine for a certain period of time his choice is may be to dig a deep pit. The depth of a pit can be calculated using the following formula. (Madeline Wage, IRC. 1991)

$$\text{Depth} = \frac{P \times S \times N}{A} + 0.5 \text{ meter}$$

Where: P = average number of users

S = Solid accumulation rate m^3 per person per year (0.025 - 0.040 m^3)

N = Minimum useful life required

A = Cross sectional area of the pit (based on the plot available)

0.5 mr. this is added into the calculated depth for the service year required because the pit has to be filled with soil when the pit is full up to 0.5 meters from the top.

It has to be noted that the longer a pit latrine (privy) will serve a family without rebuilding another one, the more certain is the health protection which it can give to the family and the community.

However, the life of a pit depends not only on the volume but also on:

1. The maintenance and care taken
2. How and where it is built (technology and soil)
3. The materials used in its construction
4. The design period or the time required for the pit to fill

It is important to remember however; that the decomposition process of the waste deposited in the pit actually starts immediately after the excreta is deposited. Through decomposition and compaction, the volume of the slowly accumulating sludge is smaller than the total amount of excreta deposited. This can be illustrated by a research made by WHO.

a. Human waste (solid and liquid) deposited in pit by a family of five at the rate of 1 liter per person per day = 14,600 liters in 8 years
b. The corresponding amount of solid waste alone was approximately = 6000 liters in 8 years
c. The rate of accumulation of sludge by volume in the dry pit = 1130-2260 liters in 8 years
d. Rate of accumulation of sludge in wet pits was = 735-1470 liters in 8 years

Other investigation conducted by WHO in India where ablution water is used showed that the average sludge accumulation rate is 25 liters per person per year. In Philippines where solid material such as grass, stone eyttc. Are used for anal cleaning a figure of 40 liters per person was obtained. The investigators recommended that for the design of the effective capacity of wet pit latrines a provision of 37 liters per person per year should be allowed. But if stone, corncob and other hard materials are used the figure has to be increased by 50 %. (E.G Wagner and J.N. Lanoix)

For all practical purposes pit privies should be designed to have at least 4 years storage capacity. The sludge volume for a dry pit is 40-60 liters per person per year. Due to the digestion of sludge, which takes place in the pit and percolation of liquid into the soil, the actual volume of material may be reduced to 20 % of the total volume of feces and urine deposited. A pit 2.5 meters deep and 90 cm. Square should serve a family of 6 for 5 years.

Volume of pit = 0.9 m length x 0.9 m. width x 2 m. depth

Volume of pit in liters = 0.9 x 0.9 x 2 mx 1000 l/ cubic meter=1620 liters

Total sludge produced by 6 persons per year = 6 x 50 liters = 300 liters.

Therefore the life span of pit latrine = 1620 liters /300= 5.4 years.

Note:

The sludge accumulation rate depends on the type of material used for anal cleaning.

1.3 Construction Methods

A pit latrine should be constructed as follows.

- Depending on the soil formation and availability of ground water near the site, the pit should be as deep as possible and not less than 1.5 meters other wise flies will breed and cause a lot of trouble. Depth is usually calculated for a number of years service for a family. The important thing is that if possible it has to serve for several years. If a circular pit is to be dug the diameter should be at least 0.90 meters (otherwise workers will not be able to move around) and not more than 1.50 meters (otherwise it will be expensive to cover the pit).
- There should be a superstructure made from local material such as grass, leaves, twigs, mud blocks, or corrugated iron sheet. The superstructure should be well ventilated and should be made fly-proof with wire mesh. It should have a well fitting door. The superstructure should aid in keeping the inside dark to discourage flies entering the pit.
- The pit latrine could be vented using a plastic pipe, large bamboo, concrete and other methods. If vents are used there may not be a need to construct a screened opening in the superstructure.
- The floor should be made from lumber or a properly made wood cover that is flat and cleanable. Concrete slab whenever

available is the best type of latrine cover. Dirt cover whose support is wood or twigs (tree branches) will absorb urine and smells. The odor attracts flies and makes cleaning difficult. A smelly latrine discourages users.

- Whenever concrete or other impervious material is used for latrine slab, the surface should be smooth, with a slight slope from all sides toward the hole in the center to let urine flow into the pit.
- A pit latrine should have mound all around the pit so that surface water will not enter the pit.
- It may be necessary to construct casing down to at least one meter depending on the soil formation.
- It is very important to construct diversion ditch around the pit perimeter to avoid surface water intrusion. (See drawing)

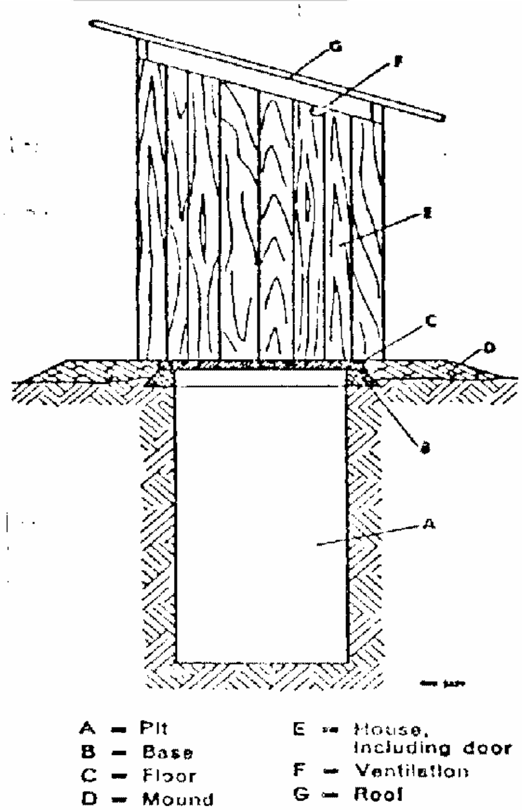


Fig: 9 Parts of a Pit latrine

II Raised Pit Latrine

In areas with hard rock near the ground surface or with a high water table, construction of latrines is only possible by raising or extending the pit above ground level (see drawing). In this case the pit should be fully lined with stone, brick, or concrete block masonry, the lining continued up to an appropriate level above the ground. The soil excavated from the latrine pit should be placed in a mound around the pit walls to provide support and to prevent any leakage from the extended latrine floor.

Construction Methods for Raised Pit Latrines

Construction involves the use of stone, blocks, bricks or ferrocement construction materials. Since most of the structure is going to be built above ground the inside of it should be plastered and made watertight. Apart from this all construction procedures are the same except that building steps or stairs to go up to the seat is mandatory for raised latrines.

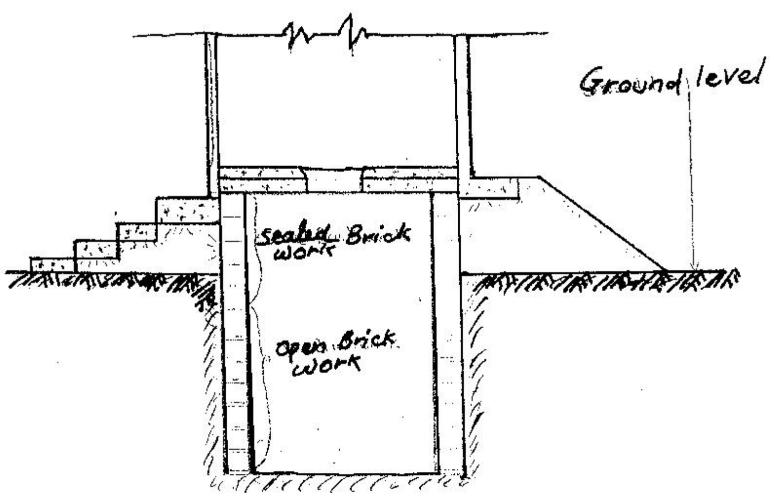


Fig. 10. Parts of a Raised Pit Latrine

(Source: Sandy Cairncross, Small Scale Sanitation, Ross Institute, Bulletin No. 8)

Advantage of a Pit Latrine

- Low cost
- Can be built easily
- Use of all type of anal cleansing (stone, corn cob, leaves, grass) materials may be used
- Minimal water requirement

Disadvantage of a Pit Latrine

- Fly and mosquito nuisance
- Waste can not be recycled
- Smell problem
- Lack of space for relocating new ones when full
- Potential for ground water pollution
- Difficulty of construction in rocky soil or Bolden laden subsoil

III. Vip Latrine

Ventilated Improved Pit (VIP) is a technical modification of simple pit latrines mentioned above. It is also a drop-and-store technology. The difference of VIP from the traditional one is the ventilation arrangement and a concrete slab cover. The pit is ventilated using large diameter pipe extending above the roof of the VIP. When it is ventilated wind passing over the top of the vent pipe causes a flow of air from the pit through the vent pipe to the atmosphere and a down draught from the superstructure through the squat hole or seat in to the pit. This continuous flow of air removes smells resulting from the decomposing excreta in the pit and vents the gases to the atmosphere at the top of the vent pipe rather than through the superstructure.

As a result of the vent technology added VIP improves the disadvantage of the pit latrine by:

- Eliminating fly breeding problem
- Reduction of odor and nuisance problems

But to control flies and reduce odor

- The vent pipe should be fitted with fly proof net (mesh)
- The inside of the superstructure should be kept dark.
- The door should face towards the prevailing wind and kept always closed to keep the inside area dark living space at floor level for air entrance.
- It is not necessary to cover the squat hole.

Materials used for a vent pipe are common AC (Asbestos Cement), PVC, bricks, and concrete blocks. For rural areas the suitable and available ones are reeds, saplings, split bamboo, large diameter bamboo or other local materials.

For sufficient air flow and to provide light to the pit the internal dimensions of the vent pipes is recommended to be 100-150 mm for asbestos cement (AC) or poly-venyl-chloride (PVC); 225, mm for brick or block work and; and 200-250mm diameter for cement rendered reed or hessian. Actually it can be reduced for up to 100 mm for PVC & AC and 200 for rural vents. The vent has to extend 50 cm above the roof and up to the apex for conical roofs. (See drawing)

Types of Vip

There are three common types of VIP latrines

1. Single pit VIP
2. Alternating double pit VIP (Permanent VIP)
3. Multiple-pit VIP (Shared)

Construction Methods

I. Single Pit

The construction of a single pit VIP as far as digging is concerned is the same as that of the pit latrine technology. Since the difference is only the vent pipe other dimension and construction techniques could be adopted from the pit latrine mentioned above. However, the important parts for a VIP latrine: vent pipe location and squat hole arrangement need special attention. The following guide could be used in the construction of any vent or squat hole on a concrete slab.

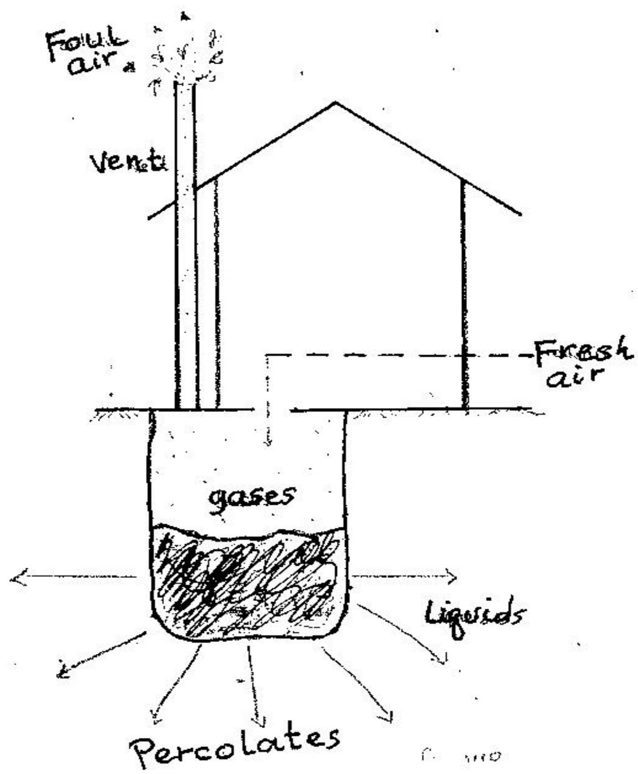


Fig. 11. Parts of a Single VIP Latrine

(Source: Madleen Wegalin-Schuringen, On-site Sanitation, Building on Local Practice, IRC. 16)

1 After site selection as indicated under pit latrine locate the exact place to start digging the pit
2. Mark the diameter of the pit before starting to dig
   2.1 Place a peg on the ground
   2.2 Tie a piece of string, which measures the radius of the latrine desired
   2.3 walk around the peg marking the ground with the piece of wood attached to the string.

3. Dig the Pit

3.1 Keep the walls of the pit as straight as possible

3.2 Make the diameter of the pit at least 0.90 meters

4. Line the Pit if Necessary

4.1 Back fill between the wall and the lining with earth and ram it

4.2 If you are using brick prepare the mortar with proportion of 8 parts clean river sand and one part cement. (if sand is dirty add cement)

5. Make the Cover Slab

5.1 Choose a level space near the pit

5.2 Mark a circle slightly bigger than the pit diameter (the diameter of the slab may need to be bigger if there is no casing)

5.3 Place a ring of bricks or dig the soil to a depth of the slab thickness which is usually 5-7 centimeters

5.4 To stop concrete sticking to the ground use the cement bag, Newspapers, false banana leaves, plastics, or sand inside the mould.

5.5 Use two bricks to make the holes for squatting hole and vent pipe

5.6 Make the concrete mixture using 4 parts gravel, 2 parts river sand

And 1 part cement (4: 2:1)

5.7 Place at least half of the mixture of concrete into the mould and Stamp down well, especially around the holes made for the squatting holes and vent pipe.

5.8 Now place reinforcing iron bar size 8 on top of the concrete inside the mould and form a grid patterns with 10-15 cm apart.

5.9 Place remaining concrete over the reinforcing iron bar.

5.10 Loosen and remove bricks from squat hole and vent pipe after the concrete is set which is usually one hour

5.11 Shape the squatting hole correctly and smoothly so that it is a suitable size. It should normally be 30 cm. long and Centimeters wide.

5.12 Over the completed concrete slab with wet sacks, cement bags, grass, etc. and keep it wet at all times (sprinkle water at least three times a day) and allow to cure for at least 5 days.

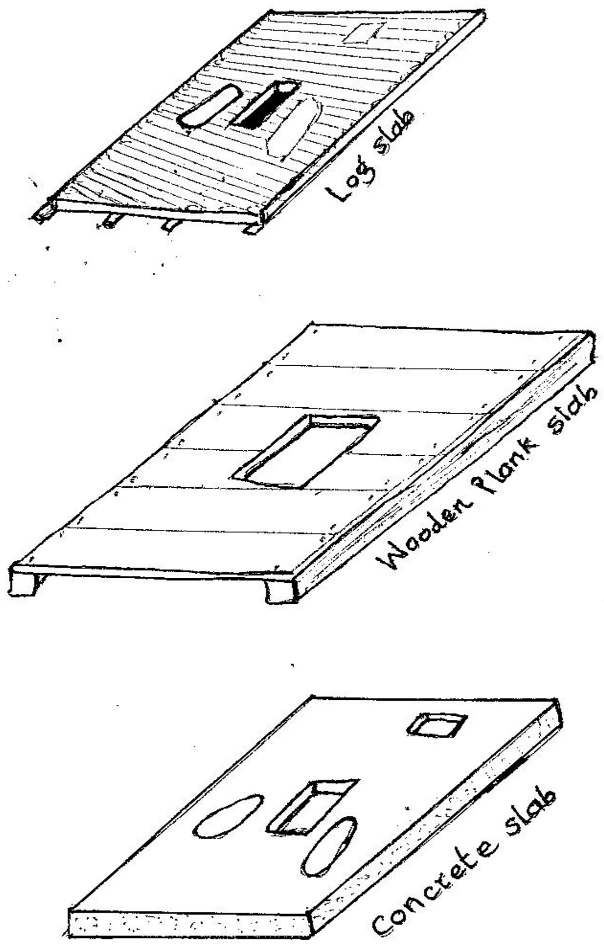


Fig. 12: Types of Pit Covers (Wooden, Concrete.)

(Source: Sandy Cairncross, Small Scale Sanitation, Ross Institute, Bulletin No. 8)

6. Install the Vent Pipe

One of the important features of a VIP latrine is its ventilation arrangement. The theory to this is that the foul gas that is formed has to escape through a vent arrangement so that every one in the family with out any objection could use the pit.

The vent pipe should have diameters mentioned above to aid air movement across the top the pipe. Air is practically sucked out of the vent pipe and the air that is forced to rise up is replaced by fresh air, which is sucked in through the squatting hole in the slab. When this air movement is taking place (hot air sucked out and new air entering the squat hole) it will be almost impossible for the foul air to escape through the squat hole to cause smell. The entire odor pass up the pipe and are diluted in the atmosphere. For best result, however, the latrine opening structure should face into the wind because at this position more air will pass through the latrine compared with a latrine opening facing away from the prevailing wind. If the latrine opening faces away from the wind, the wind will try to draw air out of the structure, while the pipe is trying to draw air into the structure. (Morgan)

There are two parts, which need periodic inspection

a) **Fly screen**: - At the top the vent should be kept clear of blockages and be quickly replaced if the screen has any holes in it. It should also be clear from wind obstructing objects as much as possible.(see drawing)

b) **Foundation: -** any sign of erosion of the foundation around the edge of the slab should be filled immediately or otherwise the whole structure will collapse. This may have been caused by soil erosion due to surface water runoffs in which case a well maintained diversion ditch is a must.

