Training Module on

Sustainable Sanitation

(SOLID AND LIQUID WASTE MANAGEMENT)

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CONTENTS

TIME PLAN

TRAINING GOAL

Ensure that the participants gain a good understanding of different technology used for the implementation of waste management in rural as well as urban settings. The participants should enhance their knowledge and understanding of the issues related to sanitation and the means and processes by which community groups can implement a sustainable sanitation plans.

Session	Learning Objectives	Topics to be covered	Activity	Time
I – Introduction to sustainable sanitation	Participants will be able to: -Gain an overall understanding of water crisis in India -Understand the challenges in achieving community water security	- Introduction and background to sanitation - Need and Urgency for sanitation programs and concept of sustainability in sanitation. - How sanitation is associated with hygiene, health and environment.	Lecture with PPT	30 min
II- Solid Waste Management	Participants will be able to: -Understand origin, types and handling of solid waste. -Enhance their knowledge about the technological aspects of solid waste management.	-Introduction, origin and types of solid waste. -Classification of municipal waste and 3R principle -Environmental issues related to waste and benefits of recycling -Integrated waste	Lecture/PPT Lecture/PPT Class discussion Poster presentation	30 min 30 min 30 min 60 min 90

	-Gain knowledge about a community level domestic waste management and reuse program.	management system - Household and community level composting.	or slide show on Integrated waste manageme nt system. Demo on household and community level composting	min
111- Human and cattle waste management	Participants will be able to: -Gain insights about Eco sanitation and issues related to sanitation in rural and urban India. -understand the concept of human excreta management. - learn different waste management technological options for different conditions.	-Eco sanitation -Human excreta management options -Problems in rural area and technological options feasible for the same. -Design of different types of toilets for different conditions, their O & M. -different components of toilet -Environmental factors, Dos and Don'ts.	Lecture/PPT Lecture/PPT Discussion Posters/slid e shows lecture	30 min 30 min 120 min 60 min 30 min
1V – Waste to Energy and Reuse of Waste	Participants will be able to: -understand the concept of waste to energy and how is it beneficial to	-What is Waste to energy system -Biogas technology -Types of biogas -Toilet linked biogas -Reuse and Recycling of	Lecture/PPT Slide show or a field visit	30 min 90 min 60 min

	environment. -Appreciate the relevance of Reuse of Waste -Gain knowledge on techniques of energy production from different types of waste	non bio-degradable waste -Reuse of greywater and Urine in agriculture. -Conversion of waste paper into pep wood, A case study -Eco friendly Plastic Fuel-A case study	Lecture Demo of the recycled products Field visit Demonstrations Experience Sharing	30 min 45 min 45 min

PART – I

SUSTAINABLE SANITATION

1.1 Objective:

To introduce the candidates with the basic concept of sanitation, the need and the urgency for sustainable sanitation system and to make them understand the linkage of sanitation with health, hygiene and environment.

1.2 Introduction:

Sanitation denotes a comprehensive concept, in fact, it is 'way of life', which is expressed in clean home, community, institutions for better health and safe environment. Moreover, safe sanitary practice is a crucial indicator for qualifying improvement in standards of living. This concern is triggered by the fact that approx 55 percent of the rural population still reported practicing open defection.
Improving this situation calls for sustained commitment and a comprehensive programme to effectively address the issues of sanitation. The Total Sanitation Campaign (TSC) is the reflection of this commitment which seeks to improve the quality of life in the rural areas through accelerated rural sanitation coverage, generation of felt need through awareness creation and health education; coverage of rural schools with sanitary facilities; encouragement for suitable, cost effective and appropriate technologies; check in absenteeism; and reduction in the incidence of water and Background sanitation related diseases. TSC has, therefore, developed strategic components to ensure full coverage of sanitation through financial and programmatic support in software and hardware component of household, school, aganwadi and community sanitation.

Amongst them, household sanitation is the prime importance to the TSC in order to check the practice of open defecation and ensure access to sanitary toilet to all persons. TSC aims to cover both below poverty line (BPL) families and above poverty line (APL) families. A wide range of technological choices is provided in TSC to make toilets affordable to households in different income levels with reference to customer preferences, construction materials and capacities. It also focuses on developing back-up services such a production centre (PCs), rural sanitary marts (RSMs), and trained masons. The individual household is at liberty to select any technological options suitable to their local and economic conditions.

1.3 Background:

The urgency for action in the sanitation sector is obvious, considering the 2.6 billion people world-wide who remain without access to any kind of improved sanitation, and the 2.2 million annual deaths (mostly children under the age of 5) caused mainly by sanitation-related diseases and poor hygienic conditions.

The United Nations, during the Millennium Summit in New York in 2000 and the World Summit on Sustainable Development in Johannesburg in 2002, developed a series of Millennium Development Goals (MDGs) aiming to achieve poverty eradication and sustainable development. The specific target set for the provision of water supply and sanitation services is to halve the proportion of people without access to safe drinking water and adequate sanitation by 2015.

The Joint Monitoring Programme 99 (JMP) of the WHO and UNICEF reported in 2004 that the number of people lacking basic sanitation services rose from 2.1 billion in 2001 to 2.6 billion by 2004. As the JMP and the UNDP Human Development Report (2006) have shown, the progress towards meeting the MDG sanitation target is however much too slow, with an enormous gap existing between the intended coverage and today's reality especially in Sub-Sahara Africa and parts of Asia as it can be seen in the amp showing the relative sizes for each country and the necessary construction of improved sanitation installations until 2015.

The reasons for this are numerous. A major issue is the fact that sanitation rarely benefits from the political attention given to other topics despite its key importance on many other sectors and on all other MDGs. Political will has been sorely lacking when it comes to placing sanitation high on the international development agenda. This has pushed sanitation into the shadows of water supply projects for example, and limited innovation in the sector.

1.4 Concepts of sustainability in sanitation:

The main objective of a sanitation system is to protect and promote human health by providing a clean environment and breaking the cycle of disease. In order to be sustainable, a sanitation system has to be not only economically viable, socially acceptable, and technically and institutionally appropriate, it should also protect the environment and the natural resources.

When improving an existing and/or designing a new sanitation system, sustainability criteria related to the following aspects should be considered:

1.4.1 Health and hygiene: Includes the risk of exposure to pathogens and hazardous substances that could affect public health at all points of the sanitation system from the toilet via the collection and treatment system to the point of reuse or disposal and downstream populations. This topic also covers aspects such as hygiene, nutrition and improvement of livelihood achieved by the application of a certain sanitation system, as well as downstream effects.

1.4.2 Environment and natural resources: Involves the required energy, water and other natural resources for construction, operation and maintenance of the system, as well as the potential emissions to the environment resulting from its use. It also includes the degree of recycling and reuse practiced and the effects of these (e.g. reusing wastewater; returning nutrients and organic material to agriculture), and the protection of other non-renewable resources, e.g. through the production of renewable energies (such as biogas).

1.4.3 Technology and operation: Incorporates the functionality and the ease with which the entire system including the collection, transport, treatment and reuse and/or final disposal can be constructed, operated and monitored by the local community and/or the technical teams of the local utilities. Furthermore, the robustness of the system, its vulnerability towards power cuts, water shortages, floods, earthquakes etc. and the flexibility and adaptability of its technical elements to the existing infrastructure and to demographic and socio-economic developments are important aspects.

1.4.4 Financial and economic issues: Relate to the capacity of households and communities to pay for sanitation, including the construction, operation, maintenance and necessary reinvestments in the system. Besides the evaluation of these direct costs also direct benefits e.g. from recycled products (soil conditioner, fertiliser, energy and reclaimed water) and external costs and benefits have to be taken into account. Such external costs are e.g. environmental pollution and health hazards, while benefits include increased agricultural productivity and subsistence economy, employment creation, improved health and reduced environmental risks.

1.4.5 Socio-cultural and institutional aspects: The criteria in this category refer to the socio-cultural acceptance and appropriateness of the system, convenience, system perceptions, gender issues and impacts on human dignity, the contribution to food security, compliance with the legal framework and stable and efficient institutional settings.

Most sanitation systems have been designed with these aspects in mind, but in practice they fail far too often because some of the criteria are not met. In fact, there is probably no system which is absolutely sustainable. The concept of sustainability is more of a direction rather than a stage to reach. Nevertheless, it is crucial, that sanitation systems are evaluated carefully with regard to all dimensions of sustainability. Since there is no one-for-all sanitation solution which fulfils the sustainability criteria in different circumstances to the same extent, this system evaluation will depend on the local framework and has to take into consideration existing environmental, technical, socio-cultural and economic conditions. Taking into consideration the entire range of sustainability criteria, it is important to observe some basic principles when planning and implementing a sanitation system. These were already developed some years ago by a group of experts and were endorsed by the members of the Water Supply and Sanitation Collaborative Council as the "Bellagio Principles for Sustainable Sanitation" during its 5th Global Forum in November 2000:

Human dignity, quality of life and environmental security at household level should be at the centre of any sanitation approach. In line with good governance principles, decision making should involve participation of all stakeholders, especially the consumers and providers of services. Waste should be considered a resource, and its management should be holistic and form part of integrated water resources, nutrient flow and waste management processes.

The domain in which environmental sanitation problems are resolved should be kept to the minimum practicable size (household, neighbourhood, community, town, district, catchment, and city).

1.5 Recommendations to make current sanitation more sustainable

Some examples for improving present sanitation practices in the short-term:

- Pit latrines could be modified to be soil-composting latrines, thus requiring some wall reinforcement, made shallow (max 1-1.5 m) and maintained using daily soil additions; the pits would be periodically closed and covered with soil in order to allow for sanitization and composting prior to emptying and reuse in agriculture.

Simple urinals with separate collector systems could be installed instead of using toilets and pit latrines for urination

- Flush toilets could be modified to use less water.

- Greywater could be source-separated from the blackwater from toilets thus simplifying its treatment and providing opportunities for reuse.

- Blackwater from toilets could be held in conservancy tanks instead of open septic tanks and cess pits and then emptied and transported to biogas fermentors; alternatively the toilets could be connected to biogas fermentors.

- Cess (or drainage) pits e.g. from pour-flush toilets could be equipped with a safety zone of additional filter material to prevent contamination of ground water.

- Toilets and especially any new toilets could be equipped with urine diversion in order to reduce primarily the nitrogen load to the environment.

- Above ground dry toilets with urine diversion could be installed in dry areas lacking water, rocky areas where pits are expensive to dig and areas with high water tables and flooding.

1.6 References:

- Sustainable Sanitation Alliance: Towards more sustainable sanitation solutions;
- Rockström, Johan et al.: Sustainable Pathways to attain the Millennium Development Goals - Assessing the Key Role of Water, Energy and Sanitation, Stockholm Environmental Institute, 2005.
- WHO/UNICEF: Meeting the MDG Drinking Water and Sanitation Target – The urban and rural challenge of the decade; (page 9);
- WSSCC/Sandec (2000): The Bellagio Statement on Sustainable Sanitation;

PART - II

SOLID WASTE MANAGEMENT

2.0.1 Objectives: To make the candidates understand different types of solid wastes and various concepts of solid waste management and its importance.

2.0.2 Definitions:

Waste according to the Basel convention: Wastes are substances or objects which are disposed or are intended to be disposed or are required to be disposed of by the provisions of national laws.

The United Nations Statistics Division (UNSD): Wastes are materials that are not prime products (that is products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose. Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals recycled or reused at the place of generation are excluded.

2.0.3 OECD definitions for selected categories of waste

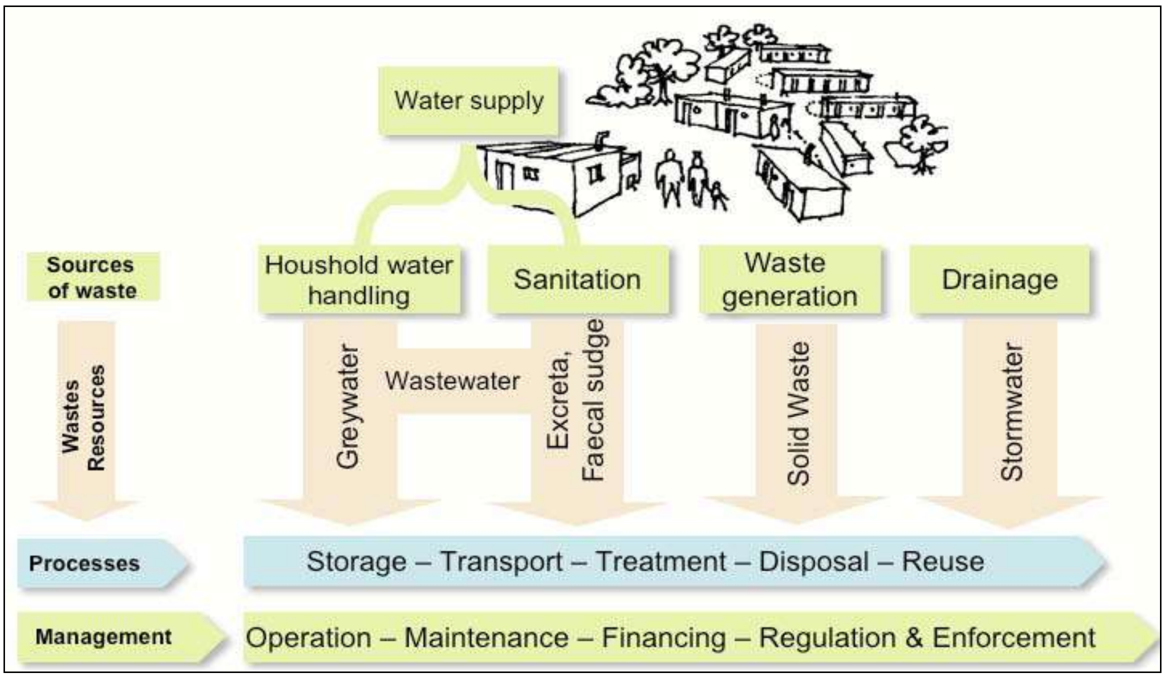
Municipal waste is collected and treated by, or for municipalities. It covers waste from households, including bulky waste, similar waste from commerce and trade, office buildings, institutions and small businesses, yard and garden, street sweepings, contents of litter containers, and market cleansing. Waste from municipal sewage networks and treatment, as well as municipal construction and demolition is excluded.

Hazardous waste is mostly generated by industrial activities and driven by specific patterns of production. It represents a major concern as it entails serious environmental risks if poorly managed: the impact on the environment relates mainly to toxic contamination of soil, water and air.

Nuclear (radioactive) waste is generated at various stages of the nuclear fuel cycle (uranium mining and milling, fuel enrichment, reactor operation, spent fuel reprocessing). It also arises from decontamination and decommissioning of nuclear facilities, and from other activities using isotopes, such as scientific research and medical activities.

Waste includes all items that people no longer have any use for, which they either intend to get rid of or have already discarded. Additionally, wastes are such items which people are requiring to discard, for example by lay because of their hazardous properties. Many items can be considered as waste e.g., household rubbish, sewage sludge, wastes from manufacturing activities, packaging items, discarded cars, old televisions, garden waste, old paint containers etc. Thus all our daily activities can give rise to a large variety of different wastes arising from different sources.

There are a number of different options available for the treatment and management of waste including prevention, minimisation, re-use, recycling, energy recovery and disposal. Under EU policy, landfilling is seen as the last resort and should only be used when all the other options have been exhausted , i.e., only material that cannot be prevented, re-used, recycled or otherwise treated should be landfilled.



2.0.3.1 Waste Generation:

On a global scale, calculating the amount of waste being generated presents a problem. There are a number of issues, including a lack of reporting by many countries and inconsistencies in the way countries report (definitions and surveying methods employed by countries vary considerably). The Basel Convention has estimated the amount of hazardous and other waste generated for 2000 and 2001 at 318 and 338 millions tonnes respectively. These figures are based on incomplete reports from the parties to the Convention. Compare this with the almost 4 billion tonnes estimated by *the OECD as generated by their 25 member countries in 2001 (Environmental Outlook, OECD) and the problems of calculating a definitive number for global waste generation are obvious.*

2.0.4 Types of Solid Waste

Solid waste can be classified into different types depending on their source:

a) Household waste is generally classified as municipal waste,
b) Industrial waste as hazardous waste, and
c) Biomedical waste or hospital waste as infectious waste.

Biodegradable and recyclable	**Non-biodegradable**	
	Recyclable	**Non-recyclable**
Kitchen waste	Plastics – carry bags, milk covers PVC pipes etc. Syringes, Glucose bottles etc. Cotton and nylon cloth Tyres & Tubes	Nitrogen sealed packing for chips
Food Cow dung/animal waste Agricultural Leaves Egg cells Henna paste Vegetable Peels, meat, bones Dead animals Paper Wood	Shampoo Bottles Glass Books/notebook Wires Caps of mineral water bottles Plastic Tin can Metal Ash/dirt	Tetrapacks Thermo cal Carbon paper Plastic coated visiting cards Sachets Modern packing materials (plastic) for food packing PET mineral water bottles

2.0.4.1 Municipal solid waste: Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. This garbage is generated mainly from residential and commercial complexes. With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing. More than 25% of the municipal solid waste is not collected at all; 70% of the Indian cities lack adequate capacity to transport it and there are no sanitary landfills to dispose of the waste. The existing landfills are neither well equipped nor well managed and are not lined properly to protect against contamination of soil and groundwater. Over the last few years, the consumer market has grown rapidly leading to products being packed in cans, aluminum foils, plastics, and other such non biodegradable items that cause incalculable harm to the environment. In India, some municipal areas have banned the use of plastics and they seem to have achieved success. Certain biodegradable items can also be composted and reused. In fact proper handling of the biodegradable waste will considerably lessen the burden of solid waste that each city has to tackle.

2.0.5 Garbage: the four broad categories

Organic waste: kitchen waste, vegetables, flowers, leaves, fruits.

Toxic waste: old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish.

Recyclable: paper, glass, metals, plastics.

Soiled: hospital waste such as cloth soiled with blood and other body fluids.

2.0.5.1 Hazardous waste

2.0.5.1.1 Industrial and hospital waste is considered hazardous as they may contain toxic substances. Certain types of household waste are also hazardous. Hazardous wastes could be highly toxic to humans, animals, and plants; are corrosive, highly inflammable, or explosive; and react when exposed to certain things e.g. gases. India generates around 7 million tonnes of hazardous wastes every year.

2.0.5.1.2 Household wastes that can be categorized as hazardous waste include old batteries, shoe polish, paint tins, old medicines, and medicine bottles.

2.0.5.1.3 Hospital waste is contaminated by chemicals used in hospitals is considered hazardous. These chemicals include formaldehyde and phenols, which are used as disinfectants, and mercury, which is used in thermometers or equipment that measure blood pressure. Most hospitals in India do not have proper disposal facilities for these hazardous wastes. In the industrial sector, the major generators of hazardous waste are the metal, chemical, paper, pesticide, dye, refining, and rubber goods industries.Direct exposure to chemicals in hazardous waste such as mercury and cyanide can be fatal.

2.0.5.1.4 Hospital waste is a potential health hazard to the health care workers, public and flora and fauna of the area. Hospital acquired infection, transfusion transmitted diseases, rising incidence of Hepatitis B, and HIV, increasing land and water pollution lead to increasing possibility of catching many diseases. Air pollution due to emission of hazardous gases by incinerator such as Furan, Dioxin, Hydrochloric acid etc. have compelled the authorities to think seriously about hospital waste and the diseases transmitted through improper disposal of hospital waste. This problem has now become a serious threat for the public health and, ultimately, the Central Government had to intervene for enforcing proper handling and disposal of hospital waste and an act was passed in July 1996 and a bio-medical waste (handling and management) rule was introduced in 1998.

A modern hospital is a complex, multidisciplinary system which consumes thousands of items for delivery of medical care and is a part of physical environment. All these products consumed in the hospital leave some unusable leftovers i.e. hospital waste. The last century witnessed the rapid mushrooming of hospital in the public and private sector, dictated by the needs of expanding population. The advent and acceptance of "disposable" has made the generation of hospital waste a significant factor in current scenario.

2.0.5.2 What is hospital waste?

Hospital waste refers to all waste generated, discarded and not intended for further use in the hospital.

Classification of hospital waste

(1) General waste: Largely composed of domestic or house hold type waste. It is non-hazardous to human beings, e.g. kitchen waste, packaging material, paper, wrappers, plastics.

(2) Pathological waste: Consists of tissue, organ, body part, human foetuses, blood and body fluid. It is hazardous waste.

(3)Infectious waste: The wastes which contain pathogens in sufficient concentration or quantity that could cause diseases. It is hazardous e.g. culture and stocks of infectious agents from laboratories, waste from surgery, waste originating from infectious patients.

(4) Sharps: Waste materials which could cause the person handling it, a cut or puncture of skin e.g. needles, broken glass, saws, nail, blades, scalpels.

(5) Pharmaceutical waste: This includes pharmaceutical products, drugs, and chemicals that have been returned from wards, have been spilled, are outdated, or contaminated.

(6)Chemical waste: This comprises discarded solid, liquid and gaseous chemicals e.g. cleaning, house keeping, and disinfecting product.

(7)Radioactive waste: It includes solid, liquid, and gaseous waste that is contaminated with radionucleides generated from in-vitro analysis of body tissues and fluid, in-vivo body organ imaging and tumour localization and therapeutic procedures.

2.0.5.2.1 Biomedical Waste:

Any solid, fluid and liquid or liquid waste, including it's container and any intermediate product, which is generated during the diagnosis, treatment or immunization of human being or animals, in research pertaining thereto, or in the production or testing of biological and the animal waste from slaughter houses or any other similar establishment. All biomedical waste are hazardous. In hospital it comprises of 15% of total hospital waste.

2.0.6 E-waste:

Electronic waste, e-waste, e-scrap, or Waste Electrical and Electronic Equipment (WEEE) describes loosely discarded, surplus, obsolete, broken, electrical or electronic devices. The processing of electronic waste in developing countries causes serious health and pollution problems due to the fact that electronic equipment contains some very serious contaminants such as lead, cadmium, beryllium and brominated flame-retardants. Even in developed countries recycling and disposal of e-waste involves significant risk for examples to workers and communities and great care must be taken to avoid unsafe exposure in recycling operations and leaching of materials such as heavy metals from landfills and incinerator ashes

2.0.6.1 Electronic waste"

May be defined as all secondary computers, entertainment device electronics, mobile phones, and other items such as television sets and refrigerators, whether sold, donated, or discarded by their original owners. This definition includes used electronics which are destined for reuse, resale, salvage, recycling, or disposal. Others define the reusable (working and repairable electronics) and secondary scrap (copper, steel, plastic, etc.) to be "commodities", and reserve the term "waste" for residue or material which was represented as working or repairable but which is dumped or disposed or discarded by the buyer rather than recycled, including residue from reuse and recycling operations. Because loads of surplus electronics are frequently commingled (good, recyclable, and no recyclable), several public policy advocates apply the term "e-waste" broadly to all surplus electronics. The United States Environmental Protection Agency (EPA) includes to discarded CRT monitors in its category of "hazardous household waste" but considers CRTs set aside for testing to be commodities if they are not discarded, speculatively accumulated, or left unprotected from weather and other damage.

2.0.7 Need for Solid Waste Management

As urbanization continues to take place, the management of solid waste is becoming a major public health and environmental concern in urban areas of many developing countries. The concern is serious, particularly in the capital cities, which are often gateways to the countries for foreign diplomats, businessmen, and tourists. Poor visual appearance of these cities will have negative impacts on official and tourist visits and foreign investment.

Recognizing its importance, a number of developing countries have requested collaboration of external support agencies, both bilateral and multilateral, in improving solid waste management in their cities in the last 20 years or so. Although some projects succeeded in providing lasting positive impacts on the management of solid waste in the recipient countries and cities, many failed to continue activities after the external support agencies ceased their support. This unsustainability of collaborative projects is due to various technical, financial, institutional, economic, and social constraints faced by both the recipient countries/cities and external support agencies.

Such constraints vary from country to country and from city to city, as developing countries and cities within them differ in solid waste management problems and they and external support agencies have different, and often limited, resources available to resolve the problems. Therefore, in order to ensure the sustainability of collaborative projects, the various constraints of both developing countries and external support agencies should be carefully examined and an approach be developed to remove such constraints within the context of the collaborative projects. This paper delineates common such constraints and suggests possible ways of removing these constraints.

2.0.8 Life cycle assessment

A 'Life Cycle Assessment' ('LCA', also known as 'life cycle analysis', 'ecobalance', and 'cradle-to-grave analysis') is the investigation and valuation of the environmental impacts of a given product or service caused or necessitated by its existence.

LCAs were an obvious extension, and became vital to support the development of eco-labeling schemes, which are operating or planned in a number of countries around the world. In order for eco-labels to be granted to chosen products, the awarding authority needs to be able to evaluate the manufacturing processes involved, the energy consumption in manufacture and use, and the amount and type of waste generated.

2.0.9 The 3Rs: of solid waste management

2.0.9.1 REDUCE – The best way to manage solid waste.

Don't create waste in the first place! Buy only what you need. Use all that you buy. Avoid heavily packaged products. Avoid disposable items – like paper plates and plastic silverware. Buy the largest size package for those items that you use are often. Refuse bags at fast food restaurants or stores when you only buy a few items. When taking care of the lawn – leave grass clippings on the lawn instead of bagging and throwing out. Start a compost pile for grass clippings, tree trimmings and fruit and vegetable scraps. Ask yourself, "What will be left when I am through with this item?" or "How much trash do I have to throw away just to get to the item?

2.0.9.1.1 Benefits of Reduction

Saves natural resources, Waste is not just created when consumers throw items away. Throughout the life cycle of a product from extraction of raw materials to transportation to processing and manufacturing facilities to manufacture and use waste is generated. Reusing items or making them with less material decreases waste dramatically. Ultimately, less material will need to be recycled or sent to landfills or waste combustion facilities.

Reduces toxicity of waste. Selecting no hazardous or less hazardous items is another important component of source reduction. Using less hazardous alternatives for certain items (e.g., cleaning products and pesticides), sharing products that contain hazardous chemicals instead of throwing out leftovers, reading label directions carefully, and using the smallest amount necessary are ways to reduce waste toxicity.

Reduces costs. The benefits of preventing waste go beyond reducing reliance on other forms of waste disposal. Preventing waste also can mean economic savings for communities, businesses, schools, and individual consumers.

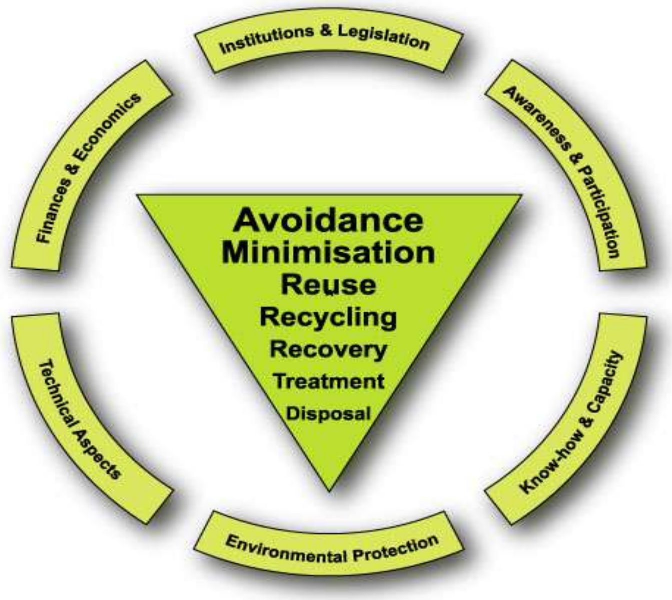


Figure: National and local factors (circular boxes) influencing the core concepts of the waste management hierarchy (triangle), in which solid waste elements diminish in priority from top to bottom.

2.0.9.2 REUSE – The better way to manage solid waste.

Reuse items – use them over and over until they are completely worn out. Lunch bags can be brought home and used for many more lunches. Borrow or share items you don't use very often. Donate unwanted items to thrift stores or charitable organizations. Have a yard sale. Repair items, instead of throwing away and buying new. Refill bottles. Bring grocery store bags back and use the same ones the next time you go shopping. Use your imagination, not the trash can!

2.0.9.2.1 Benefits of reuse '

The reuse of products, materials, and parts can have significant environmental and economic benefits. Waste is not just created when consumers throw items away. Waste is generated throughout the life cycle of a product, from extraction of raw materials, to transportation to processing and manufacturing facilities, to manufacture and use. Reusing items or making them with less material decrease waste dramatically. Ultimately, less material will need to be recycled or sent to landfills or waste-combustion facilities.

Used goods are widely available to industries, businesses, institutions, and individuals. There are secondhand markets for entire industrial production facilities, such as breweries and chemical production plants, as well as for industrial, construction, and medical equipment.

Reuse can reduce the pollution and resource use associated with manufacturing a new item, and can delay or eliminate disposal of the item. In order to experience the greatest environmental benefits, reuse of an item needs to replace, at least partially, the purchase and production of a new item

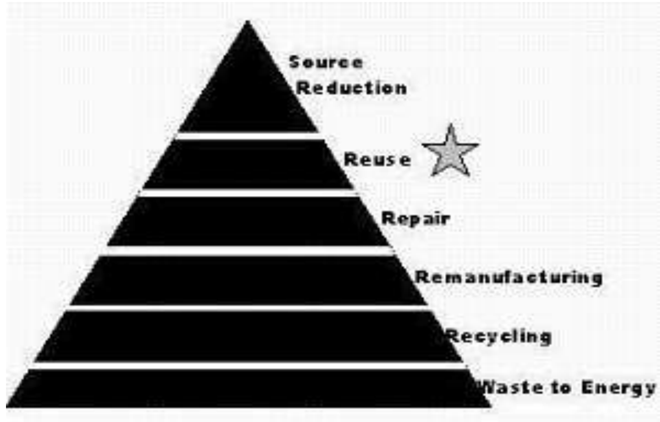
Reuse can replace the production and purchase of new items, especially when the first owner does not sell in order to be able to buy a new item. Examples of this sort include clothes and furniture, which are typically given away or sold at low prices by the first owners, and which second-hand buyers often buy instead of new items.

2.0.9.3 RECYCLE - The good way to manage solid waste.

Recycle means taking something old and making it into something new Simply rinse out containers and remove lids. That's it – it's very simple and very worthwhile. Not only does it keep items out of the landfill, recycling conserves natural resources. For example, making newspaper out of old newspaper saves a valuable natural resource – trees.
Many other items can also be recycled – such as old computers, televisions, tires and old appliances. Use the yellow pages or internet to research. Pre-cycle. This means only buy food or beverages in containers you know are accepted in your recycling program. When away from home, hold onto your containers until you get home to recycle them. Buy items made from recycled products.

2.0.9.3.1 Benefits of Recycling

Recycling reduces the need for land filling and incineration.
Recycling prevents pollution caused by the manufacturing of products from virgin materials.
Recycling saves energy.
Recycling decreases emissions of greenhouse gases that contribute to global climate change.
Recycling conserves natural resources such as timber, water, and minerals.
Recycling helps sustain the environment for future generations.



2.0.10 Conclusion

Effective management of solid waste requires the cooperation of the general public. Lifting the priority of, and allocating more resources to, the solid waste management sector needs the support from decision makers. It is, therefore, important to ensure that public and decision makers' awareness activities are incorporated into the external support package. The aim of these activities is normally long term and it takes some momentum to build up before the effects are realized. But, once the interests of the public and decision makers in improving solid waste management are created, the sustainability of solid waste management projects will be significantly improved.

Enhanced awareness of decision makers may lead to changing national socio-economic and industrial development policies and associated government programmes in favor of improving solid waste management systems in developing countries. For instance, more financial aid and tax incentives may be introduced to encourage the development of recycling industry and business, or labourer protection programmes may be provided to improve wages and working conditions of laborers, including solid waste management workers. Changing national policies in donor countries could also improve ways in which their technologies are transferred to recipient countries.

Reference: http://www.epa.gov/waste/wycd/home.htm
Reuse Development Organization, Inc. (ReDO)

Chapter 1

CLASSIFICATION OF WASTE

2.1.1 Introduction:

Proper management of solid waste is critical to the health and well being of urban residents. In most developing cities, several tons of garbage is left uncollected on the streets each day, acting as a feeding ground for pests that spread disease, clogging drains and creating a myriad of related health and infrastructural problems. The urban poor - often residing in informal settlements with little or no access to solid waste collection and often in areas that are contiguous with open dumps - are particularly vulnerable. While urban residents in developing countries produce less solid waste per-capita than in high-income countries, the capacity of their cities to collect, process, dispose of, or re-use solid waste in a cost-efficient, safe manner is far more limited. Municipal SWM efforts often focus on expensive 'end-of-pipe' measures, those involving the collection and disposal of solid waste, yet many of the 'best practices' for SWM improvement are far more accessible and cost-effective opportunities involving waste reduction programs and recycling strategies.

The challenges to be faced in collecting solid waste will dramatically increase in the next 30 years as a result of both the rapid growth of developing cities and increases in per capita waste production. It was once believed that increases in per capita waste went hand-in-hand with economic growth, but recent trends in developed countries show that aggressive efforts to reduce, recycle and reuse can break this link. Environmentally sound urban SWM strategies should address unsustainable patterns of consumption and production. A framework for improved urban SWM combines the expansion of safe collection and disposal with measures designed to minimize trash production and promote the recycling, reuse or recovery of resources from solid waste.

<u>Classification of material</u>: Waste is not homogenous in nature solid waste can be broadly classified into wet waste (biodegradable waste) and dry waste (Non-biodegradable waste)

2.1.2 Wet Waste:

This consists of biodegradable materials that can be decomposed by biological action in nature. In the recent times there are various methods of recycling and reclamation. Materials like vegetable matter, animal manure and organic refuse can be converted into a more stable form that can help in soil amendment by composting and the final product is called the compost. Generally there are two types of composting process like aerobic and anaerobic. Composting facilities are cheap and easy to operate. This process will help in reducing the volume of Municipal Solid Waste. Composting units can be individual at the household level or commercial and can follow the centralized or decentralized system.

2.1.3 Dry Waste:

Dry waste is waste that is dry and un-contaminated. Recyclables such as waste paper, metal cans, plastic bottles, floppy disks, batteries, glass bottles, old clothes, baskets, pens and shoes are all dry waste, from which we can sort out many useful materials for recycling. Recyclable waste can be sold in the market and non-recyclable waste has to be sent to a landfill. The list of recyclable material is long and it grows as technological development enables more material to be recycled. Generally the material can be grouped into five major categories –Paper, Plastic, Glass Aluminum, other metals.

2.1.3.1 Paper:

Paper is made from plant fibers called cellulose, which are found in wood. Cellulose must be converted into pulp before being used to manufacture paper. Another potential source of cellulose is paper that has been recovered for recycling. Paper can also be made of rags, cotton, grasses, sugar cane and straw. Paper is biodegradable and recyclable. Paper can be recycled and made into products.

Approximately 35 percent of the municipal solid waste stream (MSW) is made up of paper and paperboard products. Paper makes up the largest portion of the municipal waste stream and is also one of the most recovered materials. Recycling produces numerous direct and indirect benefits:

- Conserves resources
- Prevents emissions of many greenhouse gases and water pollutants
- Saves energy
- Supplies valuable raw materials to industry
- Creates jobs
- Stimulates the growth of greener technologies
- Reduces the need for new landfills and incinerators

Paper recovered for recycling is categorized into “grades.” Each grade of paper has specific characteristics, as well as its own value to manufacturers. Dozens of grades exist, however, they are generally grouped into categories including corrugated (”cardboard”), newsprint, mixed (different colors and types, like inserts and circulars) and office paper.

The type of paper collected determines the new product that can be made from it. Generally, the lower grades, such as corrugated and newsprint go back into the same new products. Higher grades, such as the high quality fiber found in offices and schools, can go back into printing and writing papers, among other uses.

2.1.3.1.1 Closing the loop:

Recycling process will depend on the market available for recycled products. The recycling paper units cannot continue to produce recycled paper if people don't buy these products.
Putting your rubbish in a recycling bank or separating it for collection is only one element of the recycling loop.
To fully play your part you should also consider buying products that have a recycled content.

2.1.3.2 Plastic:

Plastics can be classified by their chemical structure, namely the molecular units that make up the polymer's backbone and side chains. Some important groups in these classifications are the acrylics, polyesters, silicones, polyurethanes, and halogenated plastics. Plastics can also be classified by the chemical process used in their synthesis; e.g., as condensation, polyaddition, cross-linking. Due to their relatively low cost, ease of manufacture, versatility, and imperviousness to water, plastics are used in an enormous and expanding range of products, from paper clips to spaceships. They have already displaced many traditional materials, such as wood; stone; horn and bone; leather; paper; metal; glass; and ceramic, in most of their former uses. The vast majority of plastics are composed of polymers of carbon and hydrogen alone or with oxygen, nitrogen, chlorine or sulfur in the backbone. The backbone is that part of the chain on the main "path" linking a large number of repeat units together. Plastics often contain a variety of toxic additives. For example, plasticizers like adipates and phthalates are often added to brittle plastics like polyvinyl chloride (PVC) to make them pliable enough for use in food packaging, children's toys and teethers, tubing, shower curtains and other items. Traces of these chemicals can leach out of the plastic when it comes into contact with food. Out of these concerns, the European Union has banned the use of DEHP (di-2-ethylhexyl phthalate), the most widely used plasticizer in PVC. Some compounds leaching from polystyrene food containers have been found to interfere with hormone functions and are suspected human carcinogens. Moreover, while the finished plastic may be non-toxic, the monomers used in its manufacture may be toxic; and small amounts of those chemicals may remain trapped in the product. The World Health Organization's International Agency for Research on Cancer (IARC) has recognized the chemical used to make PVC, vinyl chloride, as a known human carcinogen. Some polymers may also decompose into the monomers or other toxic substances when heated.

2.1.3.2.1 Environmental Issues:

Plastics are durable and degrade very slowly; the molecular bonds that make plastic so durable make it equally resistant to natural processes of degradation. Since the 1950s, one billion tons of plastic has been discarded and may persist for hundreds or even thousands of years. In some cases, burning plastic can release toxic fumes. Also, the manufacturing of plastics often creates large quantities of chemical pollutants

Prior to the ban on the use of CFCs in extrusion of polystyrene (and general use, except in life-critical fire suppression systems; see Montreal Protocol), the production of polystyrene contributed to the depletion of the ozone layer; however, non-CFCs are currently used in the extrusion process.

To assist recycling of disposable items, the Plastic Bottle Institute of the Society of the Plastics Industry devised a now-familiar scheme to mark plastic bottles by plastic type. A plastic container using this scheme is marked with a triangle of three cyclic arrows, which encloses a number giving the plastic type:

PET (PETE), polyethylene terephthalate: Commonly found on 2-liter soft drink bottles, water bottles, cooking oil bottles, peanut butter jars.
HDPE, high-density polyethylene: Commonly found on detergent bottles, milk jugs.

PVC, polyvinyl chloride: Commonly found on plastic pipes, outdoor furniture, siding, floor tiles, shower curtains, clamshell packaging.

LDPE, low-density polyethylene: Commonly found on dry-cleaning bags, produce bags, trash can liners, and food storage containers.
PP, polypropylene: Commonly found on bottle caps, drinking straws, yogurt containers, and logos.

PS, polystyrene: Commonly found on "packing peanuts", cups, plastic tableware, and meat trays, take-away food clamshell containers.

OTHER, other: This plastic category, as its name of "other" implies, is any plastic other than the named #1–#6, commonly found on certain kinds of food containers, Tupperware, and Nalgene bottles.

Unfortunately, recycling plastics has proven difficult. The biggest problem with plastic recycling is that it is difficult to automate the sorting of plastic waste, and so it is labor intensive. Typically, workers sort the plastic by looking at the resin identification code, though common containers like soda bottles can be sorted from memory. Other recyclable materials, such as metals, are easier to process mechanically. However, new mechanical sorting processes are being utilized to increase plastic recycling capacity and efficiency. While containers are usually made from a single type and color of plastic, making them relatively easy to sort out, a consumer product like a cellular phone may have many small parts consisting of over a dozen different types and colors of plastics. In a case like this, the resources it would take to separate the plastics far exceed their value and the item is discarded. However, developments are taking place in the field of Active Disassembly, which may result in more consumer product components being re-used or recycled. Recycling certain types of plastics can be unprofitable, as well. For example, polystyrene is rarely recycled because it is usually not cost effective. These unrecycled wastes are typically disposed of in landfills, incinerated or used to produce electricity at waste-to-energy plants.

The biggest threat to the conventional plastics industry is most likely to be environmental concerns, including the release of toxic pollutants, greenhouse gas, litter, biodegradable and non-biodegradable landfill impact as a result of the production and disposal of petroleum and petroleum-based plastics. Of particular concern has been the recent accumulation of enormous quantities of plastic trash in ocean gyres. For decades one of the great appeals of plastics has been their low price. Yet in recent years the cost of plastics has been rising dramatically. A major cause is the sharply rising cost of petroleum, the raw material that is chemically altered to form commercial plastics. With some observers suggesting that future oil reserves are uncertain, the price of petroleum may increase further. Therefore, alternatives are being sought. Oil shale and tar oil are alternatives for plastic production but are expensive. Scientists are seeking cheaper and better alternatives to petroleum-based plastics, and many candidates are in laboratories all over the world.

2.1.3.3 Glass:

Generally refers to hard, brittle, transparent material, such as those used for windows, many bottles, or eyewear. Examples of such materials include, but are not limited to, soda-lime glass, borosilicate glass, acrylic glass, sugar glass, isinglass (Muscovy-glass), or aluminum oxynitride. In the technical sense, glass is an inorganic product of fusion, which has been cooled through the glass transition to a rigid condition without crystallizing. Many glasses contain silica as their main component. Glass is colored due to the addition of additives like iron, chromium and cobalt. Glass is used as a packaging material in addition to its use in the construction industry. The advantages of glass products are that they can be used until broken or becomes useless. Returning the bottle to the retailer and receiving deposit was a common practice in the past and this trend is on the decline, as consumers prefer non – refundable bottles. Recycling glass bottles is one of the best option because it can be recovered and refilled and also will not add unto the solid waste stream if managed properly. `It usually consist 2 percentage of the total waste and it can be kept of the waste stream and send back for recycling as its structure does not deteriorate when reprocessed and there is a strong market for recycled glass containers.

2.1.3.3.1 Benefits of Recycling Glass

Glass recycling is the process of taking old glass products and turning them into new, reusable glass products. Recycling old glass uses 40% less energy than manufacturing it from new. When glass is produced, soda ash, lime and sand are heated together and shaped into glass products. This creates huge fossil fuel emissions. But for every ton of glass we recycle we could save up to the equivalent of nine gallons of fuel oil that would otherwise be burned to create new glass products.

Here are some benefits of glass recycling:

- Glass can be recycled over again and never lose its quality or quantity
- Creates 20% less air pollution
- Reduces water pollution by 50%
- Saves enough energy to light a 100-watt light bulb for hours
- It reduces that amount of landfill space that is used
- The typical glass container is made up of as much as 70 percent recycled glass.
- It is estimated that 80 percent of recycled glass, as a whole, will end up as new glass containers.
- Unlike other substances such as paper, glass can be recycled infinitely without any loss of purity or quality.
- To create new glass, substances such as sand must be heated to 2,600° Fahrenheit, which consumes energy and creates pollution from factories.
- Recycled glass first becomes “cullet,” or crushed glass. When making new products from cullet, 40 percent less energy is consumed in place of making glass from new products, because it melts at a lower temperature than virgin ingredients.
- A glass bottle can take up to one million years to breakdown.
- Most glass bottles are eligible for a cash refund in 11 different U.S. states, meaning that recycling them can earn you some money.
- A recycled glass container can go from a recycling bin to a store shelf in as little as 30 days.
- Because glass is made from naturally-occurring materials like sand, it has a low rate of chemical interaction with the contents of the container, which makes it a safe material to be reused.
- Recycled glass can be used in numerous areas, such as creating sports turf, manufacturing kitchen tiles and providing sand to depleted beaches.

2.1.3.3.2 Environmental Benefits of Glass Recycling

Apart from the economic benefits from recycling glass you'll also be helping to minimize your businesses environmental impacts. Some of the benefits of recycling glass are listed below:

Making glass bottles and jars from recycled ones saves energy. The energy saving from recycling one bottle will:

- Power a 100 watt light bulb for almost an hour
- Power a computer for 20 minutes
- Power a colour TV for 15 minutes
- Power a washing machine for 10 minutes
- Glass can be recycled again and again without ever losing its clarity or purity.

Every tonne of glass recycled prevents the quarrying of 1.2 tonnes of raw materials and prevents the release of 300kg of CO_2 into the atmosphere helping to prevent climate change.

2.1.3.4 Aluminum

Aluminum is the most abundant metal in the Earth's crust, and the third most abundant element therein, after oxygen and silicon. It makes up about 8% by weight of the Earth's solid surface. Aluminum is too reactive chemically to occur in nature as a free metal. Instead, it is found combined in over 270 different minerals. The chief source of aluminum is bauxite ore. Aluminum is remarkable for its ability to resist corrosion due to the phenomenon of passivation and the metal's low density. Structural components made from aluminum and its alloys are vital to the aerospace industry and very important in other areas of transportation and building. Its reactive nature makes it useful as a catalyst or additive in chemical mixtures, including being used in ammonium nitrate explosives to enhance blast power.

2.1.3.4.1 Recycling of aluminium

- Aluminum is 100% recyclable without any loss of its natural qualities. Recovery of the metal via recycling has become an important facet of the aluminum industry.

- Recycling involves melting the scrap, a process that requires only five percent of the energy used to produce aluminum from ore. However, a significant part (up to 15% of the input material) is lost as dross (ash-like oxide).

- Recycling was a low-profile activity until the late 1960s, when the growing use of aluminum beverage cans brought it to the public awareness.

- In Europe aluminum experiences high rates of recycling, ranging from 42% of beverage cans, 85% of construction materials and 95% of transport vehicles.

- Recycled aluminum is known as secondary aluminum, but maintains the same physical properties as primary aluminum. Secondary aluminum is produced in a wide range of formats and is employed in 80% of the alloy injections. Another important use is for extrusion.

2.1.3.4.2 Environmental Benefits

- Recycling aluminum cans saves precious natural resources, energy, time and money – all for a good cause – helping out the earth, as well as the economy and local communities.
- Aluminum cans are unique in that in 60 days a can is recycled, turned into a new can & back on store shelves.
- Aluminum is a sustainable metal and can be recycled over and over again.
- In 2003, 54 billion cans were recycled, saving the energy equivalent of 15 million barrels of crude oil – America's entire gas consumption for one day.

2.1.3.4.3 Economic Benefits

➢ The aluminum can is the most valuable container to recycle and is the most recycled consumer product in the U.S. today.

➢ Each year, the aluminum industry pays out over $800 million dollars for empty aluminum cans – that's a lot of money that can go to organizations, like Habitat for Humanity, the Boy or Girl Scouts of America, or even a local school. Money earned from recycling cans helps people help themselves and their communities. Recycling helps build new homes, pays for a group trip, supports a project or buys a lunch!

➢ Today it is cheaper, faster and more energy-efficient to recycle aluminum than ever before. The aluminum can is 100 percent recyclable and can be recycled indefinitely. The can remains the most recyclable of all materials.

➢ Used aluminum beverage cans are the most recycled item in the U.S., but other types of aluminum, such as siding, gutters, car components, storm window frames, and lawn furniture can also be recycled.

➢ Aluminum has a high market value and continues to provide an economic incentive to recycle. When aluminum cans are recycled curbside, they help pay for community services.

2.1.3.5 Other metals

Metals can be classified into ferrous and non-ferrous.

Ferrous: *These are metals, which contain iron. They may have small amounts of other metals or other elements added, to give the required properties. All ferrous metals are magnetic and give little resistance to corrosion*

Non ferrous: These are metals which do not contain any iron. They are not magnetic and are usually more resistant to corrosion than ferrous metals. Examples are aluminum, copper, lead. Zinc and tin.

The reusable nature of the metal contributes to their sustainability. The primary sources of metals are ores and the secondary is recycled materials. Once the product completes it lifespan they become scrap. Both ferrous and non ferrous metals can be recycled and sold in market though most of the recycling is done in the formal sector the informal sector is also involved in this. The nature of the product is such that very little waste is generated at household level. Major contributor is industries. Today even households contribute due to the change in lifestyles and this contribute 1percentage of the total waste thus effective recycling measures need to be taken to make sure that they are disposed safely

Some of the prominent metals in the waste streams are
Copper and copper alloy scrap: major source is the electrical wires used at house hold level

Iron and steel scrap: These are widely used material and hence recycling is important

Things you can do to help reduce waste

- **Product stewardship**: Design all products for the environment and for safety
- **Zero waste:** Reuse or recycle all waste materials
- **Benign emissions**: Eliminate from manufacturing sites all emissions that adversely impact the environment
- **Closed loop**: Fully integrate products and processes in the recycling loop to conserve natural resources
- **Zero occupational injuries and illnesses**: Create a workplace free of occupational injuries and illnesses
- **Green energy**: Use energy in highly efficient ways at sites and increase use renewable energy

2.1.4 Conclusion:

In today's world the importance of recycling is becoming greater of a concern both for the general public and also to the economy. Recycling has become a major issue as scientific research has been suggesting for years that the earth is being depleted too fast to sustain a healthy balance. The earth's natural resources are being consumed at a rate that reinforces the idea that we are living for today and the future generations will be paying for the consequences. Recycling along with reducing consumption is our best means to counter the damage we have been doing to the earth for centuries. The importance of recycling is now held in such a high regard even famous people are taking up the plight. Al Gore is now on a mission to educate the world on the effects of global warming. He is also concerned about how we can reduce the causes of global warming. A major part reducing the warming is how we can recycle much of what we use instead of turning it into unusable waste. Recycling is incredibly important as a means to reduce poisonous emissions into the atmosphere and also to spare our natural resources. Today many companies and individuals are improving their recycling habits by coming up with ways to reduce what they use. They are also reusing much of the original materials sent out for consumer use. The importance of recycling is not only beneficial for the earth but also for businesses as they secure better relations with the consumers over the matter of saving the environment. They will also spend less on production costs and the consumers will pay less for the goods which will encourage more purchasing as their dollar will have more value on recycled products. People want to support companies that have a positive influence in society and that can be respected for reasons of morality. When companies and the consumers can work together they can combine the importance of recycling and truly make a difference to the Earth's health

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Chapter 2

INTEGRATED WASTE MANAGEMENT

2.2.1 Introduction:

Waste generation increases with population expansion and economic development. Improperly managed solid waste poses a risk to human health and the environment. Uncontrolled dumping and improper waste handling causes a variety of problems, including contaminating water, attracting insects and rodents, and increasing flooding due to blocked drainage canals or gullies. In addition, it may result in safety hazards from fires or explosions. Improper waste management also increases greenhouse gas (GHG) emissions, which contribute to climate change (for more information on climate change and the impacts from solid waste, see next page). Planning for and implementing a comprehensive program for waste collection, transport, and disposal—along with activities to prevent or recycle waste—can eliminate these problems.

Integrated Solid Waste Management (ISWM) is a comprehensive waste prevention, recycling, composting, and disposal program. An effective ISWM system considers how to prevent, recycle, and manage solid waste in ways that most effectively protect human health and the environment. ISWM involves evaluating local needs and conditions, and then selecting and combining the most appropriate waste management activities for those conditions. The major ISWM activities are waste prevention, recycling and composting, and combustion and disposal in properly designed, constructed, and managed landfills. Each of these activities requires careful planning, financing, collection, and transport.

Figure 1—Integrated Solid Waste Management

2.2.2 Steps for integrated waste management

2.2.2.1 Source Reduction: Waste prevention—also called “source reduction”—seeks to prevent waste from being generated. Waste prevention strategies include using less packaging, designing products to last longer, and reusing products and materials. Waste prevention helps reduce handling, treatment, and disposal costs and ultimately reduces the generation of methane.

2.2.2.2 Recycling and Composting: Recycling is a process that involves collecting, reprocessing, and/or recovering certain waste materials (e.g., glass, metal, and plastics, paper) to make new materials or products. Some recycled organic materials are rich in nutrients and can be used to improve soils. The conversion of waste materials into soil additives is called composting. Recycling and composting generate many environmental and economic benefits. For example, they create jobs and income, supply valuable raw materials to industry, and produce soil-enhancing compost, and reduce greenhouse gas emissions and the number of landfills and combustion facilities.

2.2.2.3 Disposal (land filling and combustion): These activities are used to manage waste that cannot be prevented or recycled. One way to dispose of waste is to place it in properly designed, constructed, and managed landfills, where it is safely contained. Another way to handle this waste is through combustion. Combustion is the controlled burning of waste, which helps reduce its volume. If the technology is available, properly designed, constructed, and managed landfills can be used to generate energy by recovering methane. Similarly, combustion facilities produce steam and water as a byproduct that can be used to generate energy.

2.2.3 Developing a Plan for Integrated Solid Waste Management

Planning is the first step in designing or improving a waste management system. Waste management planners should, for example, take into consideration institutional, social, financial, economic, technical, and environmental factors. These factors vary from place to place. Based on these factors, each community has the challenge of selecting the combination of waste management activities that best suits its needs. Because integrated solid waste management involves both short- and long-term choices, it is critical to set achievable goals. While developing your ISWM plan, you should identify goals or objectives (e.g., protect human health, protect water supplies, eliminate open dumping, increase recycling or composting). The ISWM plan will help guide you through the implementation process. Do not neglect to ask for the community’s input in developing your plan, so as to ensure an informed public and to increase public acceptance. Government plays an important role in developing and enforcing waste management standards, providing funding, and managing day-to-day Operations of solid waste management activities. Each level of government may have responsibility in your ISWM plan: national governments typically set standards for solid waste management; the state, provincial or regional governments may help monitor and enforce these standards; and local governments often play the primary role of managing solid waste activities on a daily basis. All levels may also provide funding for solid waste management activities. Two primary costs must be considered in any waste management system: initial capital costs (to purchase equipment or construct new facilities) and ongoing operations and maintenance costs. These costs can be funded in a number of ways including private equity, government loans, local taxes, or user's fees.

