Solid and Liquid Waste Management in Rural Areas

A Technical Note

सम्पूर्ण स्वच्छता अभियान

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Foreword

Rural Sanitation has certainly come a long way since the launch of the Nirmal Gram Puraskar Scheme under the Total Sanitation Campaign (TSC). In the last three years, over 5000 Panchayati Raj Institutions have won this award for achieving the status of clean/green villages/blocks, free from the practice of "Open defecation". Sanitation coverage is now close to 45 percent of the total population, the goal of achieving full sanitation coverage by 2012 seems within our reach now. The benefits of investments in sanitation through the Total Sanitation Campaign and the Nirmal Gram Puraskar are many but the most endurable will be the long term impact it will have on the health profiles and quality of life of our rural population.

The time has now come to move onward, to garner the benefits of other aspects of environmental cleanliness, and use the present momentum to achieve important milestones in a "Sanitation Plus" drive to Holistic Waste Management in every village. Indeed total Waste Management treating every waste as a Resource will be key to briging Sustainability and permanence to the benefits which are accuring from good toilet and personal hygiene practices.

Government of India has earmarked ten percent of the project funds the Total Sanitation Campaign for Solid and Liquid Waste Management as an important component. Besides, financial resources, technical advice and models are required for effective Solid and Liquid Waste Management.

We have many successful stories in our country itself which need to be highlighted and replicated wherever it is possible. This technical note seeks to capture some of the best practices both from the technological and management aspects and to share these with all stakeholders.

A number of professionals have worked tirelessly developing this technical note, ably assisted by the UNICEF. I wish to place on record our deep appreciation of this effort and hope that **TSC programme managers will use this document as a Reference Manual.**

Santha Sheela Nair
Secretary (DWS)

Preface

With recent acceleration in TSC implementation, India is experienceing paradigm shift in rural sanitation. Mobilisation, motivation and innovative financial incentives are bringing about positive sanitation and hygiene behavior changes amongst rural communities. With the increased number of Panchayats becoming open defecation free, necessity has been felt to address the problems of solid and liquid waste management in rural communities in order to really make them clean and green. The Departemnt of Drinking water Supply has already made recent policy changes in TSC guidelines and incorporated this element as one of the important activities.

To translate the vision of Governement of India to manage the solid liquid waste properly in rural areas, it is essential that proper technical guidance is extended to all stakeholders who are implementing TSC. They need to be inspired by the various technologies successfully developed and practiced in rural areas.

This technical note presents some cost effective technologies of solid and liquid waste disposal and recycling with detailed scientific inputs. The note has two parts-one primarily deals with technological as well as managements aspects while another captures some of the successful cases in the solid and liquid management.

The cases demonstrate that the community, as a resource, can play an active role in taking responsibility for their garbage and liquid waste. The experiences also show that waste has economic value for a community. The guidelines confirm that the recent transformations in the way in which waste is being dealt with has found its way to rural India. This transformation is being summarized in the simple formala of the 3R's: Reduce, Reuse and Recycle.

The note has been collectively developed after rigorous field visits, case compilation followed by two days workshop in December 2006 at UAA, Nainital. A large number of sector professionals and support staff have contributed in developing this technical note. We would therefore like to extend our thanks to all those who have contributed with inputs both content and logistics wise.

We wholeheartedly thank for Dr S V Mapuskar of Appa Patwardhan Safai o Tantra Niketan, Dehugaon, Pune and Mr Srikant Navrekar of Niraml Nirmithi Kendra Nashik in giving extensive inputs for developing this technical note. We also thank Dr M M Datta Retd WHO professional who did the initial compilation work. We have received full cooperation from Prof Ishwarbhai Patel, Ahmedabad, Mr Chandi Charan Dey, Kolkata, Mr A K Singh, Lucknow, Mr P Toshniwal, Kanpur, Mr M Subburaman, Trichy, Mr M Kalshetty, Maharashtra in documenting the case studies in fiels.

The compilation of the note was commissioned to Uttaranchal Academy of Administration (UAA) and our special thanks to its entire team led by mr D S Dhapola, Dy Director for facilitating and brining all required inputs in the preparation of this note. Finally, we express deep gratitude to Department of Drinking Water Supply, Governemnt of India for suggesting preparing this note and subsequently for their valuable inputs in the process.

We hope that all TSC programme managers and field functionaries will find this note useful and enriching in their efforts to promote cost effective solid and liquid waste technologies. Best we hope that it will reap benefits to communities, families and especially their children.

We are certain that this note will inspire a new generation of visionaries and moblisers who are able to translate ideas and theory into new initiatives in solid and liquid waste management.

Lizette Burgers
Chief-WES, Unicef Delhi

Part A

Solid and Liquid Waste Management in Rural Areas:

A Technical Note

Chapter 1

Introduction to Solid and Liquid Waste Management

1.1 Background

The need for genuine and organized initiatives in the rural waste management has been regularly voiced in India. With the emerging concern on large quantity of the waste being produced both in the form of solid and liquid waste, the concept of waste management becomes one of the key focus of sustainable development principles which is based on policies, and practices that are resource-conserving, follow standards that can be met in the long term, and respect values of equity in human access to resources. In definitional terms solid and liquid waste management (SLWM) is the collection, transport, processing, recycling or disposal of waste materials, usually ones produced by human activity, in an effort to reduce their effect on human health or local aesthetics or amenity.

SLWM is one of the seven key components of any sanitation initiatives which is rightly emphasized and focused in the currant Government of India's flagship programme of Total Sanitation Campaign (TSC). Although the TSC guidelines initially focused on human excreta management and eliminating the practice of open defecation from rural areas, with introduction of Nirmal Gram Puraskar (NGP) a large number of PRIs have been able to achieve the distinction of eliminating practice of open defecation. Such *Panchyati Raj* Institutions (PRIs) are not only getting good amount of incentive fund but are also mobilised for taking up next generation sanitation activities. In view of this, the Department of Drinking Water Supply (DDWS) in the Ministry of Rural Development (MoRD), Government of India has modified the TSC guidelines and included a component of solid and liquid waste management with funds provisioned up to 10% of the TSC project cost of a particular district.

The changes in the TSC guidelines and success of NGP strategy has created a scope of organizing the initiatives on SLWM in the form of technical guidelines including a compilation of some of the best practices to the TSC implementing agencies for proper utilization of funds available for solid and liquid waste management. There are various models of SLWM practiced in different parts of the country; few of them have been compiled. Based on these practices this technical note has been prepared. It is expected that the TSC programme managers will be able to use this document to understand and implement various cost effective SLWM technologies as per their local needs.