Fly Control

According to Peter Morgan who is the architect of Blair latrine (VIP), fly control is another best feature of VIP latrine. The theory is simple. Flies are attracted by any smell for which latrine smell could invite all available in the vicinity. Flies are also photopositive in which they will be attracted by light and so they could be drawn away from odor if there is a light source available. Once inside the pit flies breed and when they emerge they fly towards the strongest light source which in pit latrines is the squat hole and in VIP the vent pipe. Once the flies are attracted and fly up the pipe they will be trapped by the screen arrangement that is fitted into the vent pipe. They cannot fly back because there is no strong light in the pit, where eventually, they are trapped and die.

For best results the pipe should always be clear of spider webs so that flies could very easily fly up to the top. Flushing a bucket of water from the top periodically does cleaning of the pipe. It was suggested, but no more absolutely valid that a vent pipe painted black and sun shining on it will aid the air to rise in the pipe even if there is no wind.

7. Construct the Superstructure

Superstructure for VIP could be constructed just like any pit latrine except that it may not be necessary to have an eve opening for ventilation as we do for pit latrines. VIP vent is enough to expel foul air. The opening left under the door is also enough to admit fresh air from the outside.

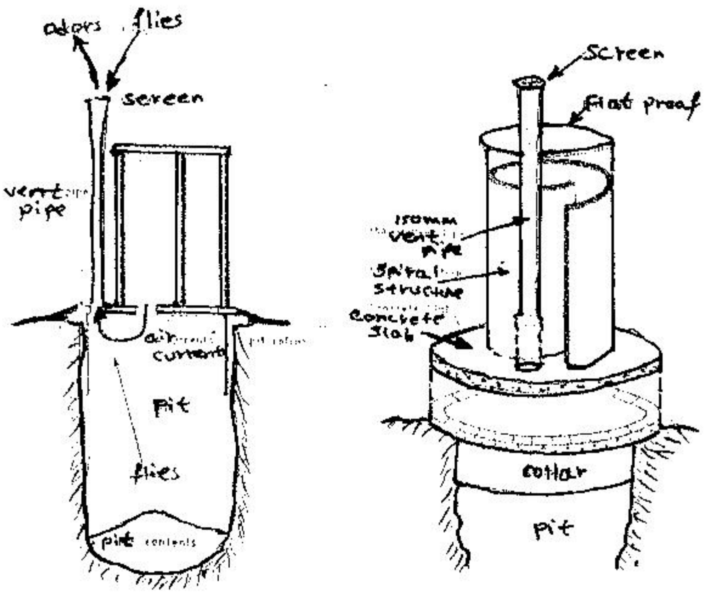


Fig. 13. Parts of Vent Pipe

III. Alternate or Double VIP

The construction of alternate pit some times called 'double vault compost latrine' or 'permanent VIP' is different than the technologies mentioned above. This type is primarily meant to recycle the waste including garbage and other organic hence, the vault has a door arrangement, the size is much smaller than the pits, and it demands water proofing or concrete work.

It is a reasonably safe way for an individual to prepare excreta and other waste for use as fertilizer is for him to compost it in such a pit. The method is based on anaerobic decomposition of organic wastes, which are left undisturbed during a period of at least ix months to ensure destruction of pathogens and ova of helminthes.

A pit larger than one cubic meter in size times two is dug in the ground. The floor of the pit will then be covered with concrete so that the composted or decomposed latrine will be removed easily. The walls are built from bricks or blocks. A concrete slab cover is put on the vault. A superstructure is built for privacy and to protect the user from adverse weather condition. (See the drawing)

One of the vaults will be made on use until it is full up to 0.50 meters from the top. When it is full the rest of the space will be filled with dirt and other refuse and sealed. After this the second vault is made operational. By the time the second pit is filled the content of the first pit is decomposed or stabilized. The vault door will then be opened and the content evacuated. The compost can be used as soil conditioner for plants or vegetables. Such alternate use of the pits will make this type of latrine permanent.

Apart from its initial cost, alternate VIPs are useful technologies especially in the crowded urban communities where there is no space to dig pit latrines when ever one is full. The latrine is easy to maintain and apart for regular cleaning and repairs, it needs no other attention.

For best result in using such latrines people should use or sprinkle ash after deification. This will eliminate odor and dehydrate the stool and urine which this will aid decomposition of the waste material.

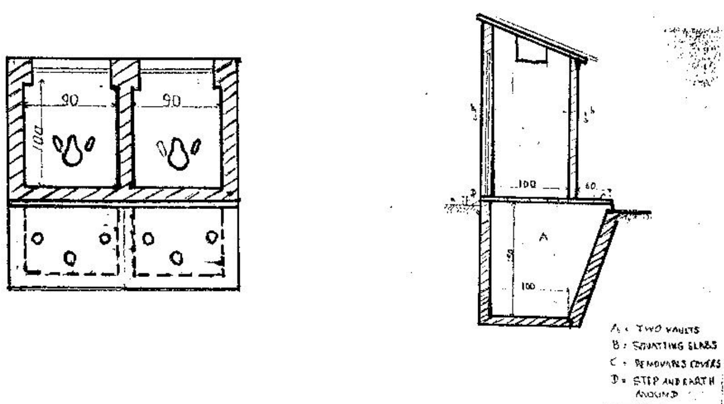


Fig. 14. Double Vault Latrine Showing Parts of the System

(Source: Uno Winblad and Wen Kilman, Sanitation without water. 1985)

General Construction Methods

The privy pit, location, slab construction and other features are practically the same with any other drop-and-store system. Since this type id going to be used for waste recycling construction of this system entails to follow the following details.

1. Dig a pit of required size, the bottom of which should always be above ground water level
2. It is advisable to cover the bottom of the pit with grass cutting, garbage, leaves and other organic compostable materials but no inorganic materials such as glass or tin cans.
3. During the operation of the compost pit add the daily garbage and other compostable organic waste into the pit. The urine that may be soaked in the garbage, grass etc. will enrich the compost with plant nutrient.
4. If cow dung, horse, sheep, goat or chicken manure is to be added the compost pit should be provided with the largest possible capacity so that it will not fill too fast.
5. When a pit's content reaches a level about 50 cm. below ground level it should be leveled, and filled with grass clipping and leaves up to 35 cm. below ground. The last 35 cm. will be willed with soil and sealed. During this time the second pit will be operational.

III. Multiple-seat Vip

Multiple pits VIP are exactly the same as that of a single pit VIP latrine in that site selection, construction and venting are the same as that of the VIP technology mentioned. The only difference is the volume, size and cost. It is also intended for a slum area or an institution (school, prison, and health facilities) where many people have to share each pit.

The vents in such cases should be adequate enough to evacuate gas and odor from the pit. It should therefore be arranged in such a way that one vent is set for every two or three pits. (See drawing)

Although multiple seats VIP functions exactly the same as the single pit VIP; the waste is not recycled. The installation is considered permanent because such technology is very expensive to abandon each time it is full and dig a new one. Rather, availability of a vacuum track in the locality is a necessity to evacuate the pit content when ever necessary. The waste could be used in a composting plant if there is such a recycling and processing program in the locality.

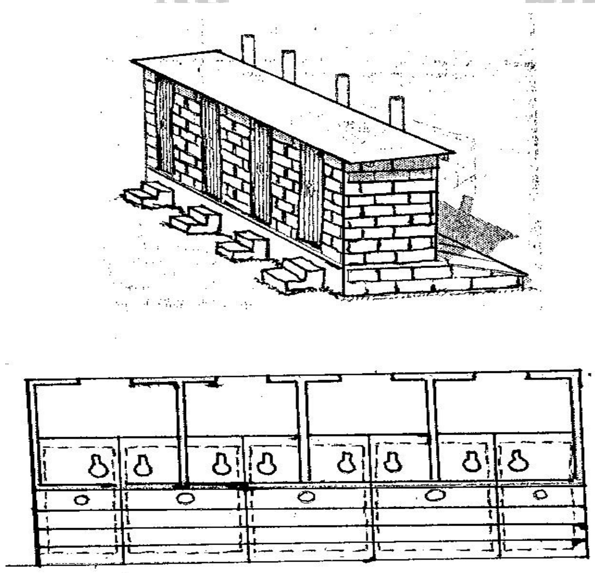


Fig. 15: Floor Plan of a Multiple Pit VIP

(Source: Sandy Cairencross, Small Scale Sanitation, Ross Instiotute, Bulletin No. 8. 1988)

Advantages of a VIP Latrines

- Low annual cost
- Easy construction and maintenance
- All types of anal cleansing materials can be used
- Absence of odor and minimal fly & mosquito nuisance

Disadvantage of a VIP Latrine

- Lack of space for relocating the pit in urban areas
- Potential for ground water pollution
- Relatively expensive than simple pit latrine
- The door need to be always closed

Note to the Teacher:

This is a very good time for you to give some practical training to your students. We have now seen how latrines whose components are similar (simple pi latrine, VIP latrine, Raised latrine) are constructed. The ordinary pit and the VIP are both a drop-and-store systems. Take your students to a site where these two systems can be shown and evaluated by the students.

Divide them into groups and assign each group of students to evaluate the waste disposal system in terms of site, type of construction, smell, fly breeding, simplicity, what users think of about the type of system they use? How was it covered (slab, dirt or wood), which one was darker? Which one was well maintained? Which one has more flies?

Ask them to prepare reports and present it in the class by group. In this exercise one group will add things that another group did not see and at the end the class exercise will be very useful.

Other Systems

1. The Roec

A variation of VIP latrine is the Reed Odorless Earth Closet (ROEC). In this system the excreta is deposited into the pit via a chute located at the base of the squat hole or seat. (See drawing). The ROEC is fitted with a vent pipe to control odor and insect nuisance.

Advantage of ROEC

1. Is larger than VIP and hence have longer life

2. Pit can easily be emptied
3. The pit is displaced and with good care there will not be any smell or other nuisance
4. Children have no fear of falling into it

Disadvantage of ROEC

1. The major problem of this system is that the chute is easily fouled with excreta, thereby providing a site for flies and odor nuisance.

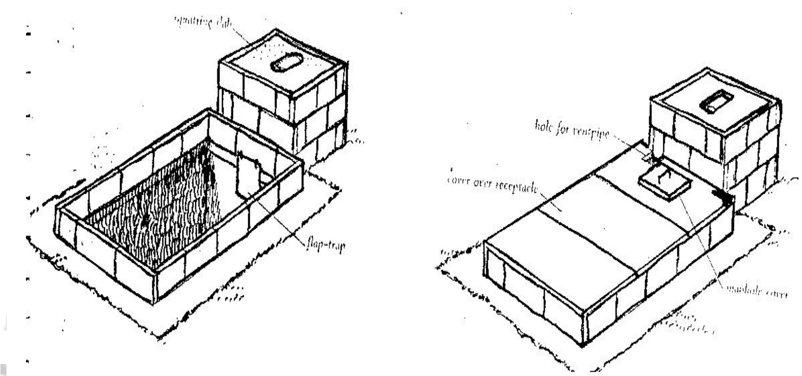


Fig. 16: Parts of Reed Odorless Earth Closet.

(Source: Uno Winblad, Wen Kilman, Sanitation without Water, 1985)

2. Aqua Privy

The aqua privy was considered to be one of the viable technologies that can fulfil the criteria or requirement as laid out by Ehlers and Steel. The aqua privy consists of a tank filled with water into which a chute or drop-pipe carry the urine and feces. Aqua privy is similar to a septic tank. Human excreta undergo anaerobic decomposition in both systems; the sludge is also accumulated in the bottom of the tanks. Both systems also need a soakage pit or subsurface drain system for the effluent.

Construction Methods

As far as possible the use of local materials for the construction of aqua privy is recommended. The need to make aqua privy watertight demand the use of concrete or cement product. Such materials may, however be scarce and prohibitive especially for rural areas in Ethiopia. The fact that it is also a permanent installation initial investment may be worth it for those who can afford it.

A. Tank

The size of the tank depends on the number of users. It has been estimated when the technology was popular that the capacity should not be less that one cubic meter. Smaller tanks were also recommended but for efficient performance water should be added daily to maintain the depth and amount of water needed in the tank.

The essential steps in the construction of the tank, according to E.G.Wagner and Lanoix (1958) are as follows.

1 Dig a pit to fit the size of the tank and place therein a 10-cm. layer of gravel, which should be well tamped to make a firm foundation.

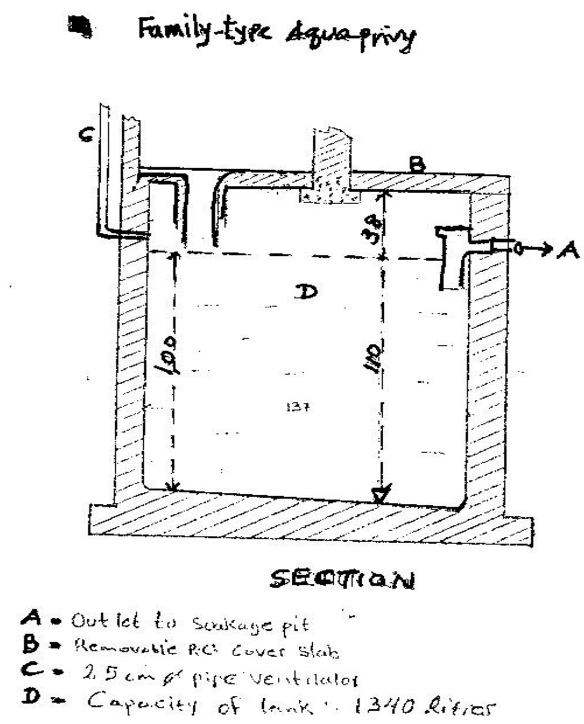


Fig. 17: Shape and Parts of Aqua Privy

(Source: Ehlers and Steel, Municipal and Rural Sanitation, 1965)

2 Pour at one stretch the bottom concrete, at least a 10 cm. thick, together with 20 cm. of bottom wall using a 1:2:4 cement-sand-gravel mix with not more than 23 liters of water per bag of cement.

3 Continue the wall, inserting the outlet tee and vent pipe connections at the proper levels. Then plaster the inside surface of the tank with a 1.25 cm. coat of a rich 1:3 cement-sand mixture paying particular care to the joints in the concrete walls.

4 After the concrete has set, test the tank for water tightness by filling with water for 24 hours.

5 Lay the slab (floor), and complete the superstructure

6 Dig the seepage pit for the effluent.

The advantage of aqua privy is that it can be constructed above ground especially in areas where the ground water is high or rocky formation will not allow digging of pits.

The tank should be watertight because it function is to receive, store, and digest the waste matte. Therefore, construction materials mostly used for such tanks are ferro-cement or block or brick plastered with cement.

B. Floor Slab

The floor or slab of Aqua privy is the same as that of a pit latrine, except that the squat slab of aqua privy is provided with a chute or drop pipe. The chute that is immersed in the tank water will deliver the feces below scum level. This prevents flies from having access to water or scum. In addition it prevents gas escape from the pit.

C. Tank Ventilation

The anaerobic decomposition process in aqua privy will produce gases such as methane, which is offensive. The vent should be installed below the slab but above the scum line to avoid pipe choking. The pipe vent should be extended above the superstructure. The vent pipe is preferred to be plastic as the gas could very easily corrode metals.

D. Effluent Disposal

As mentioned water should be added to the tank in order to keep the level. Also, when feces and urine is added into the tank the volume of water increased. Since the effluent is designed at a level, therefore, for any volume of water or excreta added an equal amount of water from the tank is displaced. This displaced water is literally "sewage" water, hence, it has to be handled carefully and disposed properly because, it could have pathogens, cysts and other harmful bacteria. As mentioned in page74 disposal of the waste displaced can be effected in a soak pit.

E. Location

A properly operated aqua privy is a clean and odorless installation, which may be safety, placed close to a dwelling. If proper operation and maintenance cannot be guaranteed, the distance from the dwelling should be increased.

Operation starts with filling the tank with water up to the invert level of effluent pipe. For quick digestion action to start it is necessary to seed the tank with activated sludge from other waste disposal system such as for example pit latrines. This way digestion may commence immediately or other wise it may take 6-8 weeks to reach an efficient level of operation.

Since heavy materials such as stones, husks, and corncobs etc will not disintegrate it is absolutely necessary to refrain from not using such materials for anal cleaning.

One other difficulty faced in using poorly maintained aqua privy is that the drop pipe or chute gets choked with fresh feces upon which flies lay their eggs. Care should be taken that such things will not happen. Some times using a stick to push the feces down will be necessary.

3. Bucket Latrine

Bucket latrine was one of the types of technologies used in many parts of the world. This type of system was once popularly used in the crowded township of Harar. In India it was the basic installation. The excreta or night soil as is sometimes called is removed and disposed away from the residential areas. The waste is dumped in the open exposed to flies, runoff, animals etc. hence contaminating the environment. The people who remove the bucket when full were considered untouchables.

This type of installation has health hazard for the scavengers or transporters, the environment (Water body and soil) and the community in general. Smell, fly breeding and other exposed unsanitary condition prohibit the continuous use of this type of installation.

Because of especially the stigma attached to the scavengers it has become very expensive to higher some one to transport, clean the bucket and the bucket site, thus, this type of installation is now considered to be expensive to operate and maintain.

In general the contamination it causes in sidewalks, when waste spillover at site, the fly breeding problem and other disadvantages will make bucket latrine one of the uneconomical and unsanitary Installation.

4. Trench Latrines

Trench latrines are those latrines that are constructed usually for emergencies such as natural disasters and wars. It is a temporary installation which is a long and shallow pit having a cross section of not more than 40 cm. width 40 cm. Depth and length as desired as it depends on the number of people intended to be served. The whole concept is that a number of people will use it for a short period of time after which the content of the pit will be filled with earth and left to decompose. If necessary another trench will be dug for use.

For best use of the trench latrine and to discourage flies and minimize smell users should be encouraged to cover the feces with earth after defecation. The urine, which normally falls outside the pit, may also cause smell and attract flies. In this case it is advisable to discourage users from doing so rather to incorporate it with the feces in the pit so that it will be covered with the soil after defecation.