2.2.4 Implementing an Integrated Solid Waste Management Plan

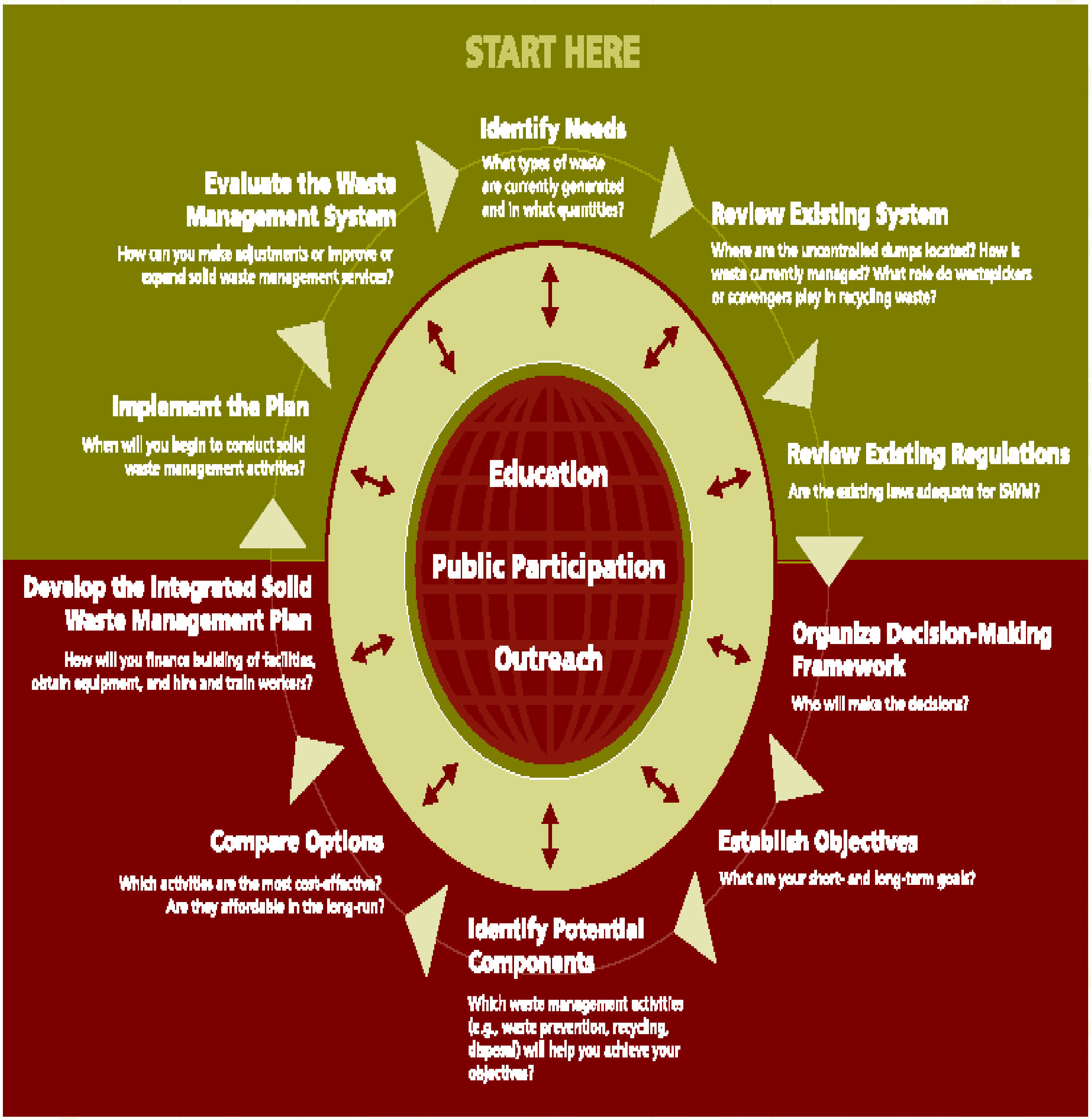
Once you have developed and written your solid waste management plan, you can begin to implement the various combinations of waste management activities. Implementing an ISWM plan is an ongoing process, so expect to make adjustments to the plan along the way. Always evaluate system inefficiencies and make adjustments to improve or expand solid waste management services. It is important to see how they fit into the comprehensive implementation process. Equally important, it emphasizes the need to provide public education and keep the community involved in every step of the process.

Table 1 - Important Questions to Consider and Steps to Take When Developing an Integrated Solid Waste Management Plan

FACTORS	QUESTIONS TO CONSIDER	STEPS TO TAKE
Institutional (laws and processes)	**Are existing laws and policies adequate to allow the government to properly implement ISWM?**	▪ Establish a national policy and pass laws on solid waste management standards and practices. ▪ Identify the roles and responsibilities of each level of government. ▪ Ensure the local government has the authority and resources to implement an ISWM plan.
Social (local customs and religious practices, public education)	**What types of waste does your community generate and how it is managed?**	▪ Encourage citizen participation in all phases of waste management planning to help gain community awareness, input, and acceptance.
Financial (funding)	**Where will you go to get funds for creating a solid waste management system?**	▪ Identify sources that can provide funding for solid waste management, including general revenues or user fees, the private sector, and government or international agency grants and loans.
Economic (costs and job creation)	**What will it cost to implement various waste management activities?**	▪ Calculate the initial capital investment requirements and long-term operating and maintenance costs associated with the various waste management activities. ▪ Evaluate the public's ability and willingness to pay. ▪ Evaluate activities based on effectiveness in handling waste and potential for job creation.
Technical (location and equipment)	**Where will you build collection and disposal facilities and what equipment will you need?**	▪ Include geological factors, transport distances, and projected waste generation in siting and design considerations. ▪ Determine what equipment and training will be necessary to perform the waste management tasks. (See *How To Establish Recycling and Composting Programs*, *What Are the Components of Waste Collection and Transport?*, and *What Are the Options for Waste Disposal?* fact sheets.)
Environmental (natural resources and human health)	**Will solid waste management activities (e.g., landfilling or combustion) affect the environment?**	▪ Establish procedures to verify the protection of groundwater and drinking water. ▪ Monitor compliance with the national standards to ensure human health risks are minimized.

Be flexible and creative when implementing your plan. If you are not making progress in a certain area, be prepared to reevaluate components of your plan. It is helpful to keep in mind the ultimate goal of ISWM: to improve human health and protect the environment.

Figure 2—Comprehensive Integrated Solid Waste Management Planning Process



2.2.5 Effective Solid waste management System:

The following steps can be taken into consideration for setting up an effective waste management system

1) Identify the types of waste
2) Identify the sources of waste
3) Determine the potential health hazards of the waste
4) Determine the volume generated
5) Identify collection methods
6) Identify transportation methods
7) Identify safe disposal methods

2.2.6 Key Components of solid waste management:

Solid waste management can be divided into five key components

a) Generation
b) Storage
c) Collection
d) Transportation
e) Disposal

2.2.6.1 Generation of solid waste: Generation of solid waste is the stage at which the material becomes useless to the owner and they no longer need it and want to get rid of it

2.2.6.2 Storage: is a system of keeping material after they have been discarded and prior to collection and disposal. Where onsite systems are implemented people can discard them directly

2.2.6.3 Collection:
The functional element of collection includes not only the gathering of solid waste and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be materials processing facility, a transfer station or a landfill disposal site.

2.2.6.4 Separation and processing and transformation of solid wastes:

The types of means and facilities that are now used for the recovery of waste materials that have been separated at the source include curbside collection, drop off and buy back centers. The separation and processing of wastes that have been separated at the source and the separation of commingled wastes usually occur at a materials recovery facility, transfer stations, combustion facilities and disposal sites.

2.2.6.5 Transfer and transport:

This element involves two steps:
i) The transfer of wastes from the smaller collection vehicle to the larger transport equipment
ii) The subsequent transport of the wastes, usually over long distances, to a processing or disposal site.

2.2.6.6 Disposal:

Today the disposal of wastes by land filling or land spreading is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from materials recovery facilities (MRFs), residue from the combustion of solid waste, compost or other substances from various solid waste processing facilities. A modern sanitary land is not a dump; it is an engineered facility used for disposing of solid wastes on land without creating nuisances or hazards to public health or safety, such as the breeding of rats and insects and the contamination of ground water.

2.2.7 Segregation of recyclable waste at source

In all parts of the country, people by and large do salvage re-usable or saleable material from waste and sell it for a price, e.g. newspaper, glass bottles, empty tins, plastic bags, old clothes etc., and to that extent such reusable / recyclable waste material is not thrown out for disposal. However, a lot of recyclable dry waste such as waste paper, plastic, broken glass, metal, packaging material etc., is not segregated and is thrown on the streets along with domestic / trade / institutional waste. Such waste is picked up to some extent by poor rag picker for their livelihood. At times they empty the dustbins and spread the contents around for effective sorting and collection. By throwing such recyclable material on the streets or into a common dustbin, the quality of recyclable material deteriorates as it gets soiled by wet waste, which often contains contaminated and hazardous waste.

Segregation of recyclable waste at source is thus not seriously practiced by households and establishments, who throw such waste on the streets or in the municipal bins unsegregated. At least 15% of the total waste can conveniently be segregated at source for recycling, which is being thrown on the streets in absence of the practice of segregation of waste at source. Part of this waste is picked up by rag-pickers in a soiled condition and sold to middle men at a low price, who in turn pass on the material to the recycling industry at a higher price after cleaning or segregation and the waste that remains uncollected finds its way to the dumping grounds.

2.2.8 Segregation of recyclable waste

It is essential to save the recyclable waste material from going to the waste processing and disposal sites and using up landfill space. Profitable use of such material could be made by salvaging it at source for recycling. This will save national resource and also save the cost and efforts to dispose of such waste. This can be done by forming a habit of keeping recyclable waste material separate from food waste and other bio-degradable wastes, in a separate bag or bin at the source of waste generation, by having a two-bin system for storage of waste at homes, shops and establishments where the domestic food waste (cooked and uncooked) goes into the Municipal system and recyclable waste can be handed over to the waste collectors (rag-pickers) at the door step.

2.2.8.1 The following measures may be taken by the local bodies towards the segregation of recyclable waste:

The local body may mobilize NGO's or co-operatives to take up the work of organizing street rag-pickers and convert them to door-step "waste collectors" by motivating them to stop picking up soiled and contaminated solid waste from the streets, bins or disposal sites and instead improve their lot by collecting recyclable clean material from the doorstep on daily basis. The local bodies may, considering the important role of rag pickers in reducing the waste and the cost to the local body in transportation of such waste, even consider extending financial help to NGO's and co-operatives in providing some tools and equipment to the rag pickers for efficient performance of their work in the informal sector.

The Local Bodies may actively associate resident associations, trade & industry associations, CBO's and NGO's in creating awareness among the people to segregate recyclable material at source and hand it over to a designated identified waste collector. The local body may give priority to the source segregation of recyclable waste by shops and establishments and later concentrate on segregation at the household level.

The upgraded rag-pickers on becoming door-step waste-collectors may be given an identity card by the NGO's organizing them so that they may have acceptability in society. The local body may notify such an arrangement made by he NGO's and advise the people to cooperate.

This arrangement could be made on "no payment on either side basis" or people may negotiate payment to such waste collectors for the doorstep service provided to sustain their efforts.

2.2.8.2 Transfer points

One of the most visible aspects of SWM is the transfer point, providing an interface between primary and secondary collection. These are often poorly designed, involving double handling of waste (once to unload tricycles, again to reload trucks) and unsanitary conditions where transfer points are not properly cleaned and used as public toilets.
Where waste generators carry their own waste, transfer points need to be located within easy walking distance (a good guide is ~ 50m) to discourage indiscriminate dumping. All transfer points and areas should be cleared daily and cleaned as necessary to prevent odours and keep rats and other disease vectors under control. They should also be designed to ensure minimum double handling. There are a number of approaches for achieving this, including 'ramp transfer points' which raise primary collection vehicles up to the loading level of demountable containers (photograph 3). Sometimes, however, space does not allow this. Another innovative solution is to use carts which carry a series of small containers that can be easily and safely lifted and emptied into containers.

2.2.8.3 Secondary collection:

Secondary collection entails the removal and transportation of waste from transfer points to processing and disposal facilities. This is often one of the most costly elements of SWM systems. Waste characterization study data will play an important part in planning secondary collection as it informs us how much waste requires collection, its weight and volume (affecting payloads), where it is located (affecting collection routes) and so on.
Basic improvements to secondary collection include optimizing the efficiency of collection routes, putting measures in place to ensure waste is dumped as intended (e.g. staff incentives), and covering waste during transportation. Increasingly, municipalities are choosing to contract secondary collection to private sector operators. This can ease over-stretched municipal budgets, remove the headache of managing transport fleets, and result in a more efficient and accountable service

Solid waste is usually transported in open trucks, compaction vehicles m tractor-trailer. These vehicles are normally owned and maintained by municipal authorities.

Chapter 3

MUNICIPAL SOLID WASTE DISPOSAL

The prevailing technologies available in India are unscientific land filling, open burning and composting. The waste is generally bought to a designated landfill on the outskirt of the cities and the choice of a site is more a matter of availability than what is suitable. Only a few cities follow such good practices but in small towns and cities the waste is dumped in ponds, banks of river

The various methods for the disposal of waste include

a) Sanitary landfill
b) Incineration
c) Composting

2.3.1 Sanitary Landfill:

Sanitary landfills are the most common waste management technology. All MSW management technologies addressed in this report require landfills for their residues, and the amount of that residue is affected by the technologies used to extract materials and energy from the waste. Even recycling requires landfills to dispose of: the impurities separated in materials recovery facilities (MRF) or later at smelters (i.e., slag); paper sludge containing fiber that is too short for reuse; fillers and inks; or small pieces of mixed-color glass. In general, recycling delays and/or reduces requirements for land disposal rather than eliminating them.

Most of the landfills in developing countries do not have any liner at the base, or a drainage layer or a proper top cover, which results in the potential problem of groundwater/surface water contamination due to the leachate. Hence, to decide whether the leachate is to be collected and treated, or may be allowed to discharge into the adjoining soil or public sewer or surface water body, it is essential to have an estimate of the amount of leachate and, more importantly, the composition and strength of the leachate and variation of leachate contaminants with time as the landfill site develops.

Improper disposal of Municipal Solid Waste (here after referred to MSW) into landfills not only creates a conducive environment for pests like flies, rats and others but also pollutes the ecosystem with the release of leachate. This study was conducted to analyze leachate characteristics and compare pollution intensity among three landfills of different level of urbanization namely urban landfill, sub-urban landfill and rural landfill. Leachate The concentration of metals, particularly Mg, was high which requires a proper wastewater treatment plant to be installed in order to prevent euthrophication in water bodies. Physical and chemical treatment would be the best option to reduce the pollution impact to the environment due to the low BOD to COD ratio (0.004 to 0.13) and the high metal content in the leachate.

2.3.1.1 Landfill Design Approach:

Landfills are to be designed to minimize environmental impact and risk and to ensure compliance with the Performance Criteria. In order to do this, the design must be based on a sound knowledge of the environmental setting including climate, surface and subsurface drainage, geology, groundwater, ecology as well as economic and social factors and must be carried out by qualified professionals.

2.3.1.2 Natural Control Landfills :

The following criteria apply to "natural control" landfills which do not rely on leachate containment/collection/disposal systems: The bottom-most solid waste cell is to be 1.2 meters above the seasonal high water table. Greater or lesser separation depths may be approved based on soil permeability and the leachate renovation capability of the soil. There is to be at least a 2 meters thick layer of low permeability soil with a hydraulic conductivity of 1 x 10-6 cm/s or less (i.e. silt or clay), below each of the bottom-most waste cells. Lesser thicknesses or no layer of low permeability soil may be approved based on the potential for leachate generation and the unsaturated depth, permeability and leachate renovation capability of the existing soil.

2.3.1.3 Engineered Landfills:

The following criteria apply to "engineered" landfills which have leachate containment/collection/disposal systems:

The minimum liner specification for leachate containment systems is a 1 metre thick, compacted soil liner with a hydraulic conductivity of 1 x 10-7 cm/s or less. Minimum bottom slopes of the liner are to be 2 percent on controlling slopes and 0.5 percent on the remaining slopes. Natural, in- situ, low permeability soils, geomembranes, or composite liners (consisting of a geomembrane and a soil layer) which provide the same level of leachate containment are acceptable equivalents. Liners with higher hydraulic conductivities may be approved depending on the leachate generation potential and the unsaturated depth, permeability and leachate renovation capability of the existing soil.

Minimum specifications for leachate collection systems are a 0.3 metre thick sand drainage layer having a hydraulic conductivity of 1 x 10-2 cm/s or greater. Synthetic

drainage nets which provide an equivalent hydraulic conductivity are an acceptable alternative.
If there is any concern for the precipitation of leachate constituents causing a plugging problem, the leachate collection system is to be designed to prevent such precipitation from occurring. The drainage layer is to be designed with appropriate grades and collection piping so that the leachate hydraulic head on the liner does not exceed 0.3 meter at any time.

2.3.2 Incineration:

Municipal solid waste (MSW) incineration plants tend to be among the most expensive solid waste management options, and they require highly skilled personnel and careful maintenance. For these reasons, incineration tends to be a good choice only when other, simpler, and less expensive choices are not available. Because MSW plants are capital-intensive and require high maintenance costs and comparatively higher technically trained operators, they are commonly adopted by developed countries. However, high capital

And maintenance costs may make MSW incineration beyond the reach of many of the lesser developing countries.. Incineration provides the best way to eliminate methane gas emissions from waste management processes. Furthermore, energy from waste projects provides a substitute for fossil fuel Combustion.

These are two ways incineration helps reduce greenhouse gas emissions. One of the most attractive features of the incineration process is that it can be used to reduce the original volume of combustibles by 80 to 95 percent. Air pollution control remains a major problem in the implementation of incineration of solid waste disposal.

2.3.2.1 Incineration Advantages:

Incineration is an efficient way to reduce the waste volume and demand for landfill space. Incineration plants can be located close to the center of gravity of waste generation, thus reducing the cost of waste transportation. Using the ash from MSW incinerators for environmentally appropriate construction not only provides a low cost aggregate but also further reduces the need for landfill capacity. In particular, incineration of waste containing heavy metals and so on should be avoided to maintain a suitable slag quality. (However, ordinary household waste does contain small amounts of heavy metals which do not readily leach under field conditions.) The slag quality should be verified before it is used. Energy can be recovered for heat or power consumption.

2.3.2.2 Incineration Disadvantages

An incineration plant involves heavy investments and high operating costs and requires both local and foreign currency throughout its operation. The resulting increase in waste treatment costs will motivate the waste generators to seek alternatives. Furthermore, waste incineration is only applicable if certain requirements are met. The composition of waste in developing countries is often questionable in terms of its suitability for auto combustion. The complexity of an incineration plant requires skilled staff. Plus, the residues from the flue gas cleaning can contaminate the environment if not handled appropriately, and must be disposed of in controlled and well-operated landfills to prevent ground and surface water pollution.

2.3.2.3 Applicability of Incineration

MSW incineration projects are immediately applicable only if the following overall criteria are fulfilled.

A high degree of interaction, either through ownership or long-term agreements, between the different parts of the waste management system and the waste incineration plant is important to avoid environmental, institutional, or financial imbalances in the overall solid waste management system.

2.3.3 Biodegradable waste

The organic component of the waste is often called the wet waste .Some useful technologies are described below

2.3.3.1 Composting

Composting is the purposeful biodegradation of organic matter, such as yard and food waste. The decomposition is performed by micro-organisms, mostly bacteria, but also yeasts and fungi. In low temperature phases a number of macro-organisms, such as springtails, ants, nematodes, isopods and earthworms also contribute to the process, as well as soldier fly, fruit flies and fungus gnats. There is a wide range of organisms in the decomposer community

A biodegradable material is capable of being completely broken down under the action of microorganisms into carbon dioxide, water and biomass. It may take a very long time for some material to biodegrade depending on its environment (e.g. wood in an arid area versus paper in water), but it ultimately breaks down completely. Many contaminating materials not dealt with in common composting are in fact "biodegrade able", and may be dealt with via bioremediation, or other special composting approaches

A compostable material biodegrades substantially under specific composting conditions. It is metabolized by the microorganisms, being incorporated into the organisms or converted into humus. The size of the material is a factor in determining compost ability, and mechanical particle size reduction can speed the process. Large pieces of hardwood may not be compostable under a specific set of composting conditions, whereas sawdust of the same type of wood may be. Some biodegrade able materials are only compostable under very specific conditions, usually with an industrial process.

2.3.3.2 Importance of composting

Composting organic kitchen and yard waste and manures into an extremely useful humus-like, soil end product, permitting the return of vital organic matter, nutrients, and particularly bacteria, that are vital to plant nutrition to the soil. Managed aerobic composting arranges environmental conditions so they are optimal for the natural processes to take place. There is a popular expression: "compost happens", but it is helpful to engineer the best possible circumstances for large amounts of organic waste to decompose quickly and efficiently, with the greatest conservation of useful nutrients and mass. Uncontrolled composting is when compost "happens", and although that may be functional in some circumstances, as with forest floor detritus, a neglected heap of kitchen and yard wastes will more likely result in "smells happen", or "rodents happen" long before useful compost does.

Chapter 4

TYPES OF COMPOSTING

2.4.1 Anaerobic decomposition:

Composting without oxygen results in fermentation. This causes organic compounds to break down by the action of living anaerobic organisms. As in the aerobic process, these organisms use nitrogen, phosphorus, and other nutrients in developing cell protoplasm. However, unlike aerobic decomposition, this reduces organic nitrogen to organic acids and ammonia. Carbon from organic compounds is released mainly as methane gas (CH_4). A small portion of carbon may be respired as CO_2.

This anaerobic process takes place in nature. Examples include decomposing organic mud at the bottom of marshes and buried organic materials with no access to oxygen. Marsh gas is largely methane. Intensive reduction of organic matter by putrefaction is usually accompanied by unpleasant odors of hydrogen sulfide and of reduced organic compounds that contain sulfur, such as mercaptans (any sulfur-containing organic compound).

Since anaerobic destruction of organic matter is a reduction process, the final product, humus, is subject to some aerobic oxidation. This oxidation is minor, takes place rapidly, and is of no consequence in the utilization of the material.

There is enough heat energy liberated in the process to raise the temperature of the putrefying material. In the anaerobic dissolution of the glucose molecule, only about 26 kcal of potential energy per gram of glucose molecules is released compared to 484 to 674 kcal for aerobic decomposition. The energy of the carbon is in the released methane (CH_4). The conversion of CH_4 to CO_2 produces large amounts of heat. This energy from anaerobic decomposition of organic matter can be used in engines for power and burned for heat.

Pathogens could cause problems in anaerobic composting because there is not enough heat to destroy them. However, aerobic composting does create high enough temperatures. Although heat does not play a part in the destruction of pathogenic organisms in anaerobic composting, they do disappear in the organic mass because of the unfavorable environment and biological antagonisms. They disappear slowly. The composted material must be held for periods of six months to a year to ensure relatively complete destruction of Ascaris eggs, for example. Ascaris are nematode worms that can infest the intestines. They are the most resistant of the fecal-borne disease parasites in wastes.

Anaerobic composting may be accomplished in large, well packed stacks or other composting systems. These should contain 40% to 75% moisture, into which little oxygen can penetrate, or 80% to 99% moisture so that the organic material is a suspension in the liquid. When materials are composted anaerobically, the odor nuisance may be quite severe. However, if the material is kept submerged in water, gases dissolve in the water and are usually released slowly into the atmosphere. If the water is replaced from time to time when removing some of the material, odor does not become a serious nuisance.

2.4.2 Aerobic Decomposition

Organic material decomposing with oxygen is an "aerobic" process. When living organisms that use oxygen feed upon organic matter, they develop cell protoplasm from the nitrogen, phosphorus, some of the carbon, and other required nutrients. Carbon serves as a source of energy for organisms and is burned up and respired as carbon dioxide (CO2). Since carbon serves both as a source of energy and as an element in the cell protoplasm, much more carbon than nitrogen is needed. Generally, organisms respire about two-thirds of the carbon they consume as CO2, while the other third is combined with nitrogen in the living cells.

Biological activity diminishes if the compost mix contains too much carbon in relation to nitrogen. Several cycles of organisms are required to burn excess carbon. This is a complex chemical process. When organisms die, their stored nitrogen and carbon become available to other organisms. These new organisms form new cells which again need nitrogen to burn excess carbon and produce CO2. Thus, the amount of carbon is reduced and the limited amount of nitrogen is recycled. Finally, when the ratio of available carbon to available nitrogen is low enough, nitrogen is released as ammonia. Under favorable conditions, some ammonia may oxidize to nitrates. Phosphorus, potash, and various micronutrients are also essential for biological growth. These are normally present in more than adequate amounts in compostable materials.

In nature, the aerobic process is most common in areas such as the forest floor, where droppings from trees and animals are converted into relatively stable organic matter. This decomposition doesn't smell when adequate oxygen is present. We can try to imitate these natural systems when we plan and maintain our landscapes. As we learn more about the biology and chemistry of composting, we can actually hasten the decomposition process.

When carbon is oxidized to CO2, a great deal of energy is released as heat. For example, if a gram of glucose molecules is dissimilated under aerobic conditions, 484 to 674 kilogram calories (kcal) of heat may be released. If organic material is in a large enough pile or arranged to provide some insulation, temperatures during decomposition may rise to over 170° F. At temperatures above 160° F, however, the bacterial activity decreases.

There are many different kinds of bacteria at work in the compost pile. Each type needs specific conditions and the right kind of organic material. Some bacteria can even decompose organic material at temperatures below freezing. These are called psychrophilic bacteria, and although they work best at around 55°, they continue to work down to 0° F. As they work, they give off small amounts of heat. If conditions are right, this heat will be enough to set the stage for the next group of bacteria, the “mesophylic,” or middle range temperature bacteria.

Mesophylic bacteria thrive from 70° to 90° F, but just survive at temperatures above and below (40° to 70° F, and 90° to 110° F) In many backyard piles, these mid range bacteria do most of the work. However, if conditions are right, they produce enough heat to activate the “thermophilic,” or heat loving bacteria. Thermophilic bacteria work fast. Their optimum temperature range is from 104° to 160° F.

High temperatures destroy pathogenic bacteria and protozoa (microscopic one celled animals), and weed seeds, which are detrimental to health and agriculture when the final compost is used on the land.

Aerobic oxidation does not stink. If odors are present, either the process is not entirely aerobic or there are materials present, arising from other sources than the oxidation, which have an odor. Aerobic decomposition or composting can be accomplished in pits, bins, stacks, or piles, if adequate oxygen is provided. To maintain aerobic conditions, it is necessary to add oxygen by turning the pile occasionally or by some other method.

2.4.3 Manure Pit

Description: Composting is carried out in a simple manure pit or garbage pit (lined or unlined).In this process aerobic microorganisms oxidize organic compounds to carbon-dioxide and oxides of nitrogen and carbon from organic compounds is used as a source of energy, while nitrogen is recycled. As discussed above, in the composting process, due to exothermic reactions, temperature of mass rises. In areas/regions with higher rainfall composting in over ground heaps is advisable.
The factors affecting the composting process are: (a) Micro-organisms; (b) Moisture, (c) Temperature and (d) Carbon/Nitrogen (C/N) ratio

2.4.3.1 Household Level Composting

At each household, two manure pits should be dug. The size of the pit will depend upon the quantity of refuse to be disposed of per day. Each day the garbage, cattle dung, straw, plant and agriculture wastes are dumped into the manure pit. When one pit is closed the other one is used. In 5 to 6 months time, the refuse is converted into manure, which can be used in the fields. This is the most effective and simplest method of disposal of waste for the rural households. Cow dung can also be disposed of easily by this method. Mixing of cow dung slurry with the garbage will help greatly in converting the refuse into compost, which provides good manure.
Household level composting pits may be constructed by adopting either lined or unlined pits as shown above.

2.4.3.2 Underground lined manure pit or garbage pit

Applicability:
• Rural areas with low rainfall
• Houses with an open space of about 7 square m
• Houses with no cattle or with a single cattle.

Action:
House owner can make this pit with little technical know how.

Description:
- Dig two pits of 1m x 1m x 1m dimension
- Give a single layer of broken bricks at the bottom
- Make a ridge with the help of mud at the periphery of the pit & compact it by light ramming.

Use and maintenance of the pit
- Go on adding garbage from the house over the layer of bricks (only biodegradable type)
- When the garbage attains a height of about 150mm, add dung slurry, mix it with garbage & level it
- Spread a very thin layer of soil over it (once a week) to avoid odour & fly nuisance
- Continue to add garbage everyday
- Follow the above procedure & repeat the layers till the pit is full. It is recommended to fill the pit up to about 300mm above ground level
- After 3-4 days the garbage above ground settles down
- Plaster it with soil
- Leave the pit as it is for 3-6 months for maturation
- After 3-6 months take out the compost & use it in the fields

- Till the manure in the pit matures, use another pit of the same dimensions, dug at a minimum distance of 1m from the first pit.

Cost: Manual labour (2 man days) to dig the pit

Limitations: Not suitable for heavy rainfall areas and rocky terrain.

2.4.3.3 Underground brick lined manure pit or garbage pit

Applicability:
- Rural areas with low rainfall
- Houses with an open space of about 7 square m
- Houses with no cattle or with a single cattle
- Loose soil structure.

Action:
House owner can make this pit with little technical know how.

Description:
- Dig two pits of 1.1m dia & 1m depth
- Construct a circular pit having an inner diameter of 1m, in honey comb 100mm thick brick masonry. The height of the circular pit should be 100mm above ground
- Plaster the top layer of the pit
- The bottom of the pit should not be cemented.
- Use and maintenance of the pit
- Go on adding garbage from the house
- over the layer of bricks (only biodegradable type)
- When the garbage attains a height of about 150mm, add dung slurry, mix it with garbage & level it
- Spread a very thin layer of soil over it (once a week) to avoid odour & fly nuisance
- Continue to add garbage everyday
- Follow the above procedure & repeat the layers till the pit is full. It is recommended to fill the pit up to about 300mm above ground level
- After 3-4 days, the garbage above ground settles down
- Plaster it with soil
- Leave the pit as it is for 3-6 months for maturation
- After 3-6 months take out the compost & use it in the fields
- Till the manure in the pit matures, use another pit of the same dimensions, dug at a minimum distance of 1m from the first pit.

Cost:
Approximately 200 bricks, 1/3 bag cement, 3 cft sand, one man day unskilled and 1/2 man day skilled labour. Approximate cost Rs 600 per pit.

Limitations:
- Not suitable for heavy rainfall areas and
- rocky terrain.

2.4.3.4 Over ground heap

Applicability:
- Rural areas with high rainfall and rocky terrain
- Houses with an open space of about 7 square m
- Houses with no cattle or with a single cattle.

Action:
House owner can make this heap with little technical know how.

Description:
Make a raised platform of 1m x 1m dimension at a suitable site by ramming the soil or by paving with bricks.

Use and maintenance of the heap
- Go on adding garbage from the house over the platform (only biodegradable type)
- When the garbage attains a height of about 150mm, add dung slurry, mix it with garbage
- Spread a very thin layer of soil over it (once a week) to avoid odour & fly nuisance
- Continue to add garbage everyday
- Follow the above procedure & repeat the layers till the heap attains the height of 1m
- After 3-4 days the garbage above ground settles down
- Plaster it with soil
- Leave the heap as it is for 3-6 months for maturation
- After 3-6 months take out the compost & use it in the fields
- Till the manure in the heap matures, make another heap of the same dimensions at a minimum distance of 1m from the first heap.

Cost:
Manual labour (2 man days) to dig the pit.

2.4.3.5 Over ground brick lined compost tank

Applicability:

- Rural areas with high rainfall and rocky terrain
- Houses with an open space of about 7 square m
- Houses with no cattle or with single cattle.

Action:

House owner can make this with little technical know how.

Description:

- Make two compost tanks of 1.1m dia &
- 1m height
- Construct a circular/square tank having an inner dimension of 1 m, in honey comb 225mm thick brick masonry. The height of the tank should be 0.8m above ground
- Plaster the top layer of the tank.

Use and maintenance of the tank

- Go on adding garbage from the house over the platform in the tank (only biodegradable type)
- When the garbage attains a height of about 150mm, add dung slurry, mix it with garbage
- Spread a very thin layer of soil over it (once a week) to avoid odour & fly nuisance
- Continue to add garbage everyday
- Follow the above procedure & repeat the layers till the heap attains the height of 1m
- After 3-4 days the garbage above ground settles down
- Plaster it with soil
- Leave the heap as it is for 3-6 months for maturation
- After 3-6 months take out the compost & use it in the fields
- Till the manure in the tank matures, make another tank of the same dimensions at a minimum distance of 1m from the first tank.

Cost:

Approximately 400 bricks, 1/2 bag cement, 5 cft sand, and one man-day unskilled and 1/2 man-day skilled labor. Approximate cost Rs 900 per tank.

2.4.3.6 Community level composting

Community level composting may be resorted to when management of solid waste at household level is not possible. For community level composting, Panchayat should select a suitable site as Compost Yard for the village. Site should be selected taking into consideration wind flow direction, so that the inhabited areas don't get any foul odour. The site should be easily accessible for transportation of waste and manure. It should not be a low lying area to avoid water logging.

<u>Size of the pit:</u> Depth of the pit should not be more than 1 meter and width should not exceed 1.5 meter. Length of the pit may go up to 3 meter. In the pit, waste takes about 4-6 months to compost. Hence, adequate number of pits will be required. Distance between two pits should be more than 1.5 meter. While digging pits, care should be taken to ensure that there is adequate facility to transport the garbage and store the manure.

<u>Action</u>
The construction of composting pit or heap is very simple and user friendly. Gram Panchayat (GP) can easily construct compost pit with little technical support from outside.

2.4.3.7 Underground unlined manure pit or garbage pit

<u>Applicability:</u>

- Rural areas with low rainfall
- Villages where there is lack of space at household level for composting.

<u>Description:</u>

- Dig adequate number of pits of not more than 1m (depth) x 1.5m (width) x 3m (length) dimension depending upon quantum of garbage generated
- Make a ridge with the help of soil at the periphery of the pit & compact it by light ramming.

<u>Use and maintenance of the pits</u>

- Go on adding collected garbage in the pits (only biodegradable type)
- Wherever possible, it is advisable to add cow dung slurry to the garbage to enhance the composting process
- Spread a very thin layer of soil over it
- (once a week) to avoid odour & fly nuisance
- Continue to add garbage everyday

- Follow the above procedure & repeat the layers till the pit is full. It is recommended to fill the pit up to about 300mm above ground level
- After 3-4 days the garbage above ground settles down
- Plaster it with soil
- Leave the pit as it is for 3-6 months for maturation and start other pits sequentially
- After 3-6 months take out the compost & use it in the fields.

Cost:
Manual labour (3 man days) to dig one pit.

Limitations:
Not suitable for heavy rainfall areas and rocky terrain.

2.4.3.8 Underground brick lined manure pit or garbage pit

Applicability:

- Rural areas with low rainfall
- Villages where there is lack of space at household level for composting.

Action:
Gram Panchayat can make these pits with little technical know how.

Description:

- Dig adequate number of pits of not more than 1m (depth) x 1.5m (width) x 3m (length) dimension depending upon quantum of garbage generated
- Construct rectangular pits having inner dimensions of 1m x 1.5m x 3m in honey comb 225mm thick brick masonry. The height of the pit should be 100mm above ground
- Plaster the top layer of the pit
- The bottom of the pit should not be cemented.

Use and maintenance of the pit

- Go on adding collected garbage from the houses in the pits (only biodegradable type)
- Wherever possible, it is advisable to add cow dung slurry to the garbage to enhance the composting process
- Spread a very thin layer of soil over it (once a week) to avoid odour & fly nuisance Continue to add garbage everyday
- Follow the above procedure & repeat the layers till the pit is full. It is recommended to fill the pit up to about 300mm above ground level
- After 3-4 days the garbage above ground settles down
- Plaster it with soil

- Leave the pit as it is for 3-6 months for maturation and start other pits sequentially
- After 3-6 months take out the compost & use it in the fields.

Cost:
Approximately 1200 bricks, 3 bags cement,
20 cft sand, 3 man day unskilled and 2 man days skilled labour. Approximate cost Rs 4000-5000 per pit.

Limitations:
- Not suitable for heavy rainfall areas and rocky terrain
- Capital intensive option

2.4.3.9 Over ground heap

Applicability:
- Rural areas with high rainfall and rocky terrain
- Villages where there is lack of space at household level for composting.

Action:
Gram Panchayat can make these heaps with little technical know how.

Description:
- Make a raised platform of 1.5m x 3m dimension at a suitable site by ramming the soil or by paving with bricks.

Use and maintenance of the heap
- Go on adding garbage collected from the houses over the platform (only biodegradable type)
- Wherever possible, it is advisable to add cow dung slurry to the garbage to enhance the composting process
- Spread a very thin layer of soil over it (once a week) to avoid odour & fly nuisance
- Continue to add garbage everyday
- The heaps should be sprinkled with water periodically to maintain the moisture level
- Follow the above procedure & repeat the layers till the heap attains the height of 0.8m
- After 3-4 days the garbage above ground settles down
- Plaster it with soil
- Leave the heap as it is for 3-6 months for maturation and start another heap
- After 3-6 months take out the compost & use it in the fields
- Till the manure in the heap matures, make another heap of the same dimensions at a minimum distance of 1m from the first heap.

Cost:
Manual labour (1 man day of unskilled labour) per heap.

2.4.3.10 Over ground brick lined compost tank

Applicability
- Rural areas with high rainfall and rocky terrain
- Villages where there is lack of space at household level for composting.

Action:
Gram Panchayat can make these tanks with little technical know how.

Description:
- Make adequate number of compost tanks of dimension 0.8m height, 1.5m width and 3m length in honey comb 225mm thick brick masonry
- Plaster the top layer of the tank.

Use and maintenance of the tank
- Go on adding collected garbage from the houses in the tank (only biodegradable type)
- Wherever possible, it is advisable to add cow dung slurry to the garbage to enhance the composting process
- Spread a very thin (1-2 inch) layer of soil over it (once a week) to avoid odour & fly nuisance
- Continue to add garbage everyday
- Follow the above procedure & repeat the layers till the heap attains the height of 1m After 3-4 days the garbage above ground settles down
- Plaster it with soil
- Leave the heap as it is for 3-6 months for maturation
- After 3-6 months take out the compost & use it in the fields
- Till the manure in the tank matures,make another tank of the same dimensions at a minimum distance of 1m from the first tank.

Cost:
Approximately 1200 bricks, 3 bags cement, 20ft sand, 3 man day unskilled and 2 man days skilled labour. Approximate cost Rs 4000-5000 per pit

2.4.4 Vermicomposting

Vermicompost, or Vcompost, is the heterogenous mixture of decomposing vegetable or food waste, bedding materials, and pure vermicast produced during the course of normal vermiculture operations. Vermicast, similarly known as worm castings, worm humus or worm manure, is the end-product of the breakdown of organic matter by some species of earthworm.

Containing water-soluble nutrients and bacteria, vermicompost is an excellent, nutrient-rich organic fertilizer and soil conditioner. The process of producing vermicompost is called vermicomposting

The earthworm species (or composting worms) most often used are
Red Wigglers (Eisenia foetida or Eisenia andrei), but European nightcrawlers (Eisenia hortensis) may also be used. European nightcrawlers are called by a variety of other names, including dendrobaenas, dendras, and Belgian nightcrawlers.

Blueworms (Perionyx excavatus) may be used in the tropics
These species are commonly found in organic-rich soils throughout Europe and North America and live in rotting vegetation, compost, and manure piles. They may be invasive species in some areas. As they are shallow-dwelling and feed on decomposing plant matter in the soil, they adapt easily to living on food or plant waste in the confines of a worm bin.

Composting worms are available to order online, from nursery mail-order suppliers or angling (fishing) shops where they are sold as bait. They can also be collected from compost and manure piles. These species are not the same worms that are found in ordinary soil or on pavement when the soil is flooded by water.

2.4.4.1 Chemical analysis of earthworm casting

Casting source	**Total nitrogen (%)**	**Nitrate**	**Total phosphorus (P)**	**Water soluble (P)**	**Total potassium**	**Water soluble potassium**
Soil	0.18	0.40	732	6.00	84.00	4.00
Cattle dung + Soil	0.38	25.00	521	2.00	37.21	88.00

2.4.4.2 Harvesting

Worms in a bin being harvested Vermicompost is ready for harvest when it contains few-to-no scraps of uneaten food or bedding. There are several methods of harvesting from small-scale systems: "dump and hand sort", "let the worms do the sorting", "alternate containers" and "divide and dump." These differ on the amount of time and labor involved and whether the vermicompost wants to save as many worms as possible from being trapped in the harvested compost.

While harvesting, it's also a good idea to try to pick out as many eggs/cocoons as possible and return them to the bin. Eggs are small, lemon-shaped yellowish things that can usually be picked out pretty easily with the naked eye

2.4.4.2.1 Benefits:

Soil

- Improves its physical structure
- Enriches soil with micro-organisms (adding enzymes such as phosphatase and cellulase)
- Microbial activity in worm castings is 10 to 20 times higher than in the soil and organic matter that the worm ingests
- Attracts deep-burrowing earthworms already present in the soil
- Improves water holding capacity

Plant growth

- Enhances germination, plant growth, and crop yield
- Improves root growth and structure
- Enriches soil with micro-organisms (adding plant hormones such as auxins and gibberellic acid

Economic

- Biowastes conversion reduces waste flow to landfills
- Elimination of biowastes from the waste stream reduces contamination of other recyclables collected in a single bin (a common problem in communities practicing single-stream recycling

Creates low-skill jobs at local level

Low capital investment and relatively simple technologies make vermicomposting practical for less-developed agricultural regions

Environmental

Helps to close the "metabolic gap" through recycling waste on-site

Large systems often use temperature control and mechanized harvesting, however other equipment is relatively simple and does not wear out quickly

Production reduces greenhouse gas emissions such as methane and nitric oxide (produced in landfills or incinerators when not composted or through methane harvest.

Vermi composting may be done using compost beds as well as tanks at both **household and community levels**.

Advantages

- Conversion of cattle dung and cattle dung based biogas slurry, kitchen/food waste, leaves etc (organic solid waste) into high quality organic manure which are otherwise wasted It is a fast process which requires only 40-45 days as compared to the conventional process
- The process is free from foul odour
- Complete destruction of weed seeds
- Vermicompost contains plant growth hormones and anti fungula elements which leads to high value addition and profitability
- Prevents vector breeding
- Prevents insanitary conditions
- The technology is simple and it is easy to adopt and replicate
- Requires very little land area.

Applicability

In household, community and mini commercial scale

Action

Construction of vermicompost pit as well as vermi tank is extremely simple and can be done by individual and masons available in rural areas. The process of vermi composting starts with collection of solid waste from individual houses and community and segregation of the waste, either at the household level or at the community level. The segregated bio degradable (organic) waste is to be used as feed material to vermicompost pit/tank.

2.4.4.3 Vermicomposting at Community Level

The steps to be followed for vermicomposting at community level are:

Initial steps

- Appropriate site selection: the site should be protected from direct sunlight and should not be in low lying areas
- Vermiculture site preparation; Proper ramming of soil or preparation of platform is required before preparation of vermicompost beds
- Construction of appropriate shed: thatched roof/tin sheds on bamboo/metal poles with proper slope to drain rain water, and proper ventilation
- The biodegradable waste should be predigested in a separate bed before transferring to the treatment beds.

2.4.4.3.1 Vermiculture bed preparation steps

- Make a basic bed of size 24 cft (L=8ft,B=3ft, Ht =1ft) with one brick (9 inch x 4 inch x 3 inch) size containment all round the bed

- Alternatively, brick tanks of same dimensions having 2 feet height may be constructed. With this worms will not escape to the surroundings. The worms are also protected from natural enemies. The tank may be easily covered with a wire mesh
- Apply a layer of cow dung slurry on the base
- Put one inch sand on the cow dung slurry plastered bed
- Followed by putting 2 inch thick organic waste
- Put 9 inch thick feeding material (cow dung/biodegradable organic matter such as leaves, kitchen waste) for earthworms in the ratio of raw cow dung: organic waste = 1:5.

2.4.4.3.2 Process

Step 1: Transfer the pre digested material in heaps to the vermin compost beds

Step 2: Apply about 100gm of earthworms for every square feet of surface area of the compost bed.

Step 3: Cover the entire bed immediately with gunny bags to reduce light penetration and create dark environment and maintain required moisture content in the feed bed for better performance of the earthworms for digestion of the feed material.

Step 4: To maintain moisture, sprinkle water on alternate day/every day in summer and 3 to 4 days intervals/twice a week in winter.

Step 5: After 1 month of introducing the earthworms, remove the gunny bags and keep the heaps open to air for a day, collect the top 2 inch layer of earthworm compost by slow & smooth scrapping of the top layer of the compost bed till you observe the earthworms. When you see earthworms, stop scrapping; this is done to send the earthworms down into feeding materials in the feed bed.

Step 6: Screen the harvested vermi compost through an appropriate sieve and reintroduce the course material as well as separated earthworms to the empty treatment beds.

Step 7: Again add the predigested material in the bed and repeat the process.

2.4.4.3.3 Precautions to be taken

- Proper covering of feed bed (local
- available materials such as coconut leaves etc may be used for covering of the vermicompost pit)
- Avoid excess water (only sprinkling)

- Protect the shed area and the beds from red ants, cockroaches etc. by using haldi (turmeric) sprinkling atta (flour) all around the perimeter of the shed and the bed
- Keep the feed beds away from birds/chicken/ducks/rodents from eating the worms.

2.4.4.4 Vermitank at Community Level

Vermitank is a specialized unit constructed in brick masonry, capable of converting biodegradable solid waste into high quality organic manure in a short period. It is very easy to operate & maintain.

2.4.4.4.1 Salient features of vermitank

- Fast process: It takes only 40-45 days for the conversion of garbage as compared to the conventional methods which require about 4-6 months.
- Zero pollution: Vermicompost made in closed vermitanks is completely free of pollution of air, water & soil.
- Freedom from foul odour: The process does not emit any foul odour; hence the vermitanks can be constructed in the vicinity of houses.
- Protection from natural enemies: Vermitank is designed to render full protection to earthworms from natural enemies like rodents & big ants.
- No predecomposition of garbage: For 2-4 compartments vermitank, no predecomposition of garbage is required as in case of vermi beds.
- Organic manure: The process converts garbage into rich organic manure, which can either be used in gardens, or it can be sold at attractive prices.
- Economic potential: 1kg of biodegradable garbage can produce about 0.40kg of vermin compost.

Vermi tank is most suitable for following places:
- Individual house
- Small communities
- Public buildings (such as Zilla Parishad office, food establishment, Gaushala, Primary Health Center, BDO office etc.)
- Institutions (schools, colleges etc.)
- Gardens
- Temples

2.4.4.4.2 Operation of vermitank
Vermitank has four pits, which are interconnected by partition walls constructed in honeycomb masonry. The four pits are to be used one by one in a cyclic manner. Each pit has a capacity to accommodate garbage for 15 days. Thus the total duration of one cycle is nearly 60 days. When the fourth pit is full, the vermicompost in the first one is ready for harvesting.

2.4.4.4.3 Feeding material:

- Quantity: 25 to 30kg per day
- Nature of garbage: Agro-waste, garden waste, floral waste (from temples), kitchen waste etc
- Additional feeding material required: cow dung: minimum 15 to 20kg per week
- Earthworms required: 1kg (1000 to 1200 live worms) for initial commissioning only
- Species of earthworms recommended:
- Eisenia foetida and 2. Eudrilus euginiae.

Particulars	Garbage fed per day	Vermicompost produced per month	Rate per kg (approx)	Cost of vermicompost per month (approx)	Cost of vermicompost per annum (approx)
Community vermin tank	25 to 30kg	250 to 300kg	Rs 3 to 5 per kg	Rs 750 to 1500	Rs 9000 to 18000

2.4.4.5 Commissioning of vermitank

(A) Basic layers

Each of the four pits should be filled up to 5" from bottom with material as shown in the table. These layers are almost permanent & need not be disturbed while removing vermicompost.

(B) Putting garbage

Layer No. (From bottom)	Particulars	Height in inches
1	Brick bat	1.5
2	Coarse sand	1.5
3	Fine sieved soil	2.0

The biodegradable garbage generated everyday, should be added to pit number 1. When this pit is full start adding garbage to pit no.2 & thereafter to pit no.3 & 4. The process of vermicompost is better if:

- The garbage is soft & green
- The garbage is chopped to smaller pieces.

It is recommended to mix cow dung slurry with garbage (10 to 20 % by weight) once or twice a week. Observe the condition of garbage in pit no.1. Introduce 1000 to 1200 live earthworms of suitable species to the garbage when it has reached a semi-decomposed state. Cover the contents with a gunny bag. This cover should be always kept moist by spraying adequate quantity of water.

Movement of earthworms:
This is a special feature of vermitank. The earthworms from pit number 1 automatically move to pit no.2 & further to no. 3 & 4 in search of food, when the contents from the respective pit are fully consumed i.e. converted into manure. This makes the maintenance of vermitank easy since it is not necessary to handle the worms.

Harvesting of vermicompost:
Vermi compost is very easy to identify by its granular nature resembling tea powder. Procedure of harvesting –

- When the fourth pit is full, the vermicompost from pit no. 1 is ready for harvest
- Before harvesting, keep the pit open to air & Sun for one day which makes it easier to take out the compost
- Remove the vermicompost up to the basic layer
- Start adding garbage to the empty pit as before.

Operation & maintenance
The user of the system may be required to undertake certain commitments for proper maintaince of the vermicomposting system (Compost Pit and Vermicompost Tank) including the following aspects:

- To ensure temperture range 20 to 30°c is maintained
- Over sprinkling of water is avoided
- Proper turning operations are followed
- Vermicompost removed periodically from the pit by careful scrapping without disturbing movement of earthworms in the pit
- To ensure that no heavy metals go along with feed materials
- To ensure feed materials of required quantity and quality are added daily to the systems
- Ensure red ants do not get entry into the system
- To ensure basic layer is not disturbed

Suggestive cost of construction

S. No.	Particulars	Quantity	Rate (Rs)	Total amount (Rs)
1	Excavation	50 cft	2.00/cft	100.00
2	Bricks	1200 nos.	2000/1000 nos.	2400.00
3	Sand	100 cft	16/cft	1600.00
4	Cement	6 bags	230/bag	1380.00
5	Stones (Dabar)	50 cft	6/cft	300.00
6	Stone metal	30 cft	12/cft	360.00

7	Cudappa	50 cft	22/cft	1100.00
8	Welded mesh	100 sft	6/sft	600.00
9	PVC pipe (1.5” dia)	5 rft	10/rft	50.00
10	Hinged lids with mesh	4 nos.	750/lid	3000.00
10	Mason	4 man days	200/m.d.	800.00
11	Labour	8 man days	100/m.d.	800.00
13	Supervision charges	--	--	1000.00
14	Miscellaneous	--	--	510.00
Total				**14000.00**

Materials required

The vermicompost pit is usually earthwork oriented below the ground. Vermicompost tank will require some masonry construction. The basic raw material required for the system are brick bats, core sand and fine sieved soil for preparation of basic layer. Material requirements are to be arrived based on detail estimate for a particular size of the system. This can be worked out with the help of a mason who will be engaged to construct the system.

Collection of vermi wash

Depending on the season, sprinkle a little quantity of water into vermin composting pit to ensure that the pit contents remain just moist for aerobic decomposition process to continue and earthworms remain active to take part in decomposition process. Arrangement to be made by providing a small pipe connection with a tap at the bottom of the vermi tank at an appropriate place for the collection of thick brown color liquid known as Vermi Wash in a small pit adjacent to the vermi tank. Vermi Wash contain different bacterial inoculants and also fluid of earthworms, which contain a variety of plant growth promoting enzymes. Vermi wash is an important by product of vermi composting process.

Limitations

- Lack of organized marketing
- Lack of awareness on agri-farming concepts with regard to benefits of EWC
- Resistance of farming community to new process
- Lack of demand of vermi compost (manure) from farmers
- Seasonal variation of composting process & production due to temperature and moisture differences
- Lack of institutional arrangements for dissemination of information for vermin
- Composting technology.

2.4.4.6 Vermitank at Household Level

The same process as mentioned for the community level vermi tank may be followed at household level also. The size of the tank may be less at the household level depending upon the quanity of garbage generated. In place of four compartments, only two compartments may be sufficient.

2.4.5 Other types of wastes

Dry Waste

Dry waste can be classified into two types the one that is recyclable and non recyclable , Recyclable materials reach the processing industries while the no recyclable are land filled

Paper Recycling

Paper waste prevention is the practice of reducing or eliminating paper use so that the potential for paper to be used inefficiently or disposed is prevented in the first place. Printing paper on both sides of the sheet—rather than on one side—is a classic example of paper waste prevention, as it can reduce the need for paper by up to 50 percent.

Prevention is the most environmentally preferable means to reduce paper waste. Even if all paper was recycled, there would still be a need for paper to be made from virgin resources, as individual paper fibers can only be recycled a finite number of times (generally 5-10). Paper waste prevention reduces the environmental impacts associated with both paper manufacture (including the demands on our forest resources) and paper recycling.

Sorting

Successful recycling requires clean recovered paper, so you must keep your paper free from contaminants, such as food, plastic, metal, and other trash, which make paper difficult to recycle. Contaminated paper which cannot be recycled must be composted, burned for energy, or land filled.

Recycling centers usually ask that you sort your paper by grade, or type of paper. Your local recycling center can tell you how to sort paper for recycling in your community. To locate your nearest dealer, look in the yellow pages of your phone book under "waste paper" or "recycling."

Collection and Transportation

You may take your sorted paper to a local recycling center or recycling bin. Often, a paper stock dealer or recycling center will collect recovered paper from your home or office. Your local dealer can tell you the options available in your community.

At the recycling center, the collected paper is wrapped in tight bales and transported to a paper mill, where it will be recycled into new paper.

Storage

Paper mill workers unload the recovered paper and put it into warehouses, where it is stored until needed. The various paper grades, such as newspapers and corrugated boxes, are kept separate, because the paper mill uses different grades of recovered paper to make different types of recycled paper products.

When the paper mill is ready to use the paper, forklifts move the paper from the warehouse to large conveyors**.**

Re-pulping and Screening

The paper moves by conveyor to a big vat called a pulper, which contains water and chemicals. The pulper chops the recovered paper into small pieces. Heating the mixture breaks the paper down more quickly into tiny strands of cellulose (organic plant material) called fibers. Eventually, the old paper turns into a mushy mixture called pulp.

The pulp is forced through screens containing holes and slots of various shapes and sizes. The screens remove small contaminants such as bits of plastic and globs of glue. This process is called screening**.**

Cleaning

Mills also clean pulp by spinning it around in large cone-shaped cylinders. Heavy contaminants like staples are thrown to the outside of the cone and fall through the bottom of the cylinder. Lighter contaminants collect in the center of the cone and are removed. This process is called cleaning.

Deinking

Sometimes the pulp must undergo a "pulp laundering" operation called deinking (de-inking) to remove printing ink and "stickies" (sticky materials like glue residue and adhesives). Papermakers often use a combination of two deinking processes. Small particles of ink are rinsed from the pulp with water in a process called washing. Larger particles and stickies are removed with air bubbles in another process called flotation.