1.2 Waste Problem in Rural Areas in India

In India especially in rural areas, waste is a severe threat to the public health concern and cleanliness. Though, the form of waste (both solid and liquid) generated in rural areas is predominantly organic and biodegradable yet becoming a major problem to the overall sustainability of the ecological balance. For e.g. it is estimated that rural people in India are generating liquid waste (greywater) of the order of 15,000 to 18,000 million liters and solid waste (organic/recyclable) 0.3 to 0.4 million metric tons per day respectively.

As a result, in the absence of proper disposal of solid and liquid waste (greywater and waste water from the hand pump), they are leading to vector born diseases such as diarrhoea, Malaria, Polio, Dengue, Cholera, Typhoid, and other water borne infections such as schistosomiasis. Close to 88% of the total disease load is due to lack of clean water and sanitation and the improper solid and liquid waste management-which intensify their occurrence, e.g.

- 5 of the 10 top killer diseases of children aged 1-14 in rural areas are related to water and sanitation
- Almost 1500 children die every day from diarrhoeal diseases
- Results in high rate of infant and children under-5 mortality. The rural IMR is 62 as compared to urban which is just 42 (NFHS-3)
- The water and sanitation related disease not only affects the nutritional status of the

Solid waste

Types of waste

Waste is any material/liquid that is thrown away as unwanted. As per physical properties, waste can be categorized as:

A: Solid waste: Any waste other than human excreta, urine & waste water, is called solid waste. Solid waste in rural areas generally includes-house sweeping, kitchen waste, garden waste, cattle dung & waste from cattle sheds, agro waste, broken glass, metal, waste paper, plastic, cloths, rubber, waste from markets & shopping areas, hotels, etc. Solid waste can also be defined as the organic and inorganic waste materials produced by households, commercial & industrial establishments that have no economic value to the owner.

As per biodegradability, solid waste can be classified as:

- **Biodegradable:** Waste that are completely decomposed by biological processes either in presence or in absence of air are called biodegradable. e.g. kitchen waste, animal dung, agricultural waste etc
- **Non-biodegradable:** Waste which cannot be decomposed by biological processes is called non-biodegradable waste. These are of two types:
  - **Recyclable:** waste having economic values but destined for disposal can be recovered and reused along with their energy value. e.g. plastic, paper, old cloth etc
  - **Non-recyclable:** Waste which do not have economic value of recovery e.g. tetra packs, carbon paper, thermo coal etc.

B: Liquid waste-Used & unwanted water is called waste water

- Black Water: Waste water generated in the toilet is called "Black water". It contains harmful pathogens
- Greywater: Waster water generated in the kitchen, bathroom and laundry is called "Greywater". It may also contain pathogens.

Liquid waste

children but also impacts their attendance in the school. Close to 50% of school going children in rural areas do not reach class V.

Even the global statistics show:

- 1.8 million people die every year from diarrhoeal diseases (including cholera); 90% of them are children under 5, mostly in developing countries.
- 1.3 million people die of malaria each year, 90% of whom are children under 5
- An estimated 160 million people are infected with schistosomiasis. It is strongly related to unsanitary excreta disposal and absence of safe water sources
- 133 million people suffer from high intensity intestinal helminths infections, which often lead to severe consequences such as cognitive impairment, massive dysentery, or anaemia. Access to safe water and sanitation facilities and better hygiene practice can reduce morbidity from ascariasis by 29% and hookworm by 4%. (Source WHO).

1.3 Objectives of Waste Management in Rural Areas

- To protect human health and improve quality of life among people living in rural areas
- To reduce environment pollution and make rural areas clean
- To promote recycling and reuse of both solid and liquid waste
- To convert bio waste into energy for ensuring greater energy security at village level
- To generate employment for rural poor by offering new opportunities in waste management by adopting cost effective and environmentally sound waste water and solid waste treatment technologies

1.4 Strategy

- Creation of awareness among key development policy makers and implementers (including PRIs) at all levels regarding the advantages of SLWM in rural areas and its potential in health & environment protection, recycling and reuse of waste, generating employment, and providing energy security
- Capacity building of implementers including PRIs about various technology options
- GP/village based action plan should be developed with the involvement of local community
- Waste management should primarily be focused at household level for sustainability and cost effectiveness. Certain elements which cannot be managed at the household level should be managed at the community level
- All sections of rural households should have equal access to safe disposal of waste water and solid waste management. Appropriate technologies suited to their needs and means should be made available to them
- SLWM should be planned and implemented following demand responsive approaches, involving all stakeholders from the beginning and ensuring transparency in management and decision making processes
- Appropriate partnerships with local NGOs, Women SHGs, and Private sector (if necessary) may be developed.

1. 5 Management Approach

The waste is generally generated at household level and also at community level e.g. market, common streets etc. In order to properly manage this waste with minimum effort and cost, focus must be on management at the household level. The waste which cannot be managed at household level and that collected from market place should be handled at the community level.

Simply, only cost effective and decentralized user friendly technologies should be disseminated.

The following steps may be followed for introducing community based Waste Management System: Information Collection, Participatory Planning and Preparation of GP/ Block level action plan.

Step 1: Information collection: In order to draw up a plan of action for community based SLWM in an area, it is essential to know the exact number of houses, institutions and commercial establishments to determine the types and amounts of waste generated in the area. The Survey findings through data collection will also serve as documents for introducing the system. For developing the SLWM plan of the GP/Block, the following information may be collected following rapid rural survey of the community.

- No. of Households
- Total Population
- Details about shops, marriage halls, market, commercial establishments, etc
- Community map of the area
- Existing system and practice of waste management
- Quantum of solid and liquid waste generated per day
- Local body's approach and future plans for SLWM
- Details of vacant spaces available in the local body
- Details and activities of NGOs & CBOs, e.g. Women Self help Groups etc available in the village.

Step 2: Participatory planning:
- The data collected is to be analyzed along with the representatives of the community
- The community should be informed about various technology options for SLWM both at household as well as community level and accordingly technology options should be decided
- Based on the discussions with the community, SLWM action plan should be prepared.

Step 3: Preparation of GP/block level action plan: GP/Block action plan should broadly contain the following:
- **Social mobilization and awareness generation:** It should focus on inter personal communication, focused group discussion, technology demonstration and exposure visits to successful sites
- **Technology options:** Household and community level technological options with approximate cost estimates should be worked out
- **Operation and maintenance:** Success of a technology depends upon proper O&M at the household and community level. This aspect should be discussed in detail during planning process and incorporated in the action plan.

1.6 Institutional Structure

Solid and liquid waste management is part of the TSC project. Hence, the same institutional structure as is already in place in respective states, districts and GPs will be responsible for this component also.

1.7 Capacity Building

Since SLWM is being introduced in TSC for the first time and there are a range of technology options available both at the household and community level, capacity building of a large number of stakeholders at the state, district and GP level will be required. The capacity building process will include exposure visits, classroom training, on site demonstration and other non training interventions like environment building, tools availability, knowledge sharing etc.