The advantage of a trench latrine is its being installed on the top layer of the soil where the aerobic saprophytic bacteria are most numerous and active. Their presence will activate decomposition and reduce the smell within a short period of time.

Construction Methods

One model trench latrine that has been designed in 1955 as described by E.G Wagner et al. shows the following features.

1. A pit 0.60 x 0.40 x 0.40 will be dug;
2. Above the pit a Turkish type squatting plate or slab provided with foot rest, two handles (for removal), one hole, and one gutter to divert urine towards a small pit or drain;
3. Provide with a superstructure
4. An open box or pitcher full of loose earth
5. When the pit is full, it is covered with corrugated iron sheet to prevent animals, rain run-off and soil pollution with worm larvae.
6. Remove the slab and superstructure to another hole. After six to 8 weeks, iron sheet may be removed, the feces being transformed into humus and pathogens having being destroyed.

This type which is constructed with care may not be considered a health hazard or other wise a simple temporary trench may offer serious disadvantage for the camp community. However, it should be remembered that trench latrine is easy and cheap to build and fit well with the habits of the users.

Another method that has been used in Tatek Military Camp near Addis Ababa in the 1970s was different in that it uses water to flush down the waste matter into a receiving huge covered cesspool. Eng. Woldu Mahari of the MOH, Department of Environmental Health, designed this type of trench latrine. The construction method is as follows:

1. Trenches are dug to serve a number of people at one location
2. The trench floor and sides were made water tight with masonry and cement works
3. At one end a huge cesspool is dug and at the other end a water barrel is kept full of water
4. Trenches have a slope of 1 in 100 meters
5. After the military trainees use it in the morning, noon and evening the waste matter is flushed away using the water in the barrel.
6. Any urine or stool that is left unwashed will be covered with soil or shoveled off into a pit by sanitation crew.

Several of such installations were all over Tatek Military camp to serve over 300,000 trainees effectively

The significant environmental and health hazards caused by these latrines according to E.G Wagner et al are:

1. The inevitable pollution of the soil surrounding the trench latrine since there is no protection against the access of hookworm larvae to the ground surface;
2. The breeding of flies in enormous numbers, and the access of flies and animals to uncovered or lightly covered faces in the pits;
3. The danger of pollution of both surface and ground water;
4. The easy access to and scattering of the material by rodents and other animals.
5. The odor, nuisance and aesthetic problems

5. Overhung Latrines

Overhung latrines are not known in Ethiopia. These types of latrines are common in areas where people live in water logged or near by rivers. Some African countries, Far Eastern and southeastern countries use them a lot.

The overhung latrines consist of a superstructure and a latrine floor built on top of a wood, concrete or metal frame or pole above water along banks of water or coastal flats. In areas where this type of installation is used, the contamination of the river water is inevitable. It has been mentioned in many literatures that those countries in Asia that are using such systems have to transport water from a distance or use highly contaminated water.

An evaluation has been made on such systems where criteria have been set for safe use. These criteria as mentioned in the literatures are:

1. The receiving water should be of a saline nature all year-round so that people are discouraged to use it for drinking
2. The latrine is installed over such water depth that the bed is never exposed during the dry season.
3. Every effort should be made to select a site that would provide carrying away floating materials and dilution.

Regardless, recommendation for such type of latrine is only for those areas where conventional terrestrial types such as pit latrines cannot be built.

In areas where water contact as means of seeking livelihood (fishing etc) or transport and recreation/bathing is a way of life the system is never recommended.

6. Borehole Latrine

Borehole latrine is a latrine, which is usually dug in soft ground using an augur. Such latrines are dug with different diameter of augur. An augur is a metal shaft that is rotated by people. The soil is bailed out with the augur once in a while.

The disadvantage of borehole latrines is that many latrines can be dug within a very short period of time provided that the soil is soft. The other advantage is that it is accident free.

The disadvantage of borehole latrine is being a small diameter hole it may not be used for many years. Secondly, to compensate the diameter and to increase its life people tend to dig deeper pits, which ultimately may contaminate the underground water table.

7. Other Environmental Friendly Systems

It is a well-known fact that human feces are responsible for most disease spread. This warrants designing a system that will sterilize feces so that disease-producing organisms will die before causing heath problem. To satisfy the sanitation of feces two methods were tested in many parts of the world these two methods are:

7.1 Dehydration method

7.2 Decomposition methods

Dehydration or drying of feces is easier if they are not mixed with urine or water. When feces decompose, the different living things in the feces die and are broken down into smaller parts. Thus by engaging the above two methods together or separately, germs, eggs of parasite and other potentially dangerous health threatening living things are made harmless.

The criteria to achieve a new vision are simple, but achieving the vision requires a change in how we think about sanitation. The challenge is to look for an option that will eventually make our environment waste free**- the ‘0’ waste option.**

Sanitation is a key determinant of both equity in society and society’s ability to sustain itself. Our approaches in the future must be resource minded, not waste minded. There can be no equity and sustained life and well being if all people in our societies live with out latrine or unsanitary latrine.

The criteria of a sanitary waste management system with the new vision should meet at least some of the following. These criteria can be seen together with those mentioned under pit latrine construction.

1. A sanitation system must be capable of destroying or isolating completely fecal pathogens (**prevent disease**)
2. A sanitation system must be accessible to all poor people **(affordable**)
3. A sanitation system must prevent pollution or surface contamination, return the nutrients to the soil, and conserve valuable water resources (**protect the environment)**
4. A sanitation system must be aesthetically inoffensive and consistent with cultural and social values. (Acceptable)
5. A sanitation system must be robust enough to be easily maintained with the limitation of the local technical capacity etc. **(Simple)**

Successful implementation of the '0 ' waste option and application of the criteria mentioned above require an understanding of sanitation as a system in which all components are considered together. The main components of the system are:

1. **Nature:** The variables are climate, (humidity, temperature), water (amount available, ground water level), and soil (stability, permeability,).
2. **Society**: include settlement pattern (concentrated, scattered, low/ high density), attitudes, habits, beliefs, and taboos, related to human excreta as well as the economic status of the community.
3. **Process**: the physical, biological, and chemical process by which human feces are turned into a non-dangerous, inoffensive, useful product.
4. **Device:** the onsite sanitation structures

7.1 The Dehydrating System

In this system the toilet content in the processing vault are dried with the help of natural heat, ventilation and the additional of dry material. The moisture content should be quickly brought down to below 25 %. In the process there is rapid pathogen destruction, no smell, and no fly breeding. One of the features of the dehydrating toilet is it diverts or separates the urine from the feces, thus excluding water to facilitate quick dehydration. Since urine contains most of the nutrients for plant growth but no pathogens, it may be used directly as a fertilizer without the need for a further processing. The only precaution needed is to pour it below soil surface and away from the roots of plants if used directly or to dilute it (1: 5) for direct spray on the plant.

Some of the dehydrating toilets developed in the last many years in India, China, and Vietnam etc are the following (Uno. Winblad, 1998)

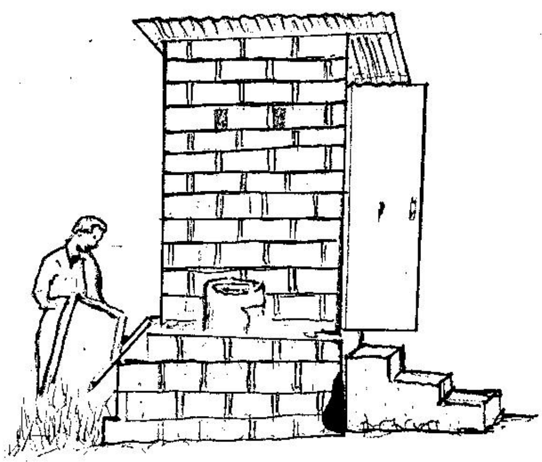


Fig 18 : The Dehydrating Toilet

(Source: Uno Winblad, Wen Kilman, Sanitation Without Water, 1985)

7.1.1. Double Vault Latrines

The classic example of a sanitation system that satisfies clean, odor free, fly breeding free and resource recovery or in general Zero Waste criteria is the double vault toilet. Double vault toilet is a concrete structure where two vaults or compartments with two squatting are built. One vault or compartment is used while the second one remains idle empty or full of waste matter.

The toilet is built above ground with the processing chambers placed on a solid floor of concrete, bricks or clay. Each vault will have a dimension of 0.8 x 0.8x 0.5 meters. Each vault should be large enough to hold at least two years' accumulation of wastes so that most pathogenic organisms die off before the compost is removed.

The difference between alternate VIP and double vault is the objectives for which they are built. VIP'S main objective is the elimination of odor and fly breeding more than waste recovery because VIP can be constructed just like pit privy except installing the vent. The double vault will achieve the function of the VIP proper but also it incorporate other organic waste and separate urine to enhance recycling by composting. If all waste matters are added together and composted the end product which is the compost and the separated urine will be used as soil conditioner or fertilizer. This process will eliminate pathogens and achieve Zero waste accumulation in the immediate environment.

The construction of the vault and the urine separation arrangement is shown in the drawing below

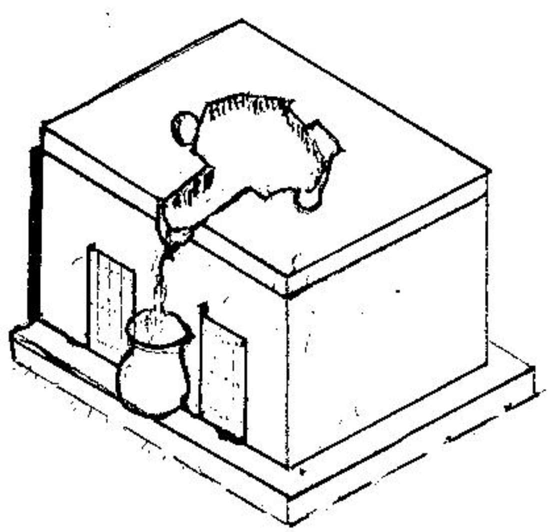


Fig. 19. Double Vault Toilet with Urine Diversion Arrangement

(Source: Uno Winblad, Wen Kilman, Sanitation without Water, 1985)

As far as operation is concerned the process is simple and biological. Initially a layer of about 100 mm of absorbent organic materials such as dry earth is put in the bottom of one vault, which is then used for defecation. After each use, the feces are covered with wood ash or similar materials to deodorize the decomposing feces and soak up excess moisture. The addition of wood ash, sawdust grasses cuttings, vegetable wastes and other organ materials is very important to control moisture content and improve the quality of the final compost.

When the vault is ¾ full, the contents are leveled with a stick and the vault is completely filled with dry powdered earth. The squat hole is then sealed. While the contents of the first vault are decomposing anaerobically, the second vault is used.

7.1.2. The composting Sanitation System

Excreta and other organic wastes start to decompose immediately after discharge. In the process of decomposition the odorous condition start to be in odorous, inoffensive, and ultimately become a stable product. The main actions of decomposition are to break down the complex organic compounds, such as protein and urea, into simpler and more stable forms. Decomposition will reduce the volume and mass to up to 80% of the decomposing material. This is achieved by the production of such gases as methane; carbon dioxide, ammonia and nitrogen, which are, dissipated into the atmosphere and by the production soluble materials which leach away into the underlying soil. Pathogenic organisms are also destroyed, as they cannot survive the process of decomposition. Bacteria and other small organisms could also be attacked by the rich biological life of the decomposing mass.

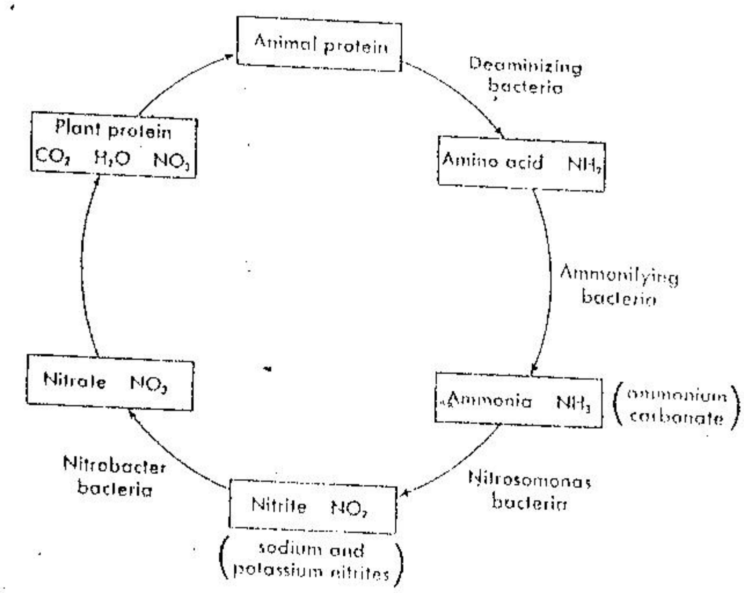


Fig.20: The Nitrogen Cycle

(Source: Ehlers and Steel, Municipal and Rural Sanitation, 1965)

The process of decomposition applies to all dead organic matter of vegetable or animal origin and particularly to their nitrogenous, sulfurous, or carbonaceous constituents (E, G, and Wagner.)

Composting is a biological process in which, under controlled conditions, bacteria, worms, and other types of organisms break down organic substance to make humus, rich, stable medium in which roots thrive. In a composting toilet human excreta, along with additional bulking agents such as vegetables scraps, straw, wood shaving (saw dust) are deposited into a processing chamber where soil based micro-organisms decompose the solids as is naturally accomplished. Temperature, airflow, and other factors such as moisture control promote optimal conditions for composting. The humus produced by this process is an excellent soil conditioner, free of disease producing pathogens.

The compost toilet appeared to meet all requirements. It could be installed inside homes; it would not pollute groundwater with urine and feces; it could be built above ground level, away from feet, flies, dogs or other animals.

A composting toilet will achieve optimal conditions for biological decomposition. This means that sufficient oxygen must be able to penetrate the compost heap to maintain aerobic conditions. The material in the composting vault should have a moisture content of 50-60 %, the carbon: nitrogen balance or ratio should be within the range of 15:1 to 30: 1 and the temperature of the composting vault should be above 15 °C.

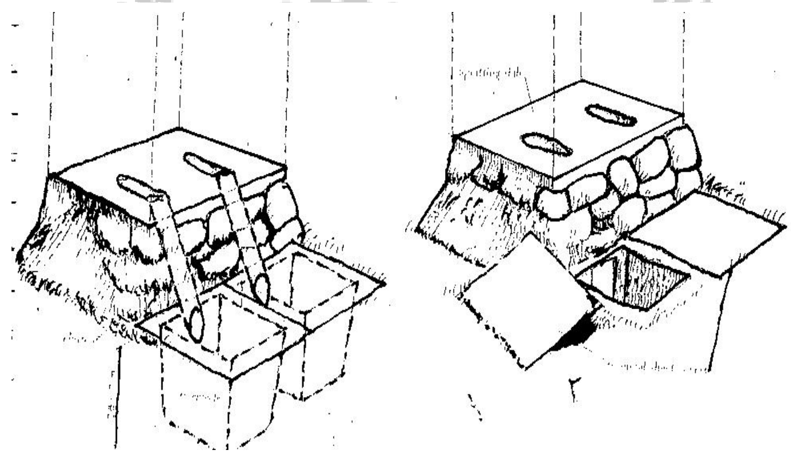


Fig. 21. Composting Toilets

(Source: Uno Winblad, Wen Kilman, Sanitation without Water, 1985)

Although composting system could often benefit from urine diversion, most examples of composting toilets collect urine and feces together. In this case the urine is used to maintain moisture content or other wise the urine would have been beneficial if used separately because the nutrient value of urine is lost in the compost. Compost, apart from pathogen destruction and rendering excreta to be beneficial in producing an excellent harmless soil conditioner it is not as good a fertilizer as urine is.

These kinds of composting toilets were introduced half a century ago in Sweden. A compost toilet such as has shown in the picture above combine urine, feces and other organic households residues. It consists of a composting vault with a slanting floor, air conduits and at the lower end a storage space. A tube connects the toilet seats-riser with the receptacle and there is often a special chute for kitchen refuse. In this type of toilet (Multrum) goes not only feces, toilet paper, and urine, but also all kinds of organic kitchen and household residues such as vegetable and meat scraps, peelings, eggshells, floor sweepings, grass clippings.

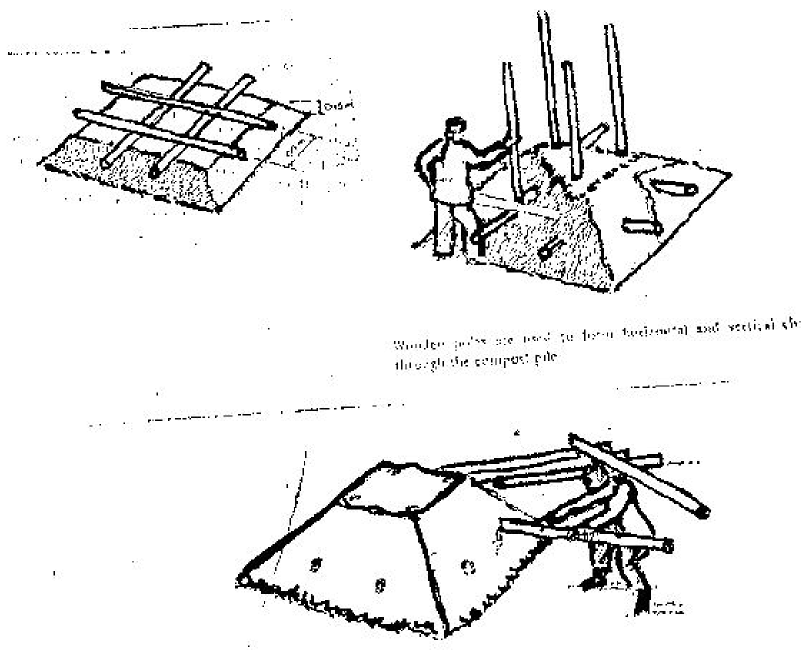


Fig. 22: Windrow Composting System

(Source: Uno Winblad, Wen Kilman, Sanitation without Water, 1985)

Because the floor of the multrum slopes, the contents are slowly sliding down from the fresh deposits at the upper end down to storage part of the vault. The process of decomposition reduces the heap to less than 10% of the original volume.