During flotation deinking, pulp is fed into a large vat called a flotation cell, where air and soap-like chemicals call surfactants are injected into the pulp. The surfactants cause ink and stickies to loosen from the pulp and stick to the air bubbles as they float to the top of the mixture. The inky air bubbles create foam or froth which is removed from the top, leaving the clean pulp behind

Refining, Bleaching and Color Stripping

During refining, the pulp is beaten to make the recycled fibers swell, making them ideal for papermaking. If the pulp contains any large bundles of fibers, refining separates them into individual fibers. If the recovered paper is colored, color stripping chemicals remove the dyes from the paper. Then, if white recycled paper is being made, the pulp may need to be bleached with hydrogen peroxide, chlorine dioxide, or oxygen to make it whiter and brighter. If brown recycled paper is being made, such as that used for industrial paper towels, the pulp does not need to be bleached.

Papermaking
Now the clean pulp is ready to be made into paper. The recycled fiber can be used alone, or blended with new wood fiber (called virgin fiber) to give it extra strength or smoothness.

The pulp is mixed with water and chemicals to make it 99.5% water. This watery pulp mixture enters the head box, a giant metal box at the beginning of the paper machine, and then is sprayed in a continuous wide jet onto a huge flat wire screen which is moving very quickly through the paper machine.

On the screen, water starts to drain from the pulp, and the recycled fibers quickly begin to bond together to form a watery sheet. The sheet moves rapidly through a series of felt-covered press rollers which squeeze out more water.

The sheet, which now resembles paper, passes through a series of heated metal rollers which dry the paper. If coated paper is being made, a coating mixture can be applied near the end of the process, or in a separate process after the papermaking is completed. Coating gives paper a smooth, glossy surface for printing.

Finally, the finished paper is wound into a giant roll and removed from the paper machine. One roll can be as wide as 30 feet and weigh as much as 20 tons! The roll of paper is cut into smaller rolls, or sometimes into sheets, before being shipped to a converting plant where it will be printed or made into products such as envelopes, paper bags, or boxes.

Recycling of plastic
Plastic recycling is the process of recovering scrap or waste plastics and reprocessing the material into useful products, sometimes completely different in form from their original state. For instance, this could mean melting down soft drink bottles then casting them as plastic chairs and tables.

Before recycling, plastics are sorted according to their resin identification code, a method of categorization of polymer types that was developed by the Society of the Plastics Industry in 1988. Polyethylene terephthalate, commonly referred to as PET, for instance, has a resin code of 1.

Processing
When compared to other materials like glass and metal materials, plastic polymers require greater processing to be recycled. Plastics have low entropy of mixing, which is

due to the high molecular weight of their large polymer chains. A macromolecule interacts with its environment along its entire length, so its enthalpy of mixing is large compared to that of an organic molecule with a similar structure. Heating alone is not enough to dissolve such a large molecule; because of this, plastics must often be of nearly identical composition in order to mix efficiently.

2.4.6 Types of plastic resins waste

All recycled plastics are divided into 7 groups according to the type of plastic resin:

1 Polyethylene Terephthalate (PET or PETE)

Use: Soft drink bottles, oven-ready meal trays, salad dressing bottles.

2 High Density Polyethylene (HDPE)

Use: Milk and juice bottles, washing-up bottles, toys, grocery bags.

3 Polyvinyl Chloride (PVC)

Use: Clear food packaging, shampoo and mineral water bottles, food trays.

4 Low Density Polyethylene (LDPE)

Use: Grocery bags, bin liners, bread bags, frozen food bags.

5 Polypropylene (PP)

Use: Microwave meal trays, ketchup bottles, margarine tubes, yogurt containers, medicine bottles.

6 Polysterene (PS)

Use: Compact disk jackets, foam meat or fish trays, coffee cups, plastic cultery, sandwich and hamburger boxes, cafeteria trays.

7 Other

Collection of plastic waste

The sources of plastics for recycling:

Industrial waste;

Agricultural waste (containers, pipes, sheets);

Waste of hotels, restaurants, shops;

Municipal waste (plastic litter collected from streets, parks, beaches);

Household waste - the type of municipal waste collected from householders.

Prior to processing the plastic waste is washed and sorted according to the coding system.

Mechanical recycling

Mechanical recycling of plastic waste is the simplest and relatively cheap recycling method.

The steps of mechanical recycling are as follows:

Cutting

Large plastic parts are cut by saw or shears for further processing.

Shredding

Plastics are chopped into small flakes.

Contaminants separation

Contaminants (e.g. paper) are separated from plastic in cyclone separators.

Floating

Different types of plastics are separated in a floating tank according to their density. The flakes are also washed and dried.

Extrusion

The flakes are fed into an extruder where they are heated to melting state and forced through the die converting into a continuous polymer product (strand).

Pelletizing

The strands are cooled by water and cut into pellets, which may be used for new polymer products manufacturing.

Chemical recycling

Chemical or feedstock recycling is a processes, in which a plastic polymer is broken down into its constituents - monomers. This process is called depolymerisation. The monomers may be then used as raw material for manufacturing a new polymer. Chemical recycling (feedstock recycling) is more expensive than mechanical recycling.

There is a range of chemical recycling methods:

Pyrolysis - chemical decomposition of polymers induced by heat in the absence of oxygen.

Polyethylene Terephtalate (PET) may be converted into dimethyl terephthalate and ethylene glycol, which are used as additives to the virgin raw materials in PET production.

Hydrogenation - chemical reaction with Hydrogen (H2).

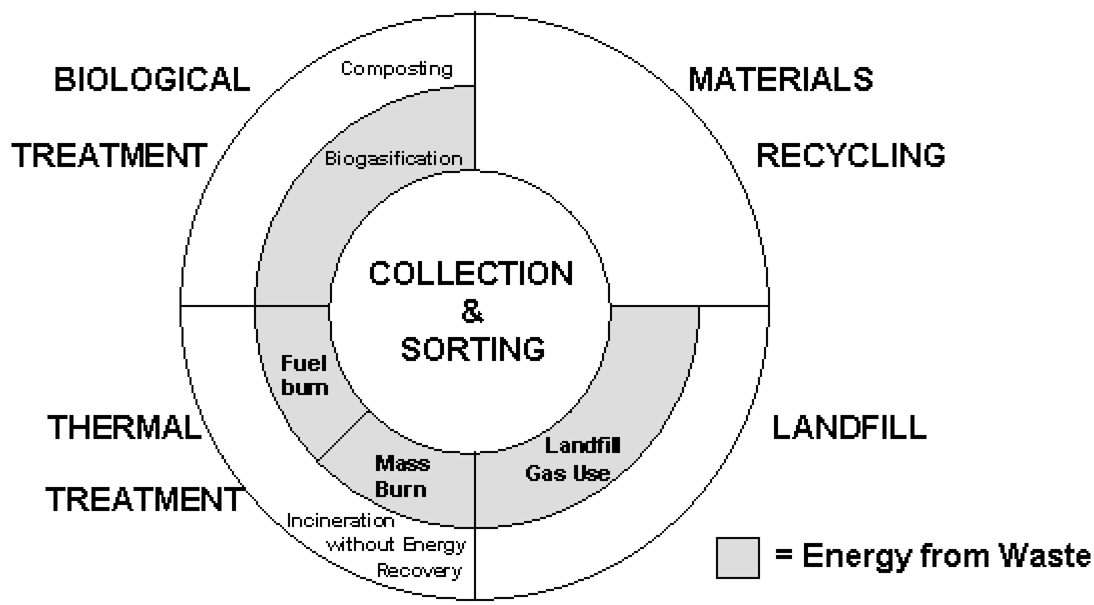
Gasification - conversion of polymers into a mixture of carbon monoxide (CO) and hydrogen.

Conclusion: Waste managers need to create sustainable systems that are economically affordable, socially acceptable and environmentally effective. Economic affordability requires that the costs of waste management systems are acceptable to all sectors of the community served, including householders, commerce, industry, institutions, and government.

Social acceptability requires that the waste management system meets the needs of the local community, and reflects the values and priorities of that society.

Environmental effectiveness requires that the overall environmental burdens of managing waste are reduced, both in terms of consumption of resources (including energy) and the production of emissions to air, water and land.

The Elements of Integrated Waste Management



Along with the overall need for sustainable waste management, it is clear that no one single treatment method can manage all materials in Municipal Solid Waste (MSW) in an environmentally effective way. Following a suitable collection system, a range of treatment options will be required. These include materials recovery, biological treatment (composting/bio gasification), thermal treatment (mass-burn incineration with energy recovery and/or burning of Refuse Derived Fuel - RDF) and land filling. Together these form an Integrated Waste Management (IWM) system.

Effective management schemes need the flexibility to design, adapt, and operate systems in ways which best meet current social, economic, and environmental conditions. These are likely to change over time and vary by location. The need for consistency in quality and quantity of recycled materials, compost or energy, the need to support a range of disposal options, and the benefit of economies of scale, all suggest that IWM systems should be organized on a large-scale, regional basis. Any scheme incorporating recycling, composting or energy from waste technologies must be market-orientated.

Whilst it uses a combination of options, the defining feature of an IWM system is that it takes an overall approach to manage all materials in the waste stream in an environmentally effective, economically affordable, and socially acceptable way. IWM systems can be optimized using the tool of Life Cycle Assessment.

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Chapter 5

Community participation in waste management

2.5.1 Introduction

Community is in the centre of all the activities, yet it is ignored by the decision makers and made to merely wait and watch and ultimately what people get in hand is what they do not want or what is not in their priority. This creates a void between the administrators and those administered and an atmosphere of apathy is created which distances people from government initiatives. Public awareness, effective community participation, transparent and clean administration, introduction of citizen charters and accountability at all levels can only bridge this gap. Solid Waste Management (SWM) is one such activity, where public participation is key to success. The local body can never be successful in Solid Waste Management without active community participation, whatever may be the investments made from the municipal or Government funds. The local bodies are the institutions of grass root democracy having elected members representing a small group of electorate. It also has an outreach service at the ward level through which it can easily interact with the people on almost all-important issues. The local body should therefore, seriously consider involving community in all programmes through a consultative process and variety of other communication approaches dealt with in this chapter later and adopt the strategy which has the acceptance of the community.

2.5.2 Strategy for Community Participation

There are various steps that taken need to be taken for an effective waste management system like identifying groups of people that need to be addressed

2.5.2.1 Residential Areas

Community may be classified into three categories

1. High Income Group - the affording
2. Middle Income Group - educated, sensitive, less affording
3. Low Income Group – un-affording

None of the above categories of people is an exception in apathy towards SWM but the level of awareness and sensitivity of each group is different and needs to be tackled differently.

Markets/Commercial Areas/Offices/Banks etc.

These places may be classified into three broad categories:-

1. Vegetable Markets
2. Shopping areas
3. Offices/Institutional areas

Identification of the Areas in Solid Waste Management Where Community Participation is Essential

Solid Waste Management involves several stages of activities where people's participation is critically required in some of them and local body has to do the rest of the work.

People's Participation is Essential in the Following Areas

1. Reduce, Reuse & Recycling (R R R) of waste.
2. Not to throw the waste/litter on the streets drains, open spaces, water bodies, etc.
3. Storage of organic/bio-degradable and recyclable waste separately at source.
4. Primary collection of waste
5. Community storage/collection of waste in flats, multi-storied buildings, societies, commercial complexes, etc..
6. Waste processing/disposal at a community level (optional)
7. Pay adequately for the services provided.

2.5.2.2 Reach the Community

The local body should decide the methodology to be adopted for reaching the community and seeking their cooperation and effective participation in SWM services. This is a very difficult area of activity and unless this is done meticulously, desired results will not be achieved. The essential steps in this direction is to select representative samples of the community and go through a consultative process to ascertain the perceptions of the people about the SWM services being given to them, their expectations and extent to which they are willing to support and participate in the process. Their choice of technological options available also needs to be ascertained.

The process can involve:

2.5.2.3 Identification of Problems

Identification of problems of waste management through site visits and consultation with local population at the time when the community is generally available for interaction. It may either be in early morning or late evening. The areas may be selected by following the method of drawl of representative samples.

Situation analysis may be done by the persons who know the subject reasonably well, know local language and can communicate with local population effectively. Such persons may be Non-Governmental Organisations, Community Based Organisations or knowledgeable individuals. They should try to find out the prevalent situation of waste management in the area under observation and ascertain the perceptions of the people about the services provided. In this exercise the local councilors, local leaders, NGOs, etc., may be invited to participate.

2.5.2.4 Finding out Optional Solutions

Having identified the deficiencies in the system and known the public perceptions, the next essential step is to think of optional solutions to tackle the problems, workout the cost implications and level of public participation needed.

2.5.2.5 Consult Community on Options Available

Having done this homework, there should be second round of consultative process where the options worked out may be discussed with the community along with cost implications and their support required. Their suggestions may be sought on each solution proposed. The community may be encouraged to give their views freely. If we ask the people straight away the solutions of the problems they may not be able to give right kind of suggestions as they have no exposure of various technological options. They must, therefore, be first appraised of the options available and then asked to give their considered opinion on what will work in their area and how much they are willing to cooperate.

2.5.2.6 Workout the Strategy of Implementation

After the consultative process, strategy for implementation of the system may be worked out and pilot projects may be taken up in the areas where better enthusiasm is noticed and demonstrate the successes to other areas and gradually implement in rest of the areas of the city/town. It is desirable to implement the new program in a few areas to begin with, monitor its success carefully and extend the program to other areas thereafter with suitable modifications wherever necessary.

2.5.2.7 System of waste management to be adopted

Having gone through the consultative process as indicated above, in a few selected areas and having taken up pilot projects, the local body should finally decide on the systems of waste management to be adopted in the city and take the following measures to ensure public participation.

2.5.2.8 Public Information, Education, Communication Programs (IEC)

For the successful implementation of any program involving public at large in SWM system, it is essential to spell out clearly and make them known the manner in which local body proposes to tackle the problem of waste management and extent to which public participation in Solid Waste Management is expected to keep the city clean and improve the quality of life in the city.

Ensure that the people become aware of the problems of waste accumulation and the way it affects their lives directly.

Ensure that the people generate less waste by cutting back on waste generating material and by following clear defined practices of waste management.

Create public awareness against big waste generators and provide information to monitor the performance of these sources of waste.

Inform the people about waste management program of the government and municipal bodies.

Promote public participation in waste management efforts through private partnership where feasible.

Propagate the message that the "Clean City Program" is both analytical and purposive and that solutions proposed are within the framework of government initiatives and legally appropriate.

Citizens co-operation is vital to reduce, reuse and recycling of waste and in keeping garbage off the streets, by keeping biodegradable "wet" kitchen and food wastes unmixed and separate from recyclable "dry" wastes and other hazardous wastes. Their participation in primary collection of waste, using community bins for storage of waste generated in multistoried buildings, societies, commercial complexes and slums is also essential. If the reasons for doing so are explained, public participation is bound to improve.

A series of measures can be taken to bring about a change in public behaviour through public awareness programs, which could be as under

2.5.3 Promote "Reduce, Re-use and Re-cycle (R-R-R)" of Waste

Reduce

Everyone is concerned with the growing problems of waste disposal in urban areas with the scarce availability of land for processing and disposal of waste and environmental remediation measures becoming ever more expensive. It is therefore necessary to not only think about effective ways and means to process and dispose of the waste that we generate each day, it is also essential to seriously consider how to avoid or reduce the generation of waste in the first place and to consider ways to re-use and recycle the waste, so that the least quantity of waste needs to be processed and disposed of.

Re-use

One person's waste can be useful material for others. Efforts should therefore be made to encourage collection of such re-usable material through waste collectors, waste producers, NGOs and private sector instead of allowing reusable waste to land up on the disposal sites. Bottles, cans, tins, drums and cartons can be reused.

Re-Cycling

In the era of excessive packaging materials being used, a lot of recyclable waste material is generated. All-out efforts are necessary to retrieve recyclable material from the households, shops and establishments and fed to the recycling industries through intermediaries such as waste purchasers, waste collectors/NGOs, etc.

2.5.4 Promote Public Participation in SWM Systems Adopted

The first and foremost thing that the citizens need to be told and made to understand is that no waste shall be thrown on the streets, drains, water bodies, open spaces, etc. and that they should form habit of:

- Storage of wet food/bio-degradable waste and dry recyclable waste separately at source
- Participation in primary collection of wastes
- Handing over of recyclable waste materials to rag pickers/waste collectors
- Use of community bins wherever directed/provided.
- Use of litter-bins on roads and public places

2.5.4.1 Awareness Programmes

The communication material developed should be utilised in public awareness programmes through variety of approaches as under.

This may be done through:

a. Group Meetings in the community
b. Workshops
c. Exhibitions
d. Lecture series
e. Panel Discussions, etc**.**

The role and responsibility of the people in ensuring safe disposal of solid waste Most citizens want a nearby facility to dispose of their waste, but nobody wants a dustbin at their doorstep. Both needs can be met by the house-to-house collection system through handcarts or tricycles. Neighborhoods can be rewarded for good response to doorstep collection of segregated waste. Groups that undertake to manage the cleaning of their own area through grants/subsidies. Many NGOs are committed to improve SWM practices in urban areas to protect the environment and have been very active in this field. They have also developed good mass-communication skills and education programs for the public. Such NGOs may be persuaded to actively support the new strategies adopted by the local body and associate in public awareness campaigns. Those who wish to conduct programs for sections of the public on the new SWM strategies may be encouraged to do so and given necessary support

2.5.5 ENFORCEMENT

All said and done, all human beings are not the same. There are people who understand easily as soon as they are told to behave, there are also people who are hard to understand and there is a special category of people who do not want to understand. While all efforts should be made to educate the people to effectively participate in the management of waste, they also need to be told that they can be punished if they fail to discharge their civic duties. The provision of penalties may be made known to the people and details of those punished should be publicized widely to deter others. To begin with, the enforcement should begin at the public places, market places, etc. and gradually extended to cover residential areas. Discipline should be brought about in the public offices first so that correct examples be set before the people.

2.5.6 SUSTAINABILITY OF COMMUNITY PARTICIPATION

The success of community participation in solid waste management depends on other actors involved, such as the municipality, community-based organizations (CBOs), micro enterprises, and local leaders. For instance, if the municipality does not collect the waste separately, it has no use for the community to separate their waste. The following factors are considered to favour the sustainability of community participation and hence of services, like waste collection and separation:

- Communication strategies are essential to generate a broad-based understanding of solid waste issues among community members on the one hand and responsiveness of the stakeholders to the demands of the community on the other.
- Representative local leaders and CBOs can stimulate community participation and ensure that community needs are taken into account.
- Women play a determining role in waste management and they form important channels of communication.
- Community initiatives and CBOs are less durable if they are not, at some point, recognised and supported by the local authority.

- Cooperation between the CBO and the local authority to maintain and operate the service system according to formal agreements with stakeholders.
- Financial and operational viability to make community services less dependent on external support.
- Follow-up support after project implementation to reinforce awareness and new practices and assist when required with operation and management of new organisations

2.5.7 CONCLUSION:

For waste management projects to have a continuing impact, community participation is a precondition and this entails involving the community at different stages and degrees of intensity in the project cycle. For example, community members can participate in different ways, such as paying collection fees, offering waste at the appropriate time and separating recyclable materials. Furthermore, community members can be involved in awareness-raising activities, participate in meetings to influence the process of the project or be part of committees that manage waste services. Communication strategies, such as awareness raising campaigns, are essential to generate a broad-based understanding of solid waste issues among community members. Important stimulators for community participation are local leaders and CBOs. They can ensure that community needs are taken into account. However, to be able to stimulate the community, leaders and CBOs must be representative. Cooperation between CBOs and the local authority, by for example entering into a contract or partnership, is very important to maintain and operate the waste service. In this way, the responsibilities can be clearly divided and efficiency of the waste collection improved. Appropriate time frame, achievable objectives and adaptive planning can effect community participation in a positive way.

Participation of the community in a neighbourhood activity should be considered as a voluntary act of civic responsibility, a commitment by the residents to one or several stagesof a collective project, (control, awareness-raising, providing information, promoting, decision-making), although the actual tasks may not always be visible. Waste collection or clean-up actions are most effective when residents gain genuine control over their content and their social or sanitary scope; that is when they take an active part in informing people, monitoring the service and/or raising their awareness at the neighbourhood level.

Chapter 6

PLANNING WASTE MANAGEMENT SYSTEMS

2.6.1 Introduction:

In the last 20 years, a number of solid waste management projects have been carried out in developing countries, in collaboration with external support agencies. Some projects were successful in producing lasting impacts on the improvement of solid waste management in developing countries. However, many projects could not support themselves or expand further when the external agencies discontinued their support. A number of technical, financial, institutional, economic, and social factors contribute to the failure to sustain the projects, and they vary from project to project.

Often the recipient countries and cities tend to accept whatever resources are provided to them without due consideration to subsequent resource requirements. The external support agencies have limitations in the amount of resources they can provide and the mandates and modes under which they can operate projects. Sometimes, projects are initiated with specific aims and expected outputs, but their scopes are not comprehensive enough to consider external factors influencing them. The external support agencies often do not fully understand socio-economic, cultural, and political factors influencing the selection of appropriate solid waste management systems. In other cases, very limited follow-up support, including human resource development activities necessary to sustain the project implementation, is provided by the external support agencies.

These problems and constraints associated with external support agencies' collaboration with developing countries in solid waste management can be minimized, and the sustainability of such collaborative projects improved by packaging efforts of external support agencies; defining clear roles of relevant agencies and improving their coordination in developing countries; creating key human resources; supporting strategic planning and follow-up implementations; developing self-financing schemes; and raising awareness of the public and decision makers.

2.6.2 Planning the system

Once the sustainability of a particular model is assessed then a plan for the system can be designed accordingly. However it is not necessary that a model should be adopted in the exact form and can be modified with the needs of the area concerned.

2.6.2.1 Analysis of Existing System

For the purpose of developing solid waste management strategies

a. Description of the components and analysis of the existing MSW management system, including social, environmental and economic impacts;
b. The estimated percentage of the regional solid waste stream which was managed through reuse, recycling, recovery and residual management
c. Information gaps to be addressed and management options to be evaluated in detail in the development of MSW management strategies

2.6.2.2 Development of Strategies

a. Detailed analysis of selected municipal solid waste management options, including those identified in the report prepared
b. A set of preferred options and recommended management strategies
c. The justification for or against utilization of existing program, sites and facilities;
d. The social, environmental and economic impacts of the recommended strategies;
e. operating requirements in sufficient detail to meet the needs of an operational certificate for sites identified by the manager;
f. An estimate of the total capital and operating cost for all sites, facilities and programs;
g. Estimation of the true disposal cost for each component of the waste stream, based on the actual contribution of the cost of that component to total waste stream disposal costs
h. Cost recovery and financing mechanisms for all sites, facilities and educational programs;
i. the opportunities for cooperation with other regional districts in the collection, processing and marketing of recyclable material and the management of municipal solid waste;

Strategies should be developed for management of the components of the existing municipal solid waste stream, according to type, class or source as identified

Without limiting the generality of (1), strategies addressing the following issues or objectives, where applicable, should be developed for inclusion in the plan:

management of recyclable materials as defined in the act and for any of the following materials which are part of the regional solid waste stream:

household hazardous products, including pesticide and herbicide containers;construction, demolition and land clearing debris; biosolids, including sewage sludge and septage, and incinerator bottom ash and fly ash.

minimizing conflicts with wildlife and domestic animals at landfill sites and transfer stations;

eliminating the open burning of municipal solid waste;

minimizing the uncontrolled discharge of gases from landfills

designing and operating residual management facilities in accordance with the provincial

providing reasonable access to recycling opportunities and disposal facilities throughout the plan area;

identifying the location of closed landfill sites and developing any remedial closure plans for such sites required by the manager;

replacement of disposal facilities whose capacity will be reached during the term of the plan; and

litter control and management, particularly in conjunction with user pay strategies.

(3) Decisions on which waste stream components are to be diverted from the waste stream should be based on variable disposal costs related to the actual impact of the component on total disposal costs.

2.6.2.3 Operating Strategies and Specifications

Operating strategies and specifications addressing the following issues should be developed for inclusion in the plan:

(a) The location or criteria for determining the location of disposal sites and transfer stations;

(b) Operating requirements that will be recommended to the manager for inclusion in operational certificates;

(c) Operating requirements and fee structures to be included in any proposed waste stream management, recycler and/or hauler licenses;

(d) Administration and operation of all programs, sites and facilities involving the management of recyclable material and municipal solid waste, including:

criteria for selection of technology to be employed for storage, collection, processing, and disposal of municipal solid waste and recyclable materials; and the utilization of existing programs, facilities and sites;

(e) Marketing of recyclable products diverted from the solid waste stream;

(f) Procedures for:

The identification, weighing and reporting of all material brought to recycling and disposal facilities, including acceptable alternative procedures, if necessary, for small or remote facilities,

The calculation of the rate of generation of municipal solid waste for the plan area in kilograms per person per day; and

(g) Upgrading of existing disposal sites in accordance with direction from the manager

2.6.2.4 Financial Strategies

(1) Financial strategies and specifications addressing the following issues should be developed for inclusion in the plan:

(a) financing the total capital and operating cost for all sites, facilities and programs to be included in the plan, including cost recovery mechanisms and the formula for allocating costs within the member municipalities and electoral areas of the regional district;

(b) criteria for risk assessment to determine the amount of security required to be posted by the owner of a site or facility storing or managing recyclable material or municipal solid waste, for the purpose of assisting the development of the operational certificate or license for the site or facility.

(2) In the development of financial and other strategies to be included in the plan,

(a) strategies involving the cost for sites or facilities should be based on the true cost of such sites or facilities, including closure and post-closure costs;

(b) user-pay systems to encourage the reduction, reuse and recycling of material which would otherwise be disposed of at a waste disposal site or facility should be implemented to the highest level practical; and

(c) the cost of reduction and recycling programs should be reduced as much as possible through cooperation with other regional districts in sharing equipment and facilities and development of educational materials.

2.6.2.5 Promotion and Education Programs

The plan should specify the promotion and education programs that will be implemented to support the management strategies.

2.6.2.6 Cooperation with Member Municipalities

Every regional district should

(a) Consult with its member municipalities and with any First Nations located within or adjacent to the plan area in the development of strategies to be included in the plan,

(b) Negotiate the measures for which those municipalities and First Nations will be responsible in the implementation of the plan, and document its efforts in this regard.

2.6.2.7 Consultation with Adjacent Regional Districts

Every regional district should consult with an adjacent regional district in the development of any strategies which might affect the adjacent regional district, and document its efforts in this regard.

2.6.2.8 Time Frame

(1) Every regional district should, in developing its strategies consider the municipal solid waste management needs of the regional district for a period of at least 10 years from the date of plan implementation.

(2) Where a major disposal site or processing facility recognized in the plan has a life span or amortization period which extends beyond the 10 year period, the regional district should consider that further time period in developing its strategies**.**

2.6.3 Plan Development Guidelines

2.6.3.1 Geographical and Organizational Setting

This section should include a map or maps at a scale appropriate for showing the area to be covered by the plan; the location, name and level of organization of the various municipalities, electoral areas and communities involved in the plan; and the location and contributing area of the existing solid waste handling and disposal facilities. As noted previously, the plan area may include the entire regional district, or the district and a portion or all of an adjacent regional district, or in special cases, one or more of its sub-regions**.**

2.6.3.2 Official Plan Designations

Since the pattern and timing of settlement and other land uses will have a significant effect on solid waste management, this section should include the relevant goals, objectives and policies from the following:

(a) Official Community Plans for municipalities and areas of the regional district;

(b) Existing Official Settlement Plans;

(c) Rural land use bylaws; and

(d) Comprehensive Development Plans.

Population

This section should include:

(a) the existing population of the plan area, both overall and for sub-areas or community components relevant to the plan;

(b) population projections for the plan area for at least the time horizon of the plan; and

(c) any demographic data which are relevant to solid waste management planning

Economic Base

This section should contain a description of the economic base of the plan area, both existing and projected, with particular reference to the existing and projected solid waste generation capacity of specific economic entities and activities. Relevant objectives and policies from existing Economic Development Plans should also be included

2.6.3.3 Physical Description / Constraints

This section should contain a general description of the climate, major landforms, terrain, soils, surface watercourses, groundwater levels, airsheds, vegetation and wildlife, with particular reference to those factors which pose constraints to the siting, economics or operation of solid waste management facilities or programs.

2.6.3.4 Fostering Linkages

No community based interventions can be feasible without the participation and support from stakeholders, hence one of the important step in planning is to identify all possible stakeholders.

ISWM requires the effective participation of community that the programme the programme needs cooperation from generators of waste at the various stages of the product life cycle.

Municipalities

They have the legal mandate for MSWM in any area.So the support of the municipality is crucial for many aspects of the operation such as,

- Issuing identity cards to waste collectors which would save themfrom harassment they face every day while collecting waste
- Provide land for composting
- Coordinating the activities of the operator with the operatio sorcurn of the municipality
- Providing resource through contract

2.6.3.5 Involving Facilitators

SWM is a complex issue and there are not many expertise available in the local levels to understand the various issues and their impacts, which may not be environmentally sustainable waste management practices, hence it may be important to involve experts and organizations who have been working in this field to help chalk strategies that are environment friendly and financially viable.

Service providers

Although the responsibility of MSWM lies with the local municipalities there are many interventions that have evolved to control chaotic situations municipalities need to realize the significance and engage private service providers to help in the process

Political buy in

The local political bodies can be involved for effective waste management systems .They can be of great help in resolving issues within the municipality.

2.6.3.6 Financial Institutions

The financial institutions are a good source of capital investment in the initial stages for example in the Kukatpally , Andhra Pradesh , the municipality gave the transportation contract to a group of women. Similarly use of Government schemes cn be made to rise funds

2.6.3.7 Networking with civil society organizations

There are several policy level issues that need to be taken at the central and state level. Many civil society organizations are actively involved in these issues so it may be useful to network with them.

2.6.3.8 Estimating cost

Feasibility of a program will depend on the expenditure likely to be incurred and the revenues to be generated. In any decentralized community based system the elements of cost will be

- Collection cost
- Transportation cost
- Operation cost
- Awareness and training
- Organizational expenditure

Elements of revenue

- User fee
- Sale of recyclables
- Sale of compost

2.6.4 Benefits of the program

Apart from providing a sustainable solution waste management this program of decentralized SWM many have some direct and indirect benefits. Some of the important benefits are

2.6.4.1 Economic benefits

Livelihood Creation: A decentralized system may have the potential to provide employment to waste collectors, supervisors and intervening organization

Source segregation keeps the recyclable material cleaner which can fetch higher price. The quality of the product made from these recyclables improve

Composting not only provides an extra source of revenue and also helps in soil improvement

2.6.4.2 Other Benefits

High landfill diversion rates: The system will help attain a landfill diversion rate for more than 80% which will save money in terms of excess land top be acquired for landfill and also conserve the environment.

Health benefits : A clean neighbourhood makes the area less prone to diseases The provivion of formalizing the waste collectors working condition provides them the oppurtunity to work in healthier conditions

Social benefits : Waste pickers can be substituted as waste collectors and their livelihoods can be formalized . They would get better recognition and dignity by working as formal waste collectors than as waste pickers

Empowered citizen : Decentralized solid waste management systems , premised upon the management and ownership by locl people contributes in strenghtening the civil society . The participative nature will result in empowered citizens who will utilize their knowledge in other spheres of life

Sustainability of the System

The sustainability of the system will depend on the financial viability of the project which in turn will depend on the level of participation of stakeholders and sale preceeds from recovered materials .

2.6.5 User Fee

Peoples participation is reflected in their willingness to pay user fee. However the equally critical issue is who collects the fee \. There are three ways by which the community can pay the fee

a. **Paying the Municipality directly :**The local body collects the cahrge for the service and makes arrangement for the work to be performed . The charges may depend on the location or the income category of the locality
b. **Paying the service provider:** The service provider collects this charges as per agrement and the service is rendered.
c. **Paying the contractors :** This arrangement is visible in comparitively bigger towns. The contractor collects the fees from the households and pay the service

providers. In some sense , they are called intermediaries. They are attracted by the margins of such operations.

2.6.6 Marketing the compost

There is an unlimited market for good quality compost ,however the cost of production , transportation and application of the compost can exceed the benefit . The price depends on the quality of the compost. The sale also needs support from the Governmnet agencies or direct procurement from the producers which require state support

2.6.7 Marketing recyclable products

The recyclable materials collected from the households is a source of revenue for the community or the operator . However they need to be sold to the dealers who can pay adequeately . It is in intrest of the community or the operator to have a long –term relationship with these waste dealers .

2.6.8 Upscaling

The issues of upscaling is associated with the success of the intervention . It can be assumed that the conditions , barring the income category of the localities m are homogenous in a single town.So replication of similar modules can be a good idea, this is also possible in other towns and also if the cost benefit analysis suggest feasibility of the interventions

Another approach is to have a combination of strategies depending on the location specific features .This allows innovation.

Chapter 7

IMPLEMENTING THE SYSTEM

2.7.1 Introduction

Successful implementation of the stratergic plan prepared for decenteralized waste management system starts with the mobilization of all the stakeholders.This is necessary , as in most cases the grassroots initiatives do not have a legal basis. Instead they can be viewed as a commercial enterpreneurial activity where the financial viability of the programme deteremines the run of th program . Environmnetal gains are the fruits of the activity which may help in solicitating the participation of various stakeholders.

2.7.2 Mobilising the community

Urban waste usually includes normal household waste. Rapid urbanization along with a constantly modernizing social behaviour has led to the doubling of household waste generation. The local municipal bodies with their limited human, technical, financial and institutional capability, particularly in a developing country like ours, have repeatedly demonstrated their inability to cope with the multi-dimensional problems of urban waste management. At the same time, it is important to either dispose off all of this waste as soon as it is generated or reduces waste generation, as waste has a huge impact on regional and global environment. Thus, the absence of adequate waste management infrastructure poses serious environmental risks that, in the long run, may even hamper a nation’s development.

Community participation is the process by which individuals and families assume responsibility for the health and welfare of their communities and contribute to the community’s overall development. It should be pointed here that every urban citizen can play a crucial role in improving the municipal solid waste management system in many ways.

Management of solid waste is a complicated task because of its close and direct relationship with the behaviour of the society. Therefore, social awareness and initiation is a key factor for a long-term solution to the waste management problem. To address this issue, awareness campaigns must be carried out at the community level explaining the importance of the desirable 3 R’s – Reduce, Reuse and Recycle. These programmes should be facilitated by the Resident Unions or the Resident Welfare Associations (RWAs) of the respective communities. Urban Communities need to act in a more responsible way and the elders must teach the importance of a clean environment to the younger generation. The society should try to reduce the total waste generated by cutting down unnecessary consumption which is also a stepping-stone leading to sustainable development. The elders of the community should behave even more responsibly and not litter or be insensitive to issues related to waste as they are also the role models for the next generation.

The biggest problem in urban waste management is faced at the stage of segregation of waste. If the waste is segregated properly, it can be disposed off in a more environment friendly manner. However, it is a difficult task and presently, all of the non-segregated waste is dumped at the same place. Communities can come forward and solve this problem to a great extent. This is because segregation of waste is most efficient when carried out right from individual houses. Waste should be divided into two broad categories at individual house level and then to broader categories at the community level. The adequately segregated waste can then be collected by the local municipal authority who can now deal with it in a better way. Such a measure will significantly reduce the amount of domestic solid waste entering urban waste streams and going to landfills, thus contaminating the environment.

Small community level composting pits can be maintained by different colonies for composting kitchen waste. This will further reduce the total waste entering the urban waste stream to a great extent. Through adopting simple technologies such as vermin composting, the waste can be converted to manure and the manure so produced can be sold on a commercial basis. The money earned can be utilized for the maintenance and sustenance of such a community based compost system

Thus, urban communities can play a pivotal role in urban waste management through their participation in household waste reduction, waste segregation, adopting recycling practices, composting, deriving manure from organic waste, exhibiting willingness to pay for waste collection services and by collaborating with waste collection crews. With increasing urban migrations and consequent increase in the population of cities, all urban communities at all levels should soon realize their role and contribute to waste management in order to keep our cities clean and green.

2.7.3 Awareness planning

To maintain a sustainable system, the community needs to know clearly what behaviours are desired. Developing an effective programme require awareness program requires planning and strategizing .The planners should be realistic about the cost of promotional efforts and benefits they yield. At the awareness stage , people need to know the difference between the existing practices and the proposed ones

2.7.3.1 Methods of publicity

2.7.3.1.1 Use of Print Media:

Advertisements may be given in a planned manner to educate the masses and local newspapers can also be requested to insert the given messages on SWM at regular intervals. They should also be encouraged to start a regular Suggestion Box from where good ideas can be picked up by the local body.

Newspapers maybe specially encouraged to give coverage to successful initiatives that have overcome SWM problems. use newspaper delivery services by inserting handbills for readers in a particular locality to announce the start of campaign from time to time and to adhere to the systems introduced.

2.7.3.1.2 Use of TV / Cable TV / Radio/Web Site:

This is the very powerful medium and can be used through local programs to inform the citizens of new waste collection arrangements made by the local body as and when they become operational and advise them to participate effectively in the prescribed manner. Contact numbers of the concerned officials for problem solving or reporting of SWM grievances may also be publicized. This media may be used to publicize successful efforts in some localities to motivate other citizens to perform likewise and get similar recognition of their effort.

Use of Cinema Halls
Slides in cinema theaters can be displayed to inform and motivate the public.

Street Plays, Puppet Shows, etc.
Street plays and puppet shows play a significant role in bringing awareness among the people. This method of communication will work well in low-income population; more particularly in slums. Well designed street plays /puppet shows can convey the messages effectively as such programs are well attended in slums.

Posters
Attractive posters with good photographs and messages with a very few words, readable from a distance, should be prepared and displayed in various parts of the city where awareness campaign is being taken up.

Pamphlets
Pamphlets, hand bills can be printed giving instructions in very simple and understandable language showing photographs in action and circulated in the community requesting public participation.

Use of Hoarding
Special hoarding may be put at strategic locations in the city carrying messages seeking public participation. Alternatively, all Municipal-licensed hoarding should have a space reserved at the bottom for civic messages. Such messages should be developed and painted by professional agencies. These hoarding should also carry the contact numbers etc.

Use of Public Transport System
Brief messages can be painted on the rear of public buses or inside the bus panels. Public and private firms having their own bus fleets may be invited to support such efforts.

Use of School Children:
Children are powerful communicators. Parents who do not listen to the advice of others often take their children seriously. Children are idealistic and would like to change their world for better. The ULB should hold regular meetingswith principals, teachers and students to explain the need for change, and the usefulness to society of new ways to manage waste. The message can be reinforced by holding essay, debate or drawing and painting competitions on the subject and publicizing the winning contestants. Social clubs can be encouraged to sponsor such events to keep the topic alive. The leading schools could be persuaded to work as a role model for other schools in taking up awareness campaigns in the city through their students, which should be highly publicized and other schools could be persuaded to follow suite.

Incentivising the programme
Theories of collective action emphasises incentivising the whole programme. It is important that people realize the significance of participation

Intrinsic incentives
Ideals of frugality , resource conservation and environmental protection could be strong intrinsic motivators in the long run. Highlighting the achievements of the program and the individuals through media can give a boost to the programme. Children’s long term awareness programs can also create an impact as they are open to ideas and can influence policy changes

Extrinsic incentives
These provide direct reward to desired activities it should be ensured that people do not connect the desired behaviour to the reward. Non – Monetary social incentives can also be effective.

Confidence building measures
People tend to prioritize their needs. So, peculiarly enough, as the experiences with various interventions suggests, at the start of interventions people may ask for related

services as well. For example people may ask for drainage clearance before committing to anything regarding solid waste with the intervening agency.

2.7.4 Capacity Building

The desired behaviour from all the stakeholders will depend on the capacity of the actors.These capacities need to be developed. Training programme as well as orientation workshops may be require

Community mobilisation
Tackle information deficit
There is a huge gap in information at community level
Need for holistic approach having an integrated approach
Use various medium to make community aware

Incentivise the programme

Design the incentives in consultation with the community and the municipality

<u>Intrinsic</u>
Highlight the achievement of the programme
Highlight the achievement through the media
Provide awards for exemplary service
Creating special events like recycling week , composting week

<u>Extrinsic</u>
Non Monetary social incentives

2.7.5 Relationship with the municipality

In most of the large towns and cities, the health officers are in charge of the SWM departments and in mega cities the Public health engineers. In some cities generalists are looking at SWM services. Apparently there is no clear cut division of roles and responsibilities. There should be information about department officials and activities with the intervening agencies.

The initial rapport may be established through inviting the municipal officials to the capacity building workshops. Such interactions will help in understanding each others role in implementation. This may also include the feeling of working in partnerships
Decision of land for onsite composting can be taken mutually where municipality has a large role to play .Similarly other bottlenecks can be removed through regular and frequent exchanges between residents and municipality officials.

Collection and segregation

The residents have the responsibility to help in collection. A timing need to be fixed for segregating waste in consultation with the residents this can be done through IEC material or workshops however these have to be decided through mutual consultations.

Raising resources

User fee: The charges can be decided with mutual consultation between residents and operator. Maximum participation is important.

Composting

Sale of compost is essential for the sustainability of the operation .If the quality is good it could be a source of revenue. However very few urban areas have been able to operate successfully due to a combination of the following reasons

- Inappropriate technology
- Lack of education and training
- Mechanical break down
- Poor maintenance
- High operating cost

Sale of recyclables

It is critical issue as sale also depends on the volume of the material. In smaller towns smaller quantities or low price may make options of disposal of material at the landfill cheaper. Hence solutions need to be worked together.

Gaps /Lacunae

Ownerships of the program is a critical issue. The communities on their own may not have the capacity to run the whole program, So NGO"S or expert agency carrying the operation withdraws the entire programme will collapse another issue is that there may be non participating members in the community. Though such initiatives remain outside the ambit of formal institutional arrangements. Another issue is the non participation of people , though such scenarios are included in risk analysis , it may further discourage others which may not augur well for the process.

Organizing waste collectors

To work with municipality and community to help organize the waste collector
Give adequate training to them for collection and segregation besides orientation about aspects of MSWM
Provide proper clothing and protective gears to safeguard from hazards
Attempts must be made to reduce high turn over of waste collectors so the expenditures on training and orientation of new recruits is avoided
Low turn over of collectors wills also mean continuity of services.

2.7.6 Conclusion

Institutionalisation of the entire process is the way to achieve the long term goals .It refers to efficiency of implementation of formal system. In other words it implies establishing a procedure .However it requires support from all local quarters .Political buy in at the local level may be helpful in this regard.
Meanwhile peoples participation needs to be apparent for creating sustained pressure on the authorities to incorporate such initiatives in the overall Integrated Solid Waste Management programme similarly involvement of NGO as a facilitator needs to be recognized

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Part III

LIQUID WASTE/ WASTE WATER MANAGEMENT

3.1 Objective: To introduce the candidates with different types of waste water, their origin and management. To make them understand the importance of waste water management and reuse.

3.2 Introduction

Liquid waste/Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources.

Sewage is correctly the subset of wastewater that is contaminated with feces or urine, but is often used to mean any waste water. "Sewage" includes domestic, municipal, or industrial liquid waste products disposed of, usually via a pipe or sewer or similar structure, sometimes in a cesspool emptier

3.3 Origin of Waste Water:

Broadly waste water can be categorized into following

3.3.1 Domestic Waste Water

- Wastewater or sewage can come from (text in brackets indicates likely inclusions or contaminants):
- Human waste (fæces, used toilet paper or wipes, urine, or other bodily fluids), also known as blackwater, usually from lavatories;
- Cesspit (sewage or refuse chamber) leakage;
- Septic tank discharge;
- Sewage treatment plant discharge;
- Washing water (personal, clothes, floors, dishes, etc.), also known as greywater or sullage;
- Groundwater infiltrated into sewage;
- Blackwater (surface water contaminated by sewage);
- Surplus manufactured liquids from domestic sources (drinks, cooking oil, pesticides, lubricating oil, paint, cleaning liquids, etc.);

Quantification and Characterization

No.	Source of waste water	Types of waste water	Quantity/day/person
1.	Toilets	Black water	3 liters
2.	Bathing	Greywater	20-30 liters
3.	Kitchen	Greywater	5-10 liters
4.	Washing cloth	Greywater	15-20 liters
5.	Animals	Greywater	10-15 liters

3.3.2 Rain & Storm runoff

- Rainfall collected on roofs, yards, hard-standings, etc. (generally clean with traces of oils and fuel);
- Urban rainfall runoff from roads, carparks, roofs, sidewalks, or pavements (contains oils, animal fæces, litter, fuel or rubber residues, metals from vehicle exhausts, etc.);
- Seawater ingress (high volumes of salt and micro-biota);
- Direct ingress of river water (high volumes of micro-biota);
- Highway drainage (oil, de-icing agents, rubber residues);
- Storm drains (almost anything, including cars, shopping trolleys, trees, cattle, etc.);

3.3.3 Industrial Waste Water

- Direct ingress of manmade liquids (illegal disposal of pesticides, used oils, etc.);
- Industrial site drainage (silt, sand, alkali, oil, chemical residues);
- Industrial cooling waters (biocides, heat, slimes, silt);
- Industrial process waters;
- Organic or bio-degradable waste, including waste from abattoirs, creameries, and ice cream manufacture;
- Organic or non bio-degradable/difficult-to-treat waste (pharmaceutical or pesticidal manufacturing);
- Extreme pH waste (from acid/alkali manufacturing, metal plating);
- Toxic waste (metal plating, cyanide production, pesticide manufacturing, etc.);
- Solids and Emulsions (paper manufacturing, foodstuffs, lubricating and hydraulic oil manufacturing, etc.);
- Agricultural drainage, direct and diffuse

3.4 Main Constituents of Waste Water:

The composition of wastewater varies widely. This is a partial list of what it may contain:

- Water (> 95%) which is often added during flushing to carry waste down a drain;
- Pathogens such as bacteria, viruses, prions and parasitic worms;
- Non-pathogenic bacteria (> 100,000 / ml for sewage);
- Organic particles such as faeces, hairs, food, vomit, paper fibers, plant material, humus, etc.;
- Soluble organic material such as urea, fruit sugars, soluble proteins, drugs, pharmaceuticals, etc.;
- Inorganic particles such as sand, grit, metal particles, ceramics, etc.;
- Soluble inorganic material such as ammonia, road-salt, sea-salt, cyanide, hydrogen sulfide, thiocyanates, thiosulfates, etc.;
- Animals such as protozoa, insects, arthropods, small fish, etc.;
- Macro-solids such as sanitary napkins, nappies/diapers, condoms, needles, children's toys, dead animals or plants, body parts, etc.;
- Gases such as hydrogen sulfide, carbon dioxide, methane, etc.;
- Emulsions such as paints, adhesives, mayonnaise, hair colorants, emulsified oils, etc.;
- Toxins such as pesticides, poisons, herbicides, etc

3.5 Waste Water Management:

The management of waste water constitutes of following major stages:

Collection, Treatment, Disposal and Reuse

3.5.1 Sewage disposal

In some urban areas, sewage is carried separately in sanitary sewers and runoff from streets is carried in storm drains. Access to either of these is typically through a manhole. During high precipitation periods a sanitary sewer overflow can occur, causing potential public health and ecological damage.

Sewage may drain directly into major watersheds with minimal or no treatment. When untreated, sewage can have serious impacts on the quality of an environment and on the health of people. Pathogens can cause a variety of illnesses. Some chemicals pose risks even at very low concentrations and can remain a threat for long periods of time because of bioaccumulation in animal or human tissue.

A **sanitary sewer** (also called, a foul sewer) is a type of underground carriage system for transporting sewage from houses or industry to treatment or disposal. In some areas, sanitary sewers are separate sewer systems specifically for the carrying of domestic and industrial wastewater, and are operated separately and independently of storm drains, which carry the runoff of rain and other water which wash into city streets. Sewers carrying both sewage and stormwater together are called combined sewers.

A **storm drain**, storm sewer, storm water drain or surface water system is designed to drain excess rain and ground water from paved streets, parking lots, sidewalks, and roofs. Storm drains vary in design from small residential dry wells to large municipal systems. They are fed by street gutters on most motorways, freeways and other busy roads, as well as towns in areas which experience heavy rainfall, flooding and coastal towns which experience regular storms

A **manhole** (alternatively utility hole, maintenance hole or access chamber) is the top opening to an underground utility vault used to house an access point for making connections or performing maintenance on underground and buried public utility and other services including sewers, telephone, electricity, storm drains and gas. It is protected by a manhole cover, a plug designed to prevent accidental or unauthorized access to the manhole. Those plugs are usually made of metal or constructed from precast concrete (especially in Europe). Manholes are usually outfitted with metal or polypropylene steps installed in the inner side of the wall to allow easy descent into the manhole.

Manholes are generally found in urban areas, in streets and occasionally under sidewalks. They are usually in circular shape to prevent accidental fall of the cover in the hole.

In rural and undeveloped areas, services such as telephone and electricity may be carried on pylons rather than underground.

3.6 Sewage treatment or domestic wastewater treatment

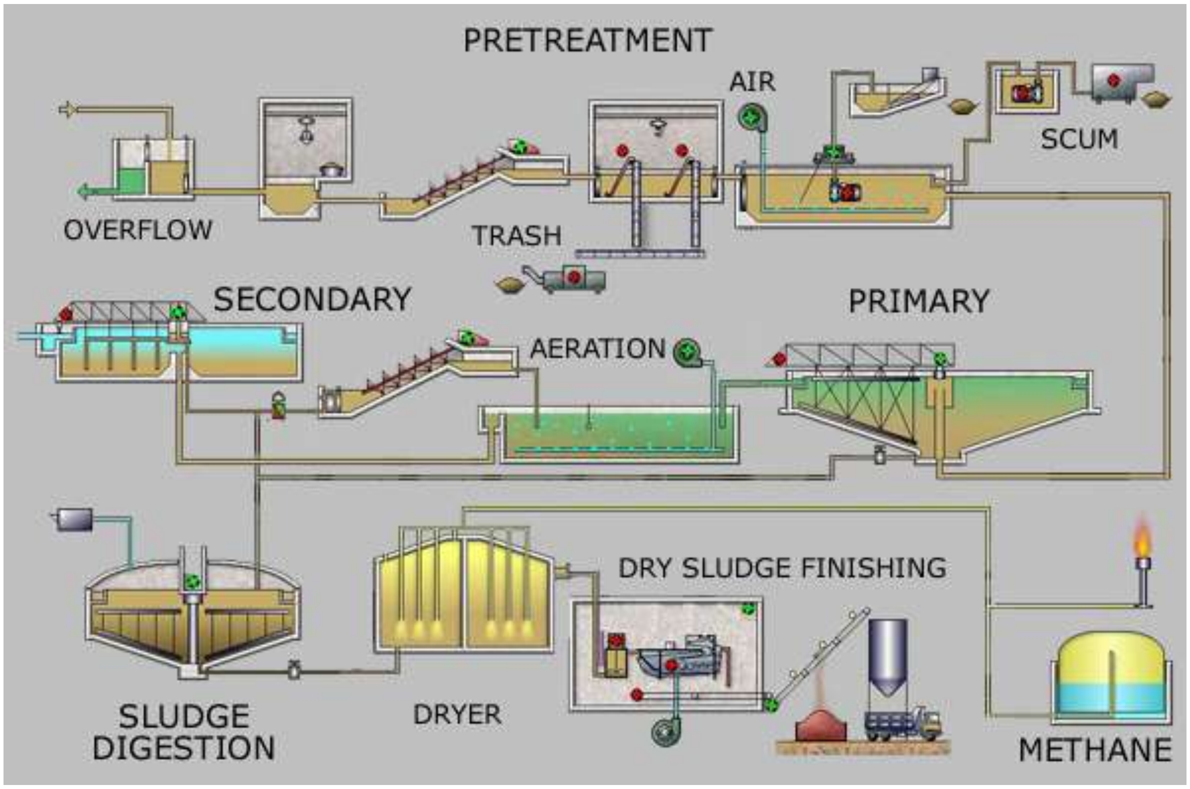
Sewage treatment, or domestic wastewater treatment, is the process of removing contaminants from wastewater and household sewage, both runoff (effluents) and domestic. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce a waste stream (or treated effluent) and a solid waste or sludge suitable for discharge or reuse back into the environment. This material is often inadvertently contaminated with many toxic organic and inorganic compounds.

3.6.1 Process overview

Sewage can be treated close to where it is created (in septic tanks, biofilters or aerobic treatment systems), or collected and transported via a network of pipes and pump stations to a municipal treatment plant (see sewerage and pipes and infrastructure). Sewage collection and treatment is typically subject to local, state and federal regulations and standards. Industrial sources of wastewater often require specialized treatment processes (see Industrial wastewater treatment).

Conventional sewage treatment involves three stages, called primary, secondary and tertiary treatment. First, the solids are separated from the wastewater stream. Then dissolved biological matter is progressively converted into a solid mass by using indigenous, water-borne micro-organisms. Finally, the biological solids are neutralized then disposed of or re-used, and the treated water may be disinfected chemically or physically (for example by lagoons and microfiltration). The final effluent can be discharged into a stream, river, bay, lagoon or wetland, or it can be used for the irrigation of a golf course, green way or park. If it is sufficiently clean, it can also be used for groundwater recharge or agricultural purposes.

Process Flow Diagram for a typical large-scale treatment plant



3.6.2 Pre-treatment

Pre-treatment removes the materials that can be easily collected from the raw wastewater and disposed of. The typical materials that are removed during pre treatment include fats, oils, and greases (also referred to as FOG), sand, gravels and rocks (also referred to as grit), larger settleable solids and floating materials (such as rags and flushed feminine hygiene products). In modern plants serving large populations, sophisticated equipment with remote operation and control are employed whilst in smaller or less modern plants manually cleaned screen may be used.

3.6.3 Screening

The influent sewage water is strained to remove all large objects carried in the sewage stream, such as rags, sticks, tampons, cans, fruit, etc. This is most commonly done with a manual or automated mechanically raked bar screen. The raking action of a mechanical bar screen is typically paced according to the accumulation on the bar screens and/or flow rate. The bar screen is used because large solids can damage or clog the equipment used later in the sewage treatment plant. The large solids can also hinder the biological process. The solids are collected and later disposed in a landfill or incineration.

Pre treatment also typically includes a sand or grit channel or chamber where the velocity of the incoming wastewater is carefully controlled to allow sand grit and stones to settle, while keeping the majority of the suspended organic material in the water column. This equipment is called a de-gritter or sand catcher. Sand, grit, and stones need to be removed early in the process to avoid damage to pumps and other equipment in the remaining treatment stages. Sometimes there is a sand washer (grit classifier) followed by a conveyor that transports the sand to a container for disposal. The contents from the sand catcher may be fed into the incinerator in a sludge processing plant, but in many cases, the sand and grit is sent to a landfill.