Key resource centers identified at the national level will help the state Communication and

Capacity Development Unit (CCDUs) and state level resource centers for building capacities of master trainers who in turn will train the district and GP level stakeholders.

1.8 Resource Mobilization

With recent changes in TSC guidelines, each TSC project may be allocated up to 10% of the district TSC project cost for SLWM. In addition to this, PRIs, state and district authorities may mobilize following types of resources for taking up SLWM activities.

- Nirmal Gram Puraskar - Award money: A large number of PRIs have received NGP. The corresponding award money should be utilized for SLWM
- Finance commission grants: Funds available under central and state finance commission grants to the PRIs may also be utilized for this purpose
- Dovetailing with MoRD programmes: Funds available with various development programmes of the Ministry of Rural Development may be dovetailed after following the respective programme guidelines
- Other resources: Resources available under state plan schemes, other centrally sponsored schemes etc. may also be dovetailed for this purpose.

Chapter 2

Solid Waste Management

2.1 Background

As discussed earlier, for management purpose, solid waste may be classified as bio degradable and non biodegradable. Waste which can be decomposed by biological processes is known as **"Biodegradable waste"**. Organic waste is biodegradable and recyclable. Biodegradable waste can be decomposed in two ways viz.

a. aerobic (with oxygen), and
b. anaerobic (without oxygen).

Aerobic decomposition: Such decomposition process takes place in the presence of air. In this process aerobic bacteria act on the complex organic matter and break it down into nutrients. In this process primarily carbon-dioxide is produced.

Table 1

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

Anaerobic decomposition: Such decomposition process takes place in the absence of air. In this process, anaerobic bacteria act on the complex organic matter and break it down into nutrients. In this process primarily methane and carbon-dioxide gases are produced.

Waste which cannot be decomposed by biological process is known as **"Non-biodegradable wastes".** Most of the inorganic waste is non-biodegradable. Non-biodegradable wastes which can be recycled are known as "Recyclable waste" and those which cannot be recycled are known as "Non-recyclable waste". The principal classification (based on types of solid waste) is given in Diagram 1.

2.2 Approaches for Solid Waste Management

For effective management of solid waste in rural areas, focus should be on management at household level. That which cannot be managed at household level should be managed at the community level. In general, the following approach should be followed:

- Segregation of solid waste at the household level (Biodegradable and non biodegradable)
- Reuse of non biodegradable waste at the household level to the extent possible
- Household level treatment of bio degradable waste

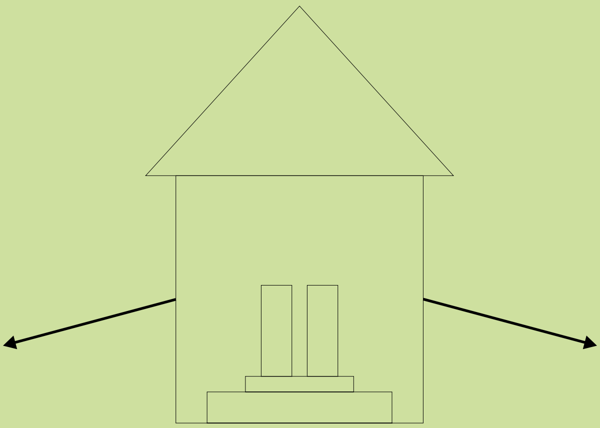
Diagram 1

Classification of solid waste

According to nature of waste

Biodegradable

- Vegetable waste
- Kitchen waste
- Garden waste
- Agro-waste
- Cattle dung....



Non Biodegradable

- Plastic
- Paper
- Cloth
- Glass
- Metal

This classification is important for selection of technology

Biodegradable

Non-Biodegradable

- Collection and transportation of segregated waste at the household level to a place identified at the community level (in cases where household level treatment is not possible)
- Community level treatment or recycling/reuse of waste
  - All the biodegradable waste should be composted at the community level
  - Non biodegradable waste may be further segregated and sold or recycled
  - Waste which cannot be composted, reused or recycled may be disposed at the landfill sites following appropriate procedure, (such waste may usually be construction waste, debris etc).

2.3 Steps for Effective Management of Solid Waste

2.3.1 Management of Household Level Solid Waste:

As far as possible, solid waste should be managed at the household level so that zero or minimum community waste is generated. This may involve the following steps:

A Sorting out or segregation at household level:

- Household waste should be sorted out or segregated at the source i.e. at the household level
- This is to be done by generating awareness to sort out waste at the household level by keeping bio degradable and non bio degradable waste in separate colour bins of 5 to 10 liters capacity each(e.g. green color bin for bio degradable waste and blue bin for non bio degradable waste)
- Reusable segregated non biodegradable waste may be reutilized at household level.

B Treatment/management of biodegradable household level waste:

Efforts should be made to treat the segregated bio degradable waste at the household level by adopting any one of the following technologies and reuse the treated products:

- Composting
- Vermi composting
- Biogas plant.

The details of all the above technology options have been discussed separately.

C Treatment/management of household level non biodegradable waste:

Some of the sorted out non bio degradable waste will be of recyclable type. Households may be encouraged to keep such waste separately and sell to the rag pickers and kabadiwalas and keep the non-recyclable products for subsequent transportation for community level management.

2.3.2 Management of Community Level Solid Waste:

In those villages where all the waste cannot be managed at household level, segregated and non-managed household waste need to be transported either to the community bins at the village level or to the treatment plant sites at community level where household level bio degradable waste can be treated by community treatment plant and recyclable and non bio degradable waste can be sorted out and sold to the kabadiwalas by gram panchayats. Waste which cannot be composted, reused or recycled may be disposed at community level at the landfill sites following appropriate procedure:

A **Collection and transportation:** For Collection and Transportation of solid waste in rural areas the following **strategy** may be followed:

- Self Help Groups (SHGs) or group of unemployed youth in the village may be identified for collection and transportation of household waste to community storage/ treatment site. Each member may be responsible for collection of waste for about 75-100 households
- SHG members may be given suitable number of carts or tricycles for collection and transportation of waste to community storage bins. The number