Composting could also be done outside the composting toilet. This can be achieved by mixing human waste, garbage and other organic waste in a windrow composting system. This system is the art of piling sorted waste matter in a row and covering it with soil and providing oxygen through holes made during piling the waste. The advantage of this system is that the temperature of the inside of the pile is raised to the extent that it kills all pathogens in the pile. (for more detail refer to the solid waste lecture note)

7.1.3. Ecological Sanitation

Basically, the dehydrating and composting toilets are ecological toilets in that the processes they use eliminate health hazards and convert the waste material into useful natural resources. Ecological sanitation may differ from the others only in that the single small chamber built above ground facilitate or give three options.

a. Keep urine and feces separate at all times
b. Mix them but drain the urine through the soil
c. Mix them and evaporate to dehydrate.

Therefore, the basic question in designing an ecological sanitation system is whether to divert urine or to receive combined urine and feces in a single vault. Ideally, an ecological sanitation system, like any other recycling systems will prevent pollution, sanitize excreted nutrients, and encourage the incorporation of other waste matters and composting for ultimate return of the processed waste back to the soil.

a. Urine Diversion

There are at least three good reasons for not mixing urine and feces:

a. It is easier to avoid excess humidity or wetness in the processing vault
b. The urine remains relatively free from pathogenic organisms
c. The uncontaminated urine is an excellent fertilizer.

The basic idea of separating urine is also simple: the defecating person should squat or sit where feces are deposited down and urine is sent to the front. Thus urine and feces is stored separately. The urine is led through a pipe from urine collector in to a special container and feces is then mixed with ash soil, leaves grass, saw dust or any other suitable biodegradable suitable material.

The feces may decompose in the vault but if not it can also be taken out and deposited in a hole dug under ground together with other organic matter and left for an indefinite period where total composting takes place. If vegetables are planted on the spot vigorous growth will take place. The separated urine will be used as fertilizer by container gardening or drip irrigation.

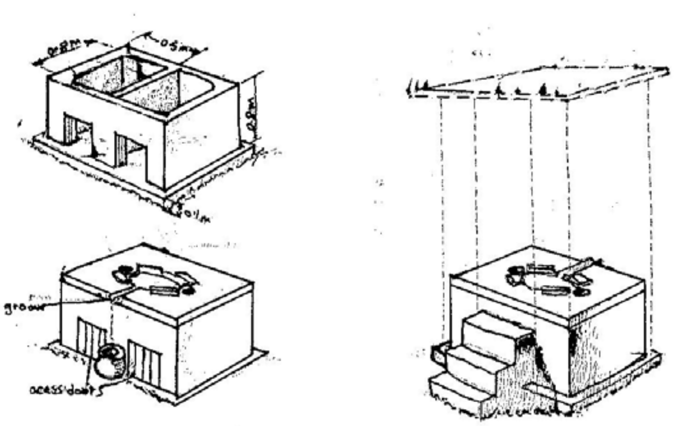


Fig. 23: Urine Diversion System

Source: Uno Winblad, Wen Kilman, Sanitation Without Water, 1985

b. Combined System

Under extremely dry climatic conditions or where large amount of absorbent materials are added it may be possible to process liquids and solids together. Also in this case urine, feces, and in some systems a small amount of water, go down the same hole.

Advantage of Ecological Systems

1. *Advantage to the Environment*

If ecological sanitation could be adopted on a large scale:

- It would protect our ground water, surface waters, from fecal contamination.
- Farmers would require less amount of expensive commercial fertilizers to improve their farm yield.
- Commercial fertilizer will not be washed down from the farm and enrich our water with nutrients.
- The 400-500 liters of urine produced from each person per year contains enough Plant nutrients to grow 250 kilogram of grain, enough to feed one person for one year (Gunder, 1998).

Urine is rich in nitrogen, phosphorus, and potassium. As much as 90 % of the fertilizer value of human excreta is in the urine. This important resource is much easier and safer to handle in the form of pure urine than it is in a mix of urine and feces. Human feces can be turned into a valuable soil conditioner, pathogens will be distracted as well as handling is easier, safer and less costly if the feces are not mixed with urine and water.

Table 4. Quantity and Nutritional Value of Feces and Urine

Parameters	***Feces***	***Urine***
Quantity (wet) per person per day	100-400g	1.0-1.3kg
Quantity (dry solids) per person per day	30-60gm	50-70gm
Moisture content	70-85%	93-96%
Approximate composition (% dry weight) organic matter	88-97%	68-85%
Nitrogen (N)	5-7gm	15-19gm
Phosphorus (as P205)	3.0-5.4 gm	2.5-5.0gm
Potassium (as K2O)	1.0-2.5 gm	3.0-4.5gm
Carbon	44-45gm	11-17gm

Calcium (as CaO)	4.5 gm	4.5-6.0 gm
C/N ratio	App. 6-10	1

Adopted from Feachem and Polprasert (1983)

Depending on diet, socioeconomic factors and waters availability the quantity and decomposition of human excreta, wastewater and solid waste is different from country to country. According to Feachem the quantity of feces produced per capita daily in some European and North American cities was 100 to 200 gram while that in developing countries was between 150 to 500 gram. Most adults produce 1 to 1.3 liters per day. The water content of fecal matter varies from 70 to 85 % with the fecal quantity generated.

According to "Agenda 21", the world leaders and scientists expressed the need to reduce ill health, increase awareness of people for their own environment and become conscious of the natural resources. The WHO expert committee on Environmental sanitation has taken note of the importance of taking care of all human excreta and refuse/garbage in a proper manner for reusing them as fertilizers/soil conditioners. The growing human population in the world and the finite natural resources dictate the recycling of natural resources. The interest for any one who is interested in eliminating or at least reduce to the minimum of all communicable disease, recover resources should aim at reducing the quantity of waste and rather use them as valuable resources.

2. Advantage to Households and Neighborhoods

If this system is properly managed and maintained it does not smell or produce flies and other insects and there is no fear of child falling into the pit. This is a great advantage over ordinary pit latrines, as it will eliminate these fears and fly problems.

3. Advantages to Municipalities

Municipalities are now faced with the problem of disludging pit latrine waste and dumping it at safe place. Since it is not also using scarce water resources for flushing waste the burden on water supply will be eliminated. Municipalities are also under increasing pressure to provide solid waste collection service for an entire urban community where adopting this system will decrease the pressure.

4. Pathogen Destruction

Stepwise Pathogen Destruction

Dry methods of processing feces are more effective at destroying pathogens than wet methods. The combination of low moisture, low amount of organic matter, and high pH make for the most rapid destruction.

Pathogen destruction is theoretically simple but in practice it often requires careful attention through a series of steps (Steven Esrey, 1998).

4.1 **Step one**: Keep the volume of dangerous material small by diverting the urine and not adding water in it

4.2 **Step two**: prevent the dispersal of material containing pathogens by storing it in some kind of secure device until safe for recycling.

4.3 **Step three**: Reduce the volume and weight of pathogenic material by dehydration and or decomposition to facilitate storage transports and further treatment.

How Pathogens Die

Thousands of pathogens or parasitic eggs, are excreted with feces each time an infected person relief himself. However, after they are excreted into the environment all pathogens eventually die or become incapable of causing disease. Two exceptions are salmonella and some other bacteria, which may temporarily increase in number. Some organisms remain alive and capable of causing disease longer than other organisms of the same type. The time it takes for all the organisms of the same type to die is referred as the **DIE-OFF-RATE.**

A number of environmental conditions will speed up or slow down the time it takes a pathogen to die, depending on the characteristic or level of the condition.

The environmental condition that will speed up the death of pathogens include:

1. Increase temperature to kill microorganisms
2. Decrease moisture to eliminate "
3. Decrease nutrients to eliminate "
4. Decrease the number of Microorganisms
5. Increase and concentrate sunlight
6. Increase pH to kill microorganisms

Each of the above environmental conditions has ranges that favor pathogen survival. As nature or man changes the conditions pathogen die-off- rates also changes.

Many researchers have stated that Ascariasis is one of those parasites that is common through out the world (up to 20% of the world population may be infected) and the most resistant to destruction among many. Therefore, if destruction of Ascariasis is achieved we can be sure that the method used will definitely kill other pathogens also (Robertson, 1992).

Table 5. Pathogen Survival time in Different Environmental Conditions

Survival time of pathogens in days by different disposal or treatment conditions				
Conditions	Bacteria	Viruses	Protozoa	Helminthes (Ascaris)
Soil	400	175	10	Many months
Crops	50	60	Not known	Not known
Night soil, feces, sludge 20-30 ^{o}c	90	100	0	Many months
Composting (anaerobic at ambient temperature)	60	60	30	Many months
Thermophilic composting (50-60^{o}c maintained for 7 days)	7	7	7	7
Waste stabilization ponds (retention time greater than 20 days)	20	20	20	20

Adapted from " Ecological Sanitation " ed. Uno Winblad

In general dehydrating, decomposing system especially with urine diversion are the visions in the future. If feces is combined with household refuse, garbage and other organic matter to be composted, and if urine is diverted and used with out contamination, it means that all waste matter than humans and animals produce will be put for useful purposes than to be cause of disease spread.

Construction Methods

Construction of an ecological system is very simple and safe.

1. Choose a site where there is no obstruction of the afternoon sun.
2. Since fly breeding and smell is not a problem in a properly operated toilet there is no much reason to put it very far away from the house.
3. Once site is selected flatten the ground 2meter by one with hoe or any other tool.
4. If you want or able to put cement floor then dig down about 10 cm. and fill it with small rocks or aggregate
5. If so mix sand cement and gravel (1:2:4) and spread it on the aggregate. You don't need to smoothen the surface.
6. If you can afford it you can use blocks, bricks or stone masonry to build the sides. You do not need walling at the back and front. If you cannot afford cement blocks or bricks you can use wood and mud walls.
7. Once the sidewalls are built up to 1.20 meters put slab on top of it. The slab should be constructed in such a way that the urine splashed on it will be splashed away to a container separate from the feces and into a container.
8. Extend the wall with wood if cement blocks are used or extend the wood itself if wood and mud walling is used. Build wooden wall in the front side also.
9. Inside the front wall passing through the door build two or three stairs to climb up to the toilet seat.

10. In the front is also the urine container placed at the side of the front wall.
11. The back part is covered with corrugated iron sheet, which is exposed to the sun.
12. Each time that the pile of feces and other garbage and refuse piles up one house hold member will push the feces and other wastes to the back of the toilet so that it will dry more.
13. In the process the feces have dried and decomposed at which time it will be possible to take it out to the garden and place it underground. If proper composting process is used as windraw method the humus material could be used directly on the crop (see composting above)

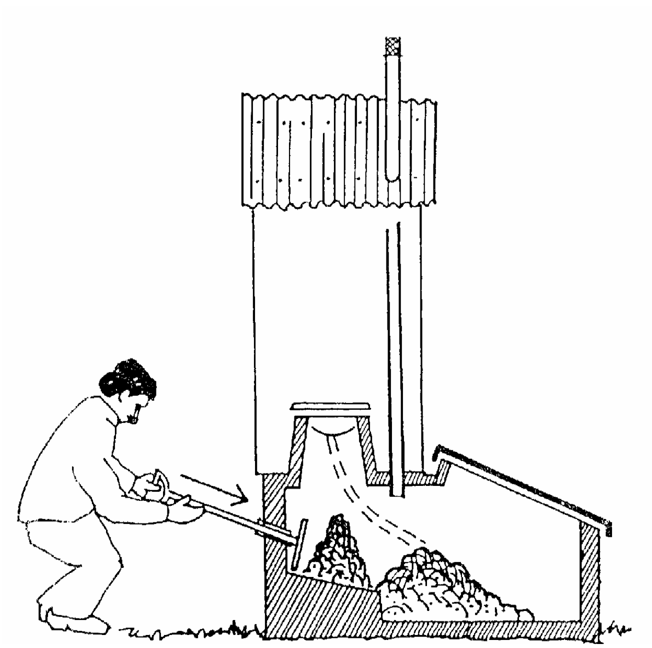


Fig. 24. Parts and Layouts for Ecological Sanitation

(Source: Uno Winblad, Wen Kilman, Sanitation without Water, 1985)

Note to the Teacher:

Composting, dehydrating or collectively called ecological toilets are not common in Ethiopia. Some ecological sanitation toilets with urine diversion techniques are available in Addis Ababa, Jimma and Harar towns. It may be possible to construct one for demonstration in your compound.

At any rate, at least the students should practice construction of such toilets and see for themselves how it works.
Composting is an aerobic process. It could be used to compost garbage and refuse. It can also be used together with feces and other vegetable matter. The principle should be installed into the head of the student if our objective of waste disposal is a " 0" option.

Along with the ecological sanitation (composting) toilet arrange plot of gardens where the student use the compost to grow some vegetables. They could also use the urine to irrigate vegetables either by diluting it 1:5 or directly under the soil and covering it to avoid evaporation and loss of the nutrient.

II Drop-and-flush Systems

1. Pour-flush Latrine

All flash latrines need to have a water seal to avoid smell and fly breeding. Therefore, pour flash latrines are also called water-seal latrines. This technology is also known as Flush-and Discharge. A person may defecate inside or near the house and pour an amount (usually one litter) of water to flush out the excreta away from the squatting area. This system requires a squatting arrangement, piping to take away the excreta to a sewer or septic tank. This has to accommodate to flush out 400-500 liters of urine and 50 liters of feces a person generates per year with 15, 000 liters of water. However the water to be used does not need to necessarily be clean water unless the system is connected to the running water.

Thus whenever we use the flush-and-discharge process the problem of liquid waste comes into our head. The human feces are a dangerous component in the sewage system. It contaminates not only the harmless urine but also the huge amount of pure water used for flushing the excreta.

The water seal toilets can be manufactured in an industry or casted by local people using cement and sand mixes. Ceramic industries produce a product that is expensive but well designed pedestal toilet complete with water seal and water cistern for flushing. The water cistern could be a pull-chain or a push button type.

The general method of manufacturing a pour-flash seat that could be casted in situ with a trap that assumes a P-shape or S-shape is as follows.

1. A form is prepared in the shape of the bowel and trap
2. The form is plastered with a mixture of cement and sand
3. The bowel is left to harden and cure at site of manufacture
4. The finished bowel is transported to the site of installation.

The pour-flush latrine is essentially an improved pit latrine and consists of a concrete floor slab with a squatting pan or seat. A water seal is fitted below the seat Water will wash away feces after use. The pour flush is fitted with a trap to provide water seal, which is important in preventing access to flies and mosquitoes. In addition it prevents odor and nuisance. Pour flash latrines are most appropriate for people who use water for anal cleansing and squat to defecate. Otherwise solid anal cleansing materials may have blockage problem. The excreta and urine that is flushed down may enter into possible two arrangements.

1. Directly into a leach pit (soak pit) constructed under the squatting plate or slab
2. Directly through a connecting pipe into an offset leaching pit (soak pit)

Application

This system can be used both in crowded urban and peri-urban areas provided that there is a nearby reliable water source. It is particularly useful wherever water is used for ablution. Since flushing is done using jogs or tin cans containers a flushing cistern like that of the water closet system may not be necessary. A flush toilet with direct discharge into a pit requires the least amount of water, usually 1.5 to 2 liters. Water requirement for an offset leaching pit may require a little more as the need to push the solid matter to a distance away from the seat depending upon the length and gradient of the connecting pipe but usually not more than three liters.
The latrine can be located inside the house as the water seal arrangement prevents smell and other nuisances.

Design and Construction

The location of the different types of pits is determined based on their functions. For example the direct leaching pit can not be located inside the house because, the pit must be closed off with earth when full and a new pit has to be dug just like any drop-and-store system. It should not also be located near the building as the leaching of water may damage the foundation of the house.

The offset systems can be located inside the house and connected to the leaching pit, which will be dug outside the house. The pit outside should be accessible for mechanical desludging. The cover should be strong enough to withstand any load.

Design is important for the leaching pits as much as for the main pour flush latrine. The leaching pits must be located in such a way, that contamination of water supply sources is avoided. The soil must be sufficiently permeable for the estimated quantity of effluent discharge into the pit to be able to leach away.

Leaching pit serve for storage and digestion of excreta and for infiltration of wastewater liquids. According to Mara (1985) the dimensions of the pits are dependent on the following external parameters.

1. The solid accumulation rate
2. The soil leaching capacity which is the amount of water that is capable of leaching into the soil over a given period of time (see percolation rate determination)
3. The hydraulic loading on the pit, which is the total volume of liquids entering the pit from all sources, expressed I liters per day.

Direct Leaching Pits

The pit must be sealed off when it is filled to within 0,5 meters of the top, which should be filled with earth. Like with the dry pits, the deeper the pit, the longer it lasts, but also the higher the excavation cost. Because the water seal pan is directly over the pit, the pit cover has to be strong and should not have to span more than 90 cm. for a rectangular pit or 1.2 meter for a circular pit.

Single Offset Leaching Pit

If mechanical desludging services are easily available and do not cost much, there is no need to have a deep pit. However, it will be better to dig a deep pit for all eventualities. Because in Ethiopia even if the service is theoretically available, the truck might broke and may take several months even years to continue the service.