3.6.4 Primary treatment

<u>Sedimentation</u>

In the primary sedimentation stage, sewage flows through large tanks, commonly called "primary clarifiers" or "primary sedimentation tanks". The tanks are large enough that sludge can settle and floating material such as grease and oils can rise to the surface and be skimmed off. The main purpose of the primary sedimentation stage is to produce both a generally homogeneous liquid capable of being treated biologically and a sludge that can be separately treated or processed. Primary settling tanks are usually equipped with mechanically driven scrapers that continually drive the collected sludge towards a hopper in the base of the tank from where it can be pumped to further sludge treatment stages.

Secondary treatment

Secondary treatment is designed to substantially degrade the biological content of the sewage such as are derived from human waste, food waste, soaps and detergent. The majority of municipal plants treat the settled sewage liquor using aerobic biological processes. For this to be effective, the biota require both oxygen and a substrate on which to live. There are a number of ways in which this is done. In all these methods, the bacteria and protozoa consume biodegradable soluble organic contaminants (e.g. sugars, fats, organic short-chain carbon molecules, etc.) and bind much of the less soluble fractions into floc. Secondary treatment systems are classified as

Fixed-film or suspended-growth

Fixed-film treatment process including trickling filter and rotating biological contactors where the biomass grows on media and the sewage passes over its surface.

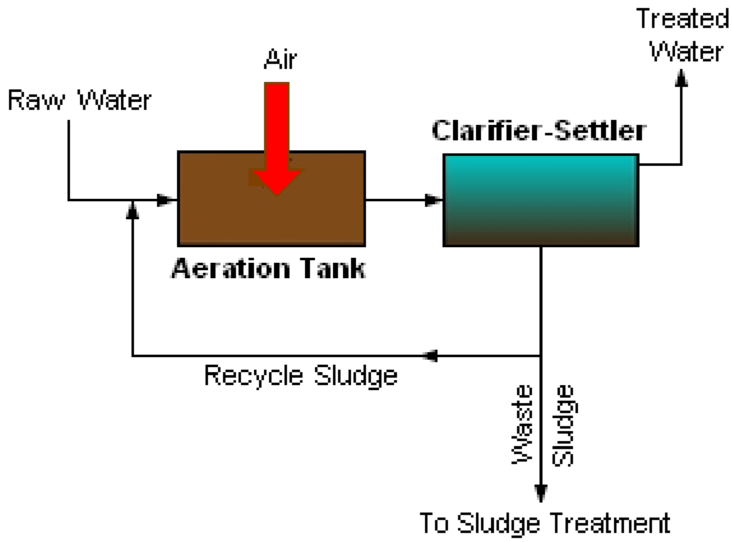
In suspended-growth systems, such as activated sludge, the biomass is well mixed with the sewage and can be operated in a smaller space than fixed-film systems that treat the same amount of water. However, fixed-film systems are more able to cope with drastic changes in the amount of biological material and can provide higher removal rates for organic material and suspended solids than suspended growth systems.

Roughing filters are intended to treat particularly strong or variable organic loads, typically industrial, to allow them to then be treated by conventional secondary treatment processes. Characteristics include typically tall, circular filters filled with open synthetic filter media to which wastewater is applied at a relatively high rate. They are designed to allow high hydraulic loading and a high flow-through of air. On larger installations, air is forced through the media using blowers. The resultant wastewater is usually within the normal range for conventional treatment processes

3.6.5 Activated sludge

In general, activated sludge plants encompass a variety of mechanisms and processes that use dissolved oxygen to promote the growth of biological floc that substantially removes organic material.

The process traps particulate material and can, under ideal conditions, convert ammonia to nitrite and nitrate and ultimately to nitrogen gas.



3.6.6 Surface-aerated basins

Most biological oxidation processes for treating industrial wastewaters have in common the use of oxygen (or air) and microbial action. Surface-aerated basins achieve 80 to 90% removal of Biochemical Oxygen Demand with retention times of 1 to 10 days. The basins may range in depth from 1.5 to 5.0 metres and use motor-driven aerators floating on the surface of the wastewater.

In an aerated basin system, the aerators provide two functions: they transfer air into the basins required by the biological oxidation reactions, and they provide the mixing required for dispersing the air and for contacting the reactants (that is, oxygen, wastewater and microbes). Typically, the floating surface aerators are rated to deliver the amount of air equivalent to 1.8 to 2.7 kg O2/kW·h. However, they do not provide as good mixing as is normally achieved in activated sludge systems and therefore aerated basins do not achieve the same performance level as activated sludge units.

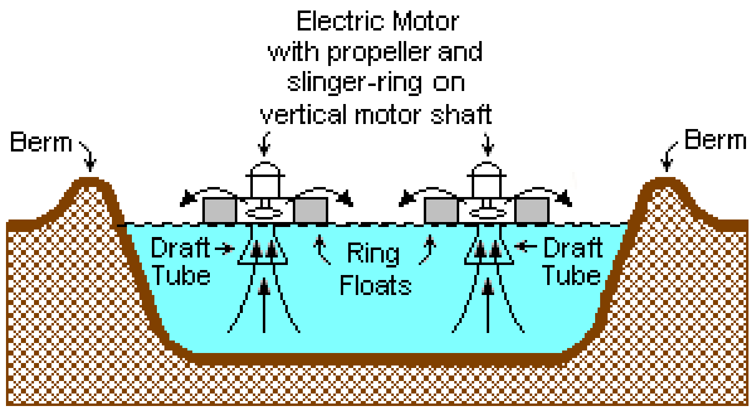
Biological oxidation processes are sensitive to temperature and, between 0 °C and 40 °C, the rate of biological reactions increase with temperature. Most surface aerated vessels operate at between 4 °C and 32 °C.

3.6.7 Filter beds (oxidizing beds)

In older plants and plants receiving more variable loads, trickling filter beds are used where the settled sewage liquor is spread onto the surface of a deep bed made up of coke (carbonized coal), limestone chips or specially fabricated plastic media. Such media must have high surface areas to support the biofilms that form. The liquor is distributed through perforated rotating arms radiating from a central pivot. The distributed liquor trickles through this bed and is collected in drains at the base. These drains also provide a source of air which percolates up through the bed, keeping it aerobic. Biological films of bacteria, protozoa and fungi form on the media's surfaces and eat or otherwise reduce the organic content. This biofilm is grazed by insect larvae and worms which help maintain an optimal thickness. Overloading of beds increases the thickness of the film leading to clogging of the filter media and ponding on the surface.

3.6.8 Biological aerated filters

Biological Aerated (or Anoxic) Filter (BAF) or Biofilters combine filtration with biological carbon reduction, nitrification or denitrification. BAF usually includes a reactor filled with a filter media. The media is either in suspension or supported by a gravel layer at the foot of the filter. The dual purpose of this media is to support highly active biomass that is attached to it and to filter suspended solids. Carbon reduction and ammonia conversion occurs in aerobic mode and sometime achieved in a single reactor while nitrate conversion occurs in anoxic mode. BAF is operated either in upflow or downflow configuration depending on design specified by manufacturer.



A TYPICAL SURFACE – AERATED BASIN

Note: The ring floats are tethered to posts on the berms.

3.6.9 Membrane bioreactors

Membrane bioreactors (MBR) combines activated sludge treatment with a membrane liquid-solid separation process. The membrane component uses low pressure microfiltration or ultra filtration membranes and eliminates the need for clarification and tertiary filtration. The membranes are typically immersed in the aeration tank (however, some applications utilize a separate membrane tank). One of the key benefits of a membrane bioreactor system is that it effectively overcomes the limitations associated with poor settling of sludge in conventional activated sludge (CAS) processes. The technology permits bioreactor operation with considerably higher mixed liquor suspended solids (MLSS) concentration than CAS systems, which are limited by sludge settling. The process is typically operated at MLSS in the range of 8,000–12,000 mg/L, while CAS are operated in the range of 2,000–3,000 mg/L. The elevated biomass concentration in the membrane bioreactor process allows for very effective removal of both soluble and particulate biodegradable materials at higher loading rates. Thus increased Sludge Retention Times (SRTs)—usually exceeding 15 days—ensure complete nitrification even in extremely cold weather.

The cost of building and operating a MBR is usually higher than conventional wastewater treatment, however, as the technology has become increasingly popular and has gained wider acceptance throughout the industry, the life-cycle costs have been steadily decreasing. The small footprint of MBR systems, and the high quality effluent produced, makes them particularly useful for water reuse applications.

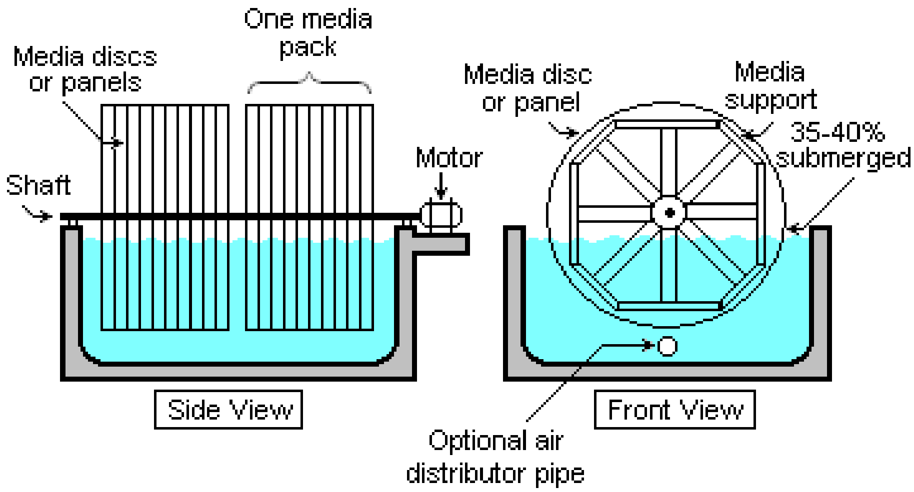
3.6.10 Secondary sedimentation

The final step in the secondary treatment stage is to settle out the biological flock or filter material and produce sewage water containing very low levels of organic material and suspended matter.

3.6.10.1 Rotating biological contactors

Rotating biological contactors (RBCs) are mechanical secondary treatment systems, which are robust and capable of withstanding surges in organic load. RBCs were first installed in Germany in 1960 and have since been developed and refined into a reliable operating unit. The rotating disks support the growth of bacteria and micro-organisms present in the sewage, which breakdown and stabilise organic pollutants. To be successful, micro-organisms need both oxygen to live and food to grow. Oxygen is obtained from the atmosphere as the disks rotate. As the micro-organisms grow, they build up on the media until they are sloughed off due to shear forces provided by the rotating discs in the sewage. Effluent from the RBC is then passed through final clarifiers where the micro-organisms in suspension settle as a sludge. The sludge is withdrawn from the clarifier for further treatment.

A functionally similar biological filtering system has become popular as part of home aquarium filtration and purification. The aquarium water is drawn up out of the tank and then cascaded over a freely spinning corrugated fiber-mesh wheel before passing through a media filter and back into the aquarium. The spinning mesh wheel develops a biofilm coating of microorganisms that feed on the suspended wastes in the aquarium water and are also exposed to the atmosphere as the wheel rotates. This is especially good at removing waste urea and ammonia urinated into the aquarium water by the fish and other animals.



3.6.10.2 Tertiary treatment

The purpose of tertiary treatment is to provide a final treatment stage to raise the effluent quality before it is discharged to the receiving environment (sea, river, lake, ground, etc.). More than one tertiary treatment process may be used at any treatment plant. If disinfection is practiced, it is always the final process. It is also called "effluent polishing".

3.6.10.3 Filtration

Sand filtration removes much of the residual suspended matter. Filtration over activated carbon removes residual toxins.

3.6.10.4 Lagooning

A sewage treatment plant and lagoon in Everett, Washington.Lagooning provides settlement and further biological improvement through storage in large man-made ponds or lagoons. These lagoons are highly aerobic and colonization by native macrophytes, especially reeds, is often encouraged. Small filter feeding invertebrates such as Daphnia and species of Rotifera greatly assist in treatment by removing fine particulates.

3.6.10.5 Constructed wetlands

Constructed wetlands include engineered reedbeds and a range of similar methodologies, all of which provide a high degree of aerobic biological improvement and can often be used instead of secondary treatment for small communities, also see phytoremediation. One example is a small reedbed used to clean the drainage from the elephants' enclosure at Chester Zoo in England.

3.6.11 Nutrient removal

Wastewater may contain high levels of the nutrients nitrogen and phosphorus. Excessive release to the environment can lead to a build up of nutrients, called eutrophication, which can in turn encourage the overgrowth of weeds, algae, and cyanobacteria (blue-green algae). This may cause an algal bloom, a rapid growth in the population of algae. The algae numbers are unsustainable and eventually most of them die. The decomposition of the algae by bacteria uses up so much of oxygen in the water that most or all of the animals die, which creates more organic matter for the bacteria to decompose. In addition to causing deoxygenation, some algal species produce toxins that contaminate drinking water supplies. Different treatment processes are required to remove nitrogen and phosphorus.

3.6.12 Nitrogen removal

The removal of nitrogen is effected through the biological oxidation of nitrogen from ammonia (nitrification) to nitrate, followed by denitrification, the reduction of nitrate to nitrogen gas. Nitrogen gas is released to the atmosphere and thus removed from the water.

Nitrification itself is a two-step aerobic process, each step facilitated by a different type of bacteria. The oxidation of ammonia ($NH3$) to nitrite ($NO2^-$) is most often facilitated by Nitrosomonas spp. (nitroso referring to the formation of a nitroso functional group). Nitrite oxidation to nitrate ($NO3^-$), though traditionally believed to be facilitated by Nitrobacter spp. (nitro referring the formation of a nitro functional group), is now known to be facilitated in the environment almost exclusively by Nitrospira spp.

Denitrification requires anoxic conditions to encourage the appropriate biological communities to form. It is facilitated by a wide diversity of bacteria. Sand filters, lagooning and reed beds can all be used to reduce nitrogen, but the activated sludge process (if designed well) can do the job the most easily. Since denitrification is the reduction of nitrate to dinitrogen gas, an electron donor is needed. This can be, depending on the wastewater, organic matter (from faeces), sulfide, or an added donor like methanol.

Sometimes the conversion of toxic ammonia to nitrate alone is referred to as tertiary treatment.

3.6.13 Phosphorus removal

Phosphorus removal is important as it is a limiting nutrient for algae growth in many fresh water systems (for negative effects of algae see Nutrient removal). It is also particularly important for water reuse systems where high phosphorus concentrations may lead to fouling of downstream equipment such as reverse osmosis.

Phosphorus can be removed biologically in a process called enhanced biological phosphorus removal. In this process, specific bacteria, called polyphosphate accumulating organisms (PAOs), are selectively enriched and accumulate large quantities of phosphorus within their cells (up to 20% of their mass). When the biomass enriched in these bacteria is separated from the treated water, these biosolids have a high fertilizer value.

Phosphorus removal can also be achieved by chemical precipitation, usually with salts of iron (e.g. ferric chloride), aluminum (e.g. alum), or lime. This may lead to excessive sludge productions as hydroxides precipitates and the added chemicals can be expensive. Despite this, chemical phosphorus removal requires significantly smaller equipment footprint than biological removal, is easier to operate and is often more reliable than biological phosphorus removal.

Once removed, phosphorus, in the form of a phosphate rich sludge, may be land filled or, if in suitable condition, resold for use in fertilizer.

3.7 Disinfection

The purpose of disinfection in the treatment of wastewater is to substantially reduce the number of microorganisms in the water to be discharged back into the environment. The effectiveness of disinfection depends on the quality of the water being treated (e.g., cloudiness, pH, etc.), the type of disinfection being used, the disinfectant dosage (concentration and time), and other environmental variables. Cloudy water will be treated less successfully since solid matter can shield organisms, especially from ultraviolet light or if contact times are low. Generally, short contact times, low doses and high flows all militate against effective disinfection. Common methods of disinfection include ozone, chlorine, or ultraviolet light. Chloramine, which is used for drinking water, is not used in wastewater treatment because of its persistence.

Chlorination remains the most common form of wastewater disinfection in North America due to its low cost and long-term history of effectiveness. One disadvantage is that chlorination of residual organic material can generate chlorinated-organic compounds that may be carcinogenic or harmful to the environment. Residual chlorine or chloramines may also be capable of chlorinating organic material in the natural aquatic environment. Further, because residual chlorine is toxic to aquatic species, the treated effluent must also be chemically dechlorinated, adding to the complexity and cost of treatment.

Ultraviolet (UV) light can be used instead of chlorine, iodine, or other chemicals. Because no chemicals are used, the treated water has no adverse effect on organisms that later consume it, as may be the case with other methods. UV radiation causes damage to the genetic structure of bacteria, viruses, and other pathogens, making them incapable of reproduction. The key disadvantages of UV disinfection are the need for frequent lamp maintenance and replacement and the need for a highly treated effluent to ensure that the target microorganisms are not shielded from the UV radiation (i.e., any solids present in the treated effluent may protect microorganisms from the UV light). In the United Kingdom, light is becoming the most common means of disinfection because of the concerns about the impacts of chlorine in chlorinating residual organics in the wastewater and in chlorinating organics in the receiving water. Edmonton and Calgary, Alberta, Canada also use UV light for their effluent water disinfection.

Ozone O3 is generated by passing oxygen O2 through a high voltage potential resulting in a third oxygen atom becoming attached and forming O3. Ozone is very unstable and reactive and oxidizes most organic material it comes in contact with, thereby destroying many pathogenic microorganisms. Ozone is considered to be safer than chlorine because, unlike chlorine which has to be stored on site (highly poisonous in the event of an accidental release), ozone is generated onsite as needed. Ozonation also produces fewer disinfection by-products than chlorination. A disadvantage of ozone disinfection is the high cost of the ozone generation equipment and the requirements for special operators.

3.8 Package plants and batch reactors

In order to use less space, treat difficult waste, deal with intermittent flow or achieve higher environmental standards, a number of designs of hybrid treatment plants have been produced. Such plants often combine all or at least two stages of the three main treatment stages into one combined stage. In the UK, where a large number of sewage treatment plants serve small populations, package plants are a viable alternative to building discrete structures for each process stage.

One type of system that combines secondary treatment and settlement is the sequencing batch reactor (SBR). Typically, activated sludge is mixed with raw incoming sewage and mixed and aerated. The resultant mixture is then allowed to settle producing a high quality effluent. The settled sludge is run off and re-aerated before a proportion is returned to the head of the works. SBR plants are now being deployed in many parts of the world including North Liberty, Iowa, and Llanasa, North Wales.

The disadvantage of such processes is that precise control of timing, mixing and aeration is required. This precision is usually achieved by computer controls linked to many sensors in the plant. Such a complex, fragile system is unsuited to places where such controls may be unreliable, or poorly maintained, or where the power supply may be intermittent.

Package plants may be referred to as high charged or low charged. This refers to the way the biological load is processed. In high charged systems, the biological stage is presented with a high organic load and the combined floc and organic material is then oxygenated for a few hours before being charged again with a new load. In the low charged system the biological stage contains a low organic load and is combined with flocculate for a relatively long time.

3.9 Electricity Use

Wastewater treatment plants are, along with water treatment plants, often the largest users of energy in a community. These processes account for 3% of electricity use in the United States. As an example, Nazareth Wastewater Treatment Plant in Nazareth, PA uses 1.6 million kWh per year to process 365 million gallons of wastewater. For each gallon of water treated, the electric power used is equivalent to leaving a 100-W equivalent (23W) Compact Fluorescent Lightbulb on for 11.4 minutes, or a 60-W equivalent (14W) bulb for 18.8 minutes.

3.10 Sludge treatment and disposal

The sludges accumulated in a wastewater treatment process must be treated and disposed of in a safe and effective manner. The purpose of digestion is to reduce the amount of organic matter and the number of disease-causing microorganisms present in the solids. The most common treatment options include anaerobic digestion, aerobic digestion, and composting.

Choice of a wastewater solid treatment method depends on the amount of solids generated and other site-specific conditions. However, in general, composting is most often applied to smaller-scale applications followed by aerobic digestion and then lastly anaerobic digestion for the larger-scale municipal applications.

3.10.1 Anaerobic digestion

Anaerobic digestion is a bacterial process that is carried out in the absence of oxygen. The process can either be thermophilic digestion, in which sludge is fermented in tanks at a temperature of 55°C, or mesophilic, at a temperature of around 36°C. Though allowing shorter retention time (and thus smaller tanks), thermophilic digestion is more expensive in terms of energy consumption for heating the sludge.

One major feature of anaerobic digestion is the production of biogas, which can be used in generators for electricity production and/or in boilers for heating purposes.

3.10.2 Aerobic digestion

Aerobic digestion is a bacterial process occurring in the presence of oxygen. Under aerobic conditions, bacteria rapidly consume organic matter and convert it into carbon dioxide. The operating costs are characteristically much greater for aerobic digestion because of the energy costs needed to add oxygen to the process.

3.10.2.1 Composting

Composting is also an aerobic process that involves mixing the sludge with sources of carbon such as sawdust, straw or wood chips. In the presence of oxygen, bacteria digest both the wastewater solids and the added carbon source and, in doing so, produce a large amount of heat.

3.11 Sludge disposal

When a liquid sludge is produced, further treatment may be required to make it suitable for final disposal. Typically, sludge’s are thickened (dewatered) to reduce the volumes transported off-site for disposal. There is no process which completely eliminates the need to dispose of bio solids. There is, however, an additional step some cities are taking to superheat the wastewater sludge and convert it into small pelletized granules that are high in nitrogen and other organic materials. In New York City, for example, several sewage treatment plants have dewatering facilities that use large centrifuges along with the addition of chemicals such as polymer to further remove liquid from the sludge. The removed fluid, called centrate, is typically reintroduced into the wastewater process. The product which is left is called "cake" and that is picked up by companies which turn it into fertilizer pellets. This product is then sold to local farmers and turf farms as a soil amendment or fertilizer, reducing the amount of space required to dispose of sludge in landfills.

3.12 Treatment in the receiving environment

The outlet of a wastewater treating plant flows into a small river. Many processes in a wastewater treatment plant are designed to mimic the natural treatment processes that occur in the environment, whether that environment is a natural water body or the ground. If not overloaded, bacteria in the environment will consume organic contaminants, although this will reduce the levels of oxygen in the water and may significantly change the overall ecology of the receiving water. Native bacterial populations feed on the organic contaminants, and the numbers of disease-causing microorganisms are reduced by natural environmental conditions such as predation or exposure to ultraviolet radiation. Consequently, in cases where the receiving environment provides a high level of dilution, a high degree of wastewater treatment may not be required. However, recent evidence has demonstrated that very low levels of certain contaminants in wastewater, including hormones (from animal husbandry and residue from human hormonal contraception methods) and synthetic materials such as phthalates that mimic hormones in their action, can have an unpredictable adverse impact on the natural biota and potentially on humans if the water is re-used for drinking water. In the US and EU, uncontrolled discharges of wastewater to the environment are not permitted under law, and strict water quality requirements are to be met. A significant threat in the coming decades will be the increasing uncontrolled discharges of wastewater within rapidly developing countries.

3.13 Sewage treatment in developing countries

There are few reliable figures on the share of the wastewater collected in sewers that is being treated in the world. In many developing countries the bulk of domestic and industrial wastewater is discharged without any treatment or after primary treatment only. In Latin America about 15% of collected wastewater passes through treatment plants (with varying levels of actual treatment). In Venezuela, a below average country in South America with respect to wastewater treatment, 97 percent of the country's sewage is discharged raw into the environment.

In a relatively developed Middle Eastern country such as Iran, Tehran's majority of population has totally untreated sewage injected to the city's groundwater. Israel has also aggressively pursued the use of treated sewer water for irrigation. In 2008, agriculture in Israel consumed 500 million cubic metres of potable water and an equal amount of treated sewer water. The country plans to provide a further 200 million cubic metres of recycled sewer water and build more desalination plants to supply even more water.

3.14 Most of sub-Saharan Africa is without wastewater treatment.

Water utilities in developing countries are chronically underfunded because of low water tariffs, the inexistence of sanitation tariffs in many cases, low billing efficiency (i.e. many users that are billed do not pay) and poor operational efficiency (i.e. there are overly high levels of staff, there are high physical losses, and many users have illegal connections and are thus not being billed). In addition, wastewater treatment typically is the process within the utility that receives the least attention, partly because enforcement of environmental standards is poor. As a result of all these factors, operation and maintenance of many wastewater treatment plants is poor. This is evidenced by the frequent breakdown of equipment, shutdown of electrically operated equipment due to power outages or to reduce costs, and sedimentation due to lack of sludge removal.

Developing countries as diverse as Egypt, Algeria, China or Colombia have invested substantial sums in wastewater treatment without achieving a significant impact in terms of environmental improvement. Even if wastewater treatment plants are properly operating, it can be argued that the environmental impact is limited in cases where the assimilative capacity of the receiving waters (ocean with strong currents or large rivers) is high, as it is often the case.

3.15 Waste Water Management for Rural Areas

From the analysis of the sources of waste water and its types, it is revealed that more than 90 percent of waste water generated is greywater. Therefore, greywater management is a major challenge in rural areas in the country. Water management may involve reuse/recycling of water after appropriate treatment for a variety of purposes including irrigation, domestic purposes and toilet flushing.

For effective management of water in rural areas, focus should be on management at household level. In case it cannot be managed at household level, management at the community level should be done. As far as possible, water generated at household level should be managed such that zero or minimum community waste is generated.

3.15.1 Technological Options for Waste Water Management

- The village level water management system should be as simple as possible for a village level person to understand and implement
- It should be decentralized
- Technological options are based on:
- Domestic (Household) level management
- Community level management.

3.15.2 Technological Options at Household Level Management

It will always be better to manage and treat domestic greywater generated in the house in the area/courtyard/land surrounding the house. The following technological options will be suitable for this purpose:

- Kitchen Garden with piped root zone system
- Kitchen Garden without piped root zone system
- Leach pit
- Soakage pit.

3.15.3 Kitchen Garden with Piped Root Zone System

- With this methodology, treated greywater can be utilized to grow vegetables, flowers or fruits in the court-yard of the house.
- **Applicability:** Houses with adequate court-yard.
- **Action:** House owner will do the installation of the system with the help of trained person.
- **Description**

The system has following components:

- A grease trap to collect silt (450mm x 350mm x 300mm)
- Perforated non pressure PVC pipe (50mm diameter and length as per requirement)
- Digging of trench (150mm to 200mm depth and 200mm width)
- Filling of trench with gravel of size (20 to 25mm size)
- Laying of perforated pipe
- Covering the trench with polythene sheet
- Putting the soil layer (50mm thickness over the polythene sheet)
- Construct a leach pit (900mm diameter with honey comb masonry and water tight cover)
- Put a layer of earth over (25mm thickness) over the pit cover
- Plant suitable vegetables or flowers on both sides of the trench.

Operation and maintenance (O&M)

- Periodical cleaning of the grease trap (every week)
- Cleaning of perforated pipes (once in a year).

Materials required

- Bricks (150 bricks)
- Fine Sand (15 gamlas)
- Cement (1/3 bag)
- 50mm non-pressure PVC pipe and length as per requirement
- Pit cover (1000mm diameter and 50mm thickness 3 to 4kg in height)
- Polythene sheet.

Approximate cost (2006 price level):

Rs 80/- per meter length including labor cost.

Advantages

- Simple and cost effective technology
- Cent percent utilization of water to produce vegetables and fruits
- Prevents water stagnation
- Prevents vector breeding.

Limitations

- Use of strong detergent may be harmful to the plants grown in the kitchen garden.
- **Kitchen Garden without Piped Root Zone System**
- With this methodology also, greywater can be utilized to grow vegetables, flowers or fruits in the court-yard of the house.
- **Applicability** Houses with adequate court-yard.
- **Action** House owner will do the installation of the system with the help of trained mason.

3.15.4 Kitchen Garden without Piped Root Zone System

Description

The system has following component:

- A grease trap to collect silt (450mm x 350mm x 300mm)
- A simple bed of appropriate size to absorb the available water
- Let the greywater flow into the bed
- Plant suitable vegetable or flowers at both the side of the trench.

Operation and maintenance (O&M)

Periodical cleaning of the grease trap (every week).

Materials required

- Bricks (50 bricks)
- Fine sand (5 gamlas)
- Cement (1/2 gamlas)

Approximate cost (2006 price level)

Rs 50/- per square meter including labor cost.

Advantages

- Simple and cost effective technology
- Cent percent utilization of water to produce vegetables and fruits
- Prevents water stagnation
- Prevents vector breeding.

Limitations

- Use of strong detergent may be harmful to the plant grown in the kitchen garden.
- **Leach Pit**
- Leach Pit is a brick lined pit constructed in honeycomb masonry having a volume of about 0.75 cubic meters.

Advantages

- It can handle large volume of water during peak period of water generation and is better suited than soak pits
- Prevents stagnation of greywater
- Prevents vector breeding.

3.15.5 Leach pit

Applicability

Houses without adequate space for kitchen garden where waste water discharge is relatively more and pit structure is such that it enhances the leaching effect.

Action

House owner will do the installation of the leach pit with the help of trained mason.

Description

Selection of site-the leach pit can be located at any convenient space near the house, keeping a safe distance between the wall and the pit as 1m

Digging of the pit-dig the pit (a diameter of 1.75m and a depth of 1m)

- Construct the pit in circular fashion with honey combing in alternate layers. The pit can be constructed with single brick (100mm) with a mortar in the ratio of 1:6

- Connect the drain pipe coming from the house to the leach pit via a grease trap
- A P-trap is necessary between the pit and the outlet from the house to avoid vectors entering the leach pit
- The pit should be covered with RCC cover or flag stone slab. The diameter of the cover should be 100mm more than that of the pit.

Operation and maintenance (O&M)

- Periodical cleaning of the P-trap
- Periodical removal of the sludge from the pit.

Materials required (approximate)

- Bricks (150 bricks)
- Fine sand (10 gamlas)
- Cement (1/3 bag).

Approximate cost (2006 price level)

Rs 1000/- per leach pit.

Limitations

Not suitable for rocky terrain.

3.15.6 Soak Pit

Soak pit is a dug out pit filled with stones or preferably over burnt bricks. The large numbers of stones or bricks increase the surface area over which biological and chemical action takes place. The water seeps into the ground and reduces danger of polluting the ground water sources.

Advantages

- This is the cheapest technology for management of water at household level
- Prevents greywater stagnation
- Prevents vector breading.

Applicability Houses without adequate space for kitchen garden.

Action

House owner can construct the pit himself by getting the information of the design.

Description

Step 1: Excavation of 1m x 1m x 1m pit.

Step 2: Filling of 1m x 1m x 1m fit by boulders from bottom 250mm by 125mm to 150mm boulders; 2nd 250mm layer by 100mm to 125mm size boulders; 3rd 250mm layer by 50 to 75mm size boulders.

Precautions

- Boulder should be firm (No morum boulders)
- Fill the pit by boulders very loosely
- Brick bats and sand should not be used as filling materials.

Step 3

Place the 225mm earthen pot (or plastic container) over the last layer of the boulders

Step 4

- Lay twigs (25mm thick) over the top 250mm boulders of size 50 to 75mm size
- Take a gunny bag, tear it out to make it a bigger piece and lay over the twig (25mm
- thick) (Remember to make a hole in the gunny bag appropriately to place the earthen pot.)
- Give one more layer of twig (25mm thick) over the torn portion of the gunny bag.
- Step 5: Put a layer of mud over the top twig layer.
- Step 6: Put some dry soil over the layer of mud; 225mm to 250mm.
- Step 7
- Make chamber of size 200mm x 200mm around the 225mm earthen pot and plaster at the inner part of the chamber, 20mm thickness (1:4) and finish it with cement.
- Step 8
- Connect the bathroom (water) chamber with a 50mm size diameter non-pressure PVC pipe.
- Step 9
- Cover the chamber with suitable lid (e.g. wooden plank or a tile).
- **Making a filter out of earthen/plastic pot**
- Step 1: Fill the earthen/plastic pot with dry soil.
- Step 2: Make it reverse on a level surface.
- Step 3: Make 5 to 6 nos. mark on the bottom the earthen/plastic pot.
- Step 4: Slowly make 5 to 6 holes on the marks by piercing with sickle. Holes should be of the size of tip of thumb.

Operation and maintenance (O&M)

- Filter to be cleaned every fortnight or month, depending on accumulation of dirt
- Make a hook of thick wire and pierce it in the filter and take filter media out and clean/wash it and dry and replace it in the earthen pot
- Soak pit looses its capacity within a period of 7 to 8 years of work. At that time take out the boulders from the pit, scrap the walls of the pit in order to remove the oily layer; let the pit dry for a period of 2 to 3 days and clean and dry the boulders and replace into the pit.

Table: Materials required

SL	Material	Quantity
1.	Boulders/over burnt bricks 125 to 150mm size	7.5 cft
2.	Boulders/over burnt 75 to 100mm size	7.5 cft
3.	Boulders/over burnt bricks 50 to 75mm size	7.5 cft
4.	Gunny bag	1 no.
5.	Earthen pot	1 no.
6.	PVC pipe	50mm dia; 1.5m length

Estimated total **cost for material** (at 2006 price level) Rs 150/- (A)

Estimated **labour Cost**: Rs 120/- (B) with the following break up: For a 200mm x 200mm Connecting Chamber connection work only: Rs 40/- (Skilled labour)

1 day excavation of a pit of size 1m x 1m x 1m by an unskilled labor@ Rs 80/- per day (Unskilled Labour: 1 day).

Grand Total cost for a soakage pit of 1m x 1m x 1m for a rural family of 5 persons=(A)+(B) = Rs 270/- (i.e. Rs 54/- per person).

Limitations

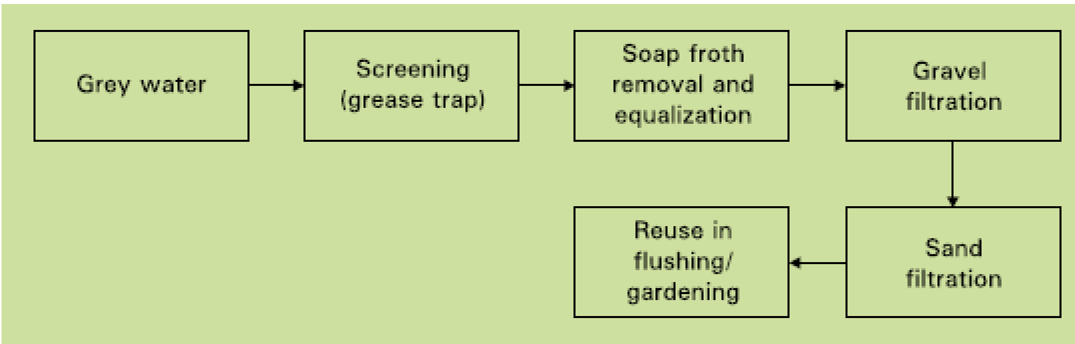
- Soakage pit is not suitable for rocky terrain
- It will over flow if wastewater flow in the pit exceeds the design flow
- If suspended solids get into the pit, the choking of the pit will take place earlier.

3.16 Household Level Greywater Treatment and Reuse System

In water scarce areas, with specific treatment the greywater can be cleaned and reused not only for gardening but for other use also.

3.16.1 Technological process

Greywater treatment process at the household level mainly involves screening (grease and silt removal), soap froth removal, equalization and filtration. Flow diagram of household based greywater treatment system is shown below:



Greywater treatment for reuse in household

Advantages

- Reduces fresh water requirement
- Prevents greywater stagnation
- Prevents vector breeding
- Use in flushing toilets to make toilets functional
- Use of greywater in gardening
- Minimal risk to users of greywater as it incorporates principles of water safety.

Applicability household

- **Action** Individual households may construct and operate this system.
- **Description**
- A three-stage greywater filtration system at household level having following components may be constructed.
- Inlet pipe: 63mm (2 inch) PVC pipe

Inlet chamber: 30cm x 30cm x 10cm (Brick masonry Cement plaster) (A sponge piece is kept in the chamber to absorb the debris coming with the water, so that these can be checked to flow further)

Treatment chamber-1: Size: 30cm x 60cm x 30 cm. filled with gravels, (40 to 60mm size), Brick masonry in 1:4 cement mortar & cement plaster 1:4 with neat cement finis

Treatment chamber-2: Water flows from chamber-1 to chamber-2 Size-40cm x 60cm x 30cm filled with fine sand

Filter water Size: 40cm x 60cm x 50cm

Storage tank: Brick masonry in 1:4 cement mortar & cement plaster 1:4 with neat cement finis

Base of all the chambers: Constructed with 1:2:4 CC work with 12mm grit size and then cement finis with 5% slope (1 in 20)

Out let: Through 63mm (2 inch) PVC pipe.

The operation and maintenance is not a skilled job in the system, as it requires washing of the sponge kept in the inlet chamber on regular basis and the washing and changing/refilling of gravel & fine sand time to time in the treatment chamber 1 and 2. Members of the beneficiary family are doing this and the system is functioning satisfactorily.

Operation & Maintenance

- Periodical cleaning of grease trap, filters and sponge
- Gravels and sand from the filtration unit need to be washed periodically
- Sedimentation tanks require de-sludging every month.

Costing and economic viability

- Appromite material cost – Rs 600/-
- Labour charges-Rs 250/-
- Approximate total cost-Rs 850/-.
- Limitations: Very frequent cleaning and user attention is required.
- **Technological Options for Community Level Management at Public Places-On Site**

Community level greywater can be divided in two types:

a. <u>Greywater in rural areas in public places</u> like public stand posts for water supply, wells, hand pumps, schools etc

b. <u>Greywater from houses</u> which can not be managed at domestic level.

The greywater from public places would have minimum quantity of pollutants. While domestic greywater which becomes community greywater in due course, will have grease, kitchen waste water, food particles, bathing and clothes washing water, silt etc.

3.16.2 On site management of community

The greywater generated at public places is usually a cleaner water. This greywater can be preferably managed on site by adopting the following technological options. These options can also be adopted for managing institutional greywater which is from bathing, clothes washing etc.

- Plantation with intercepting chamber
- Community leach pit
- Soakaway channel
- Simple process of reuse of greywater
- System of waste water treatment such as root zone system.

3.16.3 Plantation with intercepting chamber:

The greywater at public places in rural areas as stated earlier, is usually spilled over water. As such it is cleaner water. Hence this water can be reused conveniently for plantation.

Advantage

- There will be no stagnation of spilled over water
- Vector breeding will be avoided
- Main water source will not be contaminated
- There will be beneficial return from plantation e.g. fruits, vegetables, wood etc.

Applicability: The technology will be useful for greywater generated in public places for reuse.

Action

This will have to be established and maintained by Gram Panchayat/Women Self Help Group (SHG)/community based organisations.

Description

- Site selection-the plantation will have to be established taking into account of the slope of the ground and it should be down stream of the water source
- The area surrounding such public places as mentioned above should have a platform around it so that spilled water does not accumulate and is channelised towards the lower gradient
- The channel should be built from that point to the plantation area in such a way that the water does not stagnate on the platform

- At the beginning of the plantation area, silt chamber will have to be constructed
- From the silt chamber, the water can be given to plantation either by piped root zone system or without piped root zone system as discussed earlier in the domestic Greywater management.

Operation and maintenance (O&M)

- The platform and the channel will have to be cleaned daily
- The silt chamber will have to be cleaned periodically depending upon silt accumulation
- In case of piped root zone system, the pipe will have to be cleaned in case of any blockage in the pipe
- If the platform develops any cracks etc. it will have to be repaired immediately
- If required, the plantation area can be fenced off.

Materials required

As per requirements based on detailed estimate with the support of available technical personnel. Cost will accordingly vary.

Limitations

- • Availability of public land for plantation
- • Topography of the area.

3.16.4 Community Leach Pit

If land is not available for plantation, the spilled water can be absorbed in the soil by constructing a larger size leach pit.

Advantage

- There will be stagnation of spilled over water
- Prevents vector breeding
- Main water source will not be contaminated.

Applicability

- The application of the technology will help in preventing water stagnation around such public places.
- **Action**
- The system will have to be established and maintained by Gram Panchayat/Women Self Help Group (SHG).
- **Description**

- Selection of site-the leach pit can be located at any convenient space near the house keeping a safe distance between the wall and the pit as 1m
- Digging of the pit – dig the pit (the diameter should be such that the volume of the pit should be equal to the daily incoming Greywater into the pit and depth of 1.2 m.; if the diameter is more than 1.5 m, the brickwork should be 225mm thick with necessary honey comb)
- Construct the pit in circular fashion with honey combing in alternate layers. The pit can be constructed with single brick (100mm) with a mortar in the ratio of 1:6
- Connect the drain pipe coming from the waste water source to the leach pit

- A silt chamber is necessary between the pit and outlet from the waste water source to avoid entrance of mosquito vectors into the leach pit
- The pit should be covered with RCC cover or flag stone slab. The diameter of the cover should be 100mm more than that of the pit
- The top 0.3m should have corbelling to reduce the size of the opening at the top so as to have a diameter of about 0.9m

Operation and maintenance (O&M)

- Silt chamber should be periodically cleaned
- Sludge to be removed when pit is filled up.

Materials required

As per detailed estimate to be prepared with the support of available technical personnel. Cost will vary accordingly.

Limitations

Depending on the absorption capacity of the soil, the pit may over flow. In that case, additional leach pit will have to be constructed.

3.16.5 Soakaway Channel

Soak pits can be built in every house for wastewater disposal. But such small pits cannot be of much use near public wells where a large quantity of wastewater flows. In such places pits have to be built like big channels, which are called soakaway channels. Sludge tanks have to be made to clean and filter the water before entering such channels. In soak pits a pot with holes is used for filtration of water. As large quantity of water flows into soakaway channels, a sludge tank is provided instead of a pot. Such an arrangement is called soakaway channel with sludge tank.

Advantage

- Large quantities of community greywater can be absorbed without any open stagnation of greywater
- Prevents vector breeding
- Main water source will not be contaminated.

Applicability

- This technology will be more useful in rocky terrain where leach pit may not function properly.
- **Action**
- Concerned Gram Panchayat (GP) needs to establish and maintain this system.
- **Description**

The system has two major components:

- Sludge Tank
- Soakaway Channel.

Function

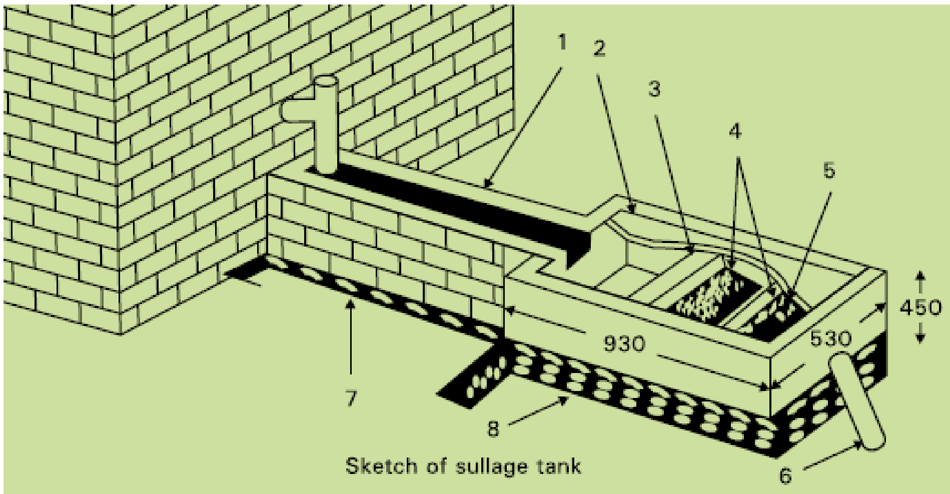
Function of a sullage tank is the same as that of the filter pot in household level soak pit on a big scale. The sullage tank intercepts ash, mud and oily substances in the water and allows the cleaned water to flow to the soakaway channel. Soakaway channel is built near the well and the water allowed to flow into it through the sullage tank.

3.17 Construction of sludge tank

A sludge tank is generally constructed at a distance of 1.2 to 1.5m away from the well and waste water is taken to it by a drain. First a 93 x 53 x 45cm (deep) pit is excavated. A 15cm thick layer of cement concrete 1:4:8 is laid on the bottom of the pit. A 11.5cm thick and 30cm high brick wall is constructed on the foundation at four sides of the pit. The height of the wall at the point where the drain meets the sullage tank is kept 22.5cm so that a notch is formed, from where wastewater enters the sullage tank. The height of this wall should be 15cm towards the inlet of water and 12.5cm towards the outlet. This wall will divide the tank into two portions each measuring by 30cm x 29.25cm. The first chamber is called grit chamber and second is called grease chamber.

In the tank, other than the one in which water falls, leave a space of 6.25 to 7.5 from the bottom and make a groove of 2.5cm wide in both the walls at center up to the top. Fit in a 25mm thick stone slab in this groove. Fix a pipe 7.5 to 10cm above the bottom in the last chamber for the outlet of water into the soakaway channel. Before using the sludge tank a 10 to 12.5cm thick layer of grass and leaves should be placed in the grease chamber.

Water from the drain first enters the grit chamber of the sludge tank where ashes, mud and other grit materials settle in this chamber and the water flows over the wall in the middle and goes to the other tank. Floating substances like charcoal, oil etc. are intercepted by grass and leaves at this place. Because of the stone slab, the water flows through the grass and leaves etc. and goes into the soakaway channel through the pipe provided at the end of this chamber. This water is well cleaned.



a. Channel for wastewater from the drain; 2. Cover of sullage tank; 3. 11.5cm wall; 4. Grass, leaves etc.; 5. 0.25mm thick stone slab; 6. Pipe to convey water to the soakaway channel; 7-8 Foundation

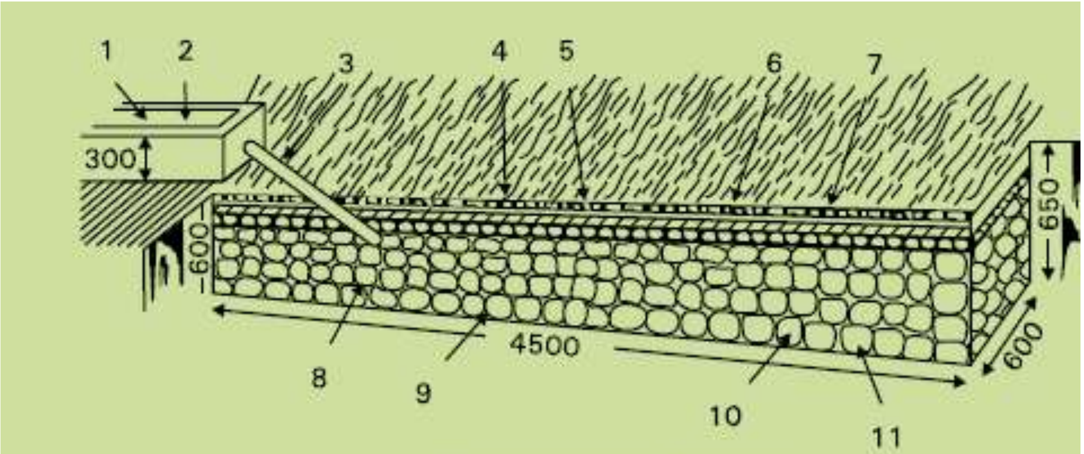
The mud, ash and gritty material collected in grit chamber should be taken out by a spade. Grass and leaves, etc. should also occasionally be removed and fresh ones placed. Some times lime and hypochlorite should be sprinkled in the grit tanks so that insects do not breed. Do not use phenyl, dettol or D.D.T. A container with holes in the bottom can also be used in the grit chamber so that if necessary it can be taken out, cleaned and replaced in the tank.

If large quantity of wastewater is coming, then an extra grease chamber should be built with a slab in it as described above for further cleaning of wastewater. The grit chamber can be built big or small according to the quantity of water used.

If drainage channel is long, smaller tanks may be constructed or colored containers be kept in the passage to intercept the sullage, mud etc. If the soakaway channel is far from the sullage tank then also a tank should be built in between.

3.18 Soak away channel

Where a large quantity of wastewater is coming, the soak pit is not of much use. Soakaway channel is built where more than 50-60 buckets of water is used.



Sketch of soakage channel

1. Handle of the cover; 2. Cover over the sullage tank; 3. Pipe to let water intothe soakage channel; 4. Small pieces of bricks; 5. Wet mud as mortar; 6. A piece of gunny clothe; 7. A layer of vegetation that does not decompose; 8. Round pebbles of 75-100mm dia meter in the 1.5ft portion; 9. Round pebbles of 100 to 125mm in the second 5ft portion; 10. Round pebbles of 150mm diameter in the third 1.5ft portion and a layer of pebbles of 75 to 100mm diameter over it and 11. Underground soakaway channel.

Construction

Dig a channel 4.5m long and 0.6m broad. It should be o.6m deep in the beginning and 0.75m in the end. It should be divided into three portions of 1.5m each. The first portion should be filled with round pebbles of 7.5 to 10cm diameter leaving a space of 12.5cm at the top. In the second portion round pebbles of 10cm to 12.5cm diameter and in the last those of 12.5cm to 15cm diameter should be placed. After this a 7.5cm thick layer of pebbles of 7.5cm to 10cm diameter should be laid on the top throughout. The outlet pipe from the sullage tank should be fixed into the first portion of the channel.

The soakaway channel is covered from above in the same ways as the soak away pit. A 2.5cm layer of non-decaying vegetable matter should be laid over the stones in the channel. Gunny cloth or plastic sheet should be used to cover it so that mud and refuse etc. may not get in. Again a similar layer of non decaying vegetation should be laid and coated with 2.5cm thick layer of mud. Then put dry earth over it, so that its level may be

15cm above ground level. Gradually this earth will get pressed and be level with the ground. Carts and trucks can pass over the soakaway channel without causing any damage to it.

Operation and maintenance (O&M)

Stone pieces should be well cleaned before putting them in the soakaway channel.

Take care that the earth does not fall in it. The pit should be cleaned before stones are laid. When the water tank is filled up, it should be cleaned after removing the cover and grass and leaves changed with fresh ones. The sullage tank should be cleaned once or twice a month. If this is regularly cleaned as described above the soak away channel will give satisfactory service for 7 to 8 years.

The soak away channel can be made 9m long and 0.9m deep if more water is directed to it. It should not be deeper than 0.9 although its length and breadth can be increased. If 9m long space is not available, then two channels each 4.5m long can be made. If one soak away channel is filled up, the other is put into use. Thus the cycle is repeated. If the soak away channel is not to be used, then the clean water coming out of the sullage tank can be utilized in the garden.

After many years when the soakaway channel gets filled up it should be opened and all the stone pieces taken out. The algae around the channel be removed and the channel left open for five or six days to dry. Later the stones should be washed, placed again as described above and the channel brought into use again.

In this way the wastewater at public places can be allowed to flow in the soakaway channels with sullage tanks and cleanliness is assured.

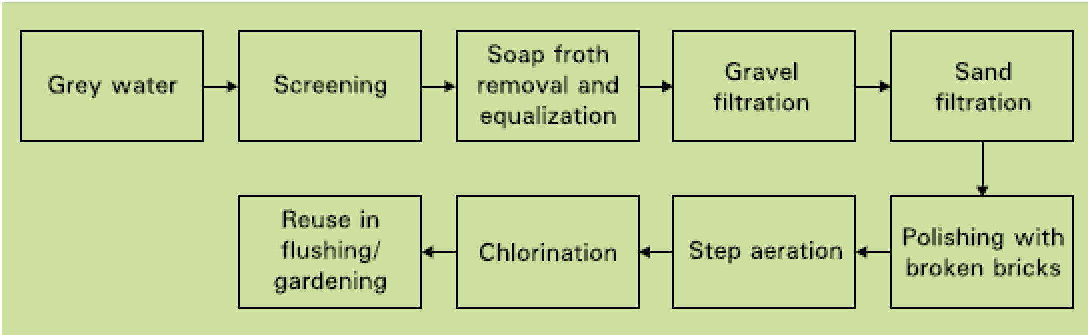
Material required

As per design for community soakaway channel system and detailed estimate with the support of available technical personal.

3.19 Grey water Treatment

3.19.1 Technological process

Greywater treatment process at the community level mainly involves screening, soap froth removal, equalization, filtration and chlorination. Flow diagram of community/school based greywater treatment system is shown below:



An overview of the technology

The greywater from the community (as also from individual) can be treated through simple process of screening, silt removal, subsequent filtration and chlorination. The treated water will be stored in a simple and small underground tank for subsequent reuse for activity like toilet flushing, toilet cleaning and gardening.

First step in treatment process includes screening which are normally done by putting screens at the source of greywater generation such as bathroom outlet. Treatment technology mainly consists of removal of soap froth using foam or sponge filter. This is done to avoid froth appearing in collection chamber provided at the end of treatment plant. Equalization is done to provide equal loading to filtration system and minimize quality fluctuations. Gravel filtration is done to remove turbidity, suspended solids and some amount of BOD and this is followed by sand filtration to remove Color, bacteria, protozoan and helminthes eggs, suspended solids and some amount of BOD from jerkwater. Polishing of treated greywater is using either charcoal or broken bricks. Step aeration is carried out to remove odour from the treated greywater before reuse.

Advantages

- Reduces fresh water requirement
- Prevents greywater stagnation
- Main water source will not be contaminated
- Prevents vector breeding
- Use in flushing toilets to make toilets functional

- Use of greywater in gardening
- Minimal risk to users of greywater as it incorporates principles of water safety.

Applicability Community and schools.

Action

Construction of greywater treatment system is extremely simple and can be done by masons available in rural areas. The process of greywater treatment starts with collection of greywater from bathroom and washing clothes. The screens should be put at the outlets of greywater generation sources. The collected wastewater is led to equalization tank provided with soap froth removal filter. Thereafter greywater is led to series of gravel and sand filtration units before letting it to polishing unit. Chlorination is later undertaken for oxidation as well as disinfection purposes.

Description of the steps to be followed and the components to be constructed

Primary treatment-pre-treatment to secondary treatment

- Screening
- Equalization.

Secondary treatment

- Gravel filtration
- Sand filtration
- Chlorination.