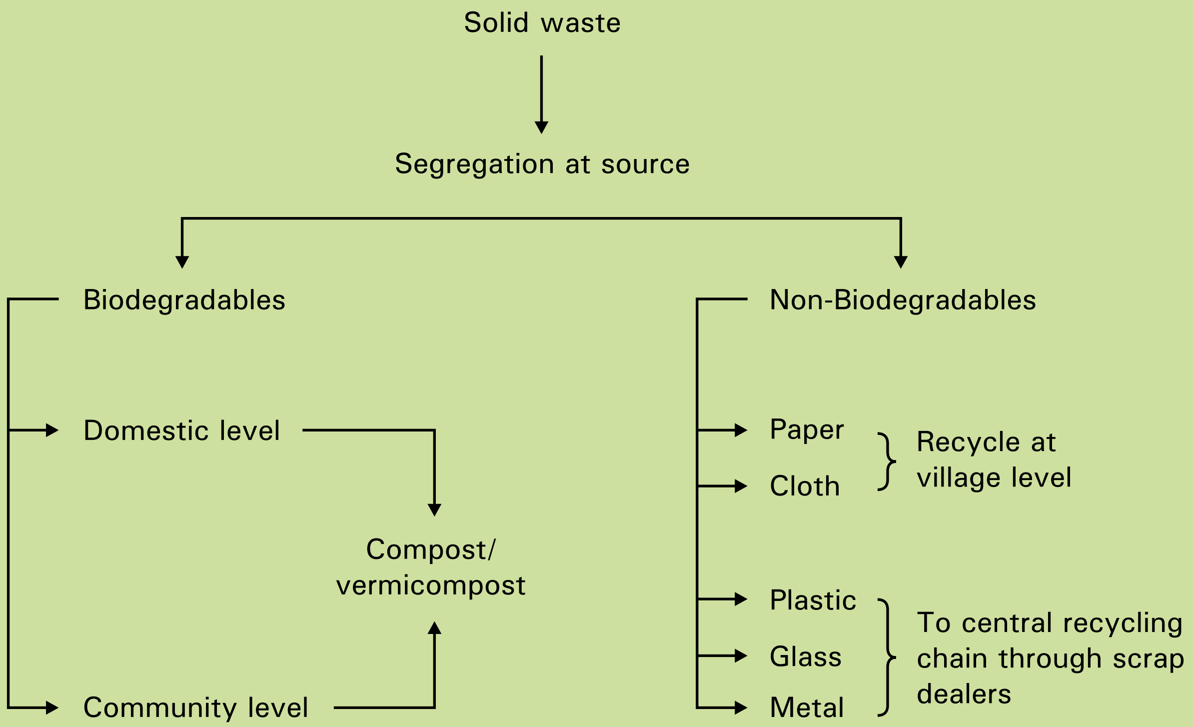
of tricycles may be decided based on the size of the PRI and the density of population. Normally one tricycle for 100-200 households should suffice the requirement
- The PRI should keep at least two-three spare tricycles so that the collection system is sustainable even in the case of breakdown of few tricycles.

B **Treatment of community level biodegradable waste:** Once the segregated waste is collected at the community level, the **biodegradable waste** may be treated by adopting any of the following technology options:
- Composting
- Vermi composting
- Biogas plant.

The details of the all the above technology options have been discussed separately.

C Treatment/management of **non biodegradable waste:** The non bio degradable waste may be further sorted into various categories (e.g. plastic, paper, metals, cloth etc). Those which are recyclable may be sold to kabadiwalas or recycled at the community level by adopting suitable technologies some of which are discussed separately. Those waste materials which can neither be recycled nor sold may be sent to the landfill sites in the village.

Ideal solid waste management at a glance



Chapter 3

Composting as Technology option for Treatment of Biodegradable Waste

3.1 Introduction

Composting is one of the options for treatment of solid waste. In composting process the organic matter breaks down under bacterial action resulting in the formation of humus like material called compost. The value of compost as manure depends on the quantity and quality of feed materials poured into the compost pit. Composting is carried out in two ways:

a. *Aerobically* (in presence of oxygen) and
b. *Anaerobically* (in absence of oxygen).

During **aeorbic** composting, aerobic micro – organisms oxidises organic compounds in the solid waste to carbon-dioxide, nitrite and nitrate. The carbon from organic compounds is used as a source of energy while nitrogen is recycled. Due to exothermic reactions, temperature of the mass rises.

During **anaerobic** process, the anaerobic micro-organisms, while metabolising the nutrients, break down the organic compounds through a process of reduction. A very small amount of energy is released during the process and the temperture of the composting mass does not rise much. The gases evolved are mainly Methane and Carbon-dioxide. An anaerobic process is a reduction process and the final product is subjected to some minor oxidations when applied to land.

Manure from composting gives better yield to farmers and it is also enviornment friendly. Bio degradable solid waste can be composted either in compost pit or in a vermi compost pit. Compost pit can be underground unlined compost pit or overground compost – heap method or overground brick line compost pit. Vermi compost can be done in vermi tank (four pit model) or vermicompost in sheds. Composting of bio degradable solid waste can take place in biogas plants also. Slurry from the biogas plant can also be utilized for production of vermi compost.

3.1.1 Advantages of Composting

- By proper decomposition, biodegradable waste gets converted into good quality organic manure whereby waste is turned into wealth
- Prevents vector breeding and breeding of rodents
- In aerobic composting process considerable heat is generated, resulting in destruction of pathogens and weed seeds
- Insanitary conditions arising out of solid waste are removed and aesthetically, environment looks neat and clean

3.2 Composting (Manure Pit)

3.2.1 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.

3.2.2 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 described below:

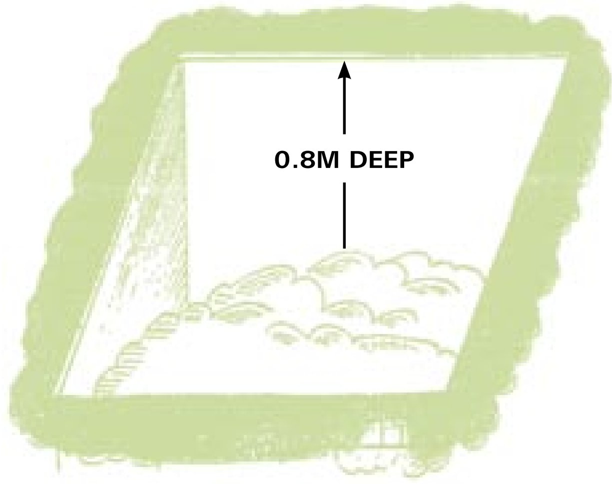
1. Underground nlined manure pit or garbage pit

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. Under ground 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 dia 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.

3. Overground 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.

4. 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 a 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.

3.2.3 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.

Size of the pit: 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.

Action
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.

1. Underground *unlined* manure pit or garbage pit
Applicability:

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

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
- Make a ridge with the help of soil at the periphery of the pit & compact it by light ramming.

Use and maintenance of the pits

- 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. Under ground 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

3. Overground 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.

4. Overground 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.

3.3 Vermi Composting

3.3.1 Overview

Vermi composting involves the stabilization of organic solid waste through earthworm consumption which converts the material into worm castings. Vermi composting is the result of combined activity of microorganisms and earthworms. Microbial decomposition of biodegradable organic matter occurs through extracellular enzymatic activities (primary decomposition) whereas decomposition in earthworm occurs in elementary tract by micro-organisms inhabiting the gut (secondary decomposition). Microbes such as fungi, actinomycetes, protozoa etc. are reported to inhabit the gut of earthworms. Ingested feed substrates are subjected to grinding in the interior part of the worms gut (gizzard) resulting in particle size reduction.