Lining of Pits

For direct leaching pit the top part has to be lined for stability, but full linings is determined by the stability of the soil. The materials required or suitable for lining are the same for the traditional pit privy.

Single offset pits are designed for permanent service. Unless they are meant to be top off by earth when full just like the direct leaching system, these pits should be lined bottom up with adequate leaching space left on the wall.

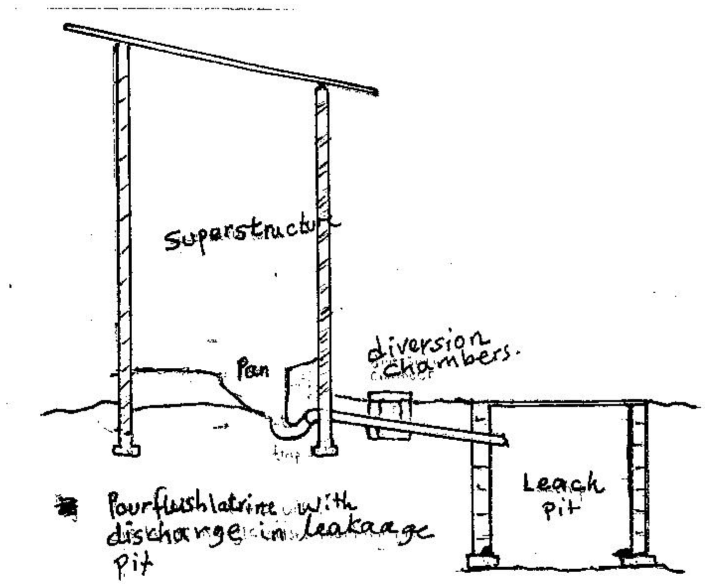


Fig. 25: Pour-FlushToilet with Leaching Pits Arrangements

(Source: Madleen Wegelin-Schuringen, IRC, 16)

Advantages of Pour Flush Latrine

- It can be installed inside homes
- It is inexpensive
- Need low volume of water for flushing
- It can be upgraded to connect to a sewer systems
- Need easy construction or maintenance
- There is potential for resource recovery
- Can act as wash water disposal facility

Disadvantage of Pour Flush Latrine

- They requires sullage disposal facility
- At least 4 Liters of water per day per person has to be available throughout the year
- Bulky anal cleansing materials are not used.
- The water seal units are frequently broken when rodding to clean blockages

- Cleaning involves removal of fresh night soil, which is serious contaminant.

1. Water Carriage System

The difference between Water Carriage System and the water flush is that the water carriage system is usually connected to a sewerage system. In order to carry the excreta to the sewers adequate water has to be used to flush it. For this reason the water carriage system as the name implies, is a system where the user is not concerned about the waste once it is flushed away to the sewers. However, many installations in Ethiopia depend on septic tank or cesspool as receiver of the wastewater. In this case, household has to think of the waste in the septic tank as the households for the pour flush latrines do for the leaching pits. Because:

1. It may fill up and require pumping,
2. The sludge has to be removed periodically,
3. Effluent from the septic tank may have to be treated or put in sub surface drain

In general, therefore pour flush toilets and water carriage system are the same as far as Ethiopia is concerned.

Technology Selection

All the technologies described above can be made to operate hygienically. Even a pit latrine, which is easy to construct, cheap, and appropriate to most local condition, could be made to give efficient service.

Technical feasibility or criteria for any excreta disposal system has the following important points to consider.

1. Cost and affordability
2. Water availability
3. Ground conditions
4. The risk of ground water contamination
5. Population density
6. Potential for future upgrading

In choosing the system it is important to involve the users in the decisions from the earliest possible stage and it is often helpful to build several pilot models for the demonstration purposes

Table 7. Choice of Sanitary System

Sanitation system	Suitable for rural areas	Population density where suitable	Construction cost	Operation cost	Ease of construction	Water requirement	Permeable soil required	Off-site facilities required
latrine	Yes	L	VL	L	very easy	None	Yes	None
P	Yes	L	L	L	Easy	None	yes	None
in pit	Yes	L/M	M	L	Need builder	None	Yes	None
mpost latrine	Yes	L/M	L	L	Easy	None	None	None
o san.	L	M	M	L	Easy	None	None	None
ur lush	Yes	L/M	L	L	Need builder	Water near by	Yes	None
ptic tank with ak way	Yes	L	H	H	Need builder	Multiple tap	yes	Sludge disposal
nall bore werage	No	H	H	M/H	Needs engineer	Yard tap	No	Sludge disposal, sewers treatment
wered pour sh	No	H	H	M/H	Need engineer	Yard Tap	No	Sludge disposal, sewers, treatment

apted from: Sandy Cairncross, Small Scale Sanitation, Ross Institute Bulletin, No 8. 1988

Key: H = High; L = Low; M = Medium;

Review Questions / Assignment

1. List at least four requirement that need to be satisfied before a sanitation technology is selected
2. Explain briefly the difference between Drop-and-store and Flush-and-discharge systems. Which ones are applicable for Ethiopia? Why?
3. If the number of users are 6, the solid accumulation rate is taken as 0.025 cubic meter per year, and the cross sectional area is 4 square meter and I want the pit to last me for 7 years what will be the depth of the pit after giving 0.5 meters allowance for back filling
4. Draw a pit latrine and shows where the mound, ventilation screen, storm water diversion ditch are located.
5. Why do you need to construct latrines raised from the ground? How do you construct it?
6. What are the difference between a multiple hole VIP and an alternate family VIP latrine?
7. How would you select or construct a VIP vent pipe? What materials are usually used for vent pipe? What maintenance requirement is there for vent pipe?
8. What is the advantage of vent pipes when installed in latrines?
9. What does ecological sanitation means? What is the difference between ecological sanitation system and double vault system? Which one do you prefer? Why?

CHAPTER FOUR

Individual Containment and Treatment Systems

Learning Objectives

At the end of this chapter the student will be able to:

1. Describe the difference between a cesspool and a septic tank
2. Describe the importance of ventilation arrangement in the design of septic tanks
3. Determine the capacity of a septic tank for a given population
4. Construct a grease tarp out of local materials
5. Define the difference and similarities of seepage pit and soak away pits
6. Determine the percolation rate of soil before constructing seepage or soak pits.

Introduction

One of the problems of urban and peri-urban towns in Ethiopia is the dumping of liquid wastes in streets, open spaces, directly to streams and rivers. In general liquid wastes from kitchen especially from big institutions, hotels, restaurants, and individual homes are dumped indiscriminately in areas where people walk, work, shop, or live.

Liquid wastes of this type may contain food wastes (scrap garbage), blood, tissue, and detergents. Due to this the waste matter discharged into the open may attract flies, rodents, and other animals such as dogs and cats. In addition, by virtue that such wastes are organic it putrefies or decomposes to cause odor.

The other serious problem concerning liquid effluents into the open is the overflowing cesspools and latrines from institutions, hotels and individual homes. It is a common site to see such wastes oozing down through residential areas and streets. The seriousness of the contamination due to this practice may be imagined.

The reason why such pollution occurs is basically lack of control and awareness creation by authorities in the sector. The other possibility is the fact that there are very limited services such as vacuum track and adoption of simple methods of disposing such wastes within the compound or jurisdiction of the violator.

This chapter will cover individual containment/ treatment systems and community wastewater treatment systems developed to solve the problem of such discharges. In Ethiopia, municipal or community treatment systems are not available and the portions will only high light the technology just for the sake of introducing the student to the science.

However, individual containment systems such as Septic tanks are most common. The sanitarian is expected to know about these systems because he will be called to design, supervise construction, and evaluate systems.

In the Ethiopian towns today you will see overflowing septic tanks and cesspools. One of the reasons for this is that the septic tanks are not evacuated in time or are not constructed to give longer life. Such effluent pollutes the soil and ultimately the water body. The effluent from the septic tank, by principle should be directed to a seepage/soak pit or into a subsurface drain field.

In this chapter these simple treatment systems, soak pit and grease traps technologies are included.

The teacher for this course should make sure that students see septic tank being constructed, overflowing tanks etc. The septic tanks in the institution can serve as a demonstration tank.

Types of Individual Containment & Treatment Systems

There are basically two types of individual waste containment and treatment systems available. These are:

1. Cesspool
2. Septic Tanks

1. Cesspool

A cesspool is a large diameter hole dug in the ground to receive waste matter from kitchen and toilets. In Ethiopia a cesspool is confused with septic tank. We see cesspools constructed in institution and individual homes with dry masonry and cover slab with no other effluent design like septic tanks.

Cesspools can be considered as an individual treatment system. In the cesspool untreated liquid waste from lavatories, kitchen, or WC are channeled with the ultimate objectives of getting the liquid part leached into the soil formation and the solid to be retained and digested anaerobically in the tank.

Construction Methods

The size is determined just like any other dry system. The methods we used for pit latrines could also apply for cesspool except that the water content of this type is greater than pit latrines. After determination of size and site the general construction methods is as follows.

1.1 Mark a rectangular or round shape on the ground. Size depends on requirements.

1.2 Dig down with smooth and vertical sides as much as possible.

1.3 Construct dry masonry wall having openings on the wall for letting liquid part to seep through the wall. If the hole dug is large construction of concrete columns may be necessary

1.4 Once the wall is finished arrange wood and lumber support to cast the slab.

Several wooden poles (number depends on the size and weight of the slab.) Are cut. The poles are arranged in the hole at standing position so that the lumbers are put on top of them to make the floor or the slab.

1.5 On the lumber surface 8 mm thick reinforcing iron bars are arranged at 20 cm. Distance length and cross wise. Each iron bar is tied with wire. While arranging the iron bar leave a space 50cm x 50 cm. in size for a manhole? So that a person can go inside to remove the poles and lumber after the concrete is Set.

1.6 Under the reinforcing bar put small stones to raise it a little from the floor.

1.7 Once that is secured concrete could be mixed and poured on the lumbers.

1.8 The thickness of the slab should not be more than 8 cm.

1.9 Once concrete is casted it has to be water morning and evening for at least 10 days.

1.10 After the concrete is set, dry and strong the wooden poles used for slab support and the lumbers can be removed from the bottom.

When the system fails to function (no seepage or percolation) because of clogging or over saturation the contents of the cesspool over flaw to the ground surface causing nuisance and health hazard.

It is very important to cover the cesspool manhole and provide a long vent. If that is not arranged smell may pass through the opening and cause nuisance. If vents are not arranged gas produced might explode.

2. Septic Tanks

Septic tank is a horizontal continuum flaw, one story sedimentation tank of masonry (cement plastered from inside), or concrete. Fiberglass or pre-cast ferro-cement tank is also manufactured for the purpose. It is designed to contain and treat all the sewage or wastewater generated in the household.

In the septic tank sewage and wastewater is allowed to flaw slowly to permit suspended matter settle at the bottom. The tank is designed in such a way that it will be able to hold or retain the waste until anaerobic decomposition is established. After anaerobic action and in the process some of the suspended organic matter is changed into liquid and gaseous substances. Such process and action will reduce the quantity of sludge to be disposed of.

Some important facts about Septic Tanks are summarized below.

a. The sludge in the septic tank is removed at comparatively longer intervals.
b. The detention period of 24 to 48 hours give best effluent after filtration
c. Septic tanks are usually built underground but a prefabricated tank could also be used above ground provided the elevation difference allows for gravity flaw of waste to and from the tank.
d. The anaerobic bacteria flourish in the absence of free oxygen and warmth, where these conditions are created in a septic tank.
e. Human excreta consists of 65% mineral matter which does not under go any chemical change in septic tank, and 35 % organic matter of which only 20 to 40% of organic matter (solids) are liquefied or gasified in the septic tank.
f. The heavier matter settles at the bottom and the lighter matter (grease and fat) which are called scum form a layer above the liquid level.
g. Septic tank installations are encouraged in the absence of municipal sewerage and treatment systems. But, this is subject to the economical standard of the people. Institutions such as schools, and health care facilities such as hospitals, health centers, etc. should be able to install the system.
h. Septic tank system should be designed in such a way that it contains and treats the generated waste of the household. If not effectively treated and contained it will over flaw to the ground surface causing nuisance and health problem.

1.1 Capacity of a Septic Tank

A septic tank should store the sewage flaw of 24 hours and an additional volume for sludge of two to three years depending on periodicity or pumping out the sludge.

If only WC is connected to the septic tank the sewage flow will be about 40 to 70 liters per capita per day. But, generally the flow of sewage depends on the number of people and how abundant water is available to the family. In addition it may also depends on the water-using behavior of the family.

When sullage is discharged to the septic tanks the sewage flow will be about 90 to 150 liters per capita per day. This also depends on the type of kitchen, whether internal plumbing is available in the kitchen or not and hygienic practices of the people working in the kitchen.

Where large quantity of sullage is expected it will be wise to separately dispose to a seepage or soak pit, just like we do for septic tank effluent than to add to the septic tank and increase the organic load.

The rate of accumulation of sludge has been recommended as 30 liters per capita per day. However, scum and sludge accumulation in the tank depends upon the characteristics of the sewage and the efficiency of sedimentation.

The minimum capacity of a septic tank depends on the amount of water supplied to the individual homes or the community. However the total tank volume should not be les than 1.5 cubic meter. The depth of liquid in the tank at start-up should not be less than 1.2 cubic meter.

Cleaning of sludge from a septic tank will be made easier if the floor of the tank slopes down towards the inlet (see drawing), thus causing most sludge to build up at one end of the tank.

Design of a Septic Tank

Total tank volume in cubic meter = 3 x waste flow (cubic meters per head per day) x population

Therefore: first compartment volume = 2 x waste flow x population

Second compartment volume= 1 x waste flow x population

Desludging should be carried out when the tank is approximately one third full of sludge. Sludge accumulation in hot areas such as Ethiopia may be estimated at 0.04 cubic meter per head per year.

Deludging can be calculated as 25x waste flow (cubic meter per head per day). For a waste flow of 0.1 cubic meter per head per day the intervals of desludging will be therefore, 25 x 0.1 years; which is every 2.5 years

The minimum capacity of a tank in western countries, which we can use as an example, is:

1. United kingdom 1365 liters per five people
2. USA 1900 liters per five people
3. India 2250 liters per 8-10 people.

1.2 Shape of Septic Tanks

Rectangular tanks are easy to construct and most suitable from the functional point of view. Circular tanks are also convenient as they offer less chances of creating stagnant pockets. However, circular tanks have the problem of short-circuiting, which may be avoided by proper designing of inlets and outlets.

Deeper tanks allow better settling but, if the depth is increased to accommodate a required treatment volume, the surface area is reduced. This will require higher vertical velocities of settling particles. More over such tanks may cause short-circuiting.

The minimum sewage depth should be 1.2 to 1.5 meters. Adequate space (30 cm) should be provided above the sewage level to accommodate the lighter part of sewage (scum) that is floating (see drawing)

Baffles should extend up to the top level of the scum but must stop a little above the bottom of the covering slab to allow for the free movement of gases (see drawing).

Higher velocities will cause greater disturbances. Thus the tanks should not be too long. Also if it is too wide, stagnant pockets are created near corners. A ratio of 1:3 to 2:3 between width and length of the tank is recommended. The width should not be less than 90 cm.

1.3 Inlets and Outlets

Inlets and outlets of the septic tank are the most important design features. They should be designed in such a way that they should not be located at sludge or scum level. Disturbing the sludge or the scum means letting unsettled or problematic wastewater to flow out to treatment of seepage pits. Inlets and outlets should not be also located at the same level to avoid short-circuiting.

The inlet should penetrate 30 cms. below the sewage level and the outlet should penetrate to about 40% of the depth of sewage. The baffles distribute the flow evenly along the width of the tank. They should be located 20 to 30 cms. away from the walls (Ehlers and Steel, 1965).

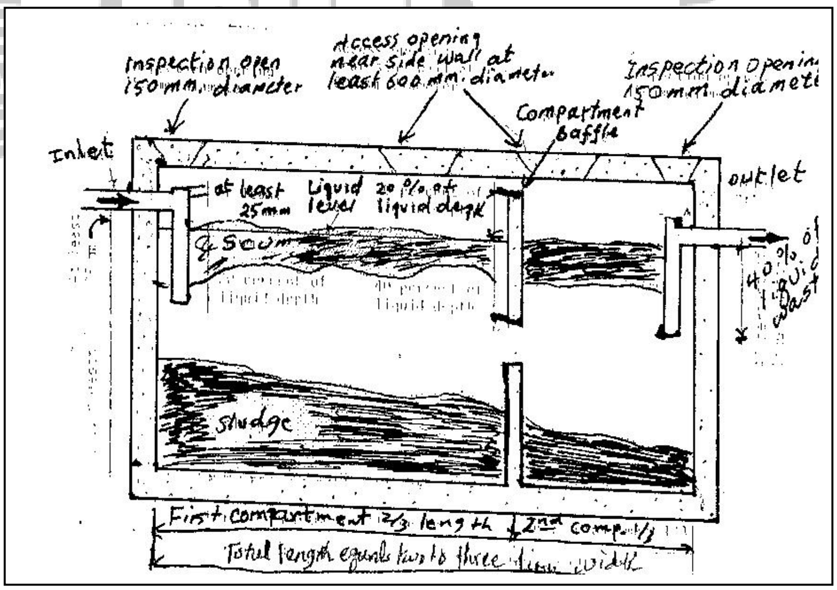


Fig. 26: Septic Tank System with Inlet and out let Arrangement

(Source: Ross Institute Bulletin No.8, 1988)

1.4 Covers and Manholes

For underground tanks, which are usually the case, the cover should be watertight. The manhole shaft should be constructed a little above ground level and fitted with watertight manhole covers. There should be one manhole for each compartment.

1.5 Ventilation

A 5 to 10 cms. diameter pipe may be provided on the wall of covering slab near the first compartment to the highest point so that it is not submerged into the scum or sludge. The vent pipe should be taken up above the roof level to avoid gas nuisance.