The system has following components (for community as well as individual; size will vary according to quantity of greywater flow):

- Inlet pipe (4kg pressure PVC pipe, size and length will depend on quantity of flow of greywater; for an individual household of 5-6 members: 63mm, 4kg pressure PVC will be sufficient)
- Inlet chamber (30cm x 30cm x 10cm in brick masonry cement plaster for an individual household of 5-6 members and 30cm x 30cm x 30cm in brick masonry cement plaster for community greywater flow of 1000liters per day)
- Sponge of appropriate size to be placed at the inlet pint in the inlet chamber
- Equalization Tank (70cm x 50cm x 60cm for community greywater flow of 1000 liters per day; brick masonry in cement plaster)

3.19.2 Filtration Units:

Treatment Unit 1 (70cm x 40cm x 60cm for community greywater flow of 1000 liters per day); Gravel size 40-60mm)

Treatment Unit 2 ((70cm x 40cm x 60cm for community greywater flow of 1000 liters per day); Gravel size 20-40mm)

Treatment Unit 3 ((70cm x 40cm x 60cm for community greywater flow of 1000 liters per day); Coarse sand size 1-1.4mm)

Treatment Unit 4 ((70cm x 40cm x 60cm for community greywater flow of 1000 liters per day); (Fine sand size 0.5-0.8mm)

Treatment Unit 5 (70cm x 40cm x 60cm for community greywater flow of 1000 liters per day); (Burn bricks size 20-40mm)

- Aeration and Chlorination tank (100cm x100cm x 100cm brick masonry with cement plaster for community greywater flow 1000 liters per day)
- Outlet pipe (37-63mm, 4kg PVC pipe)
- Treated water collection tank (Size will depend on the quantity of treated water to be stored; 200cm x 200cm x 200cm brick masonry in cement plaster for treated community greywater flow of 1000 liters per day; for an individual family of 5-6 members, size will be 40cm x 60cm x 50cm brick masonry in 1:4 cement mortar & cement plaster1:4 with neat cement finish).

Note:

- Base of all chambers to be constructed with 1:2:4 CC work with 12mm grit size and then cement finish with 5% slope (1 in 20)
- Filtration arrangement may be:
- Up flow-down flow
- Horizontal flow.

3.19.3 Design parameters for greywater reuse system

- Water availability/scarcity
- Quantity of greywater
- Land availability
- Ground slope
- Soil type
- Reuse type such as toilet flushing, gardening, floor washing etc
- Availability and cost of filter media.

O&M

The user of greywater system may be required to undertake certain commitments after system start-up including but not limited to the following:

- Proper operation through a maintenance contract between government and user
- Weekly maintenance of systems with filtering devices
- Systems with two reuse areas require regular diversion
- Sedimentation tanks require de-sludging every month.

Limitations:

Segregation of greywater should be carefully done at source of generation.

Materials required for and cost

The quantity of material required to construct water treatment system for 2500 liter of greywater is given below:

Root Zone Treatment System

The community waste water can be treated and reused by adopting Root Zone Treatment System. The mechanism followed in this system are:

- The functional mechanisms in the soil matrix that are responsible for the mineralization of biodegradable matter are characterized by complex physical, chemical and biological processes, which result from the combined effects of the filter bed material, wetland plants, micro-organisms and waste water
- The treatment processes are based essentially on the activity of microorganisms present in the soil. Smaller the grain size of the filter material and consequently larger the internal surface of the filter bed higher would be the content of microorganisms. Therefore the efficiency should be higher with finer bed material. This process, however is limited by the hydraulic properties of the filter bed; finer the bed material, lower the bed hydraulic load and higher the clogging tendency. The optimization of the filter material in terms o hydraulic load and biodegradation intensity is therefore the most important factor in designing RZTS
- The oxygen for microbial mineralization of organic substances is supplied through the roots of the plants, atmospheric diffusion and in case of intermittent wastewater feeding through suction into the soil by the out flowing wastewater. The roots of the plants intensify the process of biodegradation also by creating an environment in the rhizosphere, which enhances the efficiency of microorganisms and reduces the tendency of clogging of the pores of the bed material caused by increases of biomass

- RZTS contain aerobic, anoxic and anaerobic zones. This, together with the effects of the rhizosphere causes the presence of a large number of different strains of micro-organism and consequently a large variety of biochemical pathways are formed. This explains the high efficacy of biodegradation of substances that are difficult to treat
- The filtration by percolation through the bed material is the reason for the very efficient reduction of pathogens, depending on the size of grain of the bed material and thickness of filter, thus making the treated effluent suitable for reuse.
- Conversion of nitrogen compounds (Nitrification/Denitrification) occurs due to planned flow of waste water through anaerobic and aerobic zones
- Reduction of phosphorous depends on the availability of acceptors like iron compounds and the redox potential in the soil.

The main components of the root zone system are:

- Sedimentation tank for settlement of solids
- Inlet pipe (PVC non pressure pipe to be used);
- Inflow collection system
- Space effective root zone treatment module (gravel filtration: horizontal flow or vertical flow as per soil condition and topography)
- Outlet collection system
- Outlet pipe (Non-pressure PVC)
- Polishing pond.

COD, BOD and E. coli levels reached should be in the range that permits re-use for horticultural-agricultural purposes. The polishing pond need to be stocked with fish which will completely control mosquito breeding. Water hyacinths in the pond utilize residual plant nutrients in particular from the detergents used for laundry.

Item	**Quantity**	**Rate (Rs) (2006 price level)**	**Amount (Rs) (2006 price level)**
Excavation in soil	8.011	30	240
Excavation in rock	12.08	103	1244
Cement concreting	1.337	1174	1570
Brick work	9.667	1687	16308
Damp proof course	6.108	89	544
Filter media			
• Horizontal roughing filter • Slow sand filter • Broken brocks	1.8 m3 1.9 m3	Made available by Ashram	0 0
Cement plaster and	38 m3	40	1520

punning			
Chamber cover	5 Covers	LS	4000
Total			25426
60% above CSR			15255
Grand Total			**40680.00 Say 40000.00**

Table 14

Unit dimension	**Material requirement**
Sponge chamber cum equalization tank – 20cm x 20cm x 15cm	• Bricks – 120
Gravel filter-40cm x 60cm x 30cm	• Sand – 80-100kg *(20 tagari)*
Sand filter-40cm x 60cm x 30cm	• Gravel – 40-60kg *(10 tagari)*
Collection tank-60cm x 60cm x 50cm	• Cement – 1.5 bag
	• PVC pipe – 1m
	• GI mesh for sponge filter – 15cm x 20cm x 10cm
	Cost – Rs 750 – Rs 800/-

Advantages

- Technical simplicity
- Ecological sustainability
- Cost-effectiveness by treating waste water to a level as required on–site for re-use
- There will be no community cesspools as breading ground of mosquito vector
- There will be beneficial return from plantation e.g. vegetables, flowers, fruits, wood and add revenue to the Gram Panchayat.

Applicability

The technology is simple and can be set up by the community for treatment of community waste water.

Action

This will have to be established and maintained by the Gram Panchayat/Self Help Group with the technical support trained local technical person.

Individual responsibility for domestic wastewater treatment through root zone system can be obtained by providing ward-wise treatment system. Responsibility of construction as well as operation and maintenance may be taken up collectively by the

GP through women SHGs. Specific treatment technology should be selected as per the prevailing ground situation like availability of the land, site condition, topography etc.

O&M

The maintenance operations required are periodic desludging of the sedimentation tank, cutting the reeds and rushes in the planted root zone treatment system (two to three times per year), regular removal of water hyacinths from the pond, and pumping treated water from the pond to the gardens for irrigation (use of “Play Pump”/”Cycle Pump” may be explored to the extent possible).

The cut reeds and hyacinths may be used for composting and are regarded as assets, and the water available for garden irrigation will be profitable to meet O&M cost. The Root Zone Treatment Site may be integrated pleasantly with the village landscape.

Materials required

As per detailed estimate to be prepared with the support of trained local technical person.

Limitations

- Planted gravel filter module requires a large area per user (2sq.m. per person). Design should be more space effective by integrating with anaerobic filtration system
- Application of this technology need appropriate technical support to the Gram Panchayat.

3.20 Community Level Management of Greywater from Households

In very compact and very crowded village, effective greywater management at domestic level may not be feasible due to non availability of space around the house. In such cases domestic greywater becomes community greywater. The management of this greywater would be the responsibility of the PRI (GP).

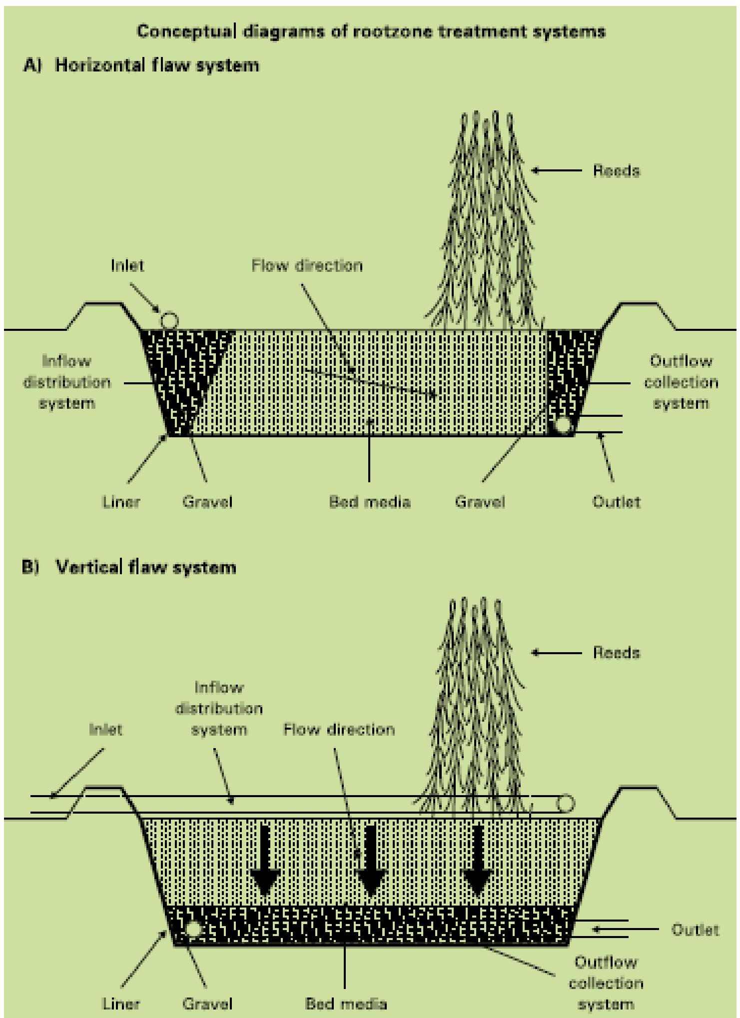
This greywater will contain grease, kitchen waste water, food particles, bathing and clothes washing water, silt etc. Therefore, the technology should be suitable to take care of these contents and to stabilize greywater as far as possible for subsequent reuse.

It will not be possible to manage this greywater ‘on site’. Therefore, ‘off site’ management options will have to be considered.

3.20.1 Off Site' Community Level Management: Collection and Transportation of Domestic Greywater:

For the community greywater of this type, the first step would be to establish a system for collecting and transporting this greywater for the final treatment on a suitable location. It will be necessary to establish a suitable drainage system for this purpose.

It will be desirable for the GP to have a master plan for establishing drainage system for the village, taking into consideration, the roads, the lanes and the number of houses on each component of the drainage line. The village land contours will have to be considered so that adequate gradient (slope) is available for smooth flow of water.



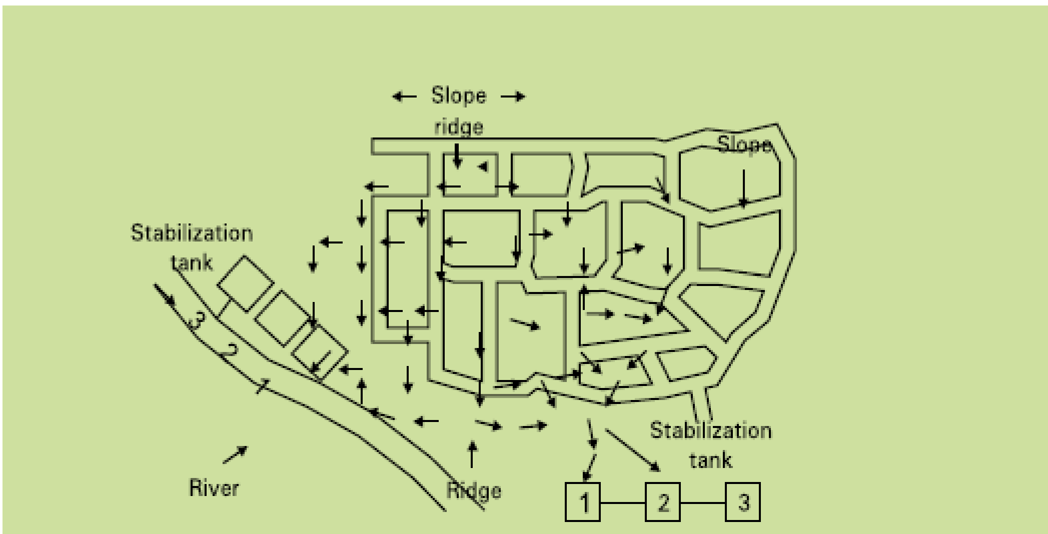
This drainage system could be of two types

a. Open drain with technically sound design, involving semicircular base and trapezoidal cross section so as to maximize self cleansing velocity for carrying away silt in greywater
b. Closed drain-small bore greywater draining system with intercepting tanks at suitable points.

Collection at suitable points:

Depending on land contours and possibility of gravity flow, collection of greywater via drainage line may be at one point or multiple points outside the village where the final treatment will have to be undertaken.

Master plan for village



3.20.2 Open or Surface Greywater

Drainage System:

For collection and transportation of greywater flowing out from the houses, surface drain has been the simplest system, whereby, the community greywater is carried away from the village for onward final treatment.

Advantages:

- This is simplest system
- This system can be established easily with available local mason
- The construction cost is minimum.

Applicability:

In villages with dense population, where houses do not have place for managing their own household greywater.

Action:

The GP will have to establish it with technical inputs from Zilla Parishad.

Description:

1. General layout for the drainage line:

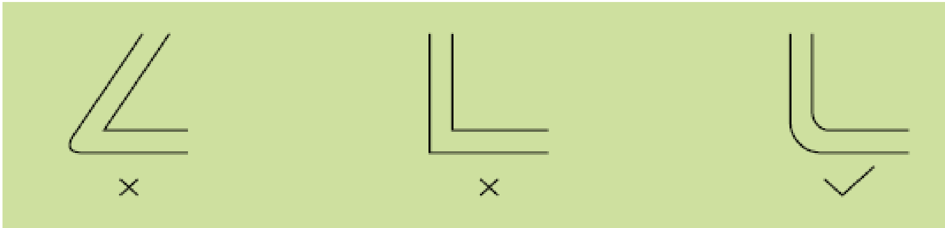
A master plan for the drainage lines will have to be prepared, taking into consideration, layout of the village, contour lines and available gradient for achieving gravity flow pattern as stated earlier.

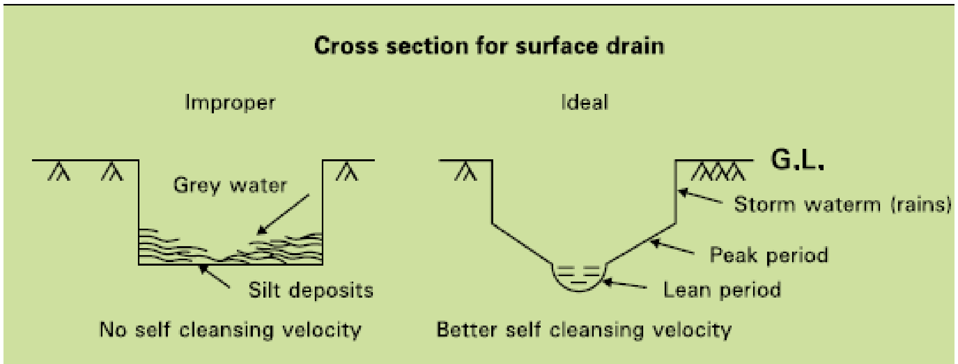
The size of the drain should be decided according to the number of houses located on the particular section of the line.

It would be necessary to see that nowhere the drainage line takes an acute angle. Sharp bends must be avoided. The turns in the drainage line should be gradually rounded.

2. Cross section of the drain

Proper designing of open (surface) drain is very important. It will be necessary to remember that the community greywater derived from the houses contains suspended solids. Therefore, the drain should be designed in such a way, that the greywater flowing through the drain has adequate self cleansing velocity so as to carry forward this silt. At the same time it will be necessary to take into consideration the quantity of greywater likely to flow through it.





For this purpose, cross section of the surface drain is important. In most of the villages the surface drain in the village functions in three different ways, taking a load of variable quantities of greywater. Therefore, it becomes necessary to see that the design for the cross section of the drain should be such that the greywater flowing through the drain maintains self cleansing velocity, a) during lean periods (e.g. night hours, afternoon hours etc.), the quantity of greywater is much less. b) in peak periods (e.g. water supply hours, morning time for bathing, cloth washing etc.), the quantity of greywater flowing through the drain increases. c) in most of the villages, the same surface drain acts as a storm water drain during rainy season.

In consideration of the above mentioned situation, the cross section of the drain becomes very important, so as to maintain self cleansing velocity in all these situations. The cross section depicted in accompanying figure will be a suitable cross section. The rounded bottom portion takes care of limited quantity of water during lean period. The round shape gives adequate velocity for the greywater flow during lean period and as the shape is rounded the accumulation of silt or suspended solids is avoided. The edges of the rounded portions can be extended upwards in a trapezoidal shape. This portion will allow adequate velocity and shape for the peak hour flow of greywater, simultaneously not allowing the accumulation of silt and suspended solids. The same edges can be extended upwards vertically to allow the flow of storm water during rainy season. The top of this drain may be maintained at a lower level compared to the road surface, so that storm water does not accumulate on the road and does not create slushy conditions on the road during rainy season.

Slope given for the drain is also very important. Proper gradient for the drains needs to be co-ordinated, while preparing a master plan for the village. If this is done, the system will work properly even if the construction work of laying the drain is done in pieces.

3.20.3 Partial closing of surface drain

The tendency to cover surface drains with flagstones or R.C.C. slab pieces is not conducive to healthy management. It is not advisable for following reasons. The closed portion of the drain cannot be cleaned properly. As a result, silt will accumulate, decompose underneath and will lead to vector breeding, hazardous for health. It will provide hiding place for mosquitoes. It will give out repelling bad odour.

Operation and maintenance (O&M):

- Gram Panchayat will have to establish a system for periodical cleaning and silt removal from the drain
- Community will have to be educated to keep the drain free from garbage, so as to avoid blockages in drain
- Care needs to be taken to avoid overflow water (effluent) from septic tank, from flowing to the open drain. This effluent should be led to leach pit covered at the top.

Material required: The quantities will have to be worked out with help of engineer from Zilla Parishad.

Limitations:

- Maintenance of surface drain is difficult for GP because of inadequate manpower and limited funds
- People have a tendency to throw solid garbage in the drain resulting in blockages.

3.20.4 Closed Drainage:

Small bore greywater drainage system:

- In rural areas, closed drain system akin to conventional sewerage systems will not be feasible because of the excessive capital & operation maintenance expenditure and the elaborate maintenance requirements.
- The small bore greywater drainage system which is laid close to the soil surface is suitable and appropriate as it is low cost and requires minimum maintenance which is easy.

- This system consists of pipe line of suitable diameter, pipes consisting of P.V.C., with intercepting tanks at suitable places. The greywater from houses can be led to the system by interposing nahani trap inside the house and silt chamber adjacent to the house before leading it to the main line.

Advantages:

- As the system is closed, materials like garbage, road side solid wastes, plastics, building materials etc. will not find access to the system
- Operation and maintenance becomes easily manageable by Gram Panchayat
- Construction cost is comparable to the cost for surface drain. It may be only marginally varying
- Road space is fully utilized.

Applicability:

- In villages with dense population, where houses do not have place for managing their own household greywater
- Useful in very narrow lanes.

Action:

Gram Panchayat will have to plan and establish the system with technical inputs from Zilla Parishad.

Description:

In this system, pipeline is laid taking into consideration land contours along the streets and lanes in the village. At intervals of 200 to 300 feet and at turnings, intercepting tanks are established for periodical, removal of sludge. Greywater from houses is led to the intercepting tanks, through connections from households. These connections are done by interposing nahani trap inside the house. Through the silt chamber placed immediately adjacent to the house, water is led to intercepting tank.

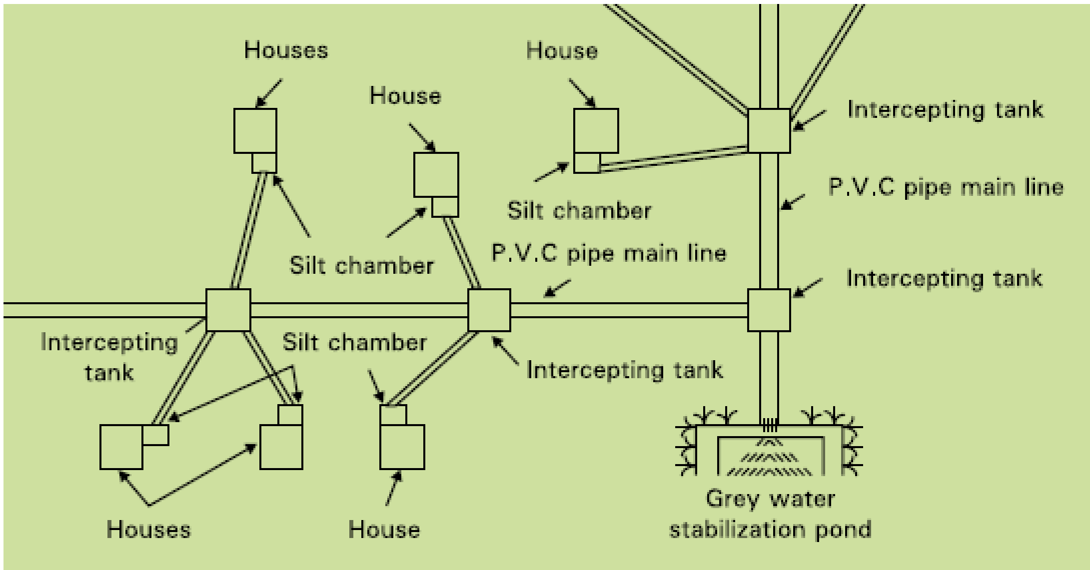
The system will compose of following components:

- Main pipe line
- Intercepting tank for catching the silt
- Household pipeline connecting to intercepting tank
- Silt chamber immediately outside the house
- Nahani trap inside the house in bathroom, kitchen platforms etc.

3.20.5 Pipe line:

The diameter of the pipeline will depend on the quantity of greywater flowing out during peak hour, as also on the material used for pipe line.

If P.V.C. pipe line is used the diameter of pipeline can be from about 100mm to 150mm.



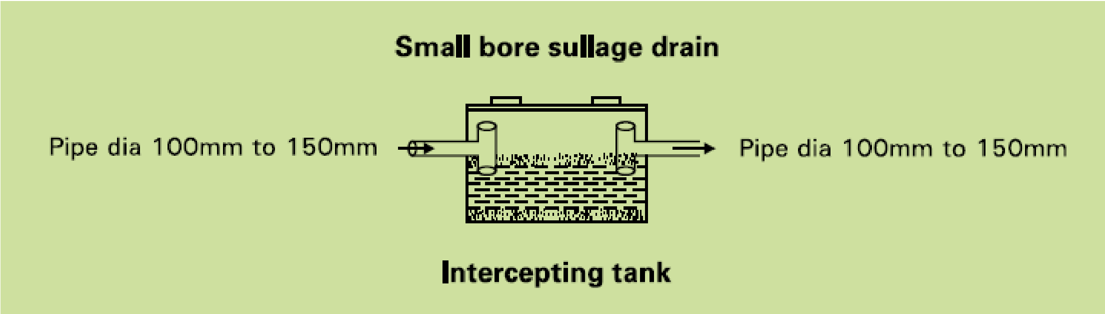
Use of P.V.C. pipe is advantageous for following reasons:

- Silt does not adhere to inside surface of the pipe which is smooth and non sticky
- Silt accumulation due to faulty jointing is avoided
- Jointing is easy
- Diameter can be reduced due to minimum resistance to flow
- It is low cost in relation to stone ware pipe or R.C.C. pipe system.

3.20.6 Intercepting tank:

In this system, intercepting tanks form a very important component. The intercepting tank can be of the size length 3ft, width 2ft and depth about 3 to 4ft. The inlets and outlets of the tank are fitted with tee fitting which prevents silt from staying in main pipe line. Silt, which gets an access to the pipe line, settles in the intercepting tank and only the clear water flows in the pipe line. As a result, pipe lines do not get blocked and do not need maintenance. Use of P.V.C. pipe is better as the joints are reduced, silt does not stick in the line and the diameter can be reduced resulting in substantial cost reduction and better performance.

The silt accumulated in the intercepting tank can be periodically removed as a part of routine maintenance, by opening removable tank cover.



3.20.7 Connections from households:

- Inside the house at various spots of water use, it is advisable to use nahani traps so that any solids do not get access to the greywater pipe lines. Further, the traps will ensure that bad odour and vectors like mosquitoes don't enter the house via household waste water pipe line.
- Outside the house, silt chamber should be placed so as to prevent silt from getting in to main pipe line. It will help in two ways i) maintenance will be easier ii) silt can be easily removed periodically.
- **Material required:**
- Bricks, sand, cement, P.V.C. pipes of appropriate diameter, P.V.C. pipe fittings, chamber and tank covers (R.C.C.). The quantities will have to be worked out with the help of engineer from Zilla Parishad.

Limitations:

Proper technical inputs necessary.

3.20.8 Final Treatment of Community Greywater

Once the community greywater is collected at one or multiple points outside the village, final treatment is required to convert it into harmless and reusable water.

The treatment technologies need to suit the following requirements.

- As low cost as possible
- O&M should be easy and low cost for Gram Panchayat
- Same cost recovery may be possible by the farmers
- Selling the treated water. Treated water could be used for public gardens or horticulture. The produce may be sold profitably
- Vector breeding is avoided

- Pollution of water from nala or river is prevented.

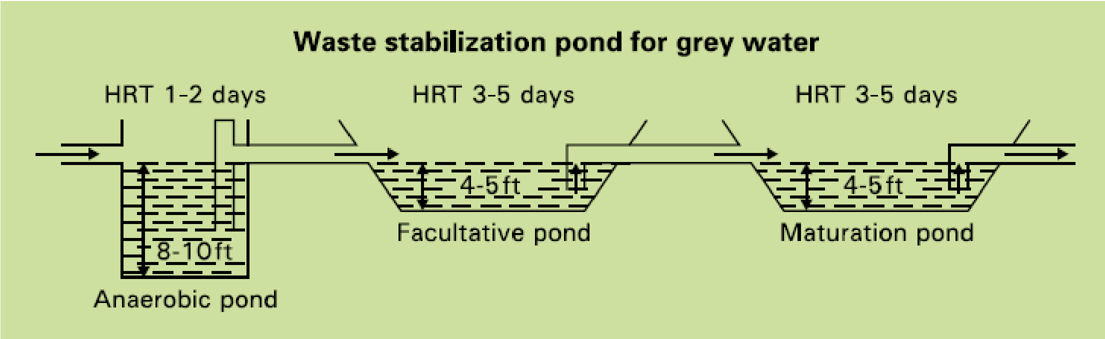
Some appropriate technologies easily manageable by Gram Panchayat could be as follows:

- Sullage stabilization pound and reuse
- Sedimentation and filtration and reuse
- Screening stabilization tank systems like DOSIWAM, DEWATS etc.

3.20.9 Sullage Stabilization Ponds

The greywater collected via drainage system is passed to large shallow basins or ponds excavated at suitable land site and placed serially as a stabilization system in which greywater is stabilized, its pathogenicity is reduced and the stabilized water becomes useable.

In this system, the collected greywater is stabilized by natural processes involving algae, bacteria and natural oxidation processes. Hot climate is very suitable, solar radiation and light is intense for efficient functioning of this system.



Advantage

- The process is a natural process. The GP only provides suitable piece of land where ponds are established
- Capital cost is very low
- O&M cost is also very low & affordable.
- The system can be managed by unskilled manpower
- Stabilized water pollution due to untreated greywater is avoided
- Surface water pollution, due to untreated greywater is avoided.

Applicability

- This technology is very suitable for the use by GP for treating greywater collected from the village via drainage system.

- **Action**
- The system will have to be established by the GP with technical inputs from engineers in ZP Operation and maintenance will have to be managed by GP.

Description

The system has three or more components:

a. Anaerobic pond
b. Facultative pond
c. Maturation pond one or more

These components are usually placed in series. Maturation ponds can be more than one. The following description and measurements are applicable only for greywater (not black water) i.e. waste water without human excreta.

The ponds of required sizes are dug in the soil either manually or with excavators. The geometrical shape should be rectangular. The sides or embankments should have a slope of 1 in 3. Steeper slope may not be stable.

a. Anaerobic ponds

The greywater reaching the pond via drain, usually has high solid content. In the anaerobic pond, these solids settle at the bottom, where these are digested anaerobically. Thus, the partially clarified liquid is discharged onwards into a facultative pond for further treatment.

The solids are expected to settle in this pond, and would be anaerbically digested at the bottom of the pond. Hence, this pond should have a depth of 8 - 10ft. The length and width or the diameter of this pond should be such that the volume of pond would provide hydraulic retention time of 1-2 days for the incoming greywater i.e. the water remains in the pond for 1-2 days. The pond may have brick lining. If the soil permits, the sides and bottom may be compacted to make it less pervious and stable. If the soil is very permeable, plastic sheeting topped with soil may be laid at bottom.

b. Facultative ponds

The partially clarified water is led to facultative pond. In this pond oxidation of greywater takes place. It is called ‘facultative’ because in this pond in the upper layer aerobic conditions are maintained while in the lower layer, anaerobic conditions exist. In this pond solids are generally taken care of by three mechanisms.

- Aeration from air through the surface (however this is limited)

- Oxidation due to oxygen liberated through photosynthetic activity of algae growing in the pond because of the availability of plant nutrients, from bacterial metabolism in water and the incident light energy from sun
- The pond bacteria utilize the algal oxygen to metabolize the organic solid content of greywater.

Thus the facultative pond plays a very important role in stabilization of greywater. The process involved is a natural process.

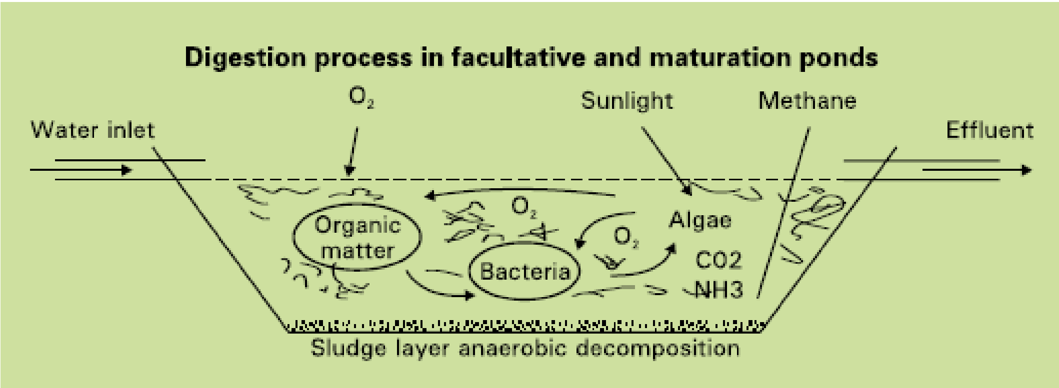
The facultative pond has a depth of about 4 - 5ft. For greywater the hydraulic retention time may be 3-5 days. Accordingly, length and width should be planned to give the desired volume. The length should preferably be 3 times the width.

The sides and bottom of the pond need to be compacted. Masonry construction is not necessary. If the soil is very permeable, plastic sheeting topped with soil may be laid at the bottom.

c. Maturation pond

The stabilized water from facultative pond is led to a maturation pond. The main function of the maturation period is the destruction of pathogens. This pond is wholly aerobic.

The dimensions of maturation pond can be similar to facultative pond i.e. depth of 4 - 5ft and volume to suit HRT of 3-5 days, length being three times the width.

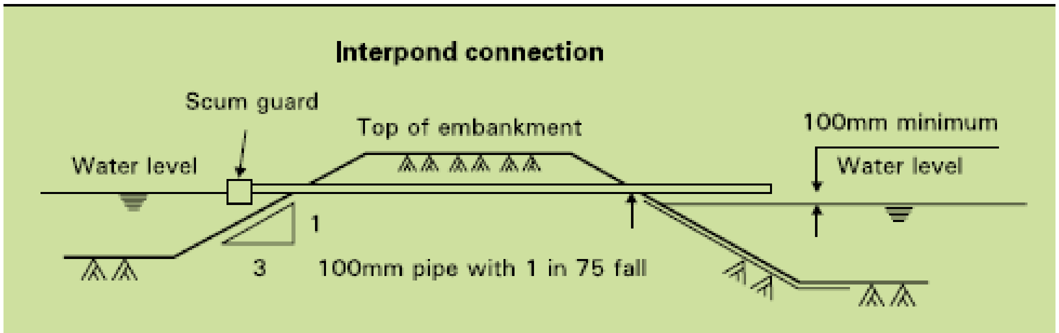


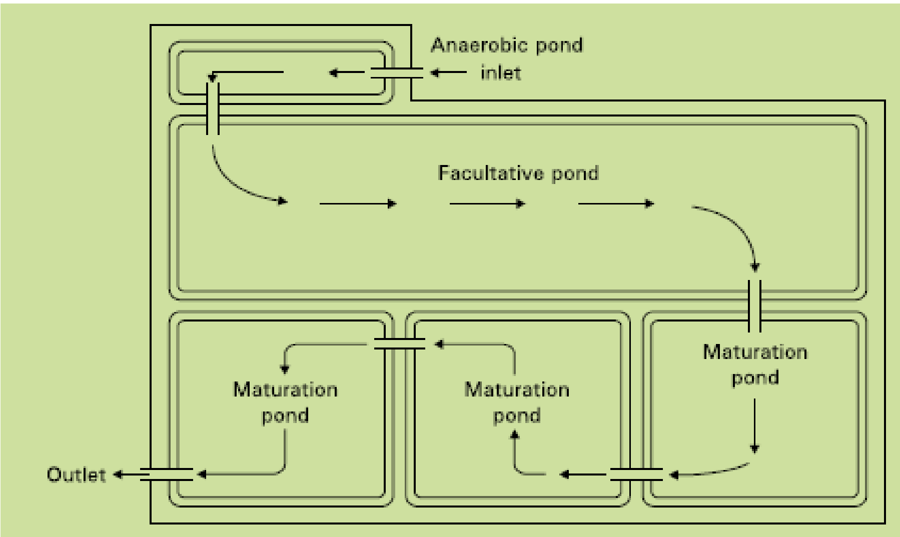
Interpond connections can be made by brick work and pipes of suitable diameter.

3.20.10 Interpond connection

It is better to have multiple ponds of smaller size than less number of large ponds.

Depending on the land availability, a suitable layout can be planned. As an example one such layout is depicted here.





Use of nala or river bank

If it is not possible to get land near the lower end of the drain, the basin of nala or the sloping river bank can be used by installing multiple bunds constructed out of stones and earth, or empty cement bags filled with sand etc. The water from the last compartment can be lifted for irrigation. GP can sell this water to farmers.

One such construction is shown in the accompanying photograph. In these pictures chlorination at final stage also is shown. However this is optional.

Operation and maintenance

- It will be the responsibility of GP

- Maintenance requirements are minimal. Regular cutting of grass on embankments and removal of any floating scum from pond surface are the only requirements
- Occasional anti mosquito spraying treatment may be necessary.

Limitations

- Availability of open land owned by GP at a desirable spot may be a problem
- During rainy reason the system is likely to be disturbed and may need renovation after rainy season
- Proper designing and technical inputs are necessary.

3.20.11 Screening, Sedimentation and Filtration

The greywater collected from drainage system can be passed through a sedimentation and filtration tank system. The treated water can be used for irrigation etc.

This system has been described in section 7.3.6 hence it is not repeated here.

Limitations

- The system would be costly as compared to stabilization ponds
- Depending on the solid content of greywater getting into the system, very frequent removal and cleaning of filtration medium will be necessary. It will increase the O&M cost. In addition, getting manpower for this kind of work in a village is likely to be problematic.

3.20.12 Stabilization Tank Systems

Greywater can be stabilized in a tank system with multiple compartments in series. The tank can be divided into about ten compartments in which flow of greywater is directed in zigzag manner horizontally as well as vertically. During the passage of greywater suspended solids settle at the bottom or float at the top and get gradually digested. Gradually oxidation takes place during the passage of greywater through multiple compartments. The stabilized water is collected at the end in stabilized water storage tank and used for irrigation.

Systems like DOSIWAM, DEWATS etc. work on this basis. In DOSIWAM system human night soil based biogas plant is included in the system. As a result, the system becomes economically viable and takes care of all wastes in integrated and complimentary way.

These systems are very useful in residential institutions etc.

Greywater stabilized and cleaned by the use of any of the above mentioned systems can be reused in many ways.

- Irrigation for agricultural use
- Irrigation for horticulture
- Fish farming.

3.21 Case Study: Black Water Management - Community Toilet in Tamil Nadu

An innovative effort in the black water from a community toilet treated and reused with objectives

- A viable solution to tackle water contamination caused by septic tank toilet model in urban and peri-urban areas
- To prevent contamination of air, water and soil by black water from community toilet, and septic tank in a most eco-friendly way
- Ensure healthy and hygienic surroundings
- Use treated water for growing vegetables, fruits
- Reuse of treated water for farming
- Resource efficiency and non-dependence on energy
- Use biogas for lighting and heating purposes.

Main treatment principles:

- Primary sedimentation in bio – gas settler
- Anaerobic treatment in baffled up-stream reactors
- Tertiary aerobic treatment in planted gravel filters.

Short description:

EXNORA International Chennai, through its unit in Tiruchi District, has taken up construction of Decentralized Waste Water Treatment System

(DEWATS) which is ideally suited for small colonies, apartments, slum areas etc.

The project was implemented under technical support from Consortium for Dissemination of DEWATS, Bangalore with financial support to the tune of Rs 8 lacs from Bremen Overseas and Development Association (Borda), Germany.

The system comprises of following components:

Salient features:

- Decentralized treatment of black water
- Reuse of treated water for raising trees, vegetables
- Use of biogas for cooking and lighting
- No Electricity or chemical is used for treatment
- Very easy for operation and maintenance since it does not have hazardous or complicated machinery

Description:

- The toilet is connected to a biogas settler (Deenabhandu model)
- The black water carrying faeces from toilet is led in to biogas settler
- The biogas generated is stored in settler itself, and connected to a gas pipe, and led into stove for cooking, or light for lighting purpose.

The stove is little different from LPG stove, but available easily in market

- The O&M is done by members of self-help group of women
- Desludging and cleaning of the gravel filter, and Anaerobic baffle reactor, is done once in three years by trained staff under guidance of Exnora
- The vegetables, and flowers are crowing well with the treated water
- Total cost Rs 8 lacs. Daily about 4000 litres of water is treated and reused for the farm
- Daily three M3 gas is generated
- The quality of water in the DEWATS is tested regularly at the Tamil Nadu Pollution Control Board; and Tamil Nadu Water and Drainage Board, Laboratories.

3.21.1 DEWATS in Tiruchi city corporation community toilet

- Toilet owned by Trichy City Corporation Council
- East Devadhanam slum area. 400 persons on an average use toilet daily
- Toilet with 10 seats for men and 10 for women, daily generates about 4000 litres of black water
- Water is supplied from bore well in the campus
- The DEWATS is designed to treat 10 m3 of water and generates three m3 gas daily The toilet is open from 4 am to 11 pm
- User fee fifty paise per use
- Maintenance is by SHG women members. Seven groups of SHGs depute two women as caretakers per day every week, on a turn basis
- The caretakers are paid Rs 40 each
- The electricity charges for motor, and lights paid by the SHG group, about Rs 800 to Rs 900 per month. Salary for SHG member 2400 per month. For cleaning powder etc. Rs 200 faulty taps, lights etc. Earns a profit of Rs 1500 plus month.

Farming activity:

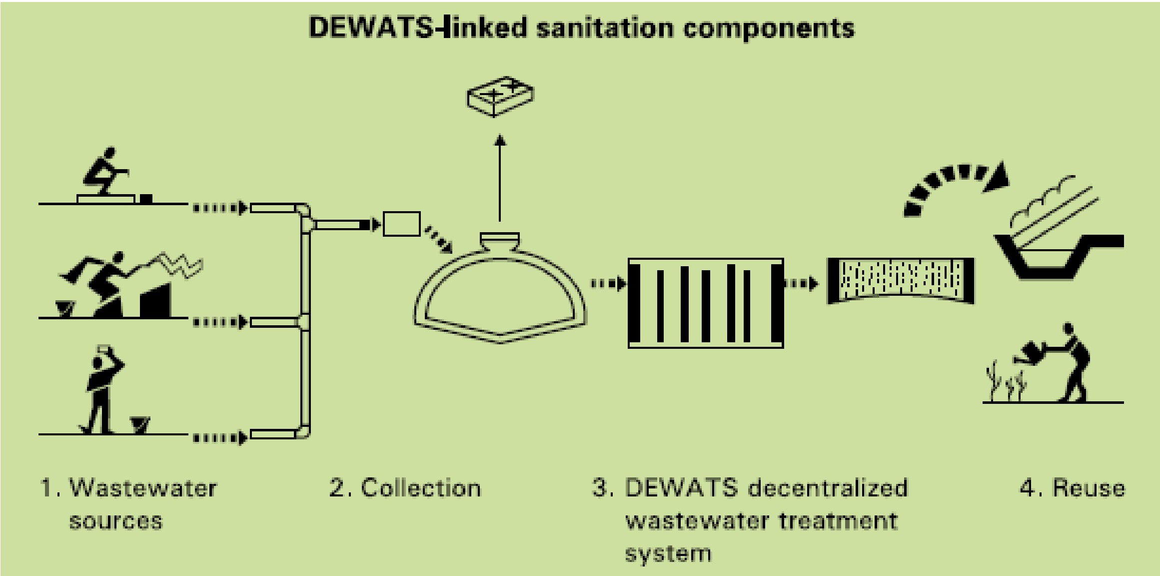
- Farms are managed by SHG members. Earned about Rs 5000 from sale of produce in first six months by raising vegetables
- Now SHGs have planted coconut saplings, banana, guava, pomegranate, neem, etc in the farm
- Child friendly toilet for children below five, without paying any fee
- Bio–gas used for heating, and cooking, for anyone in the community on nominal charges ranging from Rs 5 to Rs 10 per use
- SHG proposes to open tea and snack shop using bio–gas which is available from the Dewats.

Impact:

- Economic and social empowerment of SHG members
- Healthy and hygienic surroundings. Toilet campus looks like a park, with green lawns and colourful plants
- No dependence on corporation authorities for maintenance
- Saving on Electricity and Biogas generated used for cooking, heating and for lighting.

Replicability

- Easily replicable after giving minimum capacity building and training to persons in charge of O&M. Construction, design varies from place to place and community to community. Hence design will be obtained from CDD, Bangalore.



3.21.2 Agricultural wastewater Treatment

Agricultural wastewater treatment relates to the treatment of wastewaters produced in the course of agricultural activities. Agriculture is a highly intensified industry in many parts of the world, producing a range of wastewaters requiring a variety of treatment technologies and management practices.

3.21.3 Nonpoint source pollution

Nonpoint source pollution from farms is caused by surface runoff from fields during rain storms. Agricultural runoff is a major source of pollution, in some cases the only source, in many watersheds.

3.21.4 Sediment runoff

Soil washed off fields is the largest source of agricultural pollution in the United States. Excess sediment causes high levels of turbidity in water bodies, which can inhibit growth of aquatic plants, clog fish gills and smother animal larvae.

Farmers may utilize erosion controls to reduce runoff flows and retain soil on their fields. Common techniques include:

- contour plowing
- crop mulching
- crop rotation
- planting perennial crops
- installing riparian buffers.

3.21.5 Nutrient runoff

Nitrogen and phosphorus are key pollutants found in runoff, and they are applied to farmland in several ways:

- commercial fertilizer
- animal manure
- municipal or industrial wastewater (effluent) or sludge.

These chemicals may also enter runoff from crop residues, irrigation water, wildlife, and atmospheric deposition.

Farmers can develop and implement nutrient management plans to mitigate impacts on water quality:

- map and document fields, crop types, soil types, water bodies
- develop realistic crop yield projections
- conduct soil tests and nutrient analyses of manures and/or sludges applied
- identify other significant nutrient sources (e.g. irrigation water)
- evaluate significant field features such as highly erodible soils, subsurface drains, and shallow aquifers
- apply fertilizers, manures, and/or sludges based on realistic yield goals and using precision agriculture techniques.

3.22 Pesticides

Pesticides are widely used by farmers to control plant pests and enhance production, but chemical pesticides can also cause water quality problems. Pesticides may appear in surface water due to:

- direct application (e.g. aerial spraying or broadcasting over water bodies)
- runoff during rain storms
- aerial drift (from adjacent fields)
- Some pesticides have also been detected in groundwater

Farmers may use Integrated Pest Management (IPM) techniques (which can include biological pest control) to maintain control over pests, reduce reliance on chemical pesticides, and protect water quality.

There are few safe ways of disposing of pesticide surpluses other than through containment in well managed landfills or by incineration. In some parts of the world, spraying on land is a permitted method of disposal.

3.23 Point source pollution

Farms with large livestock and poultry operations, such as factory farms, can be a major source of point source wastewater. In the United States, these facilities are called concentrated animal feeding operations or confined animal feeding operations and are being subject to increasing government regulation.

3.23.1 Animal wastes

The constituents of animal wastewater typically contain

- Strong organic content — much stronger than human sewage
- High solids concentration
- High nitrate and phosphorus content
- Antibiotics
- Synthetic hormones
- Often high concentrations of parasites and their eggs
- Spores of Cryptosporidum (a protozoan) resistant to drinking water treatment processes
- Spores of Giardia
- Human pathogenic bacteria such as Brucella and Salmonella
- Animal wastes from cattle can be produced as solid or semisolid manure or as a liquid slurry. The production of slurry is especially common in housed dairy cattle.

Treatment

Whilst solid manure heaps outdoors can give rise to polluting wastewaters from runoff, this type of waste is usually relatively easy to treat by containment and/or covering of the heap.

Animal slurries require special handling and are usually treated by containment in lagoons before disposal by spray or trickle application to grassland. Constructed wetlands are sometimes used to facilitate treatment of animal wastes, as are anaerobic lagoons. Excessive application or application to sodden land or insufficient land area can result in direct runoff to watercourses, with the potential for causing severe pollution. Application of slurries to land overlying aquifers can result in direct contamination or, more commonly, elevation of nitrogen levels as nitrite or nitrate.

The disposal of any wastewater containing animal waste upstream of a drinking water intake can pose serious health problems to those drinking the water because of the highly resistant spores present in many animals that are capable of causing disabling in humans. This risk exists even for very low-level seepage via shallow surface drains or from rainfall run-off.

Some animal slurries are treated by mixing with straws and composted at high temperature to produce a bacteriologically sterile and friable manure for soil improvement.

3.23.2 Piggery waste

Piggery waste is comparable to other animal wastes except that many piggery wastes contain elevated levels of copper that can be toxic in the natural environment. Ascarid worms and their eggs are also common and can infect humans if wastewater treatment is ineffective.

Treatment

As for general animal waste, although the liquid fraction of the waste is frequently separated off and re-used in the piggery to avoid the prohibitively expensive costs of disposing of a copper-rich liquor.

3.23.3 Silage liquor

Fresh or wilted grass or other green crops can be made into the semi-fermented product called silage which can be stored and used as winter forage for cattle and sheep. The production of silage often involves the use of an acid conditioner such as sulfuric acid or formic acid. The process of silage making frequently produces a yellow-brown strongly smelling liquid which is very rich in simple sugars, alcohol, short-chain organic acids and silage conditioner. This liquor is one of the most polluting organic substances known. The volume of silage liquor produced is generally in proportion to the moisture content of the ensiled material.

Treatment

Silage liquor is best treated through prevention by wilting crops well before silage making. Any silage liquor that is produced can be used as part of the food for pigs. The most effective treatment is by containment in a slurry lagoon and by subsequent spreading on land following substantial dilution with slurry. Containment of silage liquor on its own can cause structural problems in concrete pits because of the acidic nature of silage liquor.

3.23.4 Milking parlour (dairy farming) wastes

Although milk has a deserved reputation as an important and valuable food product, its presence in wastewaters is highly polluting because of its organic strength, which can lead to very rapid de-oxygenation of receiving waters. Milking parlour wastes also contain large volumes of wash-down water, some animal waste together with cleaning and disinfection chemicals.

Treatment

Milking parlour wastes are often treated in admixture with human sewage in a local sewage treatment plant. This ensures that disinfectants and cleaning agents are sufficiently diluted and amenable to treatment. Running milking wastewaters into a farm slurry lagoon is a possible option although this tends to consume lagoon capacity very quickly. Land spreading is also a treatment option.

3.23.5 Slaughtering waste

Wastewater from slaughtering activities is similar to milking parlour waste (see above) although considerably stronger in its organic composition and therefore potentially much more polluting.

Treatment

Same as for milking parlour waste.

3.23.6 Vegetable washing water

Washing of vegetables produces large volumes of water contaminated by soil and vegetable pieces. Low levels of pesticides used to treat the vegetables may also be present together with moderate levels of disinfectants such as chlorine.

Treatment

Most vegetable washing waters are extensively recycled with the solids removed by settlement and filtration. The recovered soil can be returned to the land.

3.23.7 Firewater

Although few farms plan for fires, fires are nevertheless more common on farms than on many other industrial premises. Stores of pesticides, herbicides, fuel oil for farm machinery and fertilizers can all help promote fire and can all be present in environmentally lethal quantities in firewater from fire fighting at farms.

Treatment

All farm environmental management plans should allow for containment of substantial quantities of firewater and for its subsequent recovery and disposal by specialist disposal companies. The concentration and mixture of contaminants in firewater make them unsuited to any treatment method available on the farm. Even land spreading has produced severe taste and odour problems for downstream water supply companies in the past.

3.24 Industrial wastewater treatment

Industrial wastewater treatment covers the mechanisms and processes used to treat waters that have been contaminated in some way by anthropogenic industrial or commercial activities prior to its release into the environment or its re-use.

Most industries produce some wet waste although recent trends in the developed world have been to minimise such production or recycle such waste within the production process. However, many industries remain dependent on processes that produce wastewaters.

3.24.1 Sources of industrial wastewater

Iron and steel industry

The production of iron from its ores involves powerful reduction reactions in blast furnaces. Cooling waters are inevitably contaminated with products especially ammonia and cyanide. Production of coke from coal in coking plants also requires water cooling and the use of water in by-products separation. Contamination of waste streams includes gasification products such as benzene, naphthalene, anthracene, cyanide, ammonia, phenols, cresols together with a range of more complex organic compounds known collectively as polycyclic aromatic hydrocarbons (PAH).

The conversion of iron or steel into sheet, wire or rods requires hot and cold mechanical transformation stages frequently employing water as a lubricant and coolant. Contaminants include hydraulic oils, tallow and particulate solids. Final treatment of iron and steel products before onward sale into manufacturing includes pickling in strong mineral acid to remove rust and prepare the surface for tin or chromium plating or for other surface treatments such as galvanisation or painting. The two acids commonly used are hydrochloric acid and sulfuric acid. Wastewaters include acidic rinse waters together with waste acid. Although many plants operate acid recovery plants, (particularly those using Hydrochloric acid), where the mineral acid is boiled away from the iron salts, there remains a large volume of highly acid ferrous sulfate or ferrous chloride to be disposed of. Many steel industry wastewaters are contaminated by hydraulic oil also known as soluble oil.

Mines and quarries

The principal waste-waters associated with mines and quarries are slurries of rock particles in water. These arise from rainfall washing exposed surfaces and haul roads and also from rock washing and grading processes. Volumes of water can be very high, especially rainfall related arisings on large sites. Some specialized separation operations, such as coal washing to separate coal from native rock using density gradients, can produce wastewater contaminated by fine particulate haematite and surfactants. Oils and hydraulic oils are also common contaminants. Wastewater from metal mines and ore recovery plants are inevitably contaminated by the minerals present in the native rock formations. Following crushing and extraction of the desirable materials, undesirable materials may become contaminated in the wastewater. For metal mines, this can include unwanted metals such as zinc and other materials such as arsenic. Extraction of high value metals such as gold and silver may generate slimes containing very fine particles in where physical removal of contaminants becomes particularly difficult.

Food industry

Wastewater generated from agricultural and food operations has distinctive characteristics that set it apart from common municipal wastewater managed by public or private wastewater treatment plants throughout the world: it is biodegradable and nontoxic, but that has high concentrations of biochemical oxygen demand (BOD) and suspended solids (SS). The constituents of food and agriculture wastewater are often complex to predict due to the differences in BOD and pH in effluents from vegetable, fruit, and meat products and due to the seasonal nature of food processing and post harvesting.

Processing of food from raw materials requires large volumes of high grade water. Vegetable washing generates waters with high loads of particulate matter and some dissolved organics. It may also contain surfactants.

Animal slaughter and processing produces very strong organic waste from body fluids, such as blood, and gut contents. This wastewater is frequently contaminated by significant levels of antibiotics and growth hormones from the animals and by a variety of pesticides used to control external parasites. Insecticide residues in fleeces is a particular problem in treating waters generated in wool processing.

Processing food for sale produces wastes generated from cooking which are often rich in plant organic material and may also contain salt, flavourings, colouring material and acids or alkali. Very significant quantities of oil or fats may also be present.

Complex organic chemicals industry

A range of industries manufacture or use complex organic chemicals. These include pesticides, pharmaceuticals, paints and dyes, petro-chemicals, detergents, plastics, paper pollution, etc. Waste waters can be contaminated by feed-stock materials, by-products, product material in soluble or particulate form, washing and cleaning agents, solvents and added value products such as plasticisers.

3.24.2 Nuclear industry

The waste production from the nuclear and radio-chemicals industry is dealt with at Radioactive waste.

Treatment of industrial wastewater: The different types of contamination of wastewater require a variety of strategies to remove the contamination.

Solids removal

Most solids can be removed using simple sedimentation techniques with the solids recovered as slurry or sludge. Very fine solids and solids with densities close to the density of water pose special problems. In such case filtration or ultrafiltration may be required. Alternatively, flocculation may be used, using alum salts or the addition of polyelectrolytes.