Vermitechnology, a tripartite system which involves biomass, microbes and earthworms is influenced by the abiotic factors such as temperature, moisture, aeration etc. Microbial ecology changes according to change of abiotic factors in the biomass but decomposition never ceases. Conditions unfavourable to aerobic decomposition result in mortality of earthworms and subsequently no vermi composting occurs.

Hence, **preprocessing of the waste as well as providing favourable environmental condition is necessary for vermi composting.**

The vermicompost is relatively more stabilized and harmonises with soil system without any ill effect. Unfavourable conditions such as particle size of biomass and extent of its decomposition, very large temperature increase, anaerobic condition, toxicity of decomposition products etc. influence activity of worms.

The worm species that are commonly used in vermicomposting are: two exotic varieties *(Eisenia foetida and Eudrilus euginiae)* and one indigenous variety *(Lampito mauritii).* It is recommended that local variety of worms which consume garbage should be used to the extent possible. 50kg worms give 50kg manure per day. These worms are known to survive in the moisture range of 20-80% and the temperature range of 20-40°C. The worms do not survive in pure organic substrates containing more that 40% fermentable organic substances. Hence fresh waste is commonly mixed with partially or fully stabilized waste before it is subjected to vermi composting. Table below indicates the chemical analysis of earthworm casting from soil and soil mixed cattle dung.

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.

3.3.2 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

Table 2
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

Note: Values, except total nitrogen are in milligram (mg)/100 gram (gm).

- 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.

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.

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.

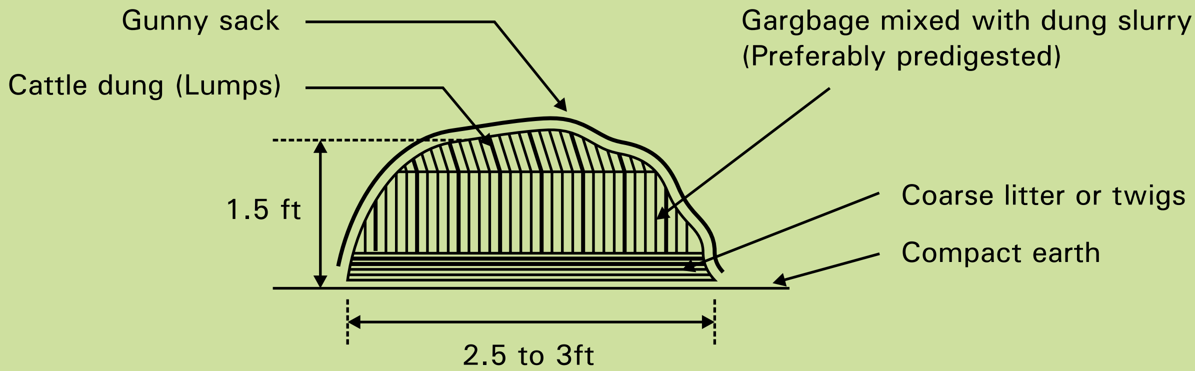
Step 3: Cover the entire bed immediately with gunny bags to reduce light penetration and create dark environment and maintain required moisture content in the feed bed for better performance of the earthworms for digestion of the feed material.

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.

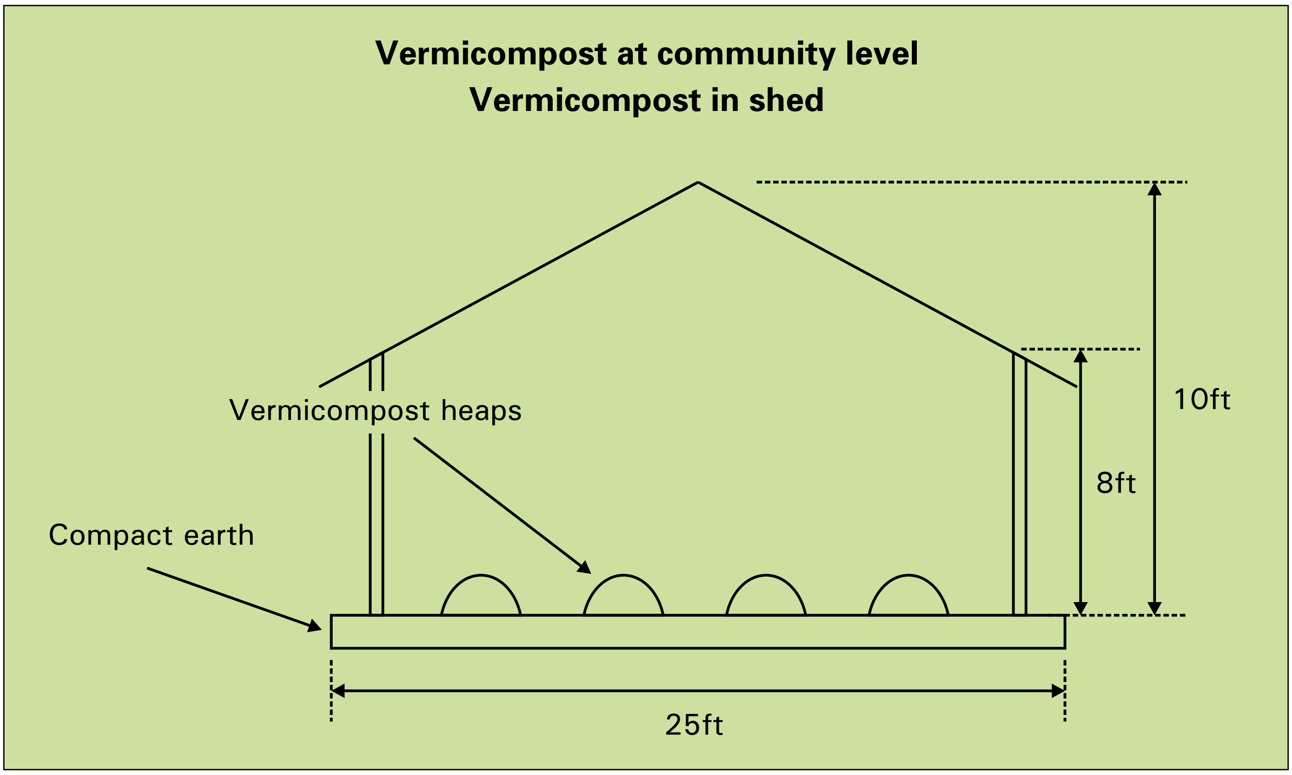
Step 5: After 1 month of introducing the earthworms, remove the gunny bags and keep the heaps open to air for a day, collect the top 2 inch layer of earthworm compost by slow & smooth scrapping of the top layer of the compost bed till you observe the earthworms. When you see earthworms, stop scrapping;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

Vermicompost in shed



Filling of individual heap



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

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.