1.6 Cleaning of Septic Tanks

Septic tank may be cleaned by scavenger's manually or mechanically using vacuum track. When cleaned mechanically, it has to be mixed or liquefied with water so that the entire content could be removed. Care should be taken to prevent spillage to avoid consequent pollution of the surrounding environment or surface waters.

1.7 Disposing of Septic Tank Effluent

Septic tank by itself does not fulfil the objectives of complete treatment and disposal of sewage. It removes suspended solids from the sewage and liquefies major portion of solids and conditions the sewage for further disposal or infiltration. In this case, it is feared that the pathogenic bacteria pass through the tank out with the effluent unaffected. The effluent from a septic tank is highly septic and requires high percentage of oxygen to stabilize. The effluent from a septic tank should therefore, not be discharged directly into a stream or on to the land to avoid health hazard and nuisances. Usually, effluents pass to one of the following receiving treatment systems.

- Subsurface drain field
- Soak pits or seepage pits
- Land Treatment

- Dilution.

The subsurface drain field or tile field system as is some times called may be convenient for urban affluent areas and societies who can afford the space and money to construct the subsurface drain field. It requires extensive and accurate surveying work, proper design and geological survey before construction and vigilant follow-up and maintenance activities. Subsurface drain field is not a suitable technology for crowded urban communities and rural areas because basically, it requires large surface area.

Land treatment is also one method that requires a careful application and prior study on the consequences of the practice on the ground or surface water and on the crop itself. Contamination risks of the person (the farmer) or those who will be exposed to that environment must be considered.

3. Soak Pits

A soak pit in its simplest form is a hole dug in the ground filled with stones, broken bricks etc. (Soak) or lined with bricks or stone masonry (seepage), to receive any Grey water or liquid effluent from septic tanks, kitchen or lavatory. Its purpose is to assimilate the waste received into the underground system. The broken bricks or stones function in creating pockets or void space for the wastewater to trickle down the hole.

However, the space between the stones or bricks may be clogged with grease, or silt unless precautionary measures are taken. When such system is clogged it overflows to ultimately cause nuisance and disease hazard.

3.1 Construction Methods

a. The site selected should be convenient to work on. The soil should also be a type that has good percolation characteristics. The pit should be located away from water sources and waterlogged areas.

b. Dig the hole as large as necessary for the daily wastewater flow. For example according to Uno Winblad (1985) for a daily flow of not more than 200-300 liters the pit should be about one meter wide, one meter long, and 0.7 to 0.8 meters deep.

c. Once it is dug fill up 1/3 of the pit with big stones (size of a head) and continues to fill with smaller stones the size of a fist all the way up to about 30 cms from the top.

d. In order to safeguard the seepage/soak pit it is very important to exclude grease or silt from entering the pit. The remedy for this is to arrange for a grease and silt trap.

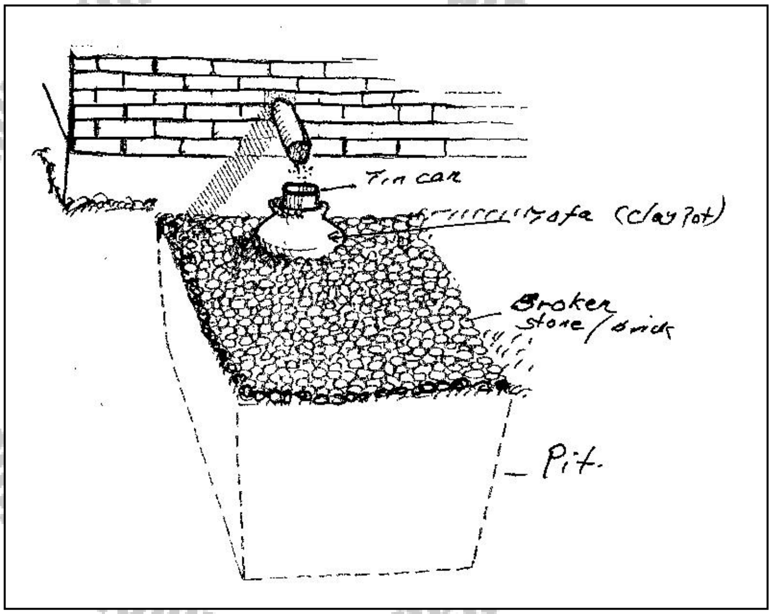


Fig. 27: Parts of a Soak Pit Showing Grease Traps

3.2 How to Make Grease or Silt Trap

1. Take an earthen ware (tofa) and make holes through the bottom
2. Take a tin can small enough to fit into the earthen pot (tofa) and make holes through the bottom
3. Place grass or any fibrous material into the pot and the tin can
4. Place the tin can on the mouth of the pot
5. Place the pot on top of the soak pit filter media

6. Fill the rest of the space left (30 cm) with gravel or any pebbles up to the tip of the pot
7. Cover the top most part with charcoal
8. Fill up the pit with earth and ram it to form mound so that water or rain falling on it will be diverted away from the pit.
9. Change the grass or fiber that is soaked with grease and silt as frequently as possible usually once every two weeks.

Soak pits used for receiving septic tank effluent may not need to have grease or silt trap. Effluent from septic tank is expected to be clear water.

4. Seepage Pits

Seepage pits may not be necessarily built in the same manner with soak pits. Seepage pit is not filled with rocks or bricks rather it is lined with open joints. In this system the liquid is assumed to infiltrate through the soil. Water pass outside of the pit through the open joints (see drawing)

4.1 Construction Methods

a. The site selected should be convenient to work on. The soil should also be a type that has good percolation characteristics. The pit should be located away from water sources and waterlogged areas.
b. Dig the pit taking the percolation rate as a base to determine the size of the pit
c. Use brick or stone masonry to construct the casing
d. The casing should have open joints so that the sewage water entering the pit will have access to infiltrate through the joints
e. Cover the pit with concrete slab or wood.

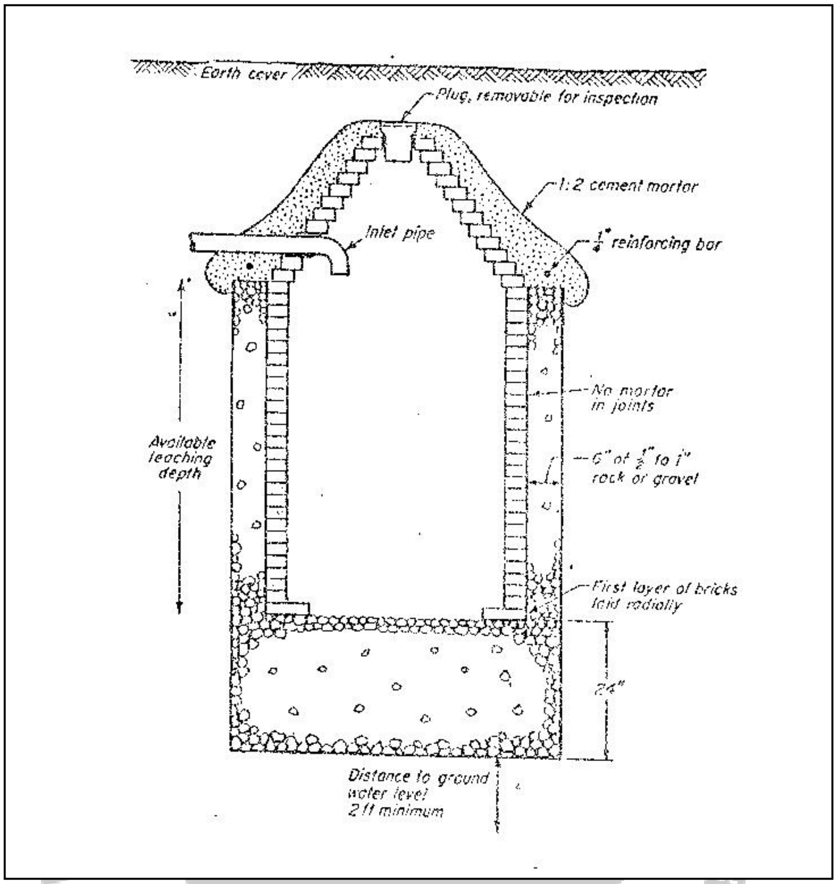


Fig. 28: Lay outs and Parts of Seepage Pits

(Source: Ehlers and Steel, Municipal and Rural Sanitation, 1965)

To use this system careful study should be conducted on the amount of waste to be disposed through this system and the characteristics of the receiving soil. The ability of the soil to absorb liquid is determined using a percolation rate test method.

4.2 Percolation Rate Test

A favorable soil is permeable and naturally well drained. Heavy clay soils will saturate very easily and will not let water pass through them after some use. Lime formation receiving sewage may endanger ground water formation basically because this type of soils are frequently fissured and permit unfiltered waste water to enter underground water sources.

According to Ehlers and Steel percolation test is done as follows.

1. A hole is dug or bored to a depth of the proposed trench or pit
2. The diameter could be 20 to 30 cm in size
3. After the hole is bored or dug the bottom and sides of the hole are scratched with a sharp instrument to provide a natural soil surface for the water to enter.
4. Remove all loose earth from the pit
5. Place about 2 cm thick of coarse sand or fine gravel in the bottom to protect clogging
6. Fill the hole with clear water to a depth of 30 cms. over the gravel or sand.
7. Water should remain in it for at least 4 hours preferably over night. This will allow saturation of the soil and the soil grains, which is the condition when the pit is operational.
8. If the water remains in the hole after the overnight period, the depth is adjusted to about 15 cms. and after 30 minutes the drop in water level is measured. This drop is used to calculate the percolation rate, which is the time; required for the water level to fall one cm. expressed in minutes. For example if the water drops 10 cm. after 30 minutes the percolation rate is 3 minutes per cm drop.
9. If no water remains overnight in the hole, clear water is added to bring the water level to 15 cms. over the gravel. The drop is measured at 30 minutes interval for 4 hours. The drop that occurs in the last 30 minutes is used to calculate the percolation rate.

1. Community Wastewater Treatment Systems

This section is meant to give the student a birds-eye-view on other methods of waste treatment. Community wastewater treatment system is a system where an organized community wide sewerage system is established to collect all water borne sewage or storm runoff to a designated area where treatment is effected before disposal. This system compared with the individual containment and treatment system is much expensive and demands qualified operators and vigilant surveillance on the performance of treatment and the quality of effluent and its effect on the receiving water or land.

Because it is expensive and the technology demands investment in foreign exchange money there has not been any installation of a conventional sewage treatment system in Ethiopia. The only sewerage and treatment available is the one in Kaliti, which is just a waste stabilization pond serving only less than 10 % of the population in Addis Ababa.

There are different methods of waste treatment. Basically each wastewater treatment problem is unique and the solution must be adapted to local resources in the supply of water, manpower and resources.

The conventional treatment of sewage is divided into two main stages

1. Preliminary or primary treatment
2. Secondary treatment

1. Primary Treatment

Primary treatment includes: -

1. Screening
2. Grit settling or removal
3. Plain sedimentation
4. Coagulation
5. Final sedimentation

2. Secondary Treatment

Secondary treatment includes: -

1. Dilution
2. Land irrigation
3. Trickling filter (first development)
4. Activated sludge treatment (second development)
5. Chlorination

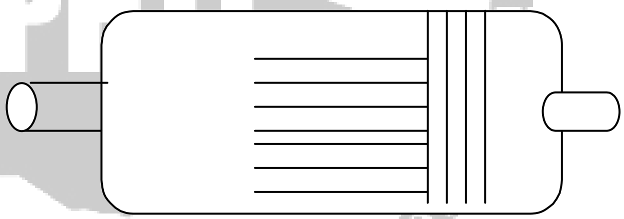
When treatment pass from preliminary treatment to the trickling filter to activated sludge and then chlorinate the final effluent it is said to be a complete treatment system. If wastewater effluent from final sedimentation is dumped directly into the receiving water for the purpose of dilution it is said that it is a partial treatment

Screening

A sewer system will deliver to a treatment plant virtually any material or object that can possibly enter the system. If heavy objects such as pieces of woods, glass, refuse and others reach the treatment plant or the pumps at the treatment plants they may interfere with the processing.

The purpose of screening is therefore, to remove floating solids and organic solids, which do not aerate and become septic. Screening is a primary treatment process, which is performed prior to any other treatment process.

Fig. 29 Bar screen



Screens are classified as “coarse or rack screens” which are made up of parallel bars 40-75 mm or 10 cm apart and fine screens made up of fine wire or perforated metal with opening of less one centimeter wide.

The fine screen are useful where a small portion of suspended solids is required to be separated before dilution, or other wise they are not frequently used owing to the fact that they clog easily and create nuisance condition. The coarse screens or racks with bars are fixed at 40^0 to 60^0 from the horizontal for an effective screening. The screens may be revolving drums or disc type. They remove suspended solids. Efficiency of removal is 10-20%. Their usefulness is:

- Replacement of primary sedimentation at least when it is not possible to have a proper sedimentation tank.
- Removal of small portion of Suspended Solids to render the sewage fit for disposal by dilution.
- Partial treatment of Industrial waste before they are discharged into municipal sewers.
- To reduce the load upon some existing plants

Screened Waste Disposal

Coarse screen removes only small amounts of screenings and has little relation with volume of sewage. The screenings from any screens (small, medium, and large) however, contain about 80% moisture and posses a density of about 1000 kg/m^3. Fine screens remove 0.06 - 0.15 m^3/million liters of sewage (Ehlers and Steel, 1965).

The disposal is effected by one of the following methods.

- They may be disintegrated into finer particles so as to pass through 5-10 mm slots to be eventually dumped into a water body or buried in trenches to be covered with dry earth.
- The screenings may be returned back into the sewage after maceration.
- The screenings may be burred in shallow trenches and covered with dry earth.
- The screening may be mixed with the house refuse and composted.
- Incineration may be adopted.

Skimming Tanks

This is employed if the sewage contains grease and fatty oils, which may form a scum in sedimentation tanks or clog the fine screens or filters in later stage and interfere with oxidation process in aeration tanks. These tanks are about 1 meter deep and have a reduced detention period from 5-15 minutes. Scum accumulation is removed by hand, later burned or burnt.

Grit Chamber

Grit in wastewater consists of the small course particles of sand, gravel, or other mineral mater generally washed in from streets or from the sewer system. The subsiding velocity is much greater than flocculated particles. If grits are not excluded they may injure pumps and other mechanical appliances and make the sludge digestion difficult.

Grit chamber is a small longitudinal detention chamber located before to the sedimentation tank. It has a slopping bottom whose capacity is kept as 1/200 or 1/300 of the daily flaw and the detention period is kept as 5-1.0 minute.

The quantity of grit is approximately 15-30 liters per million liters. The cleaning period is on an average every 12 weeks. Removal is effected from the bottom of the tank**.**

Grit is disposed to low lying areas such as depression. It may even be used for concrete work.

Sedimentation

There are two types of sedimentation

a. Plain sedimentation

b. Chemical precipitation

a. Plain Sedimentation

Plain sedimentation as its name implies is a system where wastewater is let to take its time to settle without any additional aid. The purpose of plain sedimentation is to remove suspended solids and thereby reducing the strength of sewage.

The sedimentation tanks are of three types VIZ.

- Primary sedimentation systems are those used for settlement of raw sewage located immediately after the grit chamber.
- Secondary systems are those used to settle waste from trickling filters or activated sludge plant.
- Intermediate systems are those which are located between filters in case of two stage of trickling filters

They are also classified according to flaw VIZ:

1. Vertical flaw tanks (not common)
2. Horizontal flaw tanks (most common)
3. Radial flaw tank

Sedimentation tanks are also sub-divided as:

1. **Plain single story tanks**. An example of this type is a septic tank in which the liquid and solid are in the same chamber.
2. **Double story tanks**. An example of this system is the Imhoff tank in which separate chambers are provided for liquid and solid.
3. **Mechanically cleaned tanks**. These are types that are designed for average flaw conditions. The area of tank is determined by the detention period. The depth is usually three meters.

b. Chemical Precipitation

When certain coagulating chemical are added to sewage it produce a precipitate known as floc which is insoluble or slightly soluble in water. The floc attracts small particles to form larger size particles. The chemical precipitation process involves two processes***.***

1. Chemical solution is readily mixed in sewage so that the solution disperses quickly with the entire sewage.
2. The flocculation processes is complied with reduction of speed and carried for longer period during which small particles come in contact with the chemical added

The chemicals, which are commonly used, are:

a.) Alum b.) Ferrous sulfate

c.) Ferric sulfate d.) Ferric chloride,

e.) Sodium aluminate f.) Sulfuric acid

g). Lime h.) Copperas.

These chemicals can be used alone or in combination with each other.

The dosage varies with:

- The characteristics of the sewage
- The strength of the sewage
- The degree of treatment required

Lime is frequently used for wastewater from breweries. It is added in dosage of 150 to 300 PPM. If dosage is recoverable about 60 to 90 % suspended matter, and 30 to 60 % BOD are removed. The solids in solution remain unaffected and can be removed by biological process. Most of the suspended matter is colloidal in nature and negatively charged.

The advantage of iron salt is that they provide a heavy precipitate and consequently removal is much more than in case of other salts. Also iron salts can be used over a wider range of pH levels.

The factors that affect the precipitation rate are:

1. Kind of Chemical
2. Quality of chemical
3. Character and concentration of sewage
4. PH level of sewage
5. Time of mixing and flocculation
6. Temperature
7. Violence of agitation

The advantages and disadvantages of chemical precipitation are as follows.