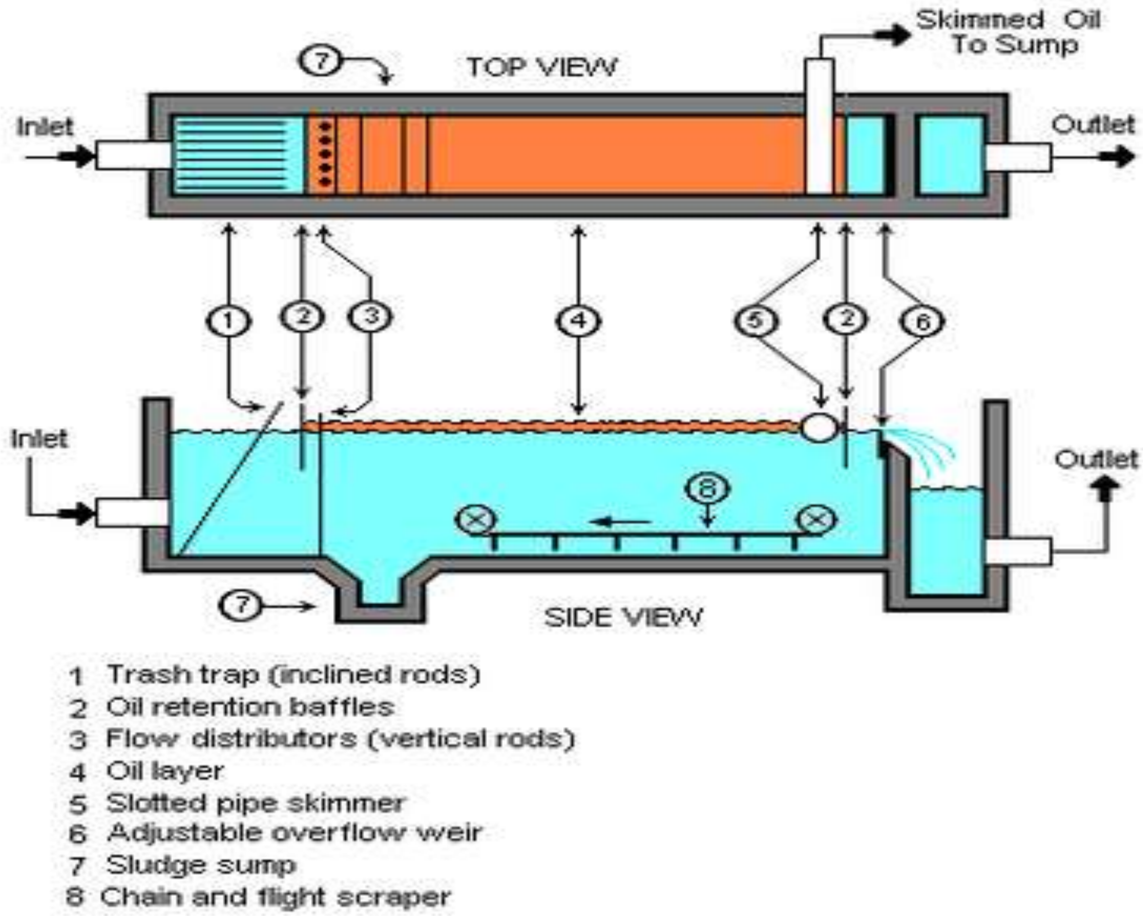
Oils and grease removal

Many oils can be recovered from open water surfaces by skimming devices. However, hydraulic oils and the majority of oils that have degraded to any extent will also have a soluble or emulsified component that will require further treatment to eliminate. Dissolving or emulsifying oil using surfactants or solvents usually exacerbates the problem rather than solving it, producing wastewater that is more difficult to treat.

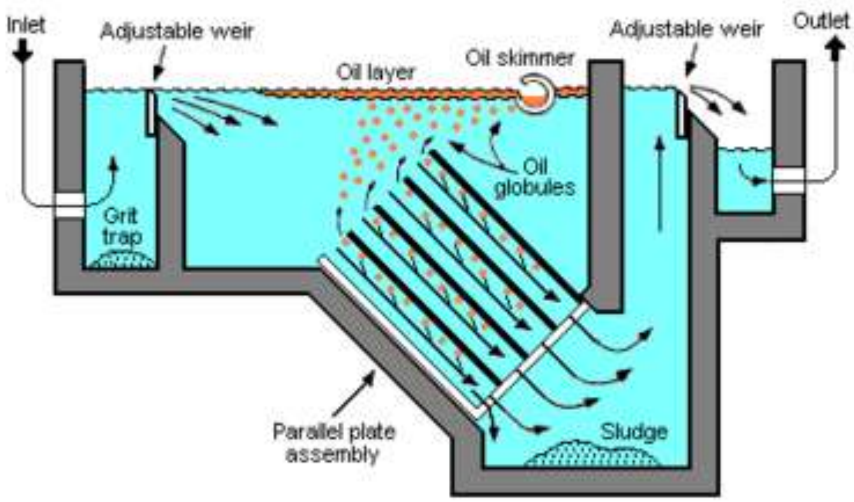
The wastewaters from large-scale industries such as oil refineries, petrochemical plants, chemical plants, and natural gas processing plants commonly contain gross amounts of oil and suspended solids. Those industries use a device known as an API oil-water separator which is designed to separate the oil and suspended solids from their wastewater effluents. The name is derived from the fact that such separators are designed according to standards published by the American Petroleum Institute (API).

The API separator is a gravity separation device designed by using Stokes Law to define the rise velocity of oil droplets based on their density and size. The design is based on the specific gravity difference between the oil and the wastewater because that difference is much smaller than the specific gravity difference between the suspended solids and water. The suspended solids settles to the bottom of the separator as a sediment layer, the oil rises to top of the separator and the cleansed wastewater is the middle layer between the oil layer and the solids.

Typically, the oil layer is skimmed off and subsequently re-processed or disposed of, and the bottom sediment layer is removed by a chain and flight scraper (or similar device) and a sludge pump. The water layer is sent to further treatment consisting usually of a dissolved air flotation (DAF) unit for additional removal of any residual oil and then to some type of biological treatment unit for removal of undesirable dissolved chemical
compounds.



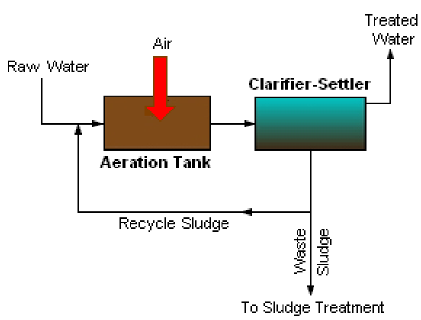
Parallel plate separators are similar to API separators but they include tilted parallel plate assemblies (also known as parallel packs). The parallel plates provide more surface for suspended oil droplets to coalesce into larger globules. Such separators still depend upon the specific gravity between the suspended oil and the water. However, the parallel plates enhance the degree of oil-water separation. The result is that a parallel plate separator requires significantly less space than a conventional API separator to achieve the same degree of separation.



Removal of biodegradable organics:

Biodegradable organic material of plant or animal origin is usually possible to treat using extended conventional wastewater treatment processes such as activated sludge or trickling filter. Problems can arise if the wastewater is excessively diluted with washing water or is highly concentrated such as neat blood or milk. The presence of cleaning agents, disinfectants, pesticides, or antibiotics can have detrimental impacts on treatment processes.

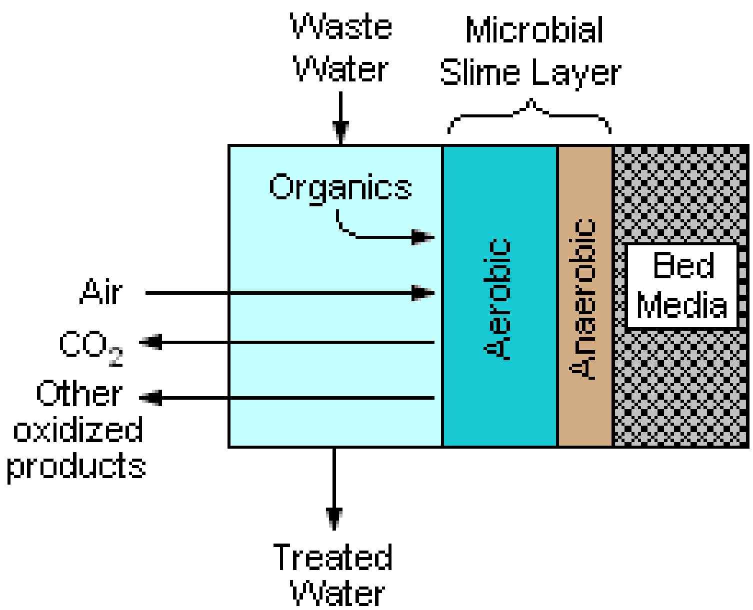
Activated sludge process: Activated sludge is a biochemical process for treating sewage and industrial wastewater that uses air (or oxygen) and microorganisms to biologically oxidize organic pollutants, producing a waste sludge (or floc) containing the oxidized material. In general, an activated sludge process includes:



An aeration tank where air (or oxygen) is injected and thoroughly mixed into the wastewater.

A settling tank (usually referred to as a "clarifier" or "settler") to allow the waste sludge to settle. Part of the waste sludge is recycled to the aeration tank and the remaining waste sludge is removed for further treatment and ultimate disposal.

Trickling filter process



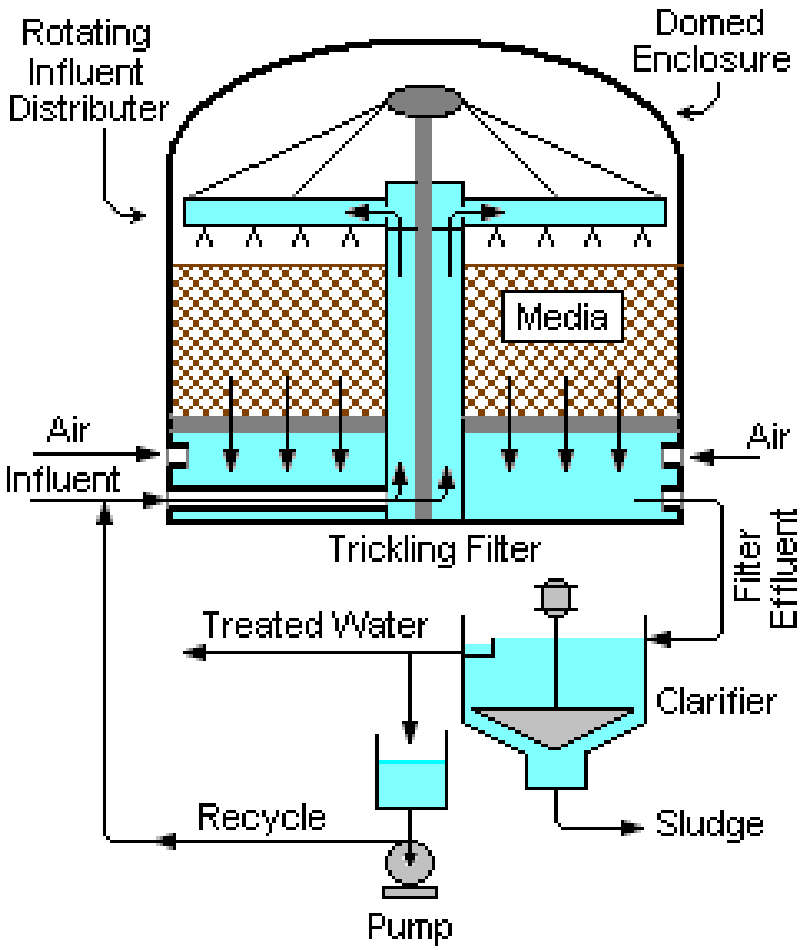
A trickling filter consists of a bed of rocks, gravel, slag, peat moss, or plastic media over which wastewater flows downward and contacts a layer (or film) of microbial slime covering the bed media. Aerobic conditions are maintained by forced air flowing through the bed or by natural convection of air. The process involves adsorption of organic compounds in the wastewater by the microbial slime layer, diffusion of air into the slime layer to provide the oxygen required for the biochemical oxidation of the organic compounds. The end products include carbon dioxide gas, water and other products of the oxidation. As the slime layer thickens, it becomes difficult for the air to penetrate the layer and an inner anaerobic layer is formed.

The components of a complete trickling filter system are: fundamental components:

- A bed of filter medium upon which a layer of microbial slime is promoted and developed.
- An enclosure or a container which houses the bed of filter medium.
- A system for distributing the flow of wastewater over the filter medium.
- A system for removing and disposing of any sludge from the treated effluent.

The treatment of sewage or other wastewater with trickling filters is among the oldest and most well characterized treatment technologies.

A trickling filter is also often called a trickle filter, trickling biofilter, biofilter, biological filter or biological trickling filter.



Treatment of other organics

Synthetic organic materials including solvents, paints, pharmaceuticals, pesticides, coking products and so forth can be very difficult to treat. Treatment methods are often specific to the material being treated. Methods include Advanced Oxidation Processing, distillation, adsorption, vitrification, incineration, chemical immobilisation or landfill disposal. Some materials such as some detergents may be capable of biological degradation and in such cases, a modified form of wastewater treatment can be used.

Treatment of acids and alkalis

Acids and alkalis can usually be neutralised under controlled conditions. Neutralisation frequently produces a precipitate that will require treatment as a solid residue that may also be toxic. In some cases, gasses may be evolved requiring treatment for the gas stream. Some other forms of treatment are usually required following neutralisation.

Waste streams rich in hardness ions as from de-ionisation processes can readily lose the hardness ions in a buildup of precipitated calcium and magnesium salts. This precipitation process can cause severe furring of pipes and can, in extreme cases, cause the blockage of disposal pipes. A 1 metre diameter industrial marine discharge pipe serving a major chemicals complex was blocked by such salts in the 1970s. Treatment is by concentration of de-ionisation waste waters and disposal to landfill or by careful pH management of the released wastewater.

Treatment of toxic materials

Toxic materials including many organic materials, metals (such as zinc, silver, cadmium, thallium, etc.) acids, alkalis, non-metallic elements (such as arsenic or selenium) are generally resistant to biological processes unless very dilute. Metals can often be precipitated out by changing the pH or by treatment with other chemicals. Many, however, are resistant to treatment or mitigation and may require concentration followed by landfilling or recycling. Disolved organics can be incinerated within the wastewater by Advanced Oxidation Processes.

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- Gram Panchayat will have to establish a system for periodical cleaning and silt removal from the drain.

Chapter 4

HUMAN WASTE

4.1 Introduction:

Human waste is a waste type usually used to refer to byproducts of digestion, such as feces and urine. Human waste is most often transported as sewage in waste water through sewerage systems. Alternatively it is disposed of in nappies (diapers) in municipal solid waste.

Human waste can be a serious health hazard, as it is a good vector for both viral and bacterial diseases. A major accomplishment of human civilization has been the reduction of disease transmission via human waste through the practice of hygiene and sanitation, including the development of sewage systems and plumbing.

Human waste can be reduced or reused through use of waterless urinals and composting toilets and greywater. The most common method of waste treatment in rural areas where municipal sewage systems are unavailable is the use of the septic tank systems. In remote rural places without sewage or septic systems, small populations allow for the continued use of honey buckets and sewage lagoons without the threat of disease presented by places with denser populations. Honey buckets are used by rural villages in Alaska where, due to permafrost, conventional waste treatment systems cannot be utilised.

4.2 Ecological Sanitation:

Every day each person of India's 1.02-billion population (2001 Census) produces 1-1.3 litres of urine and 250-400 grams of faeces which are flushed with grey water to become town sewage, get deposited in pits of on-site sanitary latrines or are simply delivered in the open – in fields in rural areas and urban open spaces.

The "flushing system" commonly used in urban areas is considered highly sanitized but only if city sewage is fully treated. Studies indicate that in India less than 10 percent of sewage is treated and rendered harmless before it is discharged into water bodies and rivers. Every day millions of litres of fresh water goes down the drain with flushing of toilets. In small towns septic tanks, cesspools and open drains carry sewage in the absence of a planned sewer system. They often have leakages and poor and faulty constructions that lead to polluting of water pipes.

An effective response to this public health threat lies in an alternative system of on-site disposal and treatment of sewage termed “ecological sanitation.” Ecological sanitation is based on three fundamental principles: (a) Prevent pollution rather than pollute and then undertake costly and energy-intensive treatment. (b) Sanitize urine and faeces for recycling as useful natural resource and (c) Utilize the products (rendered safe) for agriculture or horticulture.

In India, ecological sanitation is practiced in different forms in various parts of the country like Leh-Ladakh and Lahaul Spiti in Himachal Pradesh and more recently in Tamil Nadu. In the 1990s, practitioners and innovators in the field of sanitation, primarily NGOs, while searching for low-cost solutions for difficult hydro-geological conditions began experimenting with alternate designs and systems including ecological sanitation in both rural and urban areas.

4.2.1 Definition:

Ecological sanitation, also known as ecosan or eco-san, is a new paradigm in sanitation that recognises human excreta and household wastewater not as waste but as resources that can and are recovered, treated (where necessary), and reused.[1] Unlike most conventional sanitation methods, ecological sanitation processes human waste (as well as sometimes animal waste, and organic kitchen waste) to recover nutrients (usually for the purpose of growing crops) that would otherwise be discarded.

Ecological sanitation (Ecosan) offers a new philosophy of dealing with what is presently regarded as waste and wastewater. Ecosan is based on the systematic implementation of reuse and recycling of nutrients and water as a hygienically safe, closed-loop and holistic alternative to conventional sanitation solutions. Ecosan systems enable the recovery of nutrients from human faeces and urine for the benefit of agriculture, thus helping to preserve soil fertility, assure food security for future generations, minimize water pollution and recover bioenergy. They ensure that water is used economically and is recycled in a safe way to the greatest possible extent for purposes such as irrigation or groundwater recharge. [2]
According to the 10 Recommendations for Action, published at the 2nd international ecosan symposium 2003 in Lübeck, Germany, the main objectives of ecological sanitation are :

To reduce the health risks related to sanitation, contaminated water and waste
To prevent the pollution of surface and ground water
To prevent the degradation of soil fertility
To optimise the management of nutrients and water resources

4.3 Waste management:

4.3.1 Collection

Faeces is excreted into a container or bucket, and is sometimes collected in the container with urine and other waste. Often the deposition or excretion occurs within the residence, such as in a shophouse faced with overpopulation. This system is used in isolated rural areas and is important in developing nations or in areas that lack the adequate infrastructure to have running water. The material is collected for temporary storage and is disposed of depending on local custom.

4.3.2 Disposal

Disposal has varied through time. In urban areas, usually slums, a night soil collector will arrive regularly, at varying time periods depending on the supply and demand for night soil collection. Usually this occurs during the night, giving the night soil its name.In isolated rural areas such as in farms, the household will usually dispose of the night soil themselves, but this practice is generally not referred to as night soil, though the eventual fate of the night soil, and style of handling, is similar.After arriving at a collection point, usually as a special treatment center within the city, or perhaps an open cesspit, methods of dealing with the waste vary. The waste may go on being shipped to another larger center to be ultimately taken care of, or be disposed of at that particular juncture.

4.3.3 Sanitation issues

Without proper treatment, the use of human feces as fertilizer is a hazardous practice because of disease-causing microbes it contains. Nevertheless, in developing nations it is a common practice. Parasitic worm infections, such as Ascariasis in these countries are linked to night soil, since the larvae are in feces. There have also been cases of disease-carrying tomatoes, lettuce, and other vegetables being imported from undeveloped nations into more developed nations.

Human waste may be attractive as fertilizer because of the high demand for fertilizer and the relative availability of the material to create night soil. In areas where native soil is of poor quality, the local population may weigh the risk of using night soil.

The safe reduction of human waste into compost is possible. Many municipalities create compost from the sewage system biosolids, but then recommend that it only be used on flower beds, not vegetable gardens. Some claims have been made that this is dangerous or inappropriate without the expensive removal of heavy metals. There are other simple yet effective ways to process the compost into safe and usable material. One method, that has been successful, is known as "humanure" where the material is composted with kitchen refuse and high-carbon materials such as yard waste, heated through biological activity and kept for an optimal period of time whereby the pathogens are destroyed. Many people in the United States and other countries have been practicing this method for over ten years now without any negative consequences

4.3.4 Composting toilet

A composting toilet is an aerobic processing system that treats excreta, typically with no water or small volumes of flush water, via composting or managed aerobic decomposition. This is usually a faster process than the anaerobic decomposition at work in most wastewater systems, such as septic systems.Composting toilets are often used as an alternative to central wastewater treatment plants (sewers) or septic systems. Typically they are chosen to alleviate the need for water to flush toilets, to avoid discharging nutrients and/or potential pathogens into environmentally sensitive areas, or to capture nutrients in human excreta. Several manufactured composting toilet models are on the market, and construct-it-yourself systems are also popular.

4.3.5 Operating process

Although there are many designs, the process factors at work are the same. Rapid aerobic composting will be thermophilic decomposition in which bacteria that thrive at high temperatures (40-60 °C / 104-140 °F) oxidizes (breaks down) the waste into its components, some of which are consumed in the process, reducing volume, and eliminating potential pathogens.

Drainage of excess liquid or "leachate" via a separate drain at the bottom of the composter is featured in some manufactured units, as the aerobic composting process requires moisture levels to be controlled (ideally 50% +/- 10): too dry, and the mass decomposes slowly or not at all; too wet and anaerobic organisms thrive, creating undesirable odors (cf. Anaerobic digestion). This separated liquid may be diverted to a graywater system or collected for other uses.

An approach that is becoming more common is the "dry" toilet, or urine-separating (also: urine-diverting) toilet. Where solar heat is used, this might be called a "solar" toilet. These systems depend on desiccation to achieve sanitation safety goals features systems that make use of the separated liquid fraction for immediate area fertilization.Urine can contain up to 90 percent of the N (nitrogen), up to 50 percent of the P (phosphorus) and up to 70 percent of the K (potassium)) present in human excreta. In healthy individuals it is usually pathogen free, although undiluted it may contain levels of inorganic salts and organic compounds at levels toxic to plants.

The other requirement critical for microbial action (as well as drying) is oxygen. Commercial systems provide methods of ventilation that move air from the room, through the waste container, and out a vertical pipe, venting above the enclosure roof. This air movement (via convection or fan forced) will vent carbon dioxide and odors.

Most units require manual methods for periodic aeration of the solid mass such as rotating a drum inside the unit or working an "aerator rake" through the mass. Composting toilet brands have different provisions for emptying the "finished product," and supply a range of capacities based on volume of use. Frequency of emptying will depend on the speed of the decomposition process and capacity, from a few months (active hot composting) to years (passive, cold composting). With a properly sized and managed unit, a very small volume (about 10% of inputs) of a humus-like material results, which can be suitable as soil amendment for agriculture, depending on local public health regulations.

4.3.6 Household Sanitation

Excreta disposal is an important part of overall environmental sanitation. Inadequate and unsanitary disposal of infected human excreta leads to the contamination of the ground water and sources of drinking water supplies. It provides shelter to breed flies to lay their eggs and to carry infection from faeces to other human beings. Man is the reservoir of infection for several diseases. Faecal borne diseases and worm infestations are the main cause of deaths and morbidity in a community where they go for indiscriminate defecation.

It is interesting to note that all such diseases are controllable or preventable through good sanitary barriers through safe disposal of human excreta.

There are many ways by which disease-producing pathogen spreads or reaches the new host – the human being. Depending upon the hygiene behavior of the individual, the causative agent or pathogen from faeces takes different mode to reach the host. The technical objective of sanitary disposal of human excreta is therefore to isolate or segregate human faeces so that the disease-producing organisms in faeces cannot possibly get into a new host through the common modes of transmission. The place at which the technology is applied to break the chain of transmission from human excreta. This technology is called sanitary barrier or sanitation technology for safe human excreta disposal.

Faeco-oral disease cycle can be broken at various levels by:

- Segregating faeces
- Providing protected drinking water supply
- Keeping foods clean
- Improving personal hygiene

- Controlling files and
- Disposing waste water safely

These are some methods of breaking the faecal borne disease cycle. Of these, the most effective method is the segregation of faeces and its proper disposal. The method is called “Sanitary Barrier”. This barrier can be provided by a “Sanitary Latrine” and disposing the faeces into a pit. Sanitary latrines are made to contain the entire waste material (excreta, urine and ablution water), which efficiently prevents contact, by human beings, files or any other animals or insects. Several models of sanitary latrines are now available to the people. The models and types vary from place to place and people to people. One should not forget to choose a model that fulfils the criteria of a ‘Sanitary Latrine’.

Since, the households are first and primary unit of sanitary latrine system therefore, the importance of household sanitation becomes important part of any sanitation drive in order to ensure proper disposal of excreta waste as well prevent open defecation.

4.3.7 Extent of the Problem in Rural India

Several studies conducted in rural India have shown that there is high prevalence of indiscriminate defecation practices. Faecal borne diseases rank high among communicable diseases in our country. Nearly 80 of the total diseases occur due to lack of proper water and sanitation. High infant mortality and under nutrition are also attributed to the open air defecation which are high in rural areas. The high incidence of faecal borne diseases is aggravated with the people or community living in poor condition. Therefore, it becomes necessary to select and provide a suitable technology within affordable cost and the space available to them and to suit their location and place where they live. What they need is a sanitary latrine and good hygiene practices so that human excreta need not come into contact with the new host. In view of this, it is stressed that the sub-structures of the toilet is the most important element of making a good toilet.

A sanitary latrine is one which does not

- Pollute or contaminate soil
- Pollute or contaminate ground water
- Pollute or contaminate surface water
- Act as medium to fly breeding or access to flies and animals
- Require handling
- Produce odour and give ugly sight
- Require huge amount and high technology.

4.4 Technology for Safe disposal of Human Excreta

There are several designs and technologies available for installing a household type sanitary latrine. But several inter-related factors play important role in installing a sanitary latrine to a rural household. This includes:

- Affordability
- Space in the home
- Geographical conditions - soil/water table etc
- Cultural habits
- Availability of water/scarcity of water
- Availability of skilled or semi skilled manpower

Therefore, it is important to give several technological options or informed choices to the user to choose and own and maintain a sanitary latrine without much external support. These options must help user to select the most suitable to them in terms of cost as well as design without compromising the criteria of sanitary latrine. For example, between indiscriminate open defecation and water seal latrine, one can identify several options by applying the sanitation upgradation approach - a movement from one alternative to another alternative, which is better than the previous one. This approach is taken into account of the affordability of the community and same time it is flexible to allow for upgradation. E.g. a simple pit can be upgraded by lining the pit. A lined pit can be upgraded into a seat over the pit with a water seal. A single pit can be upgraded into a double pit. A suitable super structure can be built and upgraded.

Providing technological options/informed choices is one of the strategies of Total Sanitation Campaign. It matches with local situation and enhances the demand for owning a sanitary latrine irrespective of the socio-economic conditions and leads to sanitary way of defecation.

4.5 Technology Options for Rural Settings

There are minimum four components that define the sanitary toilet. They are - pan, pit/tank, superstructure and overall system (technology) in which they operate i.e. water seal or slab with hole.

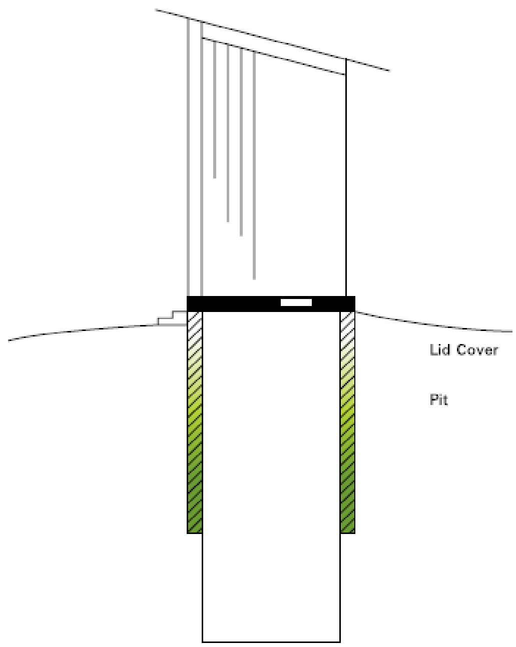
As far as toilet technology is concerned, water seal, as indicated, is more prevalent in India due to the practice of anal cleansing with water. But with many other successful experiments, we now have several sanitary technological options for rural India which can be used depending upon the soil conditions, water availability and affordability of the user. Some of the key technological options are:

1. Simple Pit Toilet
2. Ventilated Improved Pit (VIP) Toilet

3. Pour Flush Toilet
4. Eco-san Toilet

4.5.1 Conventional Pit latrine with cover

Conventional pit latrine is a non-water dependent latrine, which does not require water for functioning, though a small amount of water can be used to clean the squat plate occasionally. This type of latrine is suitable in water scarce areas or where community uses dry cleansing materials. Therefore, the introduction of an unlined or lined pit with a squat plate with or without a super structure can be the second option. This will be particularly applicable for those communities who have open defecation practice.



Advantages

- Affordable
- Simple technology
- Helps to develop practice use latrine
- Appropriate for low-income group who wants to use latrine initially Disadvantages
- Not fully sanitary latrine
- Fly breeding

- Odour
- Risk of falling into the pit
- Risk of ground water pollution

Materials required

- Capital cost for making squatting platform with hole.
- Operational cost is negligible
- Cement – 3/4th of a bag, Dry sand 70 liters, Gravel/ Jally 12 mm: 100 liters and 6 mm rod for reinforcement 2 Kg.

The conventional pit can also be upgraded by adding vent pipe, superstructure and lid for covering hole and lining pit with locally available materials. This modified and improved version is called Lid cover toilet. This is also a non-water dependent latrine which doesn't require water for functioning, though a small amount of water can be used to clean the squat plate occasionally. These groups of latrines are suitable in water-scarce areas. This is provided with a manual closing-lid (or cover) for the squat hole, to make it as fly-tight and odour-tight as much as possible.

Working Life: 2 to 3 years (depending upon number of users and pit size)

Tentative material required

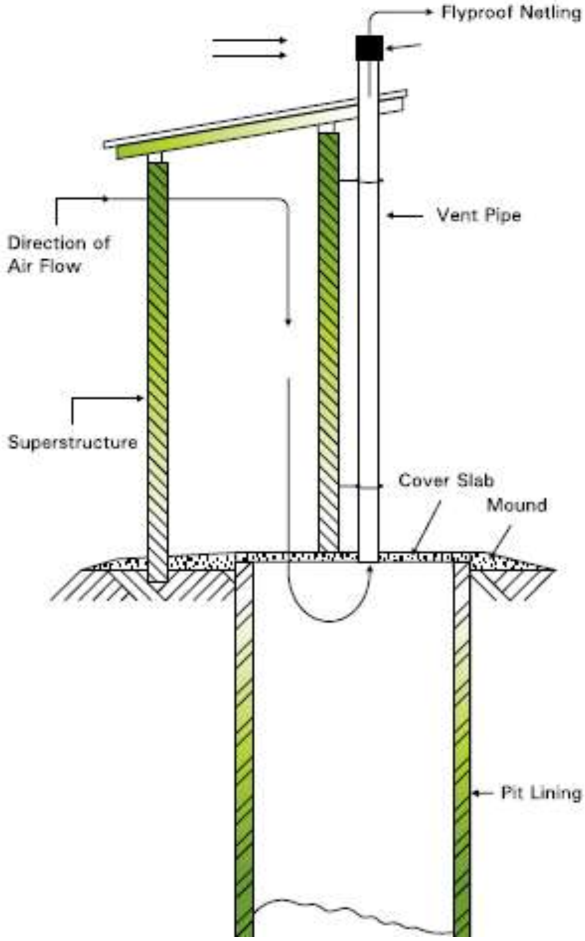
Cement: 1 bag, Dry sand: 70 lit, Gravel (12mm): 100 lit

Important features

- Squat plate with a hole
- A lid (or cover)
- Foot rests near squat hole
- A pit below the squat hole
- House or latrine room
- No need of water to operate this system although a little water can be used, especially for cleaning
- Cross ventilation will eliminate odour inside the latrine room.

4.5.2 Ventilated Improved Pit Latrine

A VIP latrine is a non-water dependent latrine, which doesn't require water for functioning, though a small amount of water can be used to clean the squat plate occasionally. These groups of latrines are suitable for water-scarce areas. A ventilated improved pit latrine is an improved conventional pit latrine, slightly offset from the pit and having a tall vertical (gradually tapered towards the pit) vent pipe with a fly-screen fitted outside the superstructure to trap flies and reduce odour nuisance.



Advantages

- Little odour
- Less chances for transmission of excreta related disease than lid or cover latrine
- Good health and hygiene practice
- Can be used as fertilizer after one year of composting
- Better life and environment
- Suitable for water scarce area, no need for water except occasional cleaning of the squat plate
- Suitable for communities using dry cleansing materials
- Can be built with local materials
- Affordable
- Construction and maintenance are easy
- Can be upgraded to pour flush latrine
- Suitable for less densely populated area where space is available for relocating the latrine when it is full

Disadvantages

- Technical support required when installed as proper construction is crucial
- Risk of groundwater and surface water contamination
- Once filled the latrine has to be moved to another location
- Odour nuisance is not fully controlled.

Working life: 3-4 years depending on number of users and pit size

Users responsibility: Needs maintenance for vent pipe, fly net, squatting plate and the superstructure.

Tentative material required

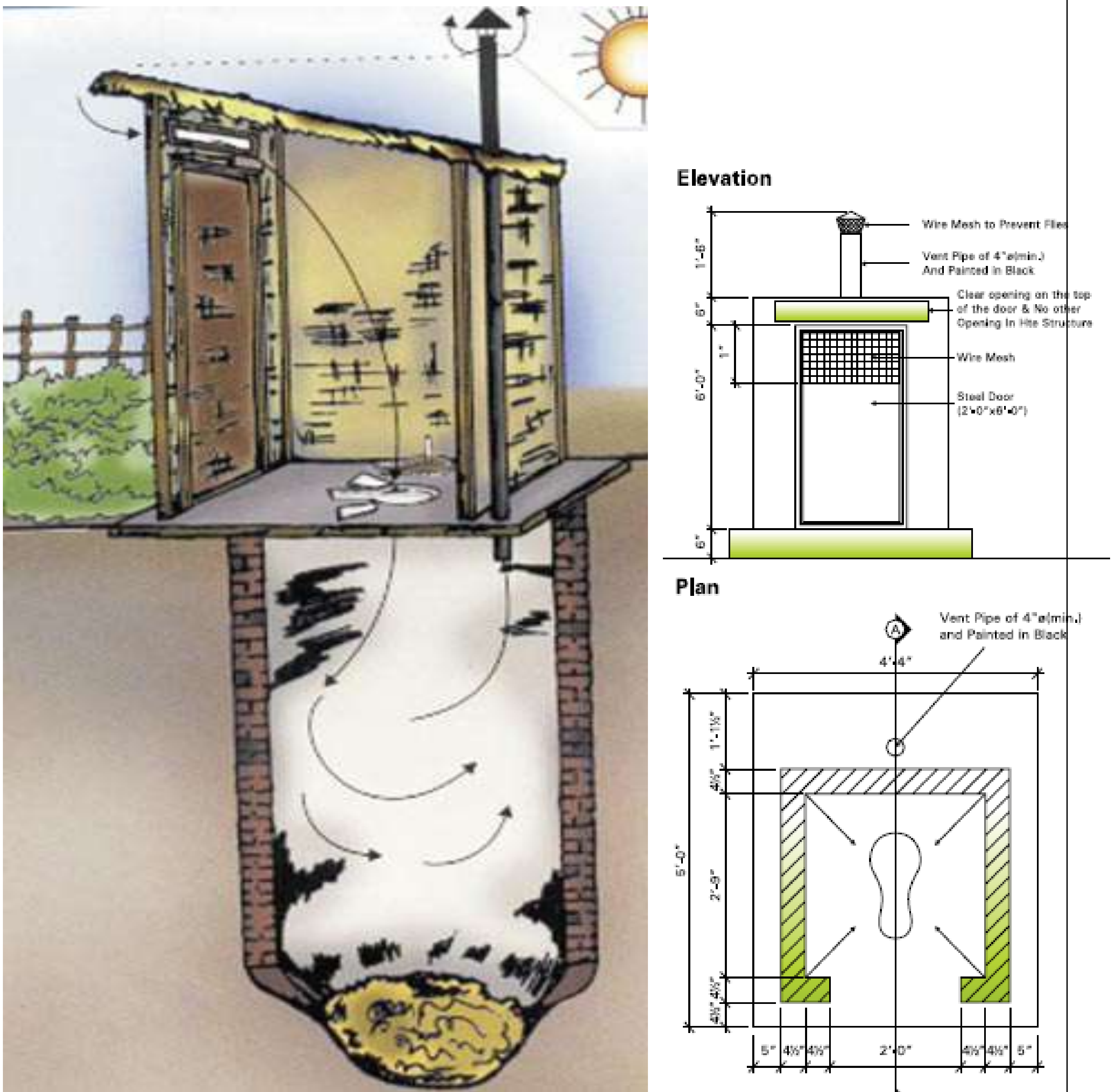
VIP latrine with brick lining:

- Cement: 88 kg
- Brick: 900 nos.
- Gravel: 0,1 m3
- Sand: 0.1 m3
- Rebar: 2.2 kg
- PVC (150 mm): 2.5 m
- Fly screen: One

Important features

- Squat plate with a hole
- Footrests near squat hole
- A vent pipe extending above roof.

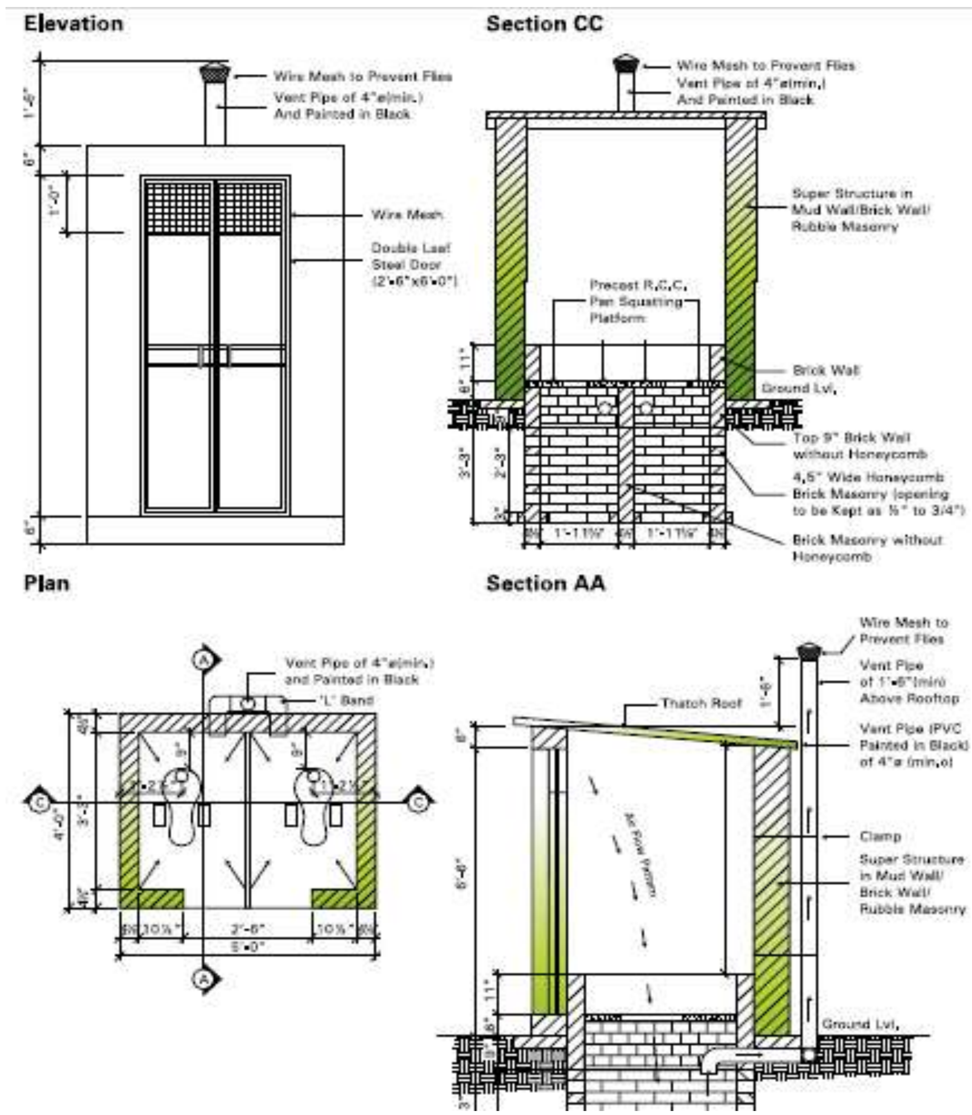
The vent pipe outside should be painted with black color and should be gradually tapered in bottom portion for getting effective functioning. Fly screen-covering top of vent pipe. Single pit under the squatting plate. House or latrine room should be oriented either on north or south to avoid direct sunlight. House should not be located under trees or structure to allow adequate wind flow. Ventilation for the latrine room should be always in the upper portion of the latrine room; preferably above of the entrance door (no other ventilation should be provided).



VIP toilet Model 1

4.5.3 Twin Pit VIP Model

VIP toilets can also be constructed with a double pit system. The toilet has two shallow pits, each with their own vent pipe but only one superstructure. The cover slab has two drop holes, one over each pit. Only one pit is used at a time. When one is full, its drop hole is covered and the second pit is used. After a period of at least one-year, the contents of the first pit can be removed safely and used as soil conditioner. The pit can be used again when the second pit is filled up. This alternating cycle can be repeated indefinitely.



4.5.4 Pour flush latrine

This is water dependent latrine that relies mainly on the usage of water. Without water, these latrines fail to operate. The water flushes out excreta from bowl, which consists of a water-seal generally known as a trap. The water dependent latrines can be further categorized on the basis of: Flushing (pour flush or mechanical flush). Pour flush, though, is more operational and suitable to the conditions of rural areas.

The pour flush latrine is a specially designed water-sealed bowl, which requires 1-2 liters of water for flushing the excreta. Some water always remains at the bottom of the pan after it has been used. This water seal latrine eliminates the entry of odour and prevents rodents to the latrine room from pit through the bowl. This pour flush latrine consists of a single pit either just below the bowl (onset type) or may be offset from the bowl (offset type) using the pour flush type bowl (pan and trap).

Comment: Water quantity required (pour flush latrine: where 1-2 liters of water is required for manual flushing.

Excreta disposal system (pit latrine) where excreta is collected and decomposed within a pit.

Advantages

- Odour free.
- Privacy.
- Little chance for transmission of excreta related disease.
- Good health and hygiene practice.
- Appropriate where water is available.
- Long lifetime and no need to move for many years.
- Water requirements for flushing is low (1-2 liters).
- Construction and maintenance are cheap and easy.
- Offset type can be adjusted in any type of dwelling without causing any foul smell.
- Suitable for less populated areas where space is available for relocating the latrine.
- Possible to upgrade it into twin pit pour flush system (for offset type).

Disadvantages

- Water necessary for flushing, 1-2 liters
- Risk of groundwater and surface water contamination.
- Not appropriate where water is not available
- Dislodging of toilet required every 3-5 years
- Locally manufactured bowls are often of bad quality due to lack of proper moulds.

- Difficult to construct in high ground water table area.

Working Life

5-10 years, depending upon pit size and number of users and soil etc.

User's responsibility

- Need awareness on how to use.
- Need to clean the squat plate and pan regularly.
- No paper, cotton etc. should be thrown into the pan; otherwise water seal will be choked.
- Water for flushing is a must after each use.
- Pan options.
  - Plain cement/plastic/mosaic/fiberglass reinforced/ceramic etc.
  - The pan (the trap portion) is different for onset type and offset type pits.
- For lined pit
  - A shovel to dig the pit and lining materials such as, bamboo/stones/earthen rings/ bricks/hollow blocks/Ferro-cement rings etc. In all cases the sidewall of the pit has to be perforated.
- Cover for offset pit in concrete or wood.
- Toilet floor with foot rest.
  - The bowl should be fixed into either a squat plate just on the top of the pit or to be aligned from toilet floor for offset pit. Proper finishing needs to be done of the floor.
- House for privacy made of any local materials.

Important features

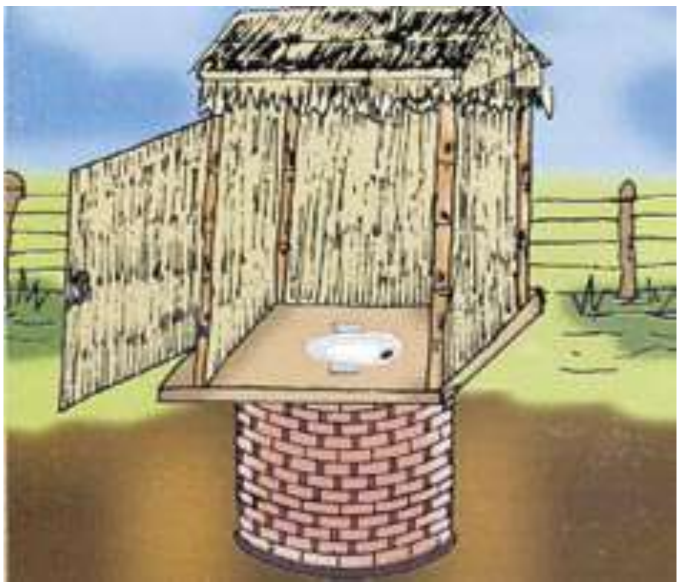
- Pour Flush Bowl (the pan and trap: water seal generally 20 mm)
- Squat platform/floor where bowl and water-seal trap fixed along with foot rest
- Lined or unlined pit for on-set type; lined pit for offset type
- Perforated sidewall for lined pit
- Suitable for areas where water supply is available

Tentative material required

- Cement 70 kg
- Sand 0.1 m3
- Gravel 0.15 m3
- Steel (dia 6 mm) 1.5 kg
- Squatting plate 1

4.5.5 Options in Pour flush/Water seal technology

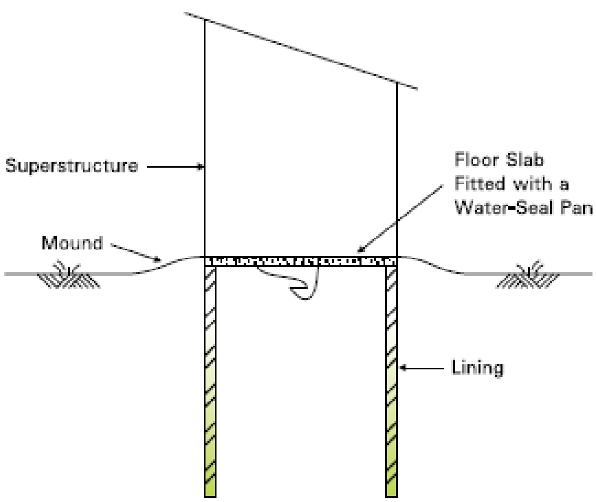
4.5.5.1 Direct Pit Water Seal Toilet



This unit consists of a squatting slab monolithically cast with a cement pan having an in-built water seal. The slab [reinforced cement concrete (RCC) or ferro-cement (FC)] can be of either a circular or a rectangular shape.

A pit is dug in the ground and the squatting slab is placed over it. Normally no pit lining is required in the case of hard and compact soil. However, in case of loose soil, the pit is to be lined in order to prevent the side from collapsing. The size of the pit should be such that it takes two years to get filled up. A superstructure may be built over it for privacy and protection.

After defecation, 1-2 liters of water is poured to flush the excreta out of the pan, which accumulates in the pit where decomposition takes place. The gas formed during decomposition escapes through the joints/ openings of the pit lining and is absorbed by the surrounding soil. The effluent is leached out and absorbed by the soil while the solid part (sludge) accumulates in the pit.

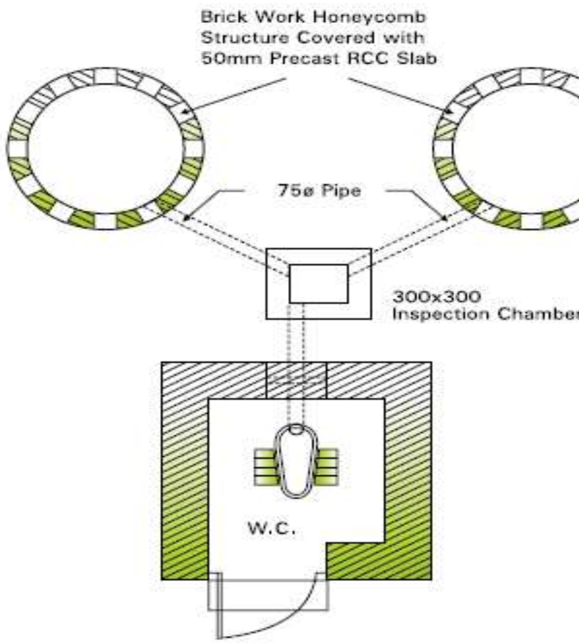


Thus, on prolonged use, the pit gets filled up. When this happens, a second pit is constructed and the squatting slab and superstructure are shifted over it. The filled up pit is covered with a thick layer of soil and allowed to be stabilized for about two years. During this time the contents of the filled-up pit will have become organic humus and safe for handling. When the second pit also gets filled up, after two years or so, the first pit is cleaned, the squatting slab and superstructure is shifted back over it and thus a continuous operation of a direct pit toilet is achieved. Since the superstructure has to be shifted repeatedly, only a temporary construction is recommended for this type of a toilet.

4.5.5.2 Twin Pit Water Seal Toilet

The 'Twin Pit Water Seal Toilet' is a complete excreta disposal system which, on one hand fulfills all the sanitary requirements and on the other hand, provides continuous operation with minimal effort. The main components of such a toilet are the water seal pan/ trap arrangement, squatting platform, junction chamber, two pits and a superstructure.

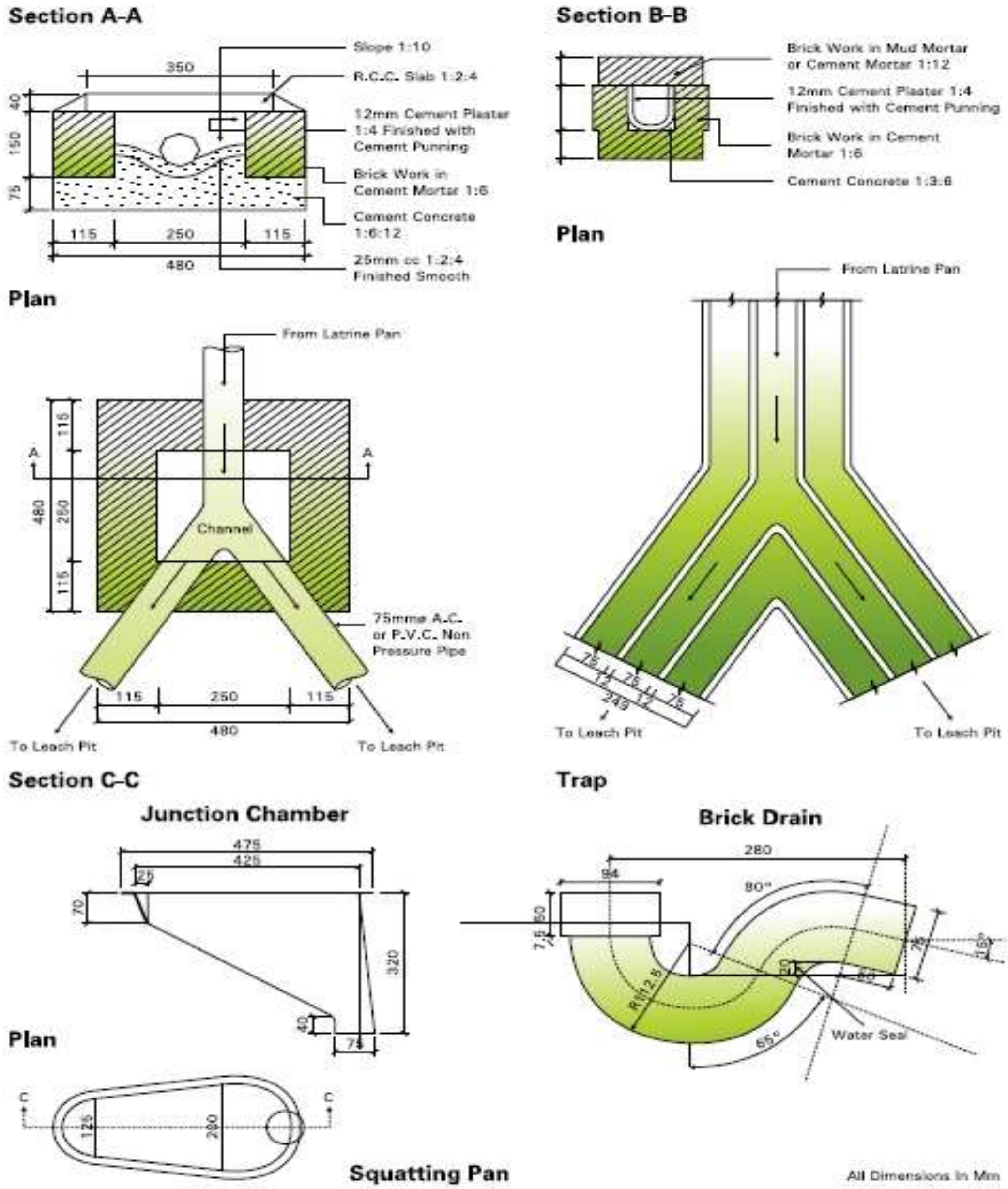
The squatting platform is a raised pucca floor constructed with appropriate plinth and foundation. The pan has a steep bottom slope which allows easy flushing of excreta. The outlet of the pan is connected with a P-trap. On flushing, some water always remains in the trap and forms a 'water seal'. The water seal prevents the bad odour coming from (and the insects reaching the) excreta. The outlet of the trap is connected with a junction chamber either by using a pipe or by constructing a covered brick drains. The junction chamber has one inlet (connected to the P-trap) and two outlets (connected to the leach pits) which are for alternate use. A temporary or permanent superstructure is constructed over the platform for privacy and protection.



For making a twin-pit toilet operational, one of the outlets of the Y-junction in the junction chamber is blocked while the other outlet is kept open to the corresponding pit. The disposal process of the excreta is the same as in a 'direct pit toilet'. In this case, when the first pit gets filled up, the flow of excreta has to be diverted to the stand-by second pit. For doing this, one has to remove the cover of the junction chamber, open the outlet connected to the second pit, block the outlet connected to the first filled up pit and replace the junction chamber cover. The contents of the filled pit will become organic humus and safe for manual cleaning in about two years. When the second pit also gets filled up, the first pit is cleaned and the same operation is repeated to divert the flow of excreta from the second pit to the first pit as was followed earlier. Thus a 'Twin-pit Water Seal Toilet' provides a continuous operation.