3.3.3 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.

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.

Accordingly the economics of the vermitanks would be as under:

Utility of vermi tank:

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

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.

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: 1. *Eisenia foetida* and 2. *Eudrilus euginiae.*

Commissioning of vermitank

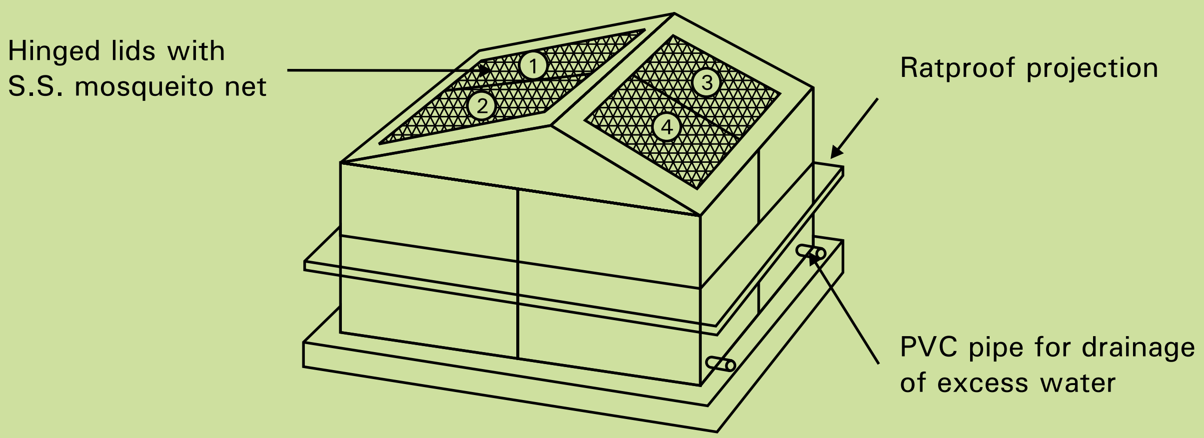
(A) Basic layers

Each of the four pits should be filled up to

Table 3

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 perkg	Rs 750 to 1500	Rs 9000 to 18000

Vermicompost at community level
Community vermitank (four pit model)



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:

Table 4

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.

Table 5

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**

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.

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.

3.3.4 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.

Chapter 4

Biogas Technology

4.1 Background

When biodegradable organic solid waste is subjected to anaerobic decomposition, a gaseous mixture of Methene (CH_4) and Carbon-dioxide (CO_2) 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.

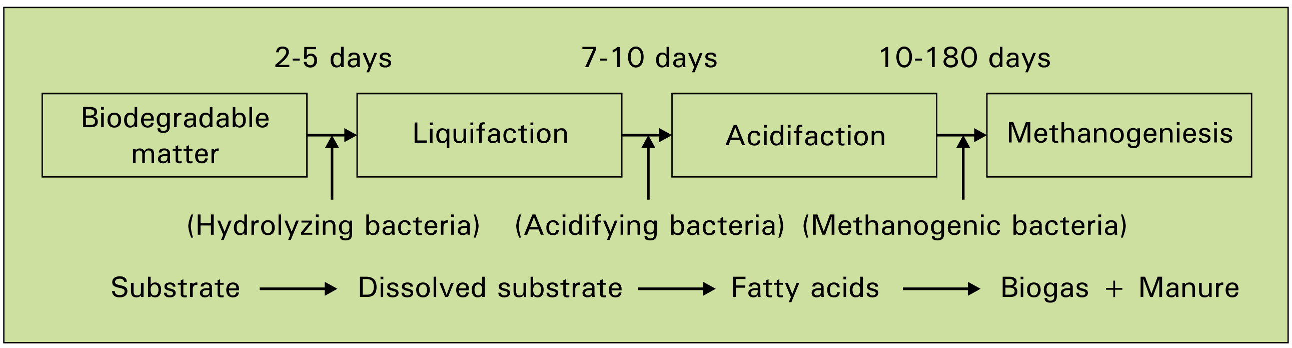
4.2 Digestion Process

The *anaerobic* digestion of the organic waste matter occurs in three different stages:

- Hydrolysis
- Acidogenesis
- Methanogenesis

4.2.1 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 (CO_2) are released and the major end product of this step is *glucose*.

4.2.2 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 CO_2 and H_2 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.

4.2.3 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 CO_2 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.

4.3 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.

4.4 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

Table 6

	Factors affecting biogas production
• 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.

4.4.1 Household Level

Kitchen waste, cattle dung, garden waste, leaves of trees can be digested and digested product reused at household level.

4.4.2 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.

4.4.3 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.

4.5 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).

4.6 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.

Table 7

Comparison of kitchen waste/vegetable waste/cattle dung/human excreta as feed material for biogas production

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.

4.6.2 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.

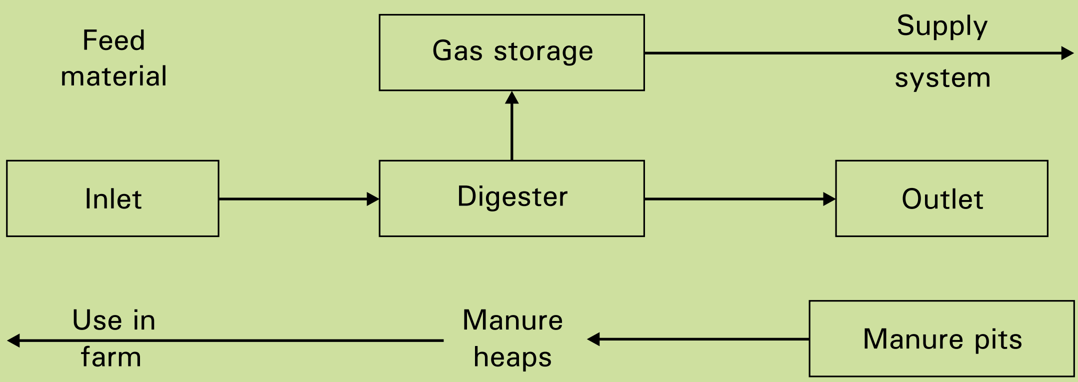
Floating gas-holder plant

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 m^3 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:

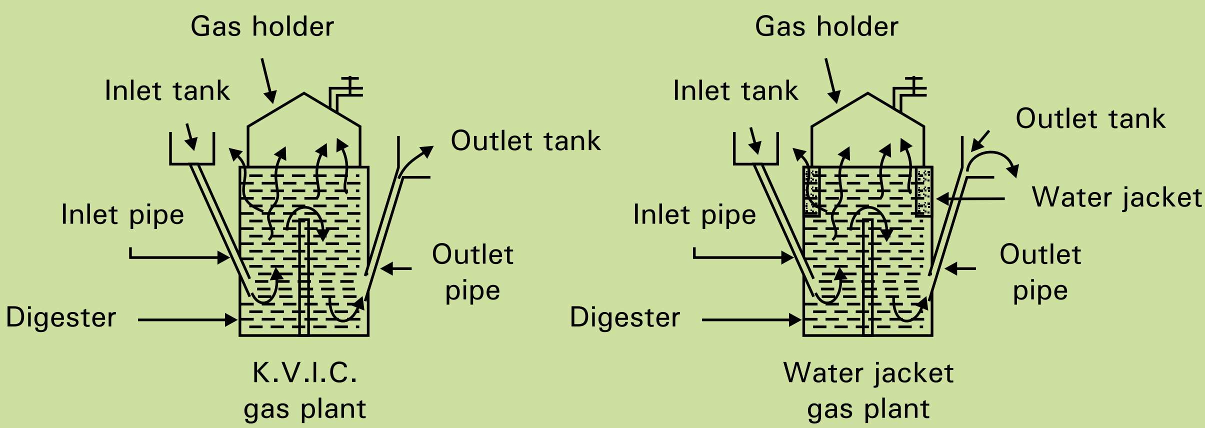
Fixed dome plant

This plant, runs on a continuous or batch basis. Accordingly, it can digest plant waste as well as

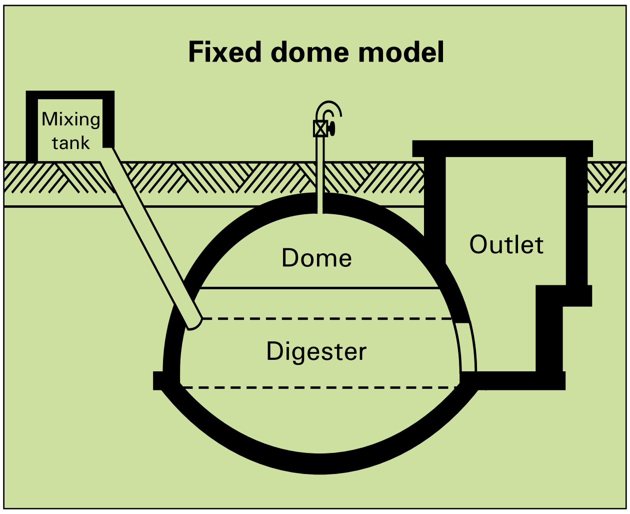
Plant components



Floating dome biogas plant components & functioning



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.** The mode of functioning of the fixed dome plants is depicted in the following drawing:

Table 8
Comparison between floating dome and fixed dome models

	Floating gas holder type	Fixed dome type
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 workshop facility.	Construction of the dome portion of the unit is a skilled job and 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 table areas.

4.6.3 Selection of Site for Biogas Plant

The site for biogas plant should be:

- Even surface - marshy land to be avoided and ground water level should be below 6-7 m
- Higher elevation than the surrounding so that there are no chances of water logging in rainy season
- As near as possible to the source of feed materials (animal waste-cattle dung, human waste-excreta and urine, kitchen/food wastes
- As near as possible to the points of utilization of biogas, say kitchen, in rural homes/hostels/ food establishments/mandis
- There should be enough open space to build biogas plant and to store digested slurry for management by its side
- A place fully exposed to sunlight
- Away from drinking water well or similar source of water
- There should not be any big trees near the site since they may prevent the sun's rays falling on the biogas plant and roots may cause damage to the digester.

4.7 Classification of Biogas Plants Based on Nature of Feeding

Based on nature of feeding, biogas plant may be broadly divided into three types, i) Batch type, ii) Semi continuous type and iii) Continuous type.

4.7.1 Batch Type

Batch type system is the one in which organic waste materials to be digested under anaerobic condition are charged only once into the digester and no more feeding will be there till the end of operation.

4.7.2 Semi-continuous Type

In this system, a predetermined quantity of feed material mixed with water is charged into the digester from one side (inlet) at specified interval of time; say once a day and the digested material (effluent) equivalent to the volume of the feed, flows out of the digester from the other side (outlet). The digestion volume remains always constant.

This type is best suited for household or family size biogas plants. In practice, it is only this type which has been adopted for all categories of biogas plants, viz. family size, large size (institutional) and community size (village level).

4.7.3 Continuous Type

In this system, the feed material is continuously charged to the digester with simultaneous discharge of the digested material (effluent). They could be either plug flow type or well mixed type. There are no chances of scum formation in this type. This may however need constant attention to monitor the loading rate, temperature, pH etc. and therefore more suited for large size units. This type may be particularly useful in sugar factories where molasses could be used for biogas generation.

Of the above three types, it is semi-continuous type that is more popular for field application.

4.8 Design Criterion for a Biogas Plant

- Volume of digester – which is interalia dependent on quality or quantity of feed and its hydraulic retention time
- Storage capacity of the gas holder – which is dependent on the requirement of gas and the intervals at which substantial quantity of gas is required
- Delivery pressure of the gas
- Volume of the mixing tank which is dependent on the quantity of daily feeding and proportion of water to be mixed
- Arrangement of heating and insulation
- The unit should be strong to have a long life, using local raw materials and labour for construction/installation and it should be leak proof for liquid and gas
- Another very important aspect is that the cost should be as minimum as possible.

4.9 Construction of Biogas Plants

Applying the above design criterion, appropriate model of biogas plant should be selected. Proper size (capacity) of the plant should be fixed based on the cattle strength and waste produced in the community. Proper site should be selected for the installation of biogas. Construction of biogas plants requires trained and skilled masons for proper installation. It is advisable that local resource institutions having proven expertise in setting up biogas plants should be engaged for training and supervision of the construction work.

Advantages

Biogas plants help in not only decomposing the solid waste but also produce good amount of clean fuel and environment friendly organic manure. Biogas is a clean fuel which does not make cooking vessels dirty and does not produce smoke to irritate eyes or lungs.

Applicability

Household level, Community level, Commercial establishments.

Limitations

- High cost for the lower middle and low income group in rural areas
- Lack of availability of required technical infrastructure in rural areas.

Chapter 5

Toilet Linked Biogas Plant

5.1 Introduction

In India in initial stages, because of its massive 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.

5.2 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 behavioral aspects need to be tackled by educational process.

5.3 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.

5.4 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.

A review of the design characteristics and functioning of various designs (predominantly KVIC, Janata and water jacket) in relation to human excreta, is self revealing.