Advantage

1. More rapid and thorough clarification
2. Removal of higher percentage of suspended matter
3. Smaller size tanks are required
4. Simplicity of operation

Disadvantages

1. High cost of chemicals
2. Large quantity of sludge which offers difficulty of removal
3. The need of skilled labor (human power)
4. Generation of putricible effluent

Waste Stabilization Ponds

Waste stabilization ponds are also considered a community wastewater treatment system. As explained above the only community wastewater treatment system available in Addis Ababa id the waste stabilization pond available in Akaki. The treatment plant is serving about 10% of the population of Addis Ababa.

In this system Wastes are treated or STABILIZED by several natural processes acting at the same time.

1. Heavier solids settle to the bottom where bacteria decompose them.
2. The lighter suspended solids or bacteria in suspension break down materials.
3. Some wastewater is disposed of by evaporation from the pond surface.

Waste Stabilization Ponds are one of those natural systems that are used to treat wastes from different sources (industrial, commercial, domestic). Waste stabilization ponds use the natural sun energy, the wind velocity and the symbiotic action of bacteria, photosynthesis etc. that is a natural phenomena in the pond system that is exposed to the ambient environment. The actions that take place in a pond are shown in the following drawing.

In aerobic or anaerobic ponds organic matter contained in the wastewater is first converted to carbon dioxide and ammonia, and finally to algae in the presence of sunlight. By utilizing the sunlight through PHOTOSYNTHESIS, the algae use the carbon dioxide in the water to produce free oxygen making it available to the aerobic bacteria that inhabit the pond. Each pound of algae in a healthy pond is capable of producing 1.6 pounds of oxygen on a normal summer day. Algae themselves live on carbon dioxide and other nutrients in wastewater. At night when light is no longer available for photosynthesis algae use the oxygen by respiration and produce carbon dioxide.

The alternative use of oxygen and carbon dioxide can result in diurnal (daily) variation of pH and dissolved Oxygen. During the day algae use carbon dioxide, which raises the pH while during the night they produce carbon dioxide and the pH is lowered.

1. Dissolved nutrient materials such as nitrogen and phosphorus are utilized by green algae which are actually microscopic plants floating and living in the water.
2. The algae use carbon dioxide and bicarbonate to build body protoplasm. In so growing, they need nitrogen and phosphorus in their metabolism such as land plants do. They release oxygen and some carbon dioxide as waste products.

Extensive studies on the performance of ponds indicate that they can serve as very effective treatment facilities. In general waste stabilization ponds are the logical high-grade waste treatment recommendable to a country like Ethiopia. This is basically because:

They are inexpensive to construct

1. They are of simple design, with very little or no mechanical equipment necessary
2. The technology is what is termed as appropriate as it is less supervision, or highly trained technical human power for construction and maintenance.

3. They perform satisfactorily under the natural conditions of Ethiopia
    - Plenty of sunshine (over 8 hours a day)
    - Topography suitable for supplying cool and gentle breeze through out the day

Pond Classification and Application

Ponding of raw wastewater, as a complete treatment process is used to treat the wastes of single families as well as large cities. Ponds are quite commonly used in series (one pond following another) after a primary wastewater treatment plant to provide additional clarification and BOD removal. Ponds are also commonly used after trickling filter plant, thus giving a form of TERRITIARY treatment, known as polishing ponds. Ponds placed in series with each other can provide a high quality effluent that is acceptable for discharge into most water curses. If the detention time is long enough, many ponds meet fecal coliform standards.

Ponds can be designed with different depth, operating conditions, and loading. A line of distinction among different types of ponds is often impossible. Currently three broad classifications are cited in almost all literature dealing with wastewater treatment system. These classifications are:

1. Aerobic ponds
2. Anaerobic ponds
3. Facultative ponds

1. Aerobic

Aerobic ponds are characterized by having dissolved oxygen distributed through out their contents practically all of the time. They usually require additional source of oxygen to supplement the rather minimal amount that can be diffused from the atmosphere at the water surface. The additional source of oxygen may also be supplied by:

- Algae during daylight hours,
- Mechanical agitation of the surface, or
- By bubbling air provided by compression throughout the pond.

2. Anaerobic

As the name implies these ponds are usually without any dissolved oxygen throughout their entire depth. Treatment depends on fermentation of the sludge at the pond bottom. This process could be quite odorous under certain condition, but it is highly efficient in destroying organic wastes. Anaerobic ponds are mainly used for processing industrial wastes, although domestic wastes could also be treated using the system

3. Facultative

These are the most common types in current use throughout the world. The upper portion (Supernatant) of these ponds is aerobic, while the bottom layer is anaerobic. Algae supply most of the oxygen to the supernatant. Facultative ponds are most common because it is almost impossible to maintain completely aerobic and anaerobic conditions all the time at all depth of the pond.

Pond use may be classified according to detention time.

1. A pond with detention time of less than three days will perform in ways similar to a sedimentation or settling tank. Some growth of algae will occur in the pond, but it will not have a major effect on the treatment of the wastewater.
2. Prolific growth of algae will be observed in ponds with detention period of three to around twenty days, but large amounts of algae will be found in pond effluent. In some effluents, the stored organic material may be greater than the amount in the influent.

Longer detention period in ponds provides time for the sedimentation of algae. Usually this will occur in facultative ponds where anaerobic conditions are on the bottom and aerobic conditions are on the surface. Combined aerobic/ anaerobic treatment provided by long detention periods produces definite stabilization of the influent.

Notes to the Teacher:

It will be very essential for you to repeat discussion on some of the theories mentioned in the classroom using an actual demonstration. Some suggestions are listed below.

1. Take your students to the nearest health facility and locate the septic tank or a cesspool in the compound open it to show them how it is constructed. Ask your students to evaluate its performance. Refresh their memory if there are things missed by the students.
2. Send students in-groups to the town, preferably to different kebeles and ask them to list at least 10 pit latrines and evaluate them (site, use, maintenance and other parameters) and present it in class

Review Questions / Assignment

1. What have you understood about the construction of septic tanks?
2. Is there any difference in the construction of a septic tank and a cesspool?
3. How do you construct a grease trap out of local pots and straw?
4. Ecological sanitation is one new emerging technology for Ethiopia. What do you think is the most important advantage of the technology? Do you think it will work in Ethiopia? If not, why not?
5. What is the difference between compost latrine and ecological sanitation?
6. How do you construct a VIP latrine?
7. What are the criteria you have to follow before constructing any drop and store system?

8. Draw a pit latrine or a VIP latrine and label each important part and explain the functions of the parts.

9. In the community treatment system it was mentioned that screening can replace sedimentation. How could that be? Can you tell the difference between the two and agree or disagree on that assumption.

10. What natural phenomena are important for waste stabilization ponds to function effectively?

CHAPTER FIVE

Industrial Wastes

Learning Objectives

At the end of this chapter the student will be able to:

1. Identify sources and characteristics of industrial wastes.
2. Describe processes of waste from different industries common to Ethiopia.
3. Describe waste strength of selected industries
4. Explain the extent o f the waste problems in some selected industries
5. List the treatment systems available for different industrial wastes.
6. Classify liquid waste effluents into their categories.

Introduction

There are many industries in Ethiopia which are processing mostly agricultural products such as cotton, flour, hides and skins, oil processing, soap factories, etc. Others such as metal works have also different types of wastes. Almost all industries are located nearby residential areas and rivers. The fact that they are located near a water body had in the past helped them dump their waste directly into the water. This practice is now threatening the water and land resources of the country.

It is very important that these industries are regulated, inspected and compelled to have some sort of waste treatment plant before they dump their waste into the water or land.

This chapter will highlight the problems and needs for treatment of industrial waste. The instructor of this course is encouraged to take his students to a processing factory or industry you may find near the teaching institutions so that the student will have first hand information.

Industrial Wastes

It is important to treat industrial waste as each type of industry imparts different kind of wastes. Industrial waste effluent may be classified into three main categories.

1. Those containing solid waste matter in suspension but no polluting matter in solution
   - Clay product manufacturers
   - Food industry
2. Those containing solid matter in suspension and polluting matter in solution
   - Distillery waste,
   - Tannery waste
3. Those containing pollutant matter in solution
   - Electroplating industry

The polluting substances may also be classified into three groups.

1. Those which are themselves toxic such as chromium, phenol, cyanide
2. Those which are more noxious after their chemical or biological decomposition, such as vegetable matter
3. Those, which are entirely mineral and not toxic directly.

1. Wastes from Food Industries

Food industries are involved with the total environment starting from the farm to the consumers. Food industry demands a water supply that is clean and to the standard.

It is necessary to study, evaluate and know the effect of the entire environment. Food industry for Ethiopia is a priority and therefore it is a concern for the Environmental Health Officer the present government policy is agricultural led industry (ALID). The Ethiopian economy is also based on agriculture.

Sources and Characteristics

Food Industries generally produce effluent, which is extremely high in soluble organic matter. Even a small seasonal plant will produce waste with a population equivalent of 15,000 to 25,000 people.

Most of the waste effluent from food processing plants is not a health hazard from the standpoint of disease or toxicity in the receiving stream. The water in most cases is treatable with biological means. In fact, a food processing waste discharged to a large enough river that ensure dilution, would provide nutrients and food for the multitude of biological life in water including fishes. However, any organic waste will eventually create nuisance and enrichment of the receiving water with abundant nutrient. It is therefore necessary that the waste be monitored and treated as much as possible.

Some of the food industries that are common in Ethiopia which are mostly located near by a river:

1. Canning Industry
2. Meat packing Industry
3. Dairy
4. Coffee processing
5. Flour mills

1.1 Canning Wastes

The average amount of clean water required to pack may differ from type to type of cannery but on the average it will take 50 gallons to produce 12 cans of tomato paste.

Canning Industries that process tomato paste or other food packers like MERTI in Awash are faced with two types of wastes- solid and liquid. As an example tomato solid waste may reach 15-30% of the total quantity of product processed.

The waste water from cannery will have an appreciable amount of solids primarily because of the washing of food products, the cleaning of equipment, the hydraulic conveyance of the product itself, spillage of food and ingredients, and from washing of floors and other areas in the plant.

1.2 Meat Packing

The meat industry is concerned with the total environment. There is a major concern about waste from the feedlot, the stockyard, the slaughterhouse, and the packinghouse.

The wastes are largely organic, putrescence and malodorous which non can be charged to a stream as it will cause rapid depletion of the dissolved oxygen

The meat industry utilizes thousands of liters of water per day depending with the size and the number of animals processed. In addition the blood, which has high BOD content, should be separated and may be recycled.

1.3 Dairy Waste

Waste from dairies is from receiving stations, bottling plants, creameries, ice cream plants, cheese plants, dried milk product plants.

Wastewaters from milk plants could be included in municipal systems or treat in the plant setting with any biological means. BOD contribution from milk plant wastes is:

- Cheese making
- Floor waste
- Spray process
- Cooling and bottling.

2. Wastes from Textile Mills

Textiles have their origin in wool, cotton or synthetic fibers or combinations of all or some.

The process consist of:

- Remove natural impurities (cotton dust, wool dust)
- Impart particular qualities of sight, touch, and durability.

1.1 Cotton

Cotton processing consists of two basic steps:

1. Weaving
2. Finishing

- Weaving is a dry processing operation where trash and foreign matter are manually or mechanically removed (opening, cleaning, picking, combing)
- The fibers are joined, straightened, drawn into thread and wound on spools (drawing, roving, spinning, winding)
- The thread is run through starch solution
- The strengthened thread is woven into cloth (greinge goods)

Pollutant problem from such processing is dust and a minimum amount of liquid waste.

The finishing mill receives the grienge well (woven garment) and processes them. The processing is totally wet type wherein:

1. Natural (wax, protein, alcohol) and acquired (un-removed size agent, dirt, oil, grease) impurities must be initially removed to make the cloth suitable for chemical processing.
2. Wet chemicals processing is performed to impart to the cloth the desired properties and appearance.
3. This process is a major source of liquid waste, natural impurities and process chemicals.

Finishing operation incorporates the following:

1. Singeing: burning loose fibers in an open gas flame at a high rate of speed (27 meter per minute)
2. Desizing: solubilizing the starch, which was applied earlier in the mills by enzymatic solution. (1 % commercial enzyme plus salt penetrant) or acid (0.5 % sulfuric acid). In this process the starch is hydrolyzed and liquor. Fresh water rising of the grienge product complete the desize operation.

3. Kiering: Cooking the griege goods with hot alkaline detergent or soap solution to remove cotton wax, dirt and grease in order to develop a white absorbent fiber that is essentially pure cellulose.

The chemicals used to prepare kier liquor are:

- Sodium hydroxide 1-8 %
- Sodium carbonate 1-3%
- Sodium silicate ¼ to 1 %
- Pine oil soap- removes natural wax
- Fatty alcohol sulfate-provide melting action

2.2 Bleaching

Bleaching is done with chlorine hypochlorite or peroxide to remove natural coloring. The cloth is first rinsed with water and rinsed again using sodium bisulfate and weak solution of sulfuric acid; followed by another water rinse and finally the cloth pass through a hypochlorite solution.

2.3 Mercerizing

Swelling of the cotton fiber add luster, and increase dye affinity. Chemical used is caustic soda solution

Other processes such as dyeing and printing also contribute waste matters.

Table 8. **Pollutant types from Cotton Processing Wastes**

Process	**Wastes PPM**		**Gallon wastes per 1000 lb. Goods**
	PH	BOD	
Slashing	7 to 9.5	620-2500	60 - 740
Desizing		1700-5200	300-1100
Bleaching	8.5-9.6	90-1700	700-14900
Mercerizing	5.5-9.5	45-65	27900-35950
	Kiering 10-13	680-2900	310-1700

(Source: Masselli and Burford, A simplification of Textile Wastes Survey and Treatment)

Pollutant Sources in cotton mills

- Desizing----------------glucose from starch________________5 %
- Scouring------------------natural wax, pectin, alcohol
- (80%) reentrant (20%)________________________31%
- Bleaching------------reentrant ___________________ 3%
- Mercerizing----------Penetrant___________________4%
- Coloring---------Sodium sulfide, sulfite, Acetic acid___17%

  Total______________________________________

  60_to_100%

3. Tannery Waste

Ethiopia has the largest livestock population in Africa with 27 million heads of cattle, 24 million sheep, and 17 million goats. The animal resource has encouraged the establishment of tannery industries in Ethiopia. At present there are 15 tanneries in Ethiopia where most are privately owned.

Since almost all of them have no satisfactory treatment process, the environment is under extreme pressure from solid and liquid wastes of leather manufacturing and this has created significant pollution problem especially to Awash River and its tributaries where the majority is built.

The current production capacity based on the 15 tanneries is estimated at 6,000,000 to 8,000,000 kilograms of hides and 20,000,000 to 25,000,000 skins. The hides are processed up to wet blues, crushed and finished leather. The wet blues are considered unfinished and they will be exported as such. The low qualities are consumed in the country.

The sources of the waste matter are from the following.

1. From the preparation of the hide and skins in the beam house.
2. The actual tanning to make leather in the tanyard

3. Finishing the leather in the post-tanning area.

The beam house is the area where soaking of hides and skins is performed to remove salt, hair, fat where COD, and BOD are washed out. After the external contaminant are removed the softened hides will be ready for unhairing process where at this stage a significant proportion of organic pollution is derived from the degraded keratin comprising the hair and epidermis.

The fleshing of hides and skins process further removes fat and other connective tissues attached. Following this de-liming or removing lime, which was used in the other processes, is removed, as it is no longer needed at this stage. Deliming using ammonium salts carries out reduction in the pH.

After these processes the following pollutants are discharged from the tannery.

1. Lime
2. SS
3. COD
4. BOD
5. Salt
6. Sulfide
7. Fleshing
8. Trimmings
9. Ammonium salt solution
10. Ammonium gas

One ton of salted rawhide will produce with the effluent:

- 50 cubic meter of liquid effluent
- 175 kg of COD
- 60 kg BOD
- 125 kg. of SS
- 6 kg of chromium
- 510 kg. of solids (trimmings, flesh)

After all these pollutants production the yield produced from one ton of hide is only 200 kg. of leather.

The effluent from these 15 tanneries containing hazardous chemicals of chrome, sulfides, minerals, and organic acids etc. are directly discharged to the nearby rivers without adequate treatment. The wastes are hazardous and considerably higher compared to the other main waste generating industries in the country namely textiles, beverages, and sugar industries.

The annual volume of liquid waste generated from these 15 tanneries based on their annual production of processed leather is between 2,000,000 to 2,500,000 cubic meter of waste. Environmental studies on tannery wastes revealed that 75 % of the offered chrome is taken up in leather, and 25 % in the effluent. Also 7 % of the offered sulfides end up in effluent and 30% of the uptakes chrome also goes out with split and other solid wastes.

Treatment of Tannery Wastes

A researcher had recently made it known to the scientific community that tannery wastes can be treated using waste stabilization ponds principles. Advanced Integrated Wastewater Ponding system as the new system is called is an improved wastewater ponding system consisting of four ponds arranged in series. The term integrated is used because the system involves a number of well-known unit processes brought together in optimal sequence. The term ponding is used because the units are mainly earthwork reservoirs of various configurations. The term system is used because the elements are organized systematically to perform various degrees of treatment.

In a pilot experiment plant the following has been achieved.

1. Solids Removal

An overall suspended and volatile solids removal of 92 % was achieved in the system. Much of these solids were removed in the horizontal settling basin within one day detention time indicating the high settling characteristics of the raw combined effluent.

2. Bod Removal

BOD, which is a measure of oxygen demand in a microbiological bio-degradation of organic wastes, was one of the pollutants. BOD removal efficiency of the system was 98 % at normal operating condition with influent BOD of 2225 mg/l. reduced to less than 55mg/l.

3. Cod Removal

The removal of COD at normal loading rate was 97%. At over loading condition the performance remained at 86 %. As with BOD, the highest COD removal efficiency of 85 % took place in the primary facultative pond.