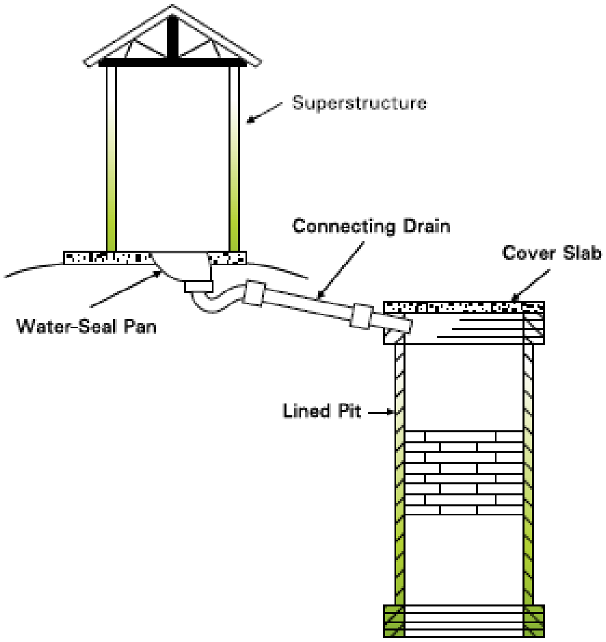
Note: The functions of different components of two-pit pour flush toilet

- W.C. Pan: To direct excreta into water seal trap.
- Water seal trap: To prevent emission of foul smell (gases) from the leach pit and entry of flies and other insects into leach pit.
- Junction chamber: To restrict flow of excreta to one leach pit at a time and facilitate removal of accidental blockage in the connecting pipes.
- Drain pipes: To carry excreta from Junction chamber to leach pits.
- Leach pits: To facilitate leaching of liquid from excreta into surrounding soil and dispersion/absorption of obnoxious gases into surrounding soil and decomposition of excreta.



4.5.5.3 Single Offset Pit Water Seal Toilet

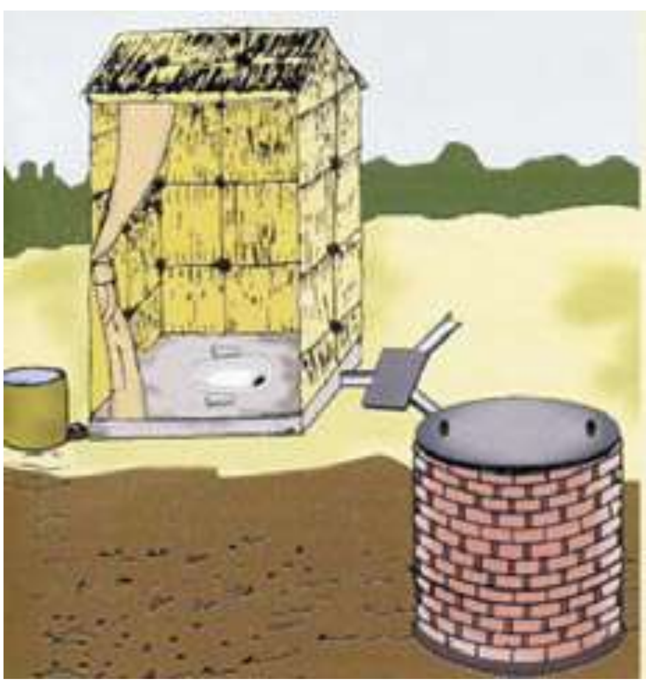
A 'Single Offset Pit Water Seal Toilet' consists of water seal pan, a squatting platform, a junction chamber, a temporary/ permanent superstructure and a single pit instead of two pits as described above. The pit is constructed away from the squatting platform and connected to the same by a pipe through a junction chamber. A single offest pit toilet functions in the same manner as a twin-pit one. Once the single offset pit gets filled up,



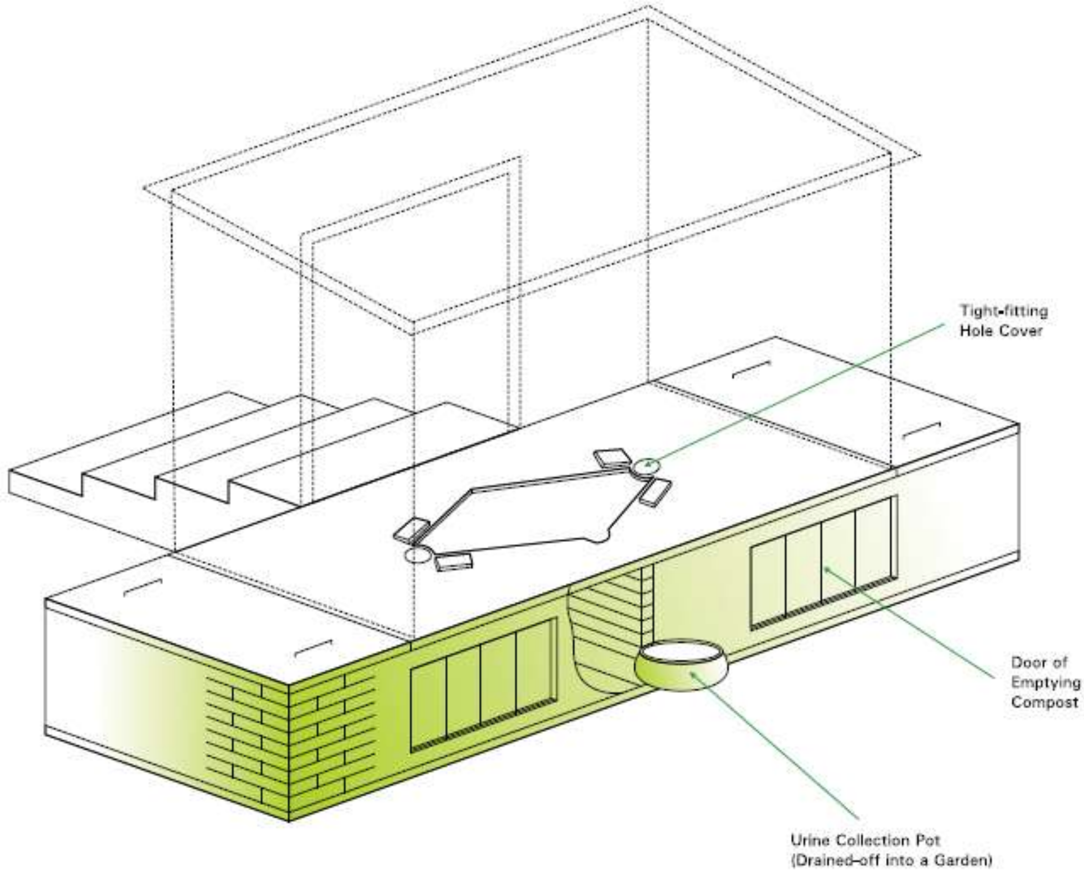
another one is dug nearby and connected with the junction chamber by a pipe. The flow of excreta is diverted to the new pit by blocking the outlet of the first pit at the junction chamber. The contents of the first pit are left undisturbed for two years after which it is safe for manual cleaning. When the second pit also gets filled up, the first one is cleaned and the flow of excreta is diverted to the same. Thus, a single offset pit toilet eventually turns into a twin-pit over a period of time.

4.5.6 Eco-san toilet

Ecological sanitation (Double Vault Compost Latrine) is based on recycling principles. In this approach, the excreta and urine are separated for disposal. The eco-san model consist the double-vault compost latrine consists of two water-tight chambers (vaults) to collect faeces. Urine is collected separately as the contents of the vault have to be kept relatively dry. Initially, a layer of absorbent organic material is put in the vault and after each use, the faeces is covered with ash (or saw-dust, shredded leaves or vegetable matter) to deodorise the faeces, soak-up excessive moisture and improve carbon/nitrogen ratio, which ensures that sufficient nitrogen is retained to make a good fertilizer. When the first vault is three quarters full, it is completely filled with dry powdered earth and sealed so that the components can decompose anaerobically. The second vault is used until it is also three quarters full and the first vault is emptied by hand, the contents are used as a fertilizer. The vaults have to be large enough to keep faeces for at least a year in order to become pathogen free. The superstructure is built over both the vaults with a squat-hole over each



vault which can be sealed-off. The latrine can be built everywhere as there is no pollution coming from the water-tight chambers to pollute the surroundings.



Advantage

- It is most ideal for areas where water is scarce and pour-flushing implies water to be carried from source, or areas where water table is high such as flood plains or coastal areas and densely populated areas where risks of ground water pollution from pits to drinking water sources is assessed high.

Disadvantage

- Proper operation needs full understanding of the concept, lack of which makes the system dyfunctional.
- Where people are eager to use the contents as fertilizer, they may not allow sufficient time for the contents to become pathogen free.
- This system is only to be used where people are motivated to use human excreta as a fertilizer.
- Inadequate number of trained masons impact the quality of construction.

Working Life

- 5-6 years, depending upon pit maintenance and numbers of users.

User's responsibility

- To ensure that the system is well-designed and quality constructed
- O&M should be done properly otherwise, the system would fail and become breeding ground for many diseases.

4.5.6.1 Various stages of eco-san toilet during construction and after construction

Construction of eco-san base *Eco-san Toilet - Vault opening door*

Soak pit *Inside Ecosan Toilet*

4.6 Selection of technology in different conditions

A particular technology can't be applied in all conditions; therefore, it really becomes a challenge to select a suitable technology. Many Easytechnological options have been discussed but for the initial selection of a suitable disposal system technology, the following box 5 may be useful.

Technology Differences								
Latrine type	**Suitable for High Ground Water table**	**Suitable for areas prone to floods, tidal floods or flushes**	**Suitable for loose soils**	**Suitable for soils of low perme-ability**	**Water requirement**	**Ease of constru-ction**	**Ease of mainte-ance**	**Remarks**
Direct Single pit Latrine Without Pour-flush	Yes, if raised	Yes, if raised	Yes, if fully clay soils lined	Not for	No	Easy	Easy	Sludge unsafe
Direct Double pit Latrine Without Pour-flush	Yes, if raised	Yes, if raised	Yes, for fully lined	Not for clay soils	No	Easy	Easy	Safe sludge
Offset Single pit Latrine with Pour-flush	Yes, if raised and with soak away	Yes, if raised	Yes, for fully lined	Yes, with soak away	Yes	Easy	Easy	Sludge unsafe
Offset Double pit Latrine with Pour-flush	Yes, if raised and with soak Away	Yes, if raised	Yes, for fully lined	Yes, with soak away	Yes	Fairly Easy	Fairly	Safe sludge easy
Solar	Yes	Yes	Yes	Yes	No	Easy	Difficult	Safe

Heated single-vault ecological latrine with urine separation								dehydrated material
Single-vault ecological latrine with urine separation	Yes	Yes	Yes	Yes	No	Easy	Difficult	Safe dehydrated material
Urinal	Yes	Yes, if raised	Yes	Yes	Yes a bit	Easy	Easy	

4.7 Components of Toilet

4.7.1 Pan and trap

Pan forms a very important item in toilet construction. There are various designs of pans available in the market. In this context, the quality and design of pan is a very important. Rural pans having higher gradient with less water consumption for flushing are technologically superior to flat pans which require more water for flushing. Flat pans are not suitable for leach pit toilet due to its requirement of low gradient. They need lot of water and pit fills up early as a result affecting the longevity of the pit.

The key specifications are.

- The bottom slope of rural pan is very steep that is less than 25 to 40 degrees
- The inner length of the pan is 425 mm and the outer length is 475 mm.
- The depth of the rural pan is 320 mm

The design of the rural pan with water seal is given below:

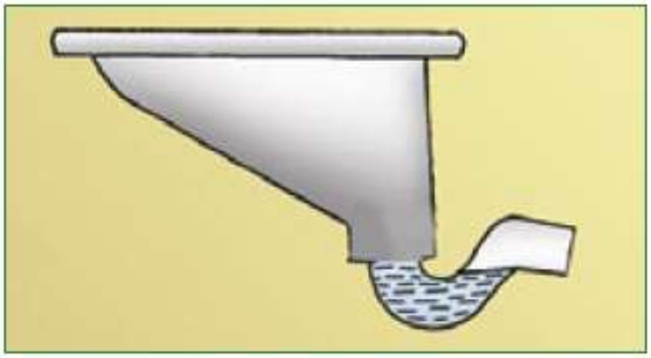


Figure-21, Rural pan with water seal

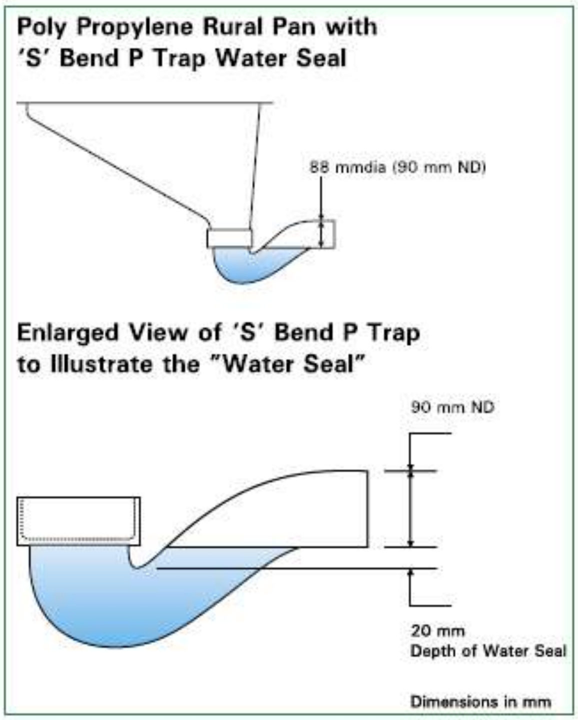


Figure 20

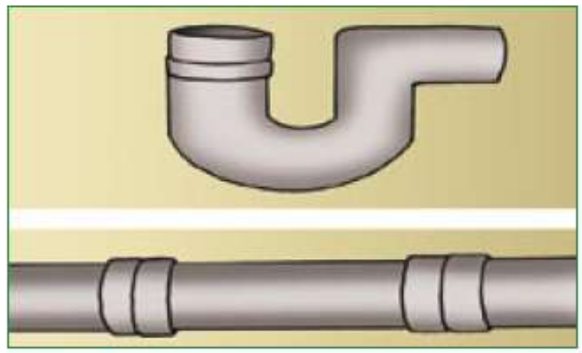


Figure-22, P-trap and pipe

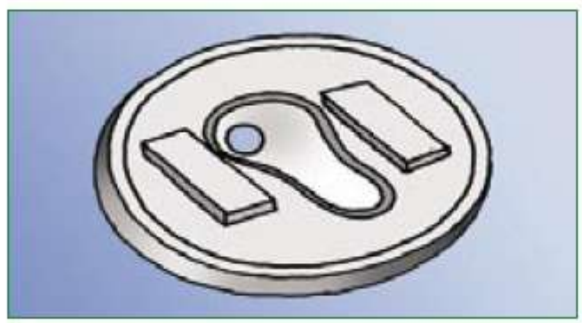
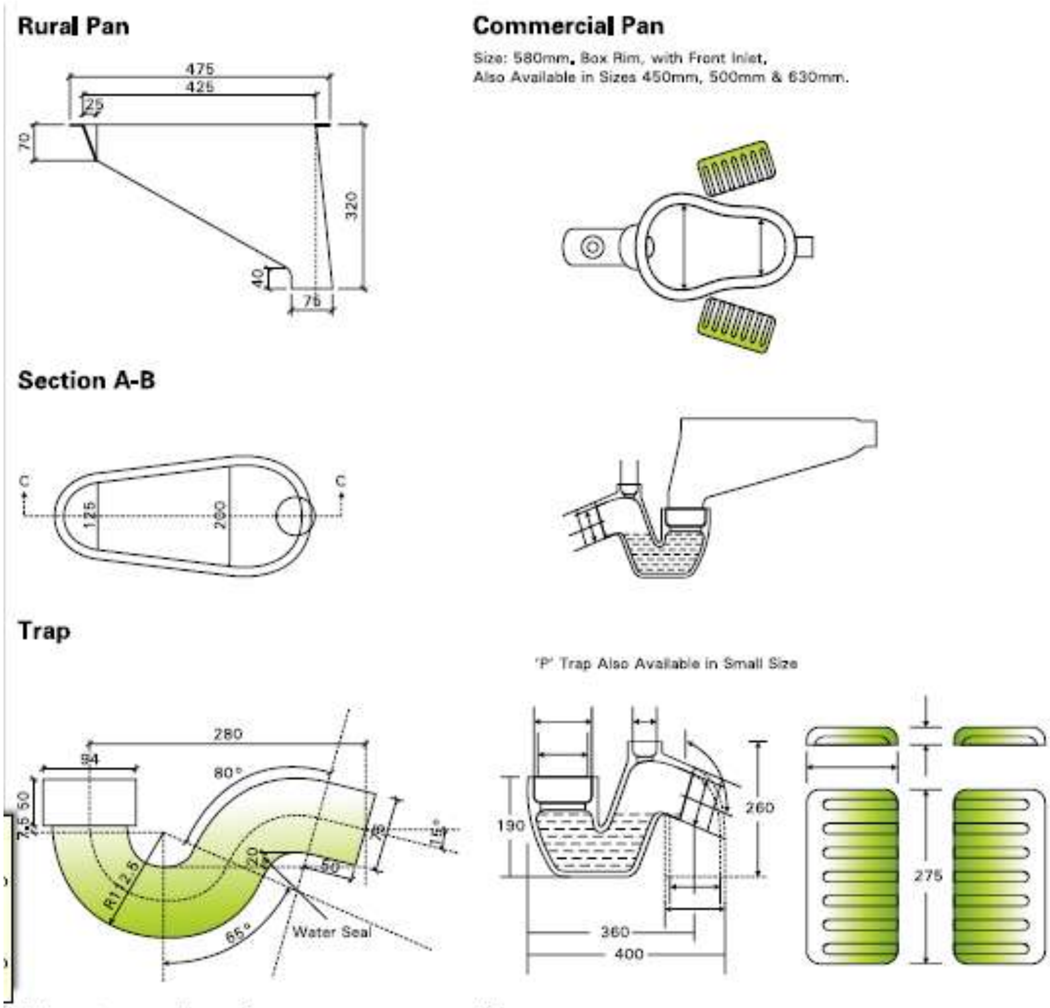


Figure-23, Pan and floor slab

The advantages of rural pan over commercial or flat pan are:

- The rural squatting pan spout diameter is less than the commercial pan (68m) so that the curvature of the trap is comparatively lesser and requires minimum quantity of water for flushing the faecal matter.
- Bottom slope of the rural pan is very steep resulting in high velocity of water and excess flushing.
- The cost of the rural pan is 1/2 of the commercial pan.
- The width of the squatting pan is comparatively less, which enables children to use them without fear and discomfort.

- The depth of the rural pan is more than the commercial pan so that the spillage can be avoided.



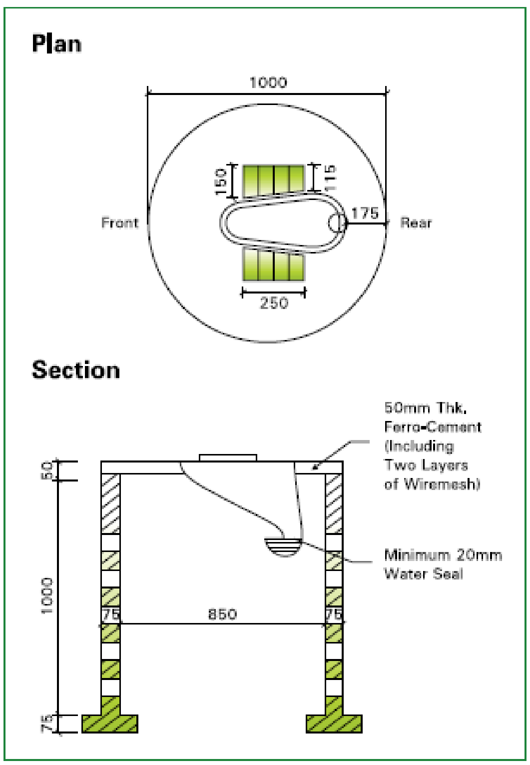
Advantages of rural pan over commercial pan

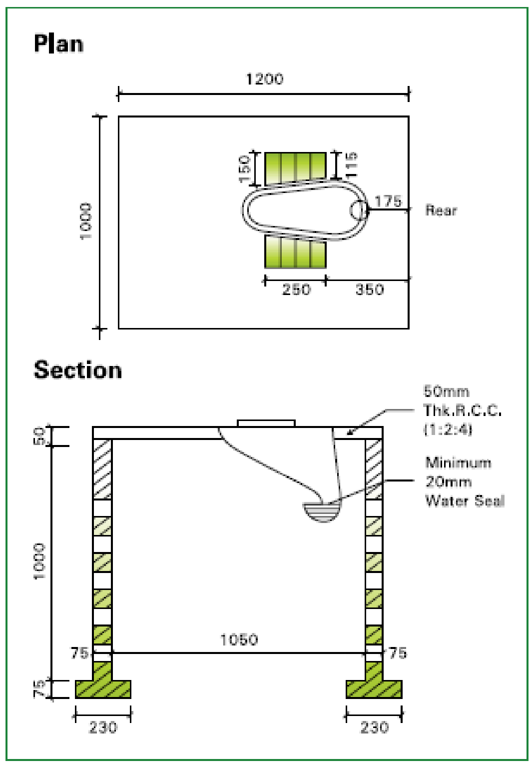
4.7.2 Pits/tanks

The function of the pit or tank is to isolate and store human excreta in such a way that no harmful bacteria is carried to new host. Though there is marked difference between pit technology and tank technology as there is practically 'nil' daily maintenance in pit technology for disposing of sewage (water mixed with excreta) as it percolates in to the soil every day, continuously. The digested solid removal needs to be attended to once in 2 to 3 years only and not daily. The dirty solid excreta are rendered harmless as humus which can be used as beneficial manure. This technology is popularly known as leach pit technology which has many advantages over tank generally known as septic which will be discussed later.

4.8 Leach Pit

According to this technology, the water and gas of the excreta gets absorbed through the pores of the pit and the solid gets decomposed into manure. This technology maintains the system under hygienic condition that is free from odour and insect nuisance. Pits may be circular, square or rectangular and squatting slabs may be circular or rectangular (refer Figure 26). These are preferably lined as it holds the soil and prevent the pit from collapsing; lining may be done with honey-combed brick wall or perforated concrete rings, apart from twigs, split bamboo matting, an old drum, stone masonry, etc. Leach pits are generally provided at the back of the squatting pan. For circular pits, the minimum distance between the two pits should not be less than the depth pit while for rectangular pits; both the pits can be clubbed together with common partition wall plastered on both the sides. The area for percolation shall have to be adequate and the dimension shall have to be slightly increased as per soil condition.





4.8.1 Selection of pit

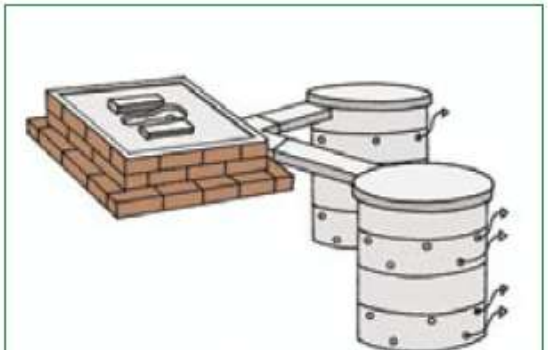
In India, according to published data, the amount of human waste is 400 gram faeces and 2200 gram urine per person per day. For selecting a type of pit, an amount of 1kg of wet weight per person per day is taken into account for calculating the pit design. Based on this, for effective depth or capacity of wet latrines a provision of 37 liters (1.3

cu.ft) per person per year should be sufficient. For dry type (where if mud/soil stones are used as cleansing material), 50 liters (2 cu.ft) per person per year is acceptable.

The pit may be single or double depending upon the need and choice. The pit may be direct or Indirect with connected with pipes or lined and unlined. Refer figures for more details.

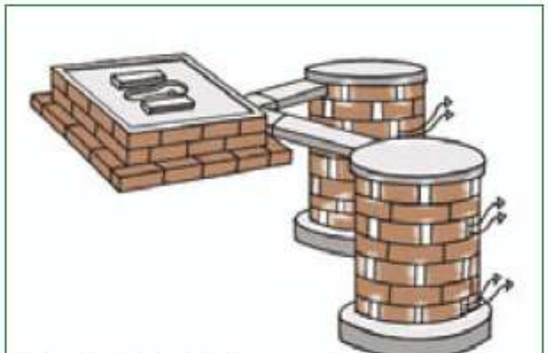
Key Points

- Remember a dry pit latrines/compost latrine fills quickly than a wet pit like leach pit.
- A minimum of 3 feet effective depth is a must for all leach pits
- Pit should be located below and away from the water point
- Pit size and location varies from soil to soil
- Pit should have life period of minimum 4 years



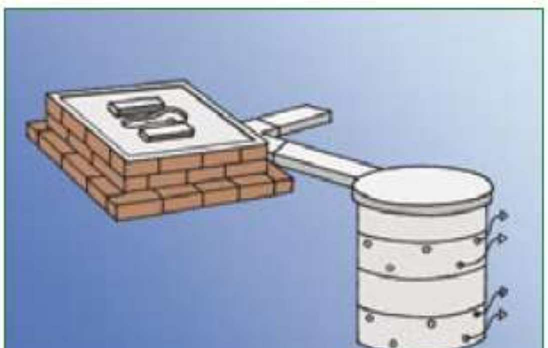
Off set double pits with RCC rings

Figure 27



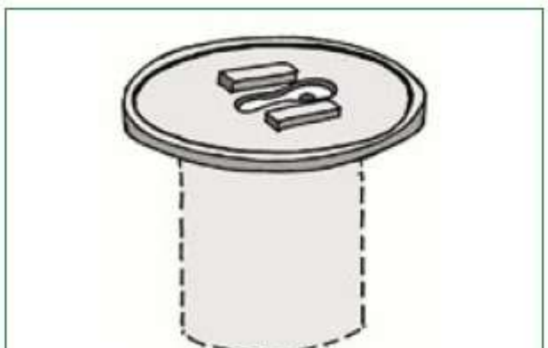
Off set double pits- brick honey comb

Figure 28



Off set single pit with RCC rings

Figure 29



Circular unlined direct pit

Figure 30

4.8.2 Leach pit in water logged and stressed areas

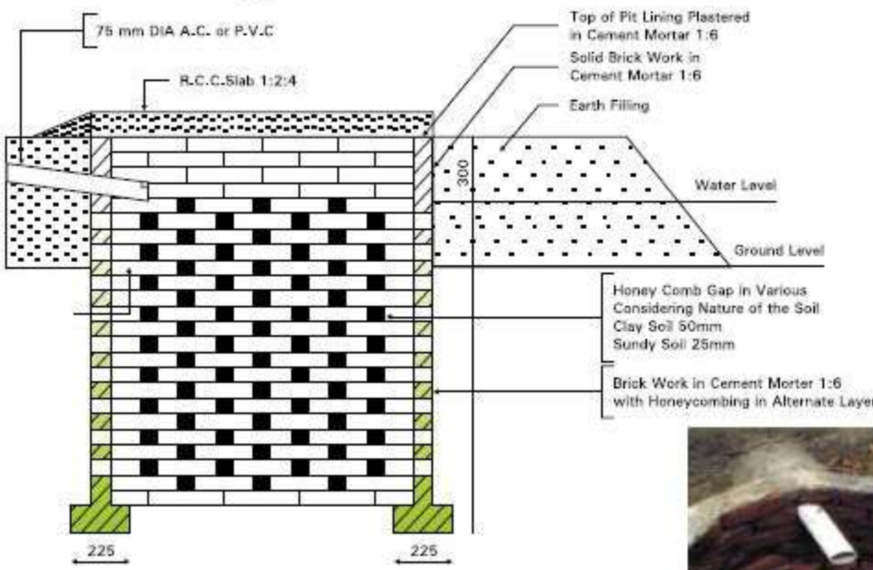
The pour flush based leach pit technology can also be used in even water stressed and water logged areas with slight modification in the design and material. Though, leach pits when constructed in the area having high water table or depression around them, the height of the pit should be raised by 60 to 80 cm above the ground together with the squatting pan and earth filling (with pervious soil) is done around the leach pit for at least 50cm length, throughout the vertical depth on the outer face and the bottom of the pits is sealed with impervious material for preventing the sub-soil water from entering through the bottom. Such arrangement provides the necessary waste water absorption zone. Pls refer figure.

4.8.3 Leach pit in clayey areas

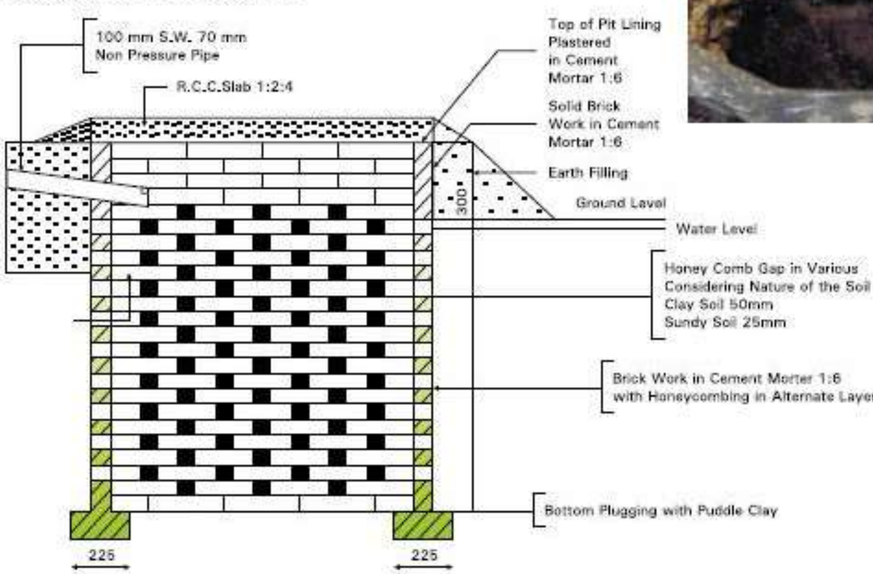
Leach pits have been found successful even in the black cotton and clayey soils. Since the quantity of water drained out of the leach pit is so little that black cotton soil poses no absorption problem but adjustment to be done for increased area of surface for percolation are given below:

- Honey-comb masonry wall structure, circular or rectangular with 30 to 40% openings constructed in half brick wall (7.5 cm thick) with 1.2 cm lining in C.M. 1:6 and the bottom most layer of 22.5 cm. (i.e. one brick wall) is provided.
- Top three layers below ground level are constructed without any honey-comb openings.
- For pits located in the depression or high water table zone, the bottom is sealed with impervious material and height of pit is raised above ground level by 60 to 80 cm and pervious soil for 50 cm length is filled up around the pit. This is necessary throughout its vertical depth of staining.
- The pit is covered with a R.C.C. slab. Locally available material can be used like stone, wooden plank etc.

Leach Pit in Water Logged Areas



Cross Section of Leach Pit



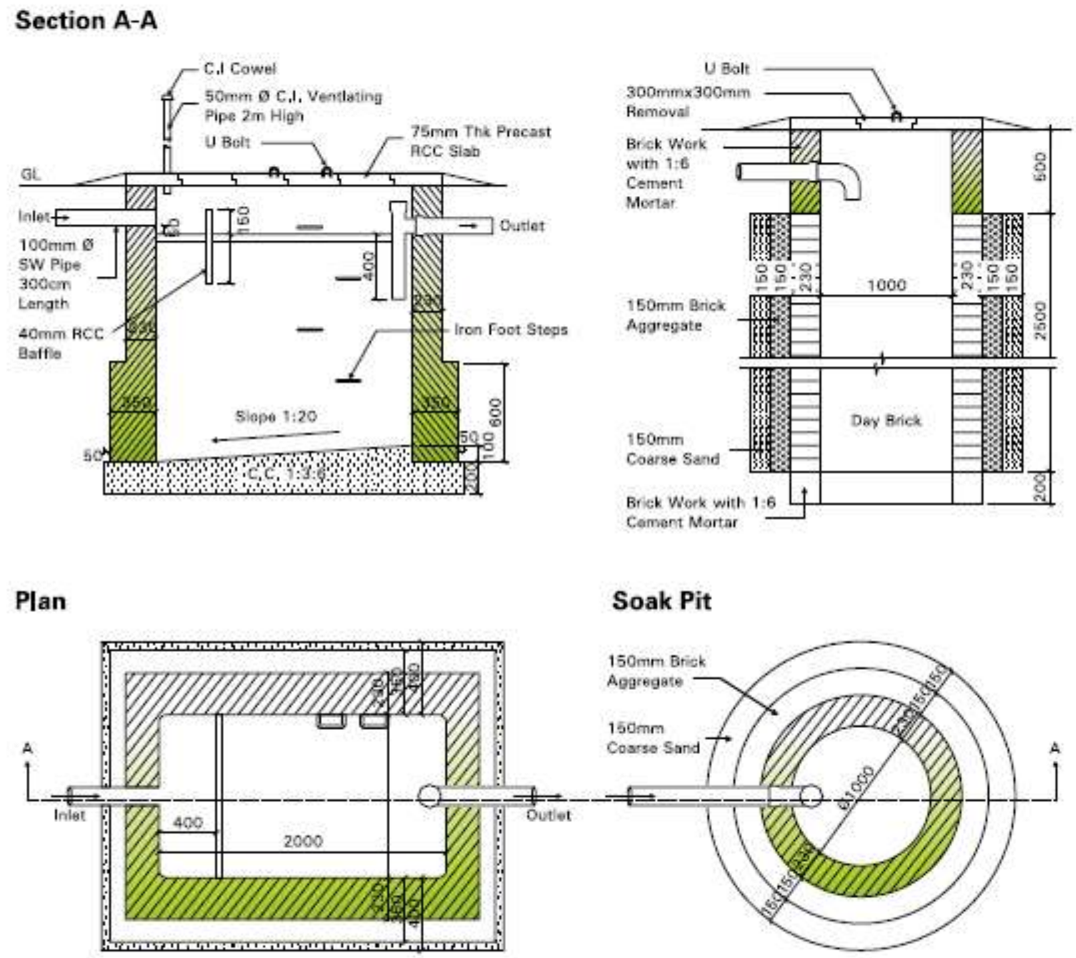
Leach Pit in High Sub Soil Water Area

4.9 Septic Tank

Septic tanks provide an excreta treatment system in locations where a sewerage system is not available. For rural areas, the septic tanks offer a limited use, especially for locations with high water table. However, institutions like schools, dispensaries or families who can afford the cost and manage the quantity of water required, a septic tank system for excreta disposal could be considered.

The system consists of a water-tight settling tank with one or two chambers/ compartments, to which waste is carried by water flushing down a pipe connected to the toilet which usually has a U-trap.

However, this system does not dispose of wastes; it only helps to separate the solid matter from the liquid. Some of the solids float on the surface, where they are known as scum, while others sink to the bottom where they are broken down by the bacteria to form a deposit called sludge. The liquid effluent flowing out of the tank is, from a health point of view, as dangerous as raw sewage and remains to be disposed off, normally by soaking into the ground through a soak-pit or with a connection to small bore sewers.



4.10 Difference between Leach pit and Septic tank

Leach Pit	**Septic Tank**
• Low cost Less space • Needs little water • Sludge handling easy- manure • No recurring cost • Pit emptying easy • No mosquitoes	• High in cost • More space • Needs more water for flushing • Sludge handling difficult • Recurrent costs for emptying • Safe disposal of effluents- pollution • Mosquito menace

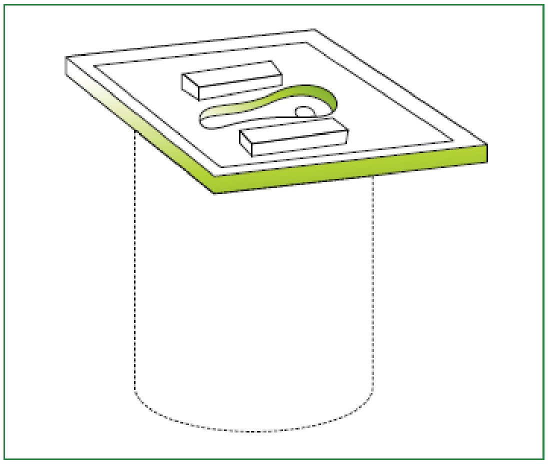


Figure 34-Leach Pit

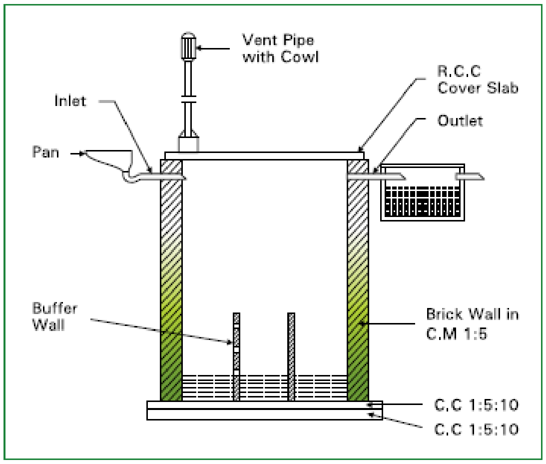


Figure 35-Septic tank

4.11 Environmental factors: Important considerations

There are different environmental factors, which play important role in deciding on the 7type of technology for the construction of the latrines, which need to be considered. Some of the considerations are depicted below.

Specific topic on which information/data is needed	Considerations
• **Type of soil-stability**	
Loose, sides of wall collapse	Line the pits. In very sandy soils, sink cement rings that are perforated or set on top of each other without cement.
Hard to dig	Use the pour flush design rather than VIP, as the pits are less deep.
• **Permeability** (how water is absorbed by soil)	
Clay soil	Test by pouring water into a hole and measuring how long it takes to be absorbed. Pits in dense clay may need back filling about 1.2 meters with more sandy soil.
Coarse sand	Back fill around the rings with denser soil and/or locate the latrine pipes far (for example, 40 meters or more) from a well used for drinking.
Hard laterite	If there might be cracks in the laterite, the latrine pits can pollute nearby drinking water sources. Place the latrine far from these sources
Ground water level in wet season (deepest level)	
Water rises higher than one meter from bottom of the latrine pit, but never completely floods the latrine pits	Locate the latrine pit far from any well used for drinking purpose and should be away for example, 40 meters or more
Water rises to or above the ground level and sludge comes out the latrines	Raise the latrines above the ground level so that the top third of the pit is always above the water level. Place latrines far from drinking water sources.
• **Distance to water sources**	
Distance from latrines pit to drinking water sources	At least 15 meters
Children or teachers may be spent extra time,for example, more than 15 minutes going one-way to collect water	VIP latrine is preferred as it uses less water.

4.12 Super-structure

In order to ensure safe disposal of excreta, the superstructure of the toilet is of least importance. Its primary function is to provide privacy and protection to the user from the natural elements. Undue emphasis on costly super-structure in the design of the toilet is not required. The norms of super-structure are purely restricted to the choice of the user though it should be built in order to ensure privacy and sustainability of the system especially for VIP latrine. The cost may vary depending upon the affordability of the user that can be built using bamboo, mud, bricks, woods, plastic cover, etc according to the atmospheric conditions, rainfall and locally available material. In some cases a temporary super structure can also be erected which can be replaced afterwards with a permanent one. Though, it should be noted that irrespective of the type, a super structure must have following minimum characteristics:

Figure-36, Superstructure-jute made

Figure-37, Superstructure-brick made

Figure-38, Superstructure-plastic made

Figure-39, Superstructure-wood made

- The super structure should be properly closed from all sides to ensure safety and privacy to every user and should not have chinks and holes in it.
- The super structure must have at least one ventilator of appropriate size for light and aeration.

- It must have a proper roof; otherwise the latrine will be out of use in rainy season. Similarly the rain water will accumulate in leach pits through exposed W.C. pan and may choke the system.
- The fixtures of door like latches should operate properly.

4.12.1 Operation and Maintenance - Do's and Don't's

For proper operation and maintenance of the toilets following Do's and Dont's should be explained to the users:

DO's

- Keep a bucket full of water outside the toilet.
- Keep a 2 liters can in the toilet filled with water for flushing.
- Before use, pour a little quantity of water to wet the pan so that excreta can slide smoothly into the pit.
- Flush the excreta after each use.
- Pour a little quantity of water, say half a liter, in the squatting pan after urination.
- The squatting pan should be cleaned daily with a soft broom or soft brush with a long handle after sprinkling a small quantity of water and detergent powder/soap.
- Use minimum quantity of water in washing the pan and toilet floor.
- Wash hands, using soap or ash, after defecation at the assigned place.
- If any construction defect is observed during the defect-liability period, report the matter to the local authority or the construction agency.
- When the pit in use is full, divert the flow to the second pit as described above in Para
- If the trap gets choked, rodding should be done from the pan side as well as from the rear side by means of a split bamboo stick, after removing the cover of the drain or junction chamber.
- Care should be taken while desludging the pits located in water-logged or high water sub-soil water areas and in case of combined pits, as humus may not be safe for handling.

DONT's

- Do not use both the pits at the same time.
- Do not use more than 2 litres of water for each flushing (if the waste is not flushed with 2 litres, pour more water at the specific spots for flushing the waste).
- Do not use caustic soda or acid for cleaning the pan.
- Do not throw sweepings, vegetable or fruit peelings, rags, cotton waste, and cleaning materials like corn cobs, mud balls, stone pieces, leaves, etc. in the pan or the pits.
- Do not allow rain water, kitchen or bath waste to enter the pits.
- Do not provide water tap in the toilet.

- Do not throw lighted cigarette butts in the pan.
- Do not desludge the pit before 1½ years of its being in use.

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PART – 5

WASTE TO ENERGY & REUSE OF WASTE

5.1 Objectives:

To make the candidates familiar with different types of energy generation options from waste and equip them with technology for the same.

5.2 Introduction:

Waste-to-energy (WtE) or energy-from-waste (EfW) is the process of creating energy in the form of electricity or heat from the incineration of waste source. WtE is a form of energy recovery. Most WtE processes produce electricity directly through combustion, or produce a combustible fuel commodity, such as methane, methanol, ethanol or synthetic fuels. The enormous increase in the quantum and diversity of waste materials generated by human activity and their potentially harmful effects on the general environment and public health, have led to an increasing awareness about an urgent need to adopt scientific methods for safe disposal of wastes. While there is an obvious need to minimize the generation of wastes and to reuse and recycle them, the technologies for recovery of energy from wastes can play a vital role in mitigating the problems. Besides recovery of substantial energy, these technologies can lead to a substantial reduction in the overall waste quantities requiring final disposal, which can be better managed for safe disposal in a controlled manner while meeting the pollution control standards.

5.3 Biogas Technology

When biodegradable organic solid waste is subjected to anaerobic decomposition, a gaseous mixture of Methene (CH4) and Carbon-dioxide (C02) known as Biogas could be produced under favourable conditions.

The decomposition of the waste materials are mainly done by the fermentation process which is carried out by different group of microorganisms like bacteria, fungus, actinomycetes etc. The group of microorganisms involved for biogas generation is mainly the bacteria.

The process involves a series of reactions by several kinds of anaerobic bacteria feeding on the raw organic matter. “In anaerobic conditions anaerobic bacteria disintegrate the biodegradable solids by a biochemical process shown below.

5.4 Digestion Process

The anaerobic digestion of the organic waste matter occurrs in three different stages:

- Hydrolysis
- Acidogenesis
- Methanogenesis

5.4.1 Hydrolysis

Most of the organic waste materials subjected to bio-methanation contain the macromolecules like cellulose, hemicellulose, lignin etc. which are insoluble in water. In the first step of digestion, these macromolecules are subjected to breakdown into micro-molecules with the help of some enzymes which are secreted by the bacteria. In the initial step, oxygen in the feed materials is used up by oxygen loving bacteria and large amounts of carbon-dioxide (CO2) are released and the major end product of this step is glucose.

5.4.2 Acid Formation

The components released during the hydrolytic breakdown become the substrate for the acid forming bacteria. The acid forming bacteria convert the water soluble substances into volatile acids.The major component of the volatile acid is acetic acid. Beside this some other acids like butric acid, propionic acid etc. and gases like CO2 and H2 are also produced. The acid forming bacteria during the conversion process utilize the amount of oxygen remaining in the medium and make the environment anaerobic.

5.4.3 Methane Formation

This is the last stage of the biogas generation. In this stage, the methanogenic bacteria convert the volatile acids formed in the second step by the acidogenic bacteria to methane and carbon- dioxide. Some excess CO2 in the medium is also converted to methane gas by reacting with the hydrogen present in the environment.

The end products of Bio-Gas Technology are:

• Biogas: It is a marsh gas, a mixture of Methane (55-65%), Carbon-dioxide

(35-45%), trace amount of Hydrogen, Hydrogen Sulphide and Amonia. It is a combustible gas and can be used for heating, lighting, powering irrigation pump, generating electric power and for local use for cooking purpose. The gas is smokeless, environment friendly and efficient fuel.

• Left over slurry: Environmental friendly manure would be produced which can be used as organic fertilizer for gardening and agricultural purpose. It can be used to enrich the soil. It can also be dovetailed to vermin composting to enrich mineral value of compost.

5.4.4 Fuel Efficiency of Biogas

The fuel efficiency of cattle dung is 11% and that of Biogas from same dung is 60%, Biogas technology holds promise of revolutionizing energy scene-conserving forests, preventing soil erosion and providing energy security in rural India. Normally a 3 cu.m. capacity biogas plant is considered sufficient to meet the heating and lighting needs of a rural family of 6 to 9 persons.

5.5 Use of Biogas Technology for Solid Waste Management

The biogas technology can be used for management of bio degradable solid waste (portion) generated from:

- Household
- Community
- Commercial establishment

Nutrients	C: N = 30: 1 (may vary 20: 1 to 40: 1)
• Solid concentration	12% (8% volatile matter)
• Temperature	35°C (less than 15° C is not favourable for gas generation)
• Retention period	30-55 days (it varies from place to place)
• PH	6.6-8.0 (7.2 pH is the optimum for gas generation)
• Toxic substance	Fungicides, Insecticides, Pesticides, Heavy metals detergents, phenyl, dettol etc. are harmful for gas generation.
• Particle size	As small as possible (by chopping or grinding)
• Mixing	It is required to prevent the digester from scum formation.

Household Level

Kitchen waste, cattle dung, garden waste, leaves of trees can be digested and digested product reused at household level.

Community Level

Community bio degradable waste such as stray cattle dung and from Gaushalas, garden waste, leaves of roadside trees, human exterca from individual/community toilet etc, can be digested in community biogas plant and end products can be reused.

Commercial Establishment

Commercial bio degradable waste generated from hotels, parks and gardens, subzi mandis (vegetable markets) and roadside tree leaves etc. can be digested in commercial biogas plant and the end products can be fruitfully utilized commercially such as gas engine, cng productions, lifting water for irrigation purposes etc.

The Gas production varies from 0.29 cu.m per kg of volatile solids added per day to 0.19 cu.m

0.16 cu.m per kg added per day in different seasons. The volatile solids destruction ranges from 40 to 55%. The sludge has good manurial value of Nitrogen, Phosphorous, Potassium

(NPK ratio is 1.6: 0.85: 0.93). The process gives a good performance at a retention time of 30 to 55 days varies as per season.

5.5.1 Feed Materials for Biogas Plant

Organic materials are used as feed materials for Biogas plant. Generally, the following organic materials are used:

- Cattle dung (gobar)-(any model)
- Human excreta (floating dome type with water jacket and fixed dome type)
- Kitchen/Vegetable waste (Floating dome model).

5.5.2 Design and Construction of Biogas Plants

There are many designs and models of biogas plants in operation with each one having some special characteristics and each popular model having some basic components. The biogas plants have following components for proper functioning of these designs.

- Digester or fermentation chamber
- Gas holder or gas dome
- Inlet (pipe or tank)
- Outlet (pipe or tank)
- Mixing tank
- Gas outlet pipe
- Inlet and outlet displacement chambers (for fixed dome biogas plants)

- Inlet and outlet gates.

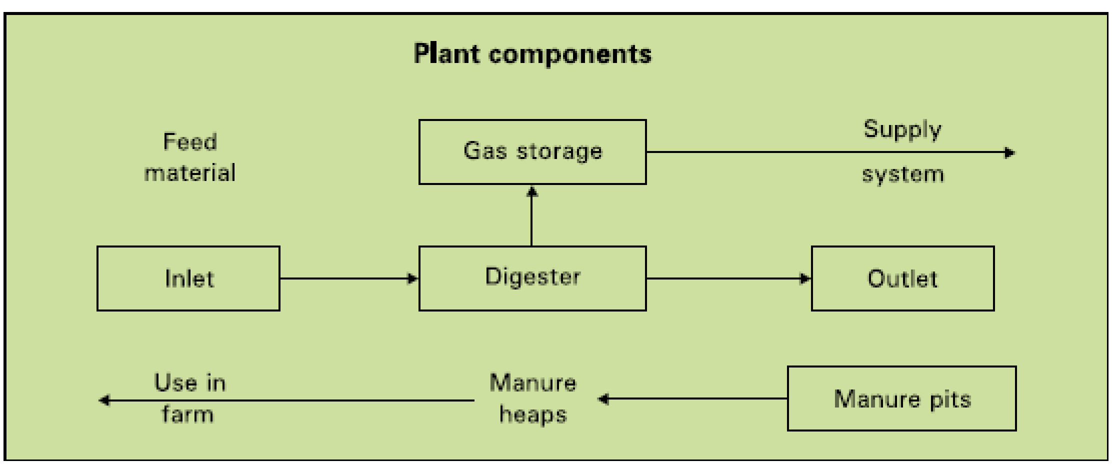
Physical characteristics	Kitchen waste	Vegetable waste	Cattle dung	Human excreta
Biogas production				
Litres/kg	122.0	100.0	32.0	130.0
Litres/kg (TS)/day	580.0	154.0		
Litres/kg (VS)/day	614.0	253.0		
Methane% in biogas	58.0	68.0	55.0	61.0
Fertilizer value of digested slurry				
Nitrogen% of dry weight	2.58	2.00	1.40	3.25
Phosphorous (P205)% of dry weight	1.24	1.00	0.72	1.0
Potassium (K20)% of dry weight				0.83

The above five components can be arranged and joined together in various ways. These multiple arrangements lead to different types of biogas plants.

5.5.3 Types of Designs of Biogas Plants

There are many designs and models of biogas plants in operation with each having some special characteristics. Following are the two groups of biogas plant designs:

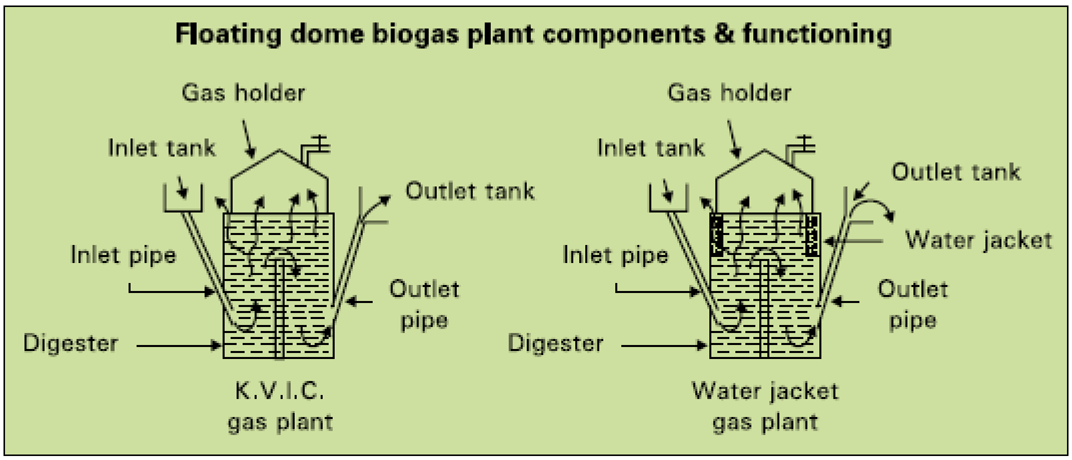
- Floating gas holder plant e.g. KVIC, water jacket, pragati etc
- Fixed dome plant e.g. Janata, Deenbandhu etc.



5.5.4 Floating gas-holder plant

This type was developed in India and is usually

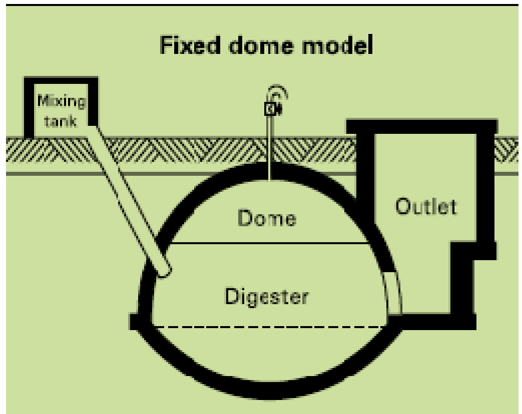
made of masonry. It runs on a continuous basis and uses mainly cattle dung as input material. The gasholder is usually made of steel although new materials such as Ferro cement and bamboo-cement have already been introduced. The original version of this floating gasholder plant was a vertical cylinder provided with partition wall except for the small sizes of 2 and 3 m3 of gas per day. The main characteristic of this type is the need for steel sheets and welding skill. The mode of functioning of these plants is depicted in the following drawing:



5.5.5 Fixed dome plant

This plant, runs on a continuous or batch basis. Accordingly, it can digest plant waste as well as human and animal waste. It is usually built below ground level hence it is easier to insulate in a cold climate. The plant can be built from several materials, e.g. bricks, concrete, lime concrete and lime clay. This facilitates the introduction and use of local materials and manpower. The available pressure inside the plant doesn't cause any problems in the use of the gas.