Other parameters such as Nitrogen removal (85%), chromium removal (86-99%), sulfate removal (79%), Phosphorus removal (72 %) and Chloride removal (20-40%) were achieved.

In general, waste stabilization pond in the advanced form designed and piloted by the researcher could be used for tannery waste treatment. It must be understood however, that chrome and other chemicals could be separately treated using other means.

CHAPTER SIX

Operation and Maintenance for Different Sanitation Installations

Learning Objectives

At the end of this chapter the student will be able to:

1. Explain the need for operation and maintenance of systems of each sanitation technologies
2. Describe the general principles of operation and maintenance.

Introduction

Despite the efforts made by government, non-government, and bilateral and multilateral organizations during the International Drinking Water and sanitation decade, the percentage of rural or urban population in Ethiopia with adequate sanitation facilities has never shown any growth from what it was before the beginning of the decade.

Sanitation development has to be accelerated and improved from year to year so that the health of the people will also improve. It has become clear; here in Ethiopia and else where in other developing countries that high coverage level for sanitation facilities does not guarantee their proper use and maintenance.

One of the problems with sanitation is that it is rarely a strongly felt need, especially in rural areas of Ethiopia. Few people realize that many diseases are caused by poor sanitation, and therefore good sanitation should be promoted for health reasons. However, the health of the people will never be improved unless they use properly a properly constructed latrine, and maintain it when ever necessary. Quite often, facilities are left unused soon after installation, or they are not repaired when maintenance is needed, or they are filthy because of lack of proper housekeeping.

Generally operation and maintenance for sanitary facilities include:

1. Consult individuals and communities about their needs and priorities and involve them in planning the facilities.
2. Once the latrine is constructed every one in the family has to use it properly. Proper use means that it is always used, always cleaned
3. Maintenance of the latrine should be a continuous process. In this, the vent pipe, runoff diversion ditch, doors and the superstructure should be maintained.
4. Always check for signs and conditions of fly breeding
5. There should be a hand washing arrangement outside the latrine
6. Sludge has to be removed before it cause treatment problem
7. Scum from septic tank has to be removed and disposed properly
8. Effluent from septic tank has to be treated and disposed properly
9. Odor, fly nuisance and other aesthetic problems have to be checked and corrected.

However, there are different operational and maintenance problems for each type of installation as will be explained.

1. Pit Latrine and Vip Latrine

Operation and maintenance requirements are the same for all types of drop-and-store or dry latrines. Some of the typical arrangement includes:

a. A suitable brush is needed inside the latrine superstructure for cleaning the slab
b. The latrine slab or seat has to be cleaned regularly with a little water to remove any excreta or urine
c. There should be a container with ashes, soil, or saw dust to sprinkle over the excreta in order to reduce odor and insect breeding
d. Proper anal cleaning material should be placed inside the latrine.
e. Replace tight fitting lid over the latrine hole after each use.(not applicable for VIP)

f. Check the slab for cracks
g. Check the superstructure for structural damage
h. Check level of excreta in the pit to be ready digs another one before it is completely fool.
i. Prohibit the adding of bottles, stones and other non-biodegradable materials into the pit or else the life of the pit will be reduced.
j. Periodic checking of the fly screen and vent pipe to ensure that they are not corroded or damaged.
k. When using an alternate VIP latrine the one filled must be sealed completely until the content is decomposed and ready to be used for soil conditioner.

2. Pour Flush System

For the wet system or the pour-flush system the following operation and maintenance points should be followed.

a. Near or preferably inside every latrine, a suitable latrine container full of water should be placed.
b. A smaller container that can hold less than a litter must be placed to take out water from the larger container for ablution and to pour water and flush the excreta.
c. A brush should be kept inside the latrine superstructure to clean the squat pan or slab
d. A bendable brush or material should also be provided to clean the U or S-trap in case of blockage.
e. Sullage from laundry, bathing or kitchen should not be disposed into the latrine unless it has been designed to receive such wastewater.
f. No solid waste such as rags, stone should be put into the squatting pan as this may block the water seal or the connecting pipe to the pit.

g. If the pit is not designed to be emptied when full, it has to be sealed off when sign of no flushing is observed during use. But, check if it is not blockage by solid matte.
h. Make sure that the immediate environment or people are not contaminated during emptying the pit content mechanically or manually.

3. Septic Tanks

Septic tanks operation and maintenance are usually periodic than routine. A septic tank constructed properly should not cause operational problem as frequently as smaller on site systems do. The septic tank is designed and constructed to receive sewage from lavatories, kitchen and toilets. If no other waste such as solid waste matter or other non-biodegradable are added to it Septic tanks will not cause any operational problem. Some of the operation and maintenance problems are the following.

a. Periodically remove scum
b. Check the vent screen, replace if torn
c. Measure the depth of sludge accumulation so that removal will be effected in time
d. Check effluents quality and efficiency of treatment facilities (drain field, seepage/soak, pits, chlorination)
e. Make sure that heavy and non-biodegradable waste matters are not channeled to the septic tank.
f. Always maintain cracks, and other small things on the septic tanks.

4. Cesspool

Operation and maintenance for cesspool is the same as septic tanks except that there is no effluent from cesspool. The liquid part in the wastewater that enters in the cesspool is percolated through the soil and in the septic tank it comes out as supernatant through the effluent pipe. In this case it may be necessary to pump out sludge from the cesspool incase infiltration is disrupted and it start to fill up.

5. Ecological Sanitation

Operation and maintenance problem for ecological sanitation is very routine as compared with other systems.

5.1 Urine separation or keeping the vault as dry as possible is an essential follow up.

5.2 The urine should be used wisely every day. Putting it underground and covering it with soil or diluting it with five parts of water and using it in the garden is another routine activity of the family using ecological sanitation.

5.3 Adding refuse, ash, vegetables or garbage scraps is also maintained every day.

5.4 Turning or pushing piles of compostable waste mater within the vault, maintaining moisture is an every day activity.

5.5 Covering feces with ash after each use and especially after children use it is a very important activity to follow.

6. Waste Stabilization Ponds

Because ponds are simple in construction and operation they are probably neglected more than any other system. Many of the problems that arise regarding ponds are the result of neglect or poor maintenance and keeping. Following are the day to day operational and maintenance duties that will help to ensure peak treatment efficiency.

1. Scum Control

Scum accumulation is a common characteristic of ponds and is usually greatest in the hotter climate and in springs where the water warms and vigorous biological activity is at its peak. Ordinarily wind action also dissipates scum accumulations and causes them to settle; however, in the absence of wind or in sheltered areas other means of removing scum must be used.

2. Odor Control

Odorous condition in almost all cases arises from a wastewater treatment plant no matter what kind of process is used. Most odors are caused by over-loading or poor cleaning and tending practices and can be remedied by taking corrective methods. If a pond is overloaded, stop loading and divert influent to other ponds.

3. Weed and Insect Control

Weed control is an essential part of good housekeeping and is not formidable task with modern herbicides available. Weeds around the edge are most objectionable because they allow a sheltered area for mosquito breeding and scum accumulation. Weed also hinders pond circulation. Some weeds that grow deeper than 90 centimeter will cause problem

4. Levee Maintenance

Levee slope erosion caused by wave action or surface runoff from precipitation is probably the most serious maintenance problem. If allowed to continue it will result in a narrowing of the levee crown that will make accessibility with maintenance equipment most difficult?

If levee slope is composed of easily erodable material, one long-range solution is the use of bank protection such as stone riprap.

5. Headwork and Screenings

The head works or the screenings (bar screen) at the inlet should be clean as frequently as possible. The screen should be inspected at least once or twice a day with more frequent visits during storm periods.

Trouble Shooting

1. In Facultative Ponds

1.1 I*ndicators: Obnoxious Odor From Lagoon Content*

Likely Cause

- Depleted oxygen
- Organic overload
- Toxic waste
- Long period of cloudy weather

Action to Take

- Use parallel flow to primary cells if two or more are available. Apply sodium nitrate for temporary relief. Provide mechanical aeration if available.
- Control organic loading as far as practical.
- Eliminate toxic waste at its source or pre-treat by neutralization and/or dilution.

1.2 Indicators: Foul Odors, Floating Mats of Wastewater Solids Including Dead Algae.

Likely Cause

- Decaying organic matter

Action to Take

- Break up mats with high-pressure water hose or by use of a motorboat, Algae bloom can be prevented by using an approved algaecide. Cooper sulfate is an effective algaecide.

1.3 Indicators: Loss of Algae

- Pond contents clear instead of pale green
- Absence of DO in the pond

Likely Cause

- Daphnia infestation

Action to Take

- Consult pest control specialists or biologists. If the pond operation is not too seriously affected, let the daphnia complete their life cycle about 10 to 15 days. They will usually eat all the algae in the pond then die of starvation

1.4 Indicators: Large Amount of Suspended Solids Including Algae in the Effluent

Likely Cause

- Discharge structure not properly baffled
- Multiple cells not being operated in series.

Action to Take

- The ponds discharge structure should consist of a baffle-inverted weir installed so that all the wastewater must pass under it.

1.5 Indicators: Decreasing ph; Reduction in Amount of Green Algae Resulting in Lower Do content

Likely Cause

- Organic overloading
- Acid compounds being discharged to the sewer system
- Long period of long cloudy weather
- Presence of higher animals such as daphnia feeding on the algae.

Action to Take

- By pass the affected cells if design permits.
- Check for organic overload
- Re-circulate pond effluent to affected cell
- Inspect for toxic substances
- Use mechanical aeration if available.
- Stop discharge until favorable weather has restored**.**

1.6 Indicators: Mosquito and Midges at Ponds

Likely Cause

Sheltered or protected breeding areas

Action to Take

- Eliminate breeding site
- Kill mosquitoes using insecticide and larvicide

CHAPTER SEVEN

Planning and Programming for Human Waste Management

Introduction

An excreta disposal program is not the only public health program necessary to improve the health of the population in Ethiopia. Even if a sanitation program was successful to get the whole village dig latrines there may not be a considerable reduction in morbidity and mortality rate in that population. The reasons are:

1. The type of the water supply
2. The environmental sanitation condition of the housing and living environment
3. The nutritional status of the population
4. The behaviors and practices of hygiene of each family member in the community
5. Health awareness level of all people in the community
6. Culture or tradition of the local population

These and other factors determine the health of the population. In order to have a holistic approach for public health improvement sanitation programs should be planned together with other activities.

The beginning of any health program is of course, to find which health problem is felt most by the community. Although we know that sanitation service in Ethiopia is deplorable it may not be the case with the people. Inorder to reach to that stage there might be other programs we want to accomplish first or together with sanitation program.

For Ethiopia starting a sanitation program should not be left to individuals alone. Governments (Local, federal) and NGOs should have a workable plan. To have coverage as well as reap benefits social marketing, hygiene/health education must be undertaken.

Essential Elements

Through out Ethiopia whether urban or rural, the disposal or management of human waste should constitute an important part for a sustainable sanitation development. Once a decision has been made for such a national undertaking, decision has to be reached when, how and who can start the program. E.G. Wagner and J.N.lanoix (1965) have suggested the following elements

1. Preparation of the Necessary Staff

Technically trained and untrained staff whose main function would be to work with other sectors and health personnel who will be responsible to study the status of sanitation of the communities. Such a study (preferably comprehensive base line study) would be expected to provide the facts on which a program could be based and to lead to decision as to the means it would be implemented. At the local level well-trained Community Health Agents (CHAs), or certificate level sanitarians will be directly in charge of the program.

2. Initiation of a Community Sanitary Survey

Sanitary survey is necessary to obtain first hand information concerning local sanitary conditions and heart felt needs of the community. The survey has to be conducted with full consent and participation of the local administration and community leaders. The survey should include:

2.1 Description of the area which will include, location, topography, climate, geology, hydrology, level of ground water table, available water sources, their yield and classification by importance to the community, Population-number, density, age sex,

2.2 Health and sanitary data which will include, general health of the population, type of communicable diseases common in the area, prevalence of soil based and other intestinal parasites, mortality and morbidity data, existing sanitary condition in the area emphasizing availability of latrine, water, vectors, and standard of housing etc.

2.3 Resources emphasizing economic level of the population (average income per capita); cooperation expected from other sectors (agriculture, education,) Housing and vehicles for transport; maintenance facilities; local construction materials and their costs, local craftsmen and wages per day, etc.

3. Health / Hygiene Education

Health or hygiene education plays an important role and should be one of the earliest considerations. It is through a well-planned health/hygiene education that we will be able to secure the understanding, support, and participation of the communities. The main purpose of health/hygiene education should be:

3.1 To create desire, interest, awareness of the relation of health and human waste and for general improvement of human waste management

3.2 To help people determine what changes are needed and desirable for improving sanitation

3.3 To encourage people to put into practice good habits of personal hygiene

3.4 To foster those learning experiences which would feature the people's participation and self help in solving sanitation and related health problems

3.5 To provide instruction in the design, materials and methods involved in building and maintaining proper installations

3.6 To secure sustained interest and participation in a community program of environmental health program.

4. Selection and Design of Units

Basically for countries like Ethiopia who cannot afford a technology that is expensive, a sound system should be sought as means of excreta disposal facility:

4.1 What the community needs and is prepared to accept

4.2 What the community can afford

4.3 What the community can operate and maintain in the future

5. Pilot Projects

When it is not possible to determine from the beginning regarding the types of units, their costs and the construction procedures to be used, a pilot project should be carried out first. Pilot projects are often desirable and may be undertaken especially in conjunction with the training of the sanitation personnel (CHA, Animators), which will ultimately be employed in the program.

6. Estimate of Costs and Budgets

Sanitation in Ethiopia has never been considered for budgeting purpose. Since it is totally considered an individual matter government (local, federal) have never allocated any budget. But, the failure of sanitation program in Ethiopia is because of lack of budget. Budgeting will be necessary for demonstration, travel, material subsidy etc. Including concrete slabs in sanitation installation in the rural communities is almost impossible unless government subsidizes the manufactured products such as cement and iron bars.

7. The Governments Role

For a productive sanitation program, Baity, H.G (1956) has suggested to follow the following steps.

1. Recognize the real benefits of sanitation in the health and well being of their people
2. Establish an Environmental sanitation unit within the National Health Service of the country, commensurate with the country's needs and resources, and staff it with personnel competent to plan and direct all phases of work in this field.
3. Integrate sanitation properly with other public health undertakings and see that first things come first in the assignment of priorities.

4. Develop a long-range plan of sanitation for the country as a whole, into which projects and programs may be logically fitted as to time and place.
5. Realize that it is possible to do something helpful in environmental sanitation under any condition and under any budget- and that the simplest things are usually the best and most important.
6. Select a point of beginning, always the most difficult step in such an undertaking and outline an orderly progression of work and objectives

GLOSSARY

Sanitation: *is the safe management of human excreta and other waste product produced by the day-to-day activities of people?*

Sludge: *Solid material which sinks to the bottom of septic tanks, ponds etc.*

Desludging: *removing accumulated sludge from septic tanks, aqua privies etc.*

Aquatic: *Living in water*

Heliminth: *a worm. Parasitic worm that can live in human body and cause disease*

Environmental sanitation: *intervention to reduce peoples exposure to disease by providing clean environment in which to live with measures to break the cycle of disease.*

Nightsoil: *Human excreta, transported by man.*

Soakaway: *A pit or trench in the ground used for the disposal of liquid waste*

Effluent: *Out flowing liquid usually from point sources*

Compost: *Decayed organic matter made purposely to recycle waste matter.*

Ecological sanitation: *A system of excreta disposal where recycling of the organic natural resources is the ultimate objective. Eco could stand for economical also, as the system will improve the economy of farmers if the use humus material produced from the decomposed human excreta and urine.*

Behavior: *Attitude and practices especially with respect to hygiene*

Ferrocement: *Structure where iron bars and cement plastering is the main materials used.*

***Septic**: Foul smelling waste product usually from cesspool or septic tank*

***Vault**: Compartment for a sanitation system- single vault or double vault latrine*

***Seepage**: The percolation of the liquid part of waste into the soil*

***Soak pit:** A pit filled with stones or broken bricks used to soak the liquid part of waste*

***Detention Time**: The design period in which waste is retained for optimum biological action*

***Waste stabilization pond**: A shallow pond dug in the ground to accept waste water from industries or households for the purpose of biological treatment using natural energy sources such as the sun's energy and prevailing wind power. Waste in the pond is treated in the presence or absence of oxygen.*

***Scum**: Lighter waste matter such as grease that floats in the septic tank*

***Trouble shooting**: Signs and symptoms of waste performance and the remedies to improve treatment efficiency*

***BOD**: Biochemical Oxygen demand which is the amount of oxygen required to oxidize waste matter*

***SS**: Suspended Solids are the solid constituents of any waste matter that can be separated from the liquid using normal filter.*

***COD**: Chemical Oxygen Demand*

***Organic loading**: the amount of organic matter that is calculated for a given treatment plant*

***1 in 200 slope**: A slope which is 1 cm, meter, or kilometer in 200 cm, meter or kilometer which means that the surface or pipe have a head of only 1 meter for every 200 meter distance.*

***Zooglial film**: A shiny or slimy growth on the surface of a filter medium (sand grains or stone) in sand filter, soak pits or trickling filter which helps in reducing organic matter such as bacteria.*

***Activated sludge**: Biologically active sludge*

***Seed:** Adding biologically active sludge so that oxidation of organic matter is expedited*

***Mixed Liquor**: Mixture of fresh sewage and biologically active sludge usually in an activated sludge waste treatment process.*

***Grienge goods**: Woven garment in a textile industry*

***Singeing:** Burning loose fibers in an open flame in a textile industry*

***Desizing:** Solublizing starch from woven garment by enzymatic action*

***Kiering**: Cooking the woven garment with hot alkali detergent*

***Bleaching**: remove natural coloring*

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