In the floating dome type plants the gas holder moves while in the fixed dome plants the slurry moves



5.5.6 Comparison between floating dome and fixed dome models

1.	Capital investment is high	Capital investment is low.
2.	Steel gas holder is a must which needs to be replaced after few years due to corrosive damage.	Steel gas holder is not required.
3.	Cost of maintenance is high.	As there is no moving part, the maintenance cost is minimized.
4.	Life span of the digester is expected to be 30 years and that of gas holder is 5 to 8 years.	Life span of the unit is expected to be comparatively more.
5.	Movable drum does not allow the use of space for other purposes.	As the unit is an underground structure, the space above the plant can be used for other purposes.
6.	Effect of low temperature during winter is more	Effect of low temperature will be less
7.	It is suitable for processing of dung and night soil slurry. Other organic materials will clog the inlet pipe.	It can be easily adapted/modified for use of other materials along with dung slurry.
8.	Release of gas is at constant pressure.	Release of gas is at variable pressure, which may cause slight reduction in the efficiency of gas appliances, to operate a diesel engine, attachment of a gas pressure regulator in the pipeline is a must.
9.	Construction of digester is known to masons but fabrication of gas holder requires	Construction of the dome portion of the unit is a skilled job and

	workshop facility.	requires thorough training of masons.
10.	Location of defects in the gas holder and repairing are easy.	Location of defects in the dome and repairing are difficult.
11	Requires relatively less excavation work	Requires more excavation work.
12.	In areas having a high water table, horizontal plants could be installed.	Construction of the plant is difficult in high water

5.5.7 Toilet Linked Biogas Plant

Introduction

In India in initial stages, because of itsmassive availability, cattle dung was used as a feed material for biogas plant. Human excreta is one such alternative feed material to biogas plant. At present, human excreta treatment is a major sanitation problem in the country. If it is used imaginatively in biogas plant, it can become an asset instead of a nuisance. Human excreta management in a biogas plant will give three benefits-health, energy and organic manure. Thus, the waste can turn into wealth. However for generating one cubic meter biogas per day in a toilet linked biogas plant, excreta of 25-30 persons per day is required.

For community toilets, where the number of users per day is more, this has proved to be a viable method for generation of biogas from human excreta. For individual family toilets, for about 5-10 users per day, biogas generation proves to be inadequate for any practical use. If neighbors are allowed to use toilets, the quantity of biogas increases so as to make the biogas plant viable.

5.5.8 General Parameters for Design

In the initial stages, the design which was found to be suitable for cattle dung was used for human excreta without any change in the design. Excreta has physical, chemical and microbial characteristics which markedly differ from those of cattle dung. Therefore, the parameters, design criteria etc. fixed for cattle dung biogas plants were found not valid for human excreta based biogas plants. General parameters could be enumerated as follows:

- There should not be any direct handling of human excreta
- Undigested excreta should not get exposed to surroundings and should be inaccessible to insects and animals
- Aesthetically there should be freedom from odour
- There should not be any contamination of subsoil or surface water
- Maintenance of the treatment process should be easy and should not evoke any repulsive feelings

- The recycling should give maximum possible advantages
- The social and behavioural aspects need to be tackled by educational process

5.5.8.1 Specific Parameters for Design

- Quantity of human excreta: 200 to 300 grams/person/day
- Quantity of gas generated from the night soil produced by one person is about 30 to 40 liters per day
- For optimum digestion, expected water use per person per day: 2.2 liters
- Optimum temperature range for effective digestion and optimum economic viability: 25 to 30 degree centigrade
- Solid content for optimum biogas generation: 5%
- Hydraulic Retention Time (HRT): 45 days for destruction of all pathogen.

Taking all the above mentioned parameters into consideration, it is felt that for human excreta biomethanation, following two designs are suitable:

- Floating dome water jacketed biogas plant developed by Shri S.P.alias Appasaheb Patwardhan in 1953
- Fixed dome 'Malaprabha Biogas Plant' developed by Dr. S.V. Mapuskar in 1981.

It was reported that while developing the design, consideration of the relevant hygiene factors along with parameters for biomethanation of human excreta had been taken into account. The relevant social factors and convenient latrine use were also considered.

5.5.8.2 Special Consideration

For the use of human excreta as feed material and efficient functioning of such plant, the parameters and the design criteria with respect to the procedures for the feeding and handling the feed, the physical and chemical characteristics of the feed, the movement of slurry, odour, aesthetics, etc. need to be considered so as to create optimum conditions for the use of human night soil.

Further, from health point of view, it will be necessary to see that the raw excreta is not exposed to environment, insects, animals etc. and is not manually handled. During the digestion process, it should not be exposed to environment. The most important parameter from health point of view will be the extent of pathogen killed or pathogen inactivation achieved, during the process so that the effluent is not pathogenic.

5.5.8.3 Operation and Maintenance

- Toilets connected to the Biogas plant should be kept clean and used regularly
- Scum formation creates problem in the digester. To minimize scum formation, it is necessary to prevent entry of undesirable foreign material into the digester

except human excreta It is necessary to remove sludge from the digester once in 5 to 10 years by suitable pumping arrangement

- Effluent from the plant should preferably be disposed of in a compost pit
- Antiseptic and disinfectants should not be used for cleaning the toilets. Occasionally organic soaps/organic detergents may be used
- Top of the vent pipe provided at the point of inlet chamber, need to be covered with nylon mesh so as to prevent the passage of mosquito or any insets.

Technical Replicability

- Field tested and accepted technology
- Availability of few skilled and knowledgeable NGOs
- Up scaling/replication possible
- Training facility at field level available.

Advantages

- Hygienic and economically efficient management of human night soil
- The biogas plant also provides rich manure
- It reduces cooking time and saves fuel cost.

Limitations

- High cost for the lower middle and low income group in rural areas
- Lack of availability of required technical infrastructure in rural areas.

5.6 Reuse and Recycling of Non-Biodegradable Solid Waste

Introduction

Efforts should be made to segregate the non-biodegradable solid waste into two portions namely a) recyclable and (b) non recyclable at household as well as community level.

Sorting out or segregation of paper, plastic, cloth, metal, glass etc may be done at the community level by the women self help groups and dovetailed with the self employment programmes of Ministry of Rural Development, Government of India implemented by the DRDAs in the respective states to recycle these waste materials. The following type of papers, plastics and clothes may be segregated for recycling/re-use purpose

Segregated waste need to be packed and stored in a safe place. Gram Panchayat can sell the recyclable segregated waste to the local recyclers as and when enough quantities accumulate. This will fetch revenue to the Gram Panchyat. Papers, plastics and clothes should be converted into appropriate recyclable products to generate revenue

5.6.1 Recycling of Papers

It is possible to convert waste paper into useful recyclable product. Making pulp from waste paper is an old art. The process has now been refined. Various articles including showpieces may be made using the pulp. The articles are so sturdy that they can be an alternative to wood to some extent. Hence it is also called Pepwood.

Applicability

Women/SHG members/Unemployed youths/after receiving thorough training can undertake this activity. It is also necessary to attain a certain level of skill.

Description of the process

- Soak the waste paper in water for 3 to 4 days
- Take out the paper and macerate it on rough surface like stone or any rough surface
- Squeeze out excess water
- Add natural adhesive like flour of fenugreek seeds/tamarind seeds
- Make a pulp out of the macerated paper like dough
- Make article of choice with the help of moulds of different shapes and sizes • Dry the articles in sun
- Paint the articles artistically as per choice.

Materials required

- Waste paper
- Flour of fenugreek or tamarind seed as adhesive
- Water
- Rough flat stones for macerating paper
- Colors
- Moulds of different shapes and sizes
- Well ventilated cupboard for storing the articles.

Advantages

- Reduction of garbage by recycling of waste paper in a decentralized manner
- Generation of income out of waste
- Prevention of burning of waste paper and clean environment
- Saving on wood articles since some of the pulp articles can be used in place of wood e.g. teepoy, serving trays, fruit baskets etc

- Some articles can be best alternatives to plastic articles.

Limitations

- Like plywood, pepwood articles should be kept away from direct contact with water
- In rainy season it becomes little difficult to make pulp articles.

5.6.2 Recycling of Plastics

In all types of solid waste in rural areas, plastics have become a major cause of concern due to:

- Non-biodegradability and
- Nuisance value in waste stream and blockage of drainage channels
- Pollution of surface water
- Random burning here and there causing air pollution problem
- There is no proper collection or disposal system of plastic waste.

Applicability

Community level

Description

Awareness among all stakeholders through appropriate IEC measures should be generated for collection, segregation and recycling of plastic waste. Individual house owner should segregate the waste at household level and gram panchayat should get it collected through a suitable mechanism. The segregated plastic at the GP level may be given to the SHGs for taking up a viable project for recycling and reuse of plastic waste. It is recommended that heating and burning of plastic waste should be completely avoided at village level. So only such projects should be taken up which are not dependent on heating or burning processes.

Some of the products which can be made at village level using shredding, cutting, weaving etc of plastics are;

- Plastic rope
- Plastic bag
- Pillows and mats
- Showpieces
- Shredding of plastic and its use in rural road making in limited quantity for mixing in coal-taar

- Few more innovations are being attempted for converting plastic waste into petrol which may also be explored.

Action by self help groups

- Collect requisite quantity of plastic waste for taking up above activities
- Purchase appropriate machines easily available in the market for making the required products.

Materials required

- Waste plastic
- Appropriate machine with accessories
- A well lighted and ventilated Room to install and operate the machine.

Advantages

- Pleasant and clean surroundings
- Prevents drainage blocking
- Prevents vector breeding
- Prevents surface water pollution
- Prevents burning of plastics
- Full utilization of plastic wastes
- Generation of wealth from plastic waste.

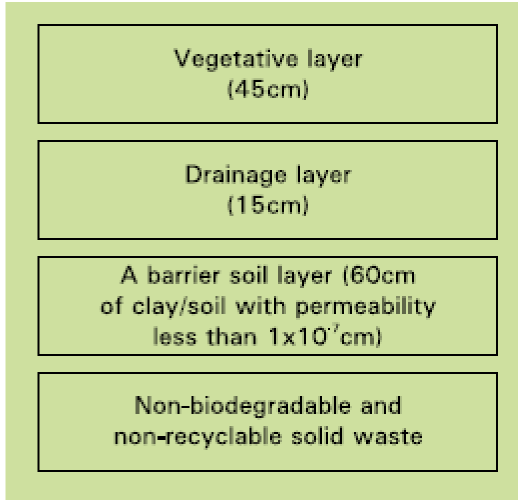
5.7 Landfill

Overview

In spite of composting, re-use and recycling, some waste remains untreated/unmanaged which requires final disposal, either by incineration or by land filling.

Incineration is a technology where waste is burnt in a specially engineered machine called Incinerator. Incineration is not simply burning, but complete combustion. Incinerators are considered to be causes of air pollution. This is not a viable option for waste management.

A landfill is a properly designated area and used for the disposal of non-biodegradable and non-recyclable inorganic solid waste. Landfill is considered to be a viable option.



Advantage

Takes care of the problem of disposal of non recyclable solid waste.

Applicability

Community level with the cooperation of individual household.

Action

Gram Panchayat to organize themselves to construct and maintain landfill. Gram Panchayat may make use of Youth Club members/Women Self Help Groups.

Description

- Selection of Landfil Site: Gram Panchayat in consultation with Zilla Parishad/Block Panchayat (as the case may be) should select the landfill site which should be:
- Located at the outskirts of the village
- Accessible
- On vacant/uncultivated land
- Located in the natural depressions with slight slopes
- Waste from landfills leaches into the aquifer below site should be such as to avoid surface water and groundwater pollution
- Before establishing any landfill site, baseline data of ground water quality in the area shall be collected and kept as a record for future reference.
- Procedures to be followed for landfill construction
- Wastes should be compacted to achieve high density
- Wastes should be immediately covered with a minimum 10cm of soil/debris/

- Before the monsoon season, an intermediate cover of soil approximately 40-65cm thick should be placed on the landfill to prevent infiltration
- Proper drainage system should be constructed to divert run-off water
- After the completion of landfill a final cover should be provided to prevent infiltration and erosion. This should be according to the given diagram
- Landfill site should be properly fenced with a provision of a gate with locking arrangements by the gram panchayat/community
- Plantation at landfill site should be encouraged to combat pollution. It should be in sufficient density to minimize soil erosion
- The plants should be locally adapted, non-edible, drought and extreme temperature resistant, short rooted and of low nutrient demanding variety.

Operation and maintenance

- Gram Panchayat/community should prevent entry of stray animals and unauthorized persons through protective measures
- Regular Monitoring of groundwater is required for maintaining groundwater quality.

Materials required

The system is labor intensive and primarily requires earthwork job for disposal of non recyclable solid waste. The size of the landfill will depend upon the quantity of non recyclable solid waste to be disposed off into the pit daily.

Limitations

- Entry of cattle and grazing on the landfill site in an unfenced landfill would be hazardous.

5.8 Reuse of Grey Water

After treatment Grey water can be reused for flushing and cleaning. Greywater stabilized and cleaned by the use of any of the systems discussed in Unit -3 can be reused in many ways.

- Irrigation for agricultural use
- Irrigation for horticulture
- Fish farming.

1. Irrigation for agricultural use

The treated greywater has large quantity of dissolved plant nutrients. As a result, its use in agriculture is beneficial. Once farmers realize it, its sale can be financially advantageous for Gram Panchayat.

2. Irrigation of horticulture

The water can be used beneficially for fruit gardens, horticulture etc. Thus it can become a source of income for GP. The water can be used also for public gardens and parks in the village.

3. Fish farming

Fish farming can be undertaken with the use of such treated water. This can become a source of income for GP.

Urine-diversion eco-toilets: Two NGOs supported by UNICEF have brought ecological sanitation into the community domain in Tamil Nadu. The NGOs – SCOPE and MYRADA – undertook projects to introduce ecological sanitation as a concept among rural families in Tiruchirapalli and Erode districts through a process of discussion with Gram Panchayats and families. Innovative eco-toilet designs were developed in the effort, in one case, to find a local solution to the problem posed by the high water table along villages located on the banks of the river Kaveri and, in a second case, a hard rocky sub-surface in a hilly area.

The design of the eco-toilet is based on the following principles:

- There is no pit in the ground; instead there are two chambers above the ground. This ensures there is no pollution of ground water.
- Separation of the solid waste (faeces) and the liquid waste (urine+wash water). The separation is essential as faeces kept separate from liquid waste desiccate and disintegrate faster and occupy less space. Separation also prevents bad odour which results from mixing of urine and faeces.
- The user of the toilet will defecate in the defecation hole and the urine is drained separately. Then the user has to move a foot backwards or sideways to wash in a separate washing trough.
- The liquid waste (urine+wash water) is drained through a mud pot into the earth adjoining the toilet about one foot below surface. This earth is below a small square plot which is used for horticulture or growing sturdy flowering plants. The waste is good for plant growth as nitrogen from urine feeds the plants directly and the pathogens in the wash water remain under the ground and become inactive in a few days.
- The second chamber is used only after the first is full.
- The full first chamber is to be opened through a lateral/back opening (closed by a single slab) only after one year has elapsed.

- The products of the first chamber – which become free of pathogens like bacteria, viruses and protozoal cysts after a year – is black humus with a pleasant odour. It is **good manure**, rich in nitrogen, phosphorus, and potassium, the three elements required in greatest quantities by plants, and an excellent conditioner that restores health and productivity of the soil.
- The users of the toilet have to understand the primary principle on which eco-friendly compost toilets are based. A family, once convinced of the usefulness of the system, and the gains in terms of water use and quality manure, is willing to contribute or spend money on constructing such a toilet.

These designs have proved very effective and both SCOPE and MYRADA have trained local masons who have installed about 500 such eco-toilets in Tiruchirapalli district and 50 units in Erode district.

In the tsunami-affected districts of Tamil Nadu, especially Nagapattinam where ground water levels have surged up, such above-ground installations with urine separation is seen as the most suitable way of managing human waste. Gramalaya and SCOPE have introduced these designs as one of the options for household toilets in tsunami-affected districts.

The price of eco-sanitation toilets installed by SCOPE ranges from Rs. 3,500 to Rs. 5,000, most of which comprises the cost of materials for the superstructure and above-ground chambers.

5.9 Case Study: Conversion of Waste Paper into "Pepwood"

Nirmal Gram Nirman Kendra believes that, "there is nothing waste as such in the world." It is the negligent attitude of the society that makes things useless & wasteful.

Waste paper generated in a household or in offices is generally thrown away indiscriminately or burnt off. Both these practices are harmful to the environment.

Waste paper of any sort can be recycled on a very small scale – even at household scale. In fact, conversion of waste paper into pulp articles is an old art. It was in practice even in small & remote villages. However with the rise of plastic era this art gradually vanished.

Nirmal Gram Nirman Kendra thought of reviving the technique as a part of its activities in the field of solid waste management. NGNK chairperson Ms. Nalini M. Navrekar studied the indigenous methods of converting waste paper into pulp. Afterwards she did exhaustive experimentation to improve & refine the process & also to make the final products of superior quality. Now the articles produced by this process are i) more elegant ii) stronger & iii) more durable. These are so sturdy that these can be an alternative to wood to some extent. Hence the name – "Pepwood".

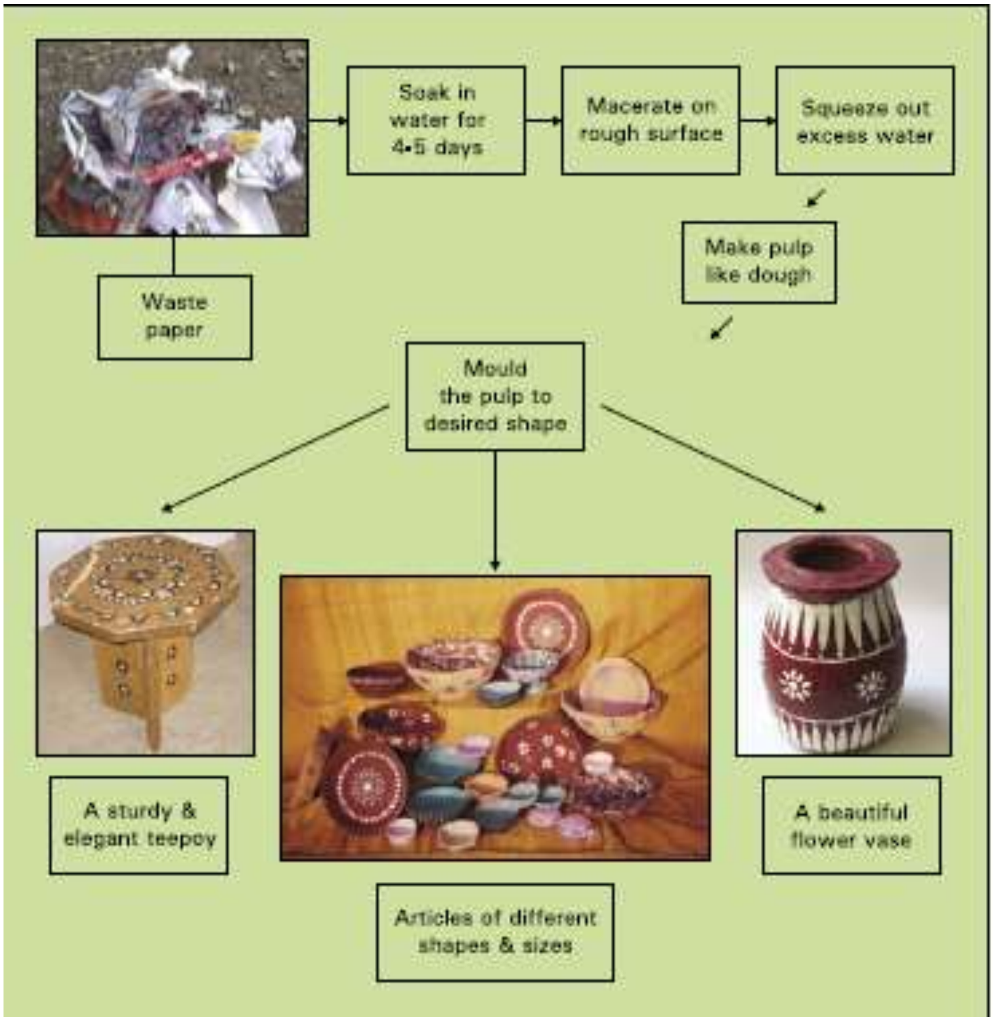
Main features of the technology

- Reduction of garbage by recycling of waste paper in a decentralized manner
- Generation of income out of waste
- Prevention of burning of waste paper & filthy sights
- Saving on wood articles since some of the pulp articles can be used in place of wood e.g. teepoy, serving trays, fruit baskets etc
- Some articles can be best alternatives to plastic articles.

Women/SHG members/unemployed youths/after receiving thorough training can undertake this activity. It is also necessary to attain a certain level of skill.

Process followed at Nirmal Gram Nirman Kendra5

- Waste paper is soaked in water for 4 – 5 days
- The soaked paper is taken out & macerated on rough surface like stone or any rough surface Excess water is squeezed out
- The macerated paper is converted into pulp by kneading like dough
- Different articles are made with the help of moulds of different shapes & sizes
- The articles are then dried in sun
- The articles are painted artistically as per customers' choice
- The product is ready for marketing



5.10 Involvement of women

The entire process is done by local village women. Although the activity requires skilled labour, anybody can attain the skill with a little training.

ReaplicabilityThe technology is available for replication & generation of employment

Cost & Economic Viability:			
Sr.No.	**Particulars**	**Quantity**	**Cost (Rs)**
1	Waste paper	5kg	20.00
2	Adhesives	--	200.00
3	colors	--	300.00
4	Skilled & unskilled labor	--	660.00

5	Total cost		1120.00
6	Price of finished goods	--	1650.00
7	Profit	7-6	530.00

5.11 Case Study: Eco Friendly Plastic Fuel

(Conversion of Waste Plastic into Liquid Hydrocarbons/ Energy)

Waste plastic problem is an ever-increasing menace for global environment. Because of flexibility, durability and economy, a phenomenal rise is observed in the plastic consumer base. More than 150 million tons of waste plastic is generated worldwide each year. Though plastics have opened the way for a plethora of new inventions and devices it has also ended up clogging the
drains and becoming a health hazard. Plastics being non biodegradable get accumulated in the environment. If this problem is not addressed properly, it will lead to mountains of waste plastic.

Throughout the world, research on waste plastic management is being carried out at war-footing. In developed countries, few waste plastic disposal /conversion methods have been implemented but are not efficient and economically feasible. According to nationwide survey conducted in the year 2003 more than 10,000 MT of plastic waste is generated every day in India. Unfortunately there is no definite policy to cater waste plastic generated.

Every year losses due choking of drainage lines due to waste Plastics are in crores of rupees. Every year millions of rupees losses are suffered by agro-economy because of death of animals due to eating plastics.

Our country faces the critical problem of fuel and energy deficiency. The fast depletion of petroleum reserves in the world and frequent rise in prices of crude oil affect our economy adversely. India is not self sufficient in case of petroleum and crude oil. The national production capacity is capable of fulfilling not even 30% of the total fuel demand. The remaining whopping 70% is fulfilled by importing crude. Most of our precious foreign exchange is spent on importing crude.

Prof. Mrs. Alka Umesh Zadgaonkar, Head of Department of Applied Chemistry at the Nagpur based G.H. Raisoni College of Engineering, invented an Environment friendly catalytic-additive process for disposal of waste plastic

The invented process involves degradation of waste plastic using `catalytic-additive' and is different from the generally existing pyrolytic processes. The products obtained in the process are Liquid hydrocarbons, Gas and residual Coke.

5.11.1 Recycling of plastic by conventional methods

Recycling is not the complete solution for disposal of the waste plastics. After third/fourth recycling the plastic is totally unfit for reuse and hence ultimately it ends up in land filling. Some types of the plastics are not suitable for recycling. However, recycling of plastics is only suitable for processing segregated plastic materials and is not suitable for assorted municipal waste plastics.

The problems associated with the recycling process are as follows:

- Many types of plastics are used hence it is difficult to segregate them for specific purpose
- Plastics contain a wide range of fillers & additives
- Many times plastic is associated with metal, Glass etc
- Sorting of plastic is technically difficult as well as expensive
- Recycling of plastic degrades the quality of the end product
- Laminated plastics are non recyclable.

Salient features of EPF (Ecofriendly Plastics Fuel) technology

- Generally the plastic waste contains about 2-4 wt% PVC, 5-8 wt% PET, 15-20 wt% PP, 20-25 wt% LDPE, 15-20 wt%, HDPE 10-15 wt%, 7-10 wt% of ABS, Nylon, etc. The output product does not change appreciably either qualitatively or quantitatively irrespective of any input changes or proportions
- Batch Process has been successfully. converted into Continuous Process
- Effects of feed variation collected from municipal waste have been studied and offers a complete solution for Waste Plastic disposal
- Improvement in product quality from variety of feed generated from municipal plastic waste has been achieved.

The process:

The invented process involves degradation waste plastic using `catalytic-additive' and is different from the generally existing pyrolytic processes. The laboratory scale set-up was developed in batch mode in which individual as well as mixed plastics were successfully converted in to fuels. Now the commercial 5MT/Day plant operates on continuous mode. The products obtained in the process are Liquid hydrocarbons (65-75%), LPG range Gas (15-20%) and residual Coke (8-12%).

In the process of conversion of waste plastic into fuels, random De-Polymerization is carried out in a specially designed Reactor in absence of oxygen and in the presence of catalytic additive. The maximum reaction temperature is 350°C.

It is a unique process in the world which converts 100% waste into 100% value added products.

In spite of the above mentioned facts, the fuel extracted from plastic waste will be utilized strictly as Non-Motorized fuel to start with.

Parameter	**Regular gasoline**	**Fuel extracted from plastic waste**
Colour, visual	Orange	Pale yellow
specific gravity at 28°C	0.7423	0.7254
Specific gravity at 15°C	0.7528	0.7365
Gross calorific value	11210	11262
Net calorific value	10460	10498
API gravity	56.46	60.65
Sulphur content (present by mass max)	0.1	<0.002
Flash point (Abel) °C	23.0	22.0
Pour point °C	<-20°C	<-20°C
Cloud point	<-20°C	<-20°C
Existent gum, (gm/m3 max.)	40	36
Reactivity with SS, MS, Cl, Al, Cu	Nil	Ni

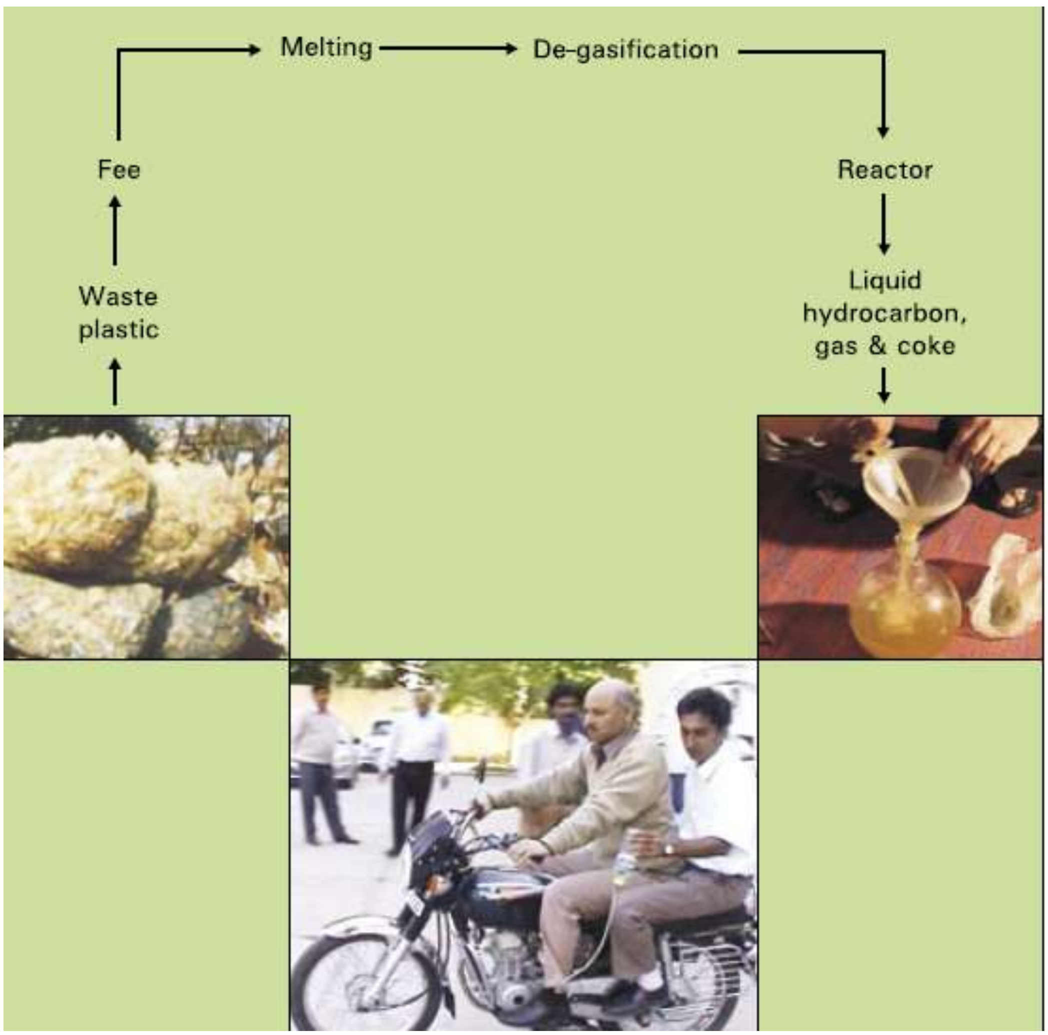
Driving test on Bajaj Pulsar (150cc)		
	Regular gasoline	**Fuel extracted from plastic waste**
Mileage	52.4	63.0
Time for 0-60 Km/Hr	22.5 Sec.	18.1 sec.
CO % at 400 RMP/HC	2.8	2.3
(Permissible range up to 4.5)		

5.11.2 Field applications

Mrs. Alka Zadgaonkar has successfully set up a 5 MT per day capacity commercial plant at: K-13, Butibori MIDC Industrial Area, Wardha Road, Nagpur.

This type of plant can also be set up in rural areas. It may not be feasible to have one plant in each village but it can operate either for a group of villages or for an entire district. The plastic waste from all the villages can be collected & transported to the central plant.

Network of such plants can be set up all over the country and fuel generated can be utilized for generation of power. From 1liter of this liquid hydrocarbon fuel 6-7 Units of electricity is generated.



While solving waste plastic problem which is a threat to the environment, network of plants based on invented technology will generate direct/indirect employment to more than 100000 rag pickers and 10,000 others,
within India.

With the experience gained from the commercial plant in last Two Years it is certain that such plants will not only be self-sustaining without any penalty for processing the hazardous plastic waste but will be profit centres for disposal of waste plastic in eco friendly manner. The plants based on the said technology are coming up in Rajasthan, Maharashtra, Mauritius and Baharin.

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5.12 Waste to Energy technologies

Introduction : Waste-to-energy (WtE) or energy-from-waste (EfW) is the process of creating energy in the form of electricity or heat from the incineration of waste source. WtE is a form of energy recovery. Most WtE processes produce electricity directly through combustion, or produce a combustible fuel commodity, such as methane, methanol, ethanol or synthetic fuels. The enormous increase in the quantum and diversity of waste materials generated by human activity and their potentially harmful effects on the general environment and public health, have led to an increasing awareness about an urgent need to adopt scientific methods for safe disposal of wastes. While there is an obvious need to minimize the generation of wastes and to reuse and recycle them, the technologies for recovery of energy from wastes can play a vital role in mitigating the problems. Besides recovery of substantial energy, these technologies can lead to a substantial reduction in the overall waste quantities requiring final disposal, which can be better managed for safe disposal in a controlled manner while meeting the pollution control standards.

5.12.1 Types of production

5.12.1.1 Incineration:

The combustion of organic material such as waste, with energy recovery is the most common WtE implementation. Incineration may also be implemented without energy and materials recovery, however this is increasingly being banned in OECD (Organisation for Economic Co-operation and Development) countries. Furthermore, all new WtE plants in OECD countries must meet strict emission standards. Hence, modern incineration plants are vastly different from the old types, some of which neither recovered energy nor materials. Modern incinerators reduce the volume of the original waste by 95-96 %, depending upon composition and degree of recovery of materials such as metals from the ash for recycling. Concerns regarding the operation of incinerators include fine particulate, heavy metals, trace dioxin and acid gas emissions, even though these emissions are relatively low from modern incinerators. Other concerns include toxic fly ash and incinerator bottom ash (IBA) management.Discussions regarding waste resource ethics include the opinion that incinerators destroy valuable resources and the fear that they may reduce the incentives for recycling and waste minimization activities. Incinerators have electric efficiencies on the order of 14-28%. The rest of the energy can be utilized for e.g. district heating, but is otherwise lost as waste heat

5.12.1.2 Technologies other than incineration

There are a number of other new and emerging technologies that are able to produce energy from waste and other fuels without direct combustion. Many of these technologies have the potential to produce more electric power from the same amount of fuel than would be possible by direct combustion. This is mainly due to the separation of corrosive components (ash) from the converted fuel, thereby allowing a higher combustion temperatures in e.g. boilers, gas turbines, internal combustion engines, fuel cells. Some are able to efficiently convert the energy into liquid or gaseous fuels:

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5.13 Thermal technologies:

Gasification (produces combustible gas, hydrogen, synthetic fuels)

Thermal depolymerization (produces synthetic crude oil, which can be further refined)

Pyrolysis (produces combustible tar/biooil and chars)

Plasma arc gasification PGP or plasma gasification process (produces rich syngas including hydrogen and carbon monoxide usable for fuel cells or generating electricity to drive the plasma arch, usable vitrified silicate and metal ingots, salt and sulphur)

5.14 Non-thermal technologies:

Anaerobic digestion (Biogas rich on methane)

Ethanol production

Mechanical biological treatment (MBT)

MBT + Anaerobic digestion

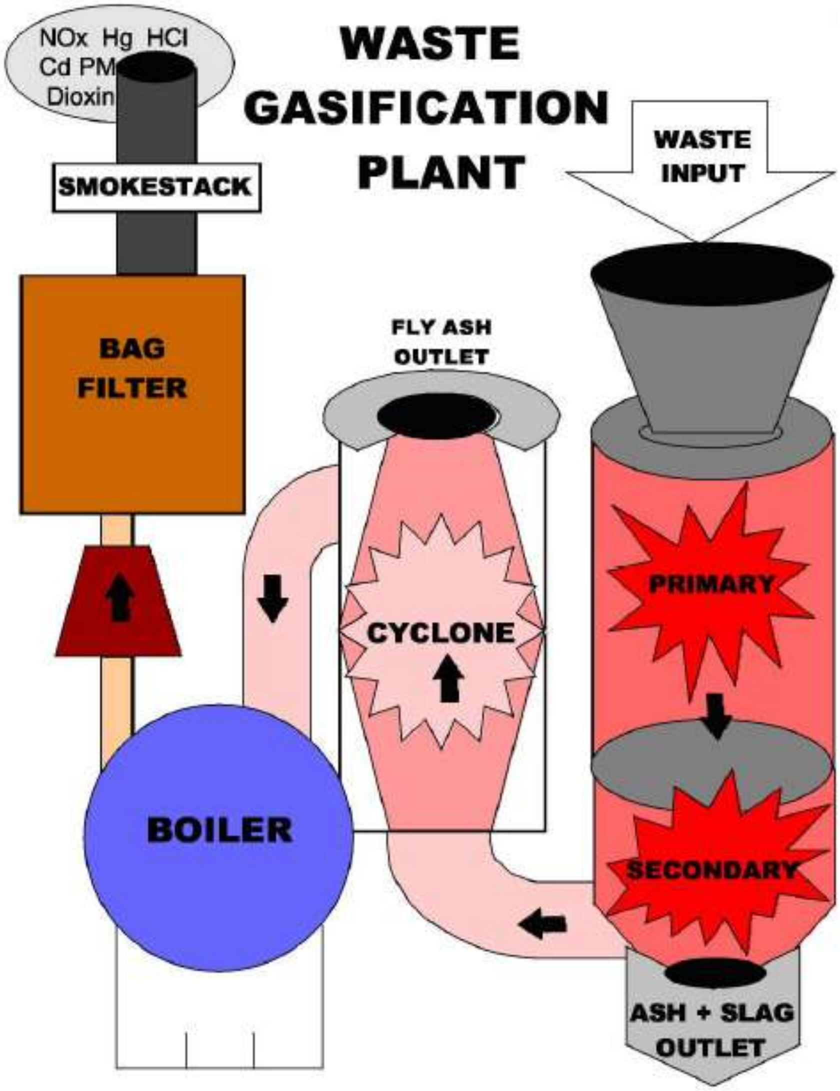
MBT to Refuse derived fuel

5.15 Gasification:

Gasification and pyrolysis are similar processes; both decompose organic waste by exposing it to high temperatures. Both processes limit the amount of oxygen present during decomposition; gasification allows a small amount of oxygen, pyrolysis allows none. In otherwords, gasification and pyrolysis limit or prevent oxidation. Gasification facilities produce gas—primarily carbon monoxide and hydrogen (85%)—plus hydrocarbon oils, char and ash. Gasification plants' air emissions also include nitrogen oxides, sulfur dioxide, particulate matter, carbon monoxide, carbon dioxide, methane, hydrogen chloride, hydrogen fluoride, ammonia, heavy metals mercury and cadmium, dioxins and furans. Gasification of municipal solid waste, household garbage and commercial waste products was used in the United States in the 1970s, but those plants were closed because of operating andfinancial problems. Today there are only a handful of pyrolysis units burning municipal solid waste, located in Japan, Taiwan, Great Britain and Canada

Gasification is a process that chemically and physically changes biomass through the addition of heat in an oxygen-starved environment. The end products of gasification include solids, ash and slag, liquids and synthesis gas, or syngas. The gas has a calorific value, or potential heat content, equivalent to 25% that of natural gas if ambient air is used or 40% if oxygen-enriched air is used.2 Figure 1 on the following page illustrates the process: combustion chambers, power boiler, pollution controls, and pollution by-products: bottom ash and slag, fly ash, and air emissions. A waste industry trade association monograph describes the starved air combustion process as follows:

This type of incineration consists of two chambers: the primary is operated at below the stochiometric air requirement and the second operated under excess air conditions. The waste is fed into the primary chamber and semi-pyrolysed, releasing moisture and volatile components. The heat is provided by the controlled combustion of fixed carbon within the waste. The syngas that is driven off contains a high calorific value and can act as a feedstock for the secondary chamber. Importantly, combustion air is then added to the syngas making it highly combustible and prone to self-ignition. The secondary chamber is equipped with a conventional burner to maintain operating temperature at all times. The combined gases are combusted in the secondary chamber



Although some gasification facilities have been designed and constructed in the past two decades, most have been demonstration and laboratory-scale systems. A few large scale demonstration plants in the US experienced technological problems and are no longer operating

5.16 Thermal depolymerization:

Thermal depolymerization (TDP) is a process using hydrous pyrolysis for the reduction of complex organic materials (usually waste products of various sorts, often known as biomass and plastic) into light crude oil. It mimics the natural geological processes thought to be involved in the production of fossil fuels. Under pressure and heat, long chain polymers of hydrogen, oxygen, and carbon decompose into short-chain petroleum hydrocarbons with a maximum length of around 18 carbons. Thermal depolymerisation is similar to other processes which use superheated water as a major step in their processing to produce fuels, such as direct Hydrothermal Liquefaction and hydrous pyrolysis. Thermochemical conversion (TCC) can mean conversion of biomass to oils using superheated water, although it more usually is applied to fuel production via pyrolysis The Thermal Conversion Process is another name for thermal depolymerisation

The process can break down organic poisons, due to breaking chemical bonds and destroying the molecular shape needed for the poison's activity. It is likely to be highly effective at killing pathogens, including prions. It can also safely remove heavy metals from the samples by converting them from their ionized or organ metallic forms to their stable oxides which can be safely separated from the other products. Along with similar processes, it is a method of recycling the energy content of organic materials without first removing the water. It can produce liquid fuel, which separates from the water physically without need for drying. Other methods to recover energy often require pre-drying (eg. burning, pyrolysis) or produce gaseous products (eg. anaerobic digestion).

5.17 Pyrolysis

Pyrolysis is the chemical decomposition of a condensed substance by heating. The word is coined from the Greek-derived elements pyro "fire" and lysys "decomposition". Pyrolysis is a special case of thermolysis, and is most commonly used for organic materials. It occurs spontaneously at high temperatures (ie above 300 °C for wood, it varies for other material), for example in wildfires or when vegetation comes into contact with lava in volcanic eruptions. It does not involve reactions with oxygen or any other reagents but can take place in their presence. Extreme pyrolysis, which leaves only carbon as the residue, is called carbonization and is also related to the chemical process of charring. Pyrolysis is heavily used in the chemical industry, for example, to produce charcoal, activated carbon, methanol and other chemicals from wood, to convert ethylene dichloride into vinyl chloride to make PVC, to produce coke from coal, to convert biomass into syngas, to turn waste into safely disposable substances, and for the cracking of medium-weight hydrocarbons from oil to produce lighter ones like gasoline. It is an important chemical process in several cooking procedures such as baking, frying, grilling, and caramelizing. Pyrolysis is also a tool of chemical analysis, for example by pyrolysis gas chromatography mass spectrometry and in carbon-14 dating. Indeed, many important chemical substances, such as phosphorus and sulfuric acid, were first obtained by this process. It has been assumed to take place during catagenesis, the conversion of buried organic matter to fossil fuels. Pyrolysis is also the basis of pyrography. Although water is normally excluded along with other reagents, the term has also been applied to the decompositon of organic material in the presence of superheated water or steam (hydrous pyrolysis), for example in the steam cracking of oil.

In vacuum pyrolysis, organic material is heated in a vacuum in order to decrease boiling point and avoid adverse chemical reactions. It is used in organic chemistry as a synthetic tool. In flash vacuum thermolysis or FVT, the residence time of the substrate at the working temperature is limited as much as possible, again in order to minimize secondary reactions

5.17.1 Processes for biomass pyrolysis

Since pyrolysis is endothermic, various methods have been proposed to provide heat to the reacting biomass particle

:Partial combustion of the biomass products through air injection. This results in poor-quality products. Direct heat transfer with a hot gas, ideally product gas that is reheated and recycled. The problem is to provide enough heat with reasonable gas flow-rates.

Indirect heat transfer with exchange surfaces (wall, tubes). It is difficult to achieve good heat transfer on both sides of the heat exchange surface.

Direct heat transfer with circulating solids: Solids transfer heat between a burner and a pyrolysis reactor. This is an effective but complex technology.

For flash pyrolysis the biomass must be ground into fine particles and that the insulating char layer that forms at the surface of the reacting particles must be continuously removed. The following technologies have been proposed for biomass pyrolysis:
Fixed beds were used for the traditional production of charcoal. Poor, slow heat transfer resulted in very low liquid yields.

5.18 Anaerobic digestion

Anaerobic digestion is a series of processes in which microorganisms break down biodegradable material in the absence of oxygen. It is widely used to treat wastewater sludges and organic waste because it provides volume and mass reduction of the input material.As part of an integrated waste management system, anaerobic digestion reduces the emission of landfill gas into the atmosphere. Anaerobic digestion is a renewable energy source because the process produces a methane and carbon dioxide rich biogas suitable for energy production helping replace fossil fuels. Also, the nutrient-rich solids left after digestion can be used as fertiliser.

The digestion process begins with bacterial hydrolysis of the input materials in order to break down insoluble organic polymers such as carbohydrates and make them available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. Acetogenic bacteria then convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Methanogens, finally are able to convert these products to methane and carbon dioxide

Previously, the technical expertise required to maintain anaerobic digesters coupled with high capital costs and low process efficiencies had limited the level of its industrial application as a waste treatment technology. Anaerobic digestion facilities have, however, been recognised by the United Nations Development Programme as one of the most useful decentralised sources of energy supply, as they are less capital intensive than large power plants. Anaerobic digestion is particularly suited to wet organic material and is commonly used for effluent and sewage treatment. Anaerobic digestion is a simple process that can greatly reduce the amount of organic matter which might otherwise be destined to be landfilled or burnt in an incinerator.

Almost any organic material can be processed with anaerobic digestionThis includes biodegradable waste materials such as waste paper, grass clippings, leftover food, sewage and animal waste. The exception to this is woody wastes that are largely unaffected by digestion as most anaerobes are unable to degrade lignin. The exception being xylophalgeous anaerobes (lignin consumers), as used in the process for organic breakdown of cellulosic material by a cellulosic ethanol start-up company in the U.S Anaerobic digesters can also be fed with specially grown energy crops such as silage for dedicated biogas production. In Germany and continental Europe these facilities are referred to as biogas plants. A co-digestion or co-fermentation plant is typically an agricultural anaerobic digester that accepts two or more input materials for simultaneous digestion

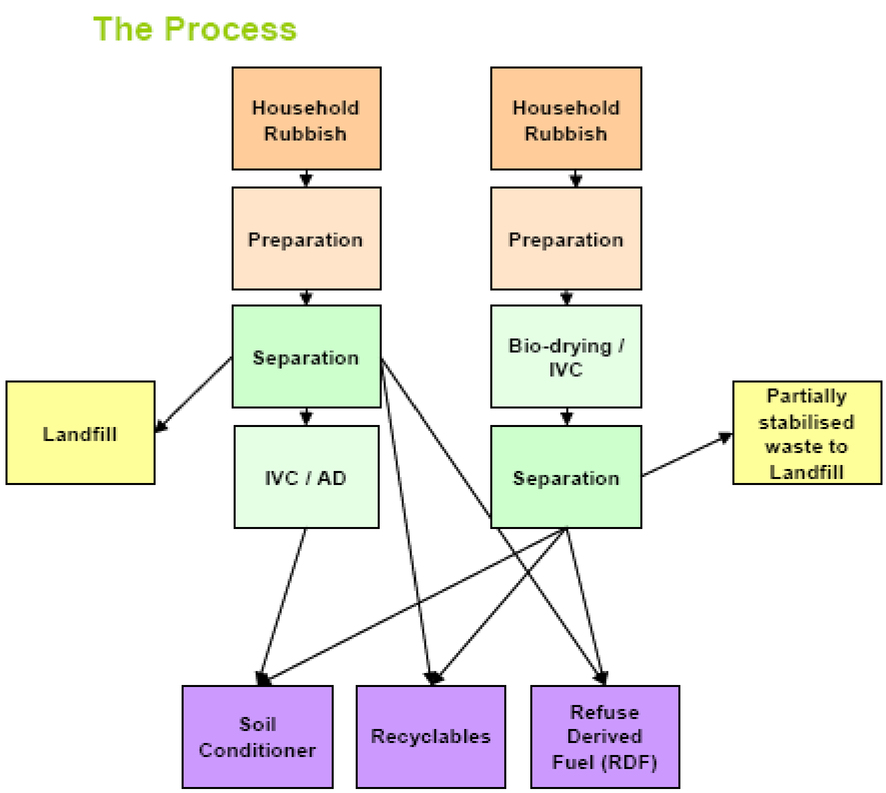
In developing countries simple home and farm-based anaerobic digestion systems offer the potential for cheap, low-cost energy for cooking and lighting Anaerobic digestion facilities have been recognized by the United Nations Development Programme as one of the most useful decentralized sources of energy supply. From 1975, China and India have both had large government-backed schemes for adaptation of small biogas plants for use in the household for cooking and lighting. Presently, projects for anaerobic digestion in the developing world can gain financial support through the United Nations Clean Development Mechanism if they are able to show they provide reduced carbon emissions.

Pressure from environmentally-related legislation on solid waste disposal methods in developed countries has increased the application of anaerobic digestion as a process for reducing waste volumes and generating useful by-products. Anaerobic digestion may either be used to process the source separated fraction of municipal waste, or alternatively combined with mechanical sorting systems, to process residual mixed municipal waste. These facilities are called mechanical biological treatment plants

5.19 Ethanol production

5.19.1 Mechanical biological treatment (MBT)

Mechanical Biological Treatment (MBT) is a term that is used to describe a number of different approaches to managing the residual waste. The main difference between the approaches is the stage at which the biological part of the waste (garden and kitchen waste) is treated – either before or after the mechanical separation of the waste**.**



5.19.2 Collection and Preparation

Your household rubbish will be collected from your kerbside and taken to the MBT plant. After being deposited in the facility it will be mixed and shredded (or similar) so that the waste is evenly mixed and of equal size.

5.19.3 Separation

The separation step can either come before the treatment of the biological part of the waste (mechanical biological treatment) or after (biological mechanical treatment). There are a number of different ways that the waste can be separated; here are a few of the more common methods

Screens can help to remove the larger Magnetic separation can remove the
ferrous metals (cans made of tin) Eddy current separation can remove the
non ferrous metals (cans made of aluminium), Optical separation can separate certain types of plastics Air classification can help to separate light and heavy materials (paper for example).

Once separated some of the materials can go on for further recycling, for example the glass collected can go on to be used as low grade aggregate (a material often used in the construction of roads as a substitute for sand). The materials recovered are of a lower quality than those materials collected separately as part of your kerbside recyclables collection and this can be a problem when looking for markets to sell the materials. It is always preferable in Wales that recyclables are collected separately from households, as this provides cleaner, better quality materials. These materials are more desirable and obtain a higher market value.

5.19.4 MBT methods

Biodrying/Biostabilisation

Air is forced through the waste to try and 'dry' it. This reduces the mass (weight and volume) of waste and starts to degrade (break down) the biological part of the waste. This process can make the waste easier to separate and can also give the waste a higher calorific value (energy content) as it removes nearly all of the noncombustible water, which means that it will produce more energy if it if burnt

In Vessel Composting

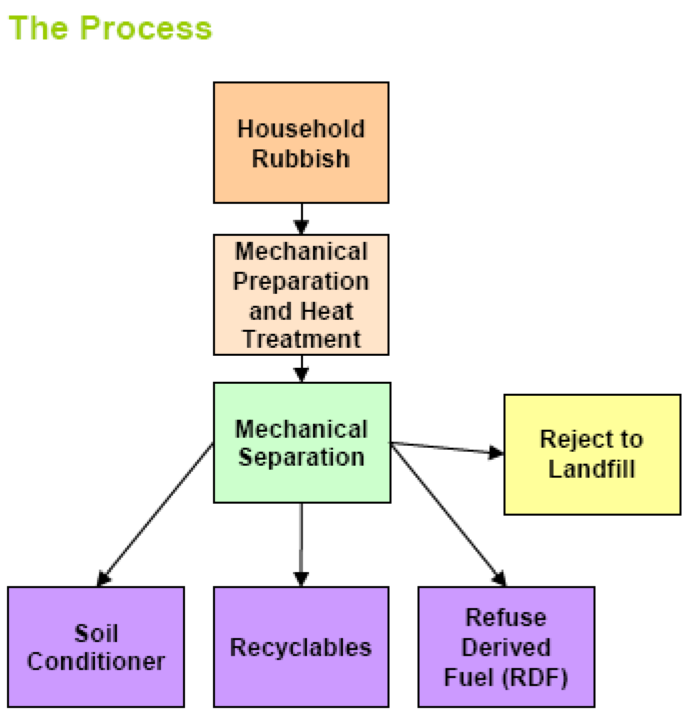
The waste is enclosed in a vessel to be composted. As the process is enclosed the composting process can be speeded up by pumping air into the waste, by either increasing or decreasing the water content of the waste and by increasing or decreasing the temperature within vessel.

Anaerobic Digestion

The waste is fed into an enclosed vessel and heated. As the material heats and breaks down a biogas (a green gas) is produced. This gas is made of a mixture of (mostly) methane and carbon dioxide. The gas is captured as part of the process and can be used to generate either heat or electricity. The ‘digestion’ process also produces a digestate, which is a liquid with some of the green waste (woody fragments) remaining in it. The digestate can be filtered so that the solid and liquid parts are separated and then either recycled back into the process or used as a soil improver or added to compost.

5.19.5 Mechanical Heat Treatment

Mechanical Heat Treatment (MHT) is a term that is used to describe a number of different processes that involve the mechanical (separation) and thermal (heat) treatment



Collection and Preparation

Your household rubbish will be collected from your kerbside and taken to the MHT plant. After being deposited in the facility it will be mixed and shredded (or similar) so that the waste is evenly mixed and of equal size.

Heat Treatment

The most common method of heat treatment currently being used in this way is Autoclaving. This method is a steam treatment process that is often used for treating clinical (hospital) waste. Waste is processed for about an hour in a pressurised container to reduce the material to what is known as a ‘flock’. Metals and glass will be partially cleaned by the process and can be removed and recycled. Plastics become deformed in the process and some types become suitable for recycling whereas others become very difficult to recycle. Once recyclables have been removed, the remaining material is used as fuel in a thermal heating process to produce energy & heat.

Separation

The separation step will follow a similar process to that described for MBT, which is a combination of screens, magnetic separation, eddy current separation, optical separation and air classification, all to allow recyclables to be extracted from the waste. The types of separation equipment used will be determined by the type of waste being accepted and the materials that are being targeted for extraction.

End Use

The MBT and MHT processes provide a number of end uses for the waste material that is processed. The quality of the end products will depend upon which process is used and in what order the stages are followed.

5.19.6 MBT to Refuse derived fuel

Refuse Derived Fuel Both MBT and MHT can be set up to produce a high energy (calorific value) fuel called RDF or Refuse (rubbish) Derived (made from) Fuel. This fuel must have a high amount of paper, plastics and card so that it is able to produce energy. The fuel can be burnt in regular combustion plants such as energy from waste facilities or cement kilns or in specially built facilities..

Refuse-derived fuel (RDF) or solid recovered fuel/ specified recovered fuel (SRF) is a fuel produced by shredding and dehydrating municipal solid waste (MSW) in a converter or steam pressure treating in an autoclave. RDF consists largely of organic components of municipal waste such as plastics and biodegradable waste. RDF processing facilities are normally located near a source of MSW and, while an optional combustion facility is normally close to the processing facility, it may also be located at a remote location. SRF can be distinguished from RDF in the fact that it is produced to reach a standard such as

Processing methods

Non-combustible materials such as glass and metals are removed during the post-treatment processing cycle with an air knife or other mechanical separation processing.

The residual material can be sold in its processed form (depending on the process treatment) or it may be compressed into pellets, bricks or logs and used for other purposes either stand-alone or in a recursive recycling process.

Advanced RDF processing methods (pressurised steam treatment in an autoclave) can remove or significantly reduce harmful pollutants and heavy metals for use as a material for a variety of manufacturing and related uses. RDF is extracted from MSW using mechanical heat treatment, mechanical biological treatment or waste autoclaves.

The production of RDF may involve some but not all of the following steps:

Preliminary liberation (not required for autoclave treatment)

Size screening (post-treatment step for autoclave treatment) Magnetic separation (post-treatment for autoclave treatment) Coarse shredding (not required for autoclave treatment) Refining separation

End markets

RDF can be used in a variety of ways to produce electricity. It can be used alongside traditional sources of fuel in coal power plants. In Europe RDF can be used in the cement kiln industry, where the strict standards of the Waste Incineration Directive are met. RDF can also be fed into plasma arc gasification modules, pyrolysis plants and where the RDF is capable of being combusted cleanly or in compliance with the Kyoto Protocol, RDF can provide a funding source where unused carbon credits are sold on the open market via a carbon exchange. However, the use of municipal waste contracts and the bankability of these solutions is still a relatively new concept, thus RDF's financial advantage may be debatable.