In KVIC (floating dome) design the gas holder floats in the digesting slurry. As a result undigested slurry is present between the outer surface of gas holder and the wall of the digester. In the case of night soil feed, undigested night soil finds access to this annular gap through which it is exposed to the surrounding. This gives rise to offensive foul smell. The insects and animals get direct access to night soil and spread disease. The night soil in visible. Many times night soil also sticks to the outside of the gasholder which needs cleaning. With exposed night soil, the chances of soil pollution are ever present.

In 'Janata' and 'Deenbandhu' Models(Fixed dome), slurry constantly move between the digester and the inlet-outlet chambers. During such movements undigested excreta will enter inlet and outlet chambers, form where it will give out foul smell. Also the insects find access to inlet and outlet chambers. In case inlet and outlet chambers are not covered properly there is a total exposure of excreta.

In water jacket design (floating dome), as has been already discussed, the gas holder floats in water jacket. The slurry is completely covered as it lies inside the inner wall of the jacket. Thus slurry is not exposed to atmosphere. Hence there is no smell. Flies, insects and animals cannot reach slurry. There is no soil contamination as only digested slurry comes out form outlet pipe.

Malaprabha biogas plant has been found very suitable for human excreta. It has, many advantages even over 'Water Jacket' design. This plant is under ground and can be installed even in the house. In case of space constraints, latrine can be conveniently placed on top of the Malaprabha Gas Plant.

It may be necessary to accommodate such a biogas plant in close proximity of the residence, perhaps in the house itself. Thus, it may be constructed in households even having very little space. Further, the cost of the unit and the space requirement could be minimized if the biogas plant and the toilet seat are made into an integrated unit where the toilet seat is superimposed on the biogas plant, although offset toilet seat may be a requirement in some situations.

Effluent from Malaprabha Biogas Plant is free from pathogens (with respect to Salmonella Typhi) However, it is desirable to monitor quality of effluent periodically and operation & maintenance (O&M) and health safety measures are to be taken.

5.5 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.

5.6 Technical Replicability

- Field tested and accepted technology
- Availability of few skilled and knowledgeable NGOs
- Up scaling/replication possible
- Training facility at field level available.

a. 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.

b. Limitations

- High cost for the lower middle and low income group in rural areas
- Lack of availability of required technical infrastructure in rural areas.

Chapter 6

Reuse and Recycling of Non-Biodegradable Solid Waste

6.1 Introduction

As explained earlier, 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: (Ref. Table 9).

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 from such waste.

6.2 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.
- Moulds of different shapes and sizes
- Well ventilated cupboard for storing the articles.

Materials required

- Waste paper
- Flour of fenugreek or tamarind seed as adhesive
- Water
- Rough flat stones for macerating paper
- Colors

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

Table 9

Paper	Plastics	Clothes, metal and glass
1. Color paper: Wall posters, Notices, Newspapers, Tissue paper	1. Carry bags	1. Cotton cloth
2. Books and magazines	2. Containers	2. Synthetic cloth
3. Notebook paper	3. Milk covers	3. Metal
4. English newspaper	4. Oil covers	4. Used wires, hangers, tins, cans, blades, etc
5. Local news paper	5. Water covers	5. Glass
6. White paper: computer bills, A4 papers, computer printing papers	6. Sari shop covers	6. Bottles, bangles, mirrors etc
7. Packaging boxes: E.g. Soap box, cigarette box, sweet box, detergent box	7. PVC pipes	
8. Paper plates and cups	8. Nylon pots, tubs, brushes	
9. Brown carton	9. Nylon wires	
10. Cardboard	10. Syringe	
	11. Glucose bottles	
	12. PET bottles	
	13. X-ray	
	14. Scan sheets	
	15. Ice-cream cup	
	16. Crushed bottle	

Table 10
Economics

S. No.	Particulars	Qty.	Cost (Rs)
1.	Waste paper	5kg	20.00
2.	Adhesives	--	200.00
3.	Colors	--	300.00
4.	Skilled & unskilled labour	--	660.00
5.	Total Cost	--	1120.00
6.	Price of finished goods	--	1650.00
7.	Profit	7-6	530.00

- 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.

6.3 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.

6.4 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.

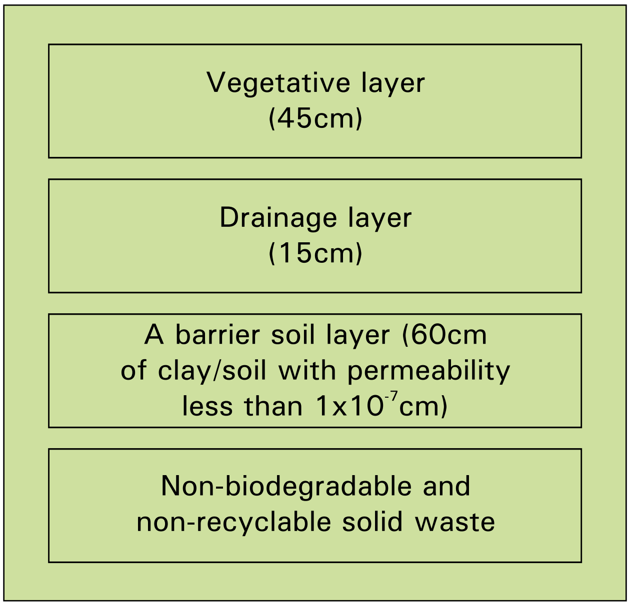
A landfill is a properly designated area and used for the disposal of non-biodegradable and non-recyclable inorganic solid waste. Landfill is considered to be a viable option.

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.

Chapter 7

Waste Water Management

7.1 Introduction

Disposal of waste water is a major public health problem in rural areas. Stagnant waste water smells bad and also acts as breeding place for mosquitoes resulting in spread of diseases like dengue, malaria, filaria etc. Proper disposal and also reuse of waste waster wherever possible will help in combating diseases as well as meeting water scarcity.

7.1.2 Sources of Waste Water

- From domestic use e.g from toilet, bathroom, washing of clothes and from kitchen
- Community e.g from industry, commercial and business activities, institutions, healthcare establishments, market places, farming activities etc.

7.1.3 Type of Waste Water

There are two types of waste water generated. These are:

- **Greywater** is waste water from bathroom, washing of clothes and kitchen. Depending on its use, water can require less treatment than black water and generally contains fewer pathogens. Treated water can be reused for garden watering, fodder raising and kitchen gardening
- **Black water** is water that has been mixed with waste from the toilet. Black water requires biological or chemical treatment and disinfection before re-use.

7.1.4 Waste Water Quantification and Characterization

Table 11
Sources of waste water and its type

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

7.1.5 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.

7.1.6 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.

7.2 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.

7.2.1 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.

7.2.2 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.

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.

7.2.3 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.

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.

7.2.4 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 12
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/- 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).

Total labour cost: Rs 120/- **(B).**

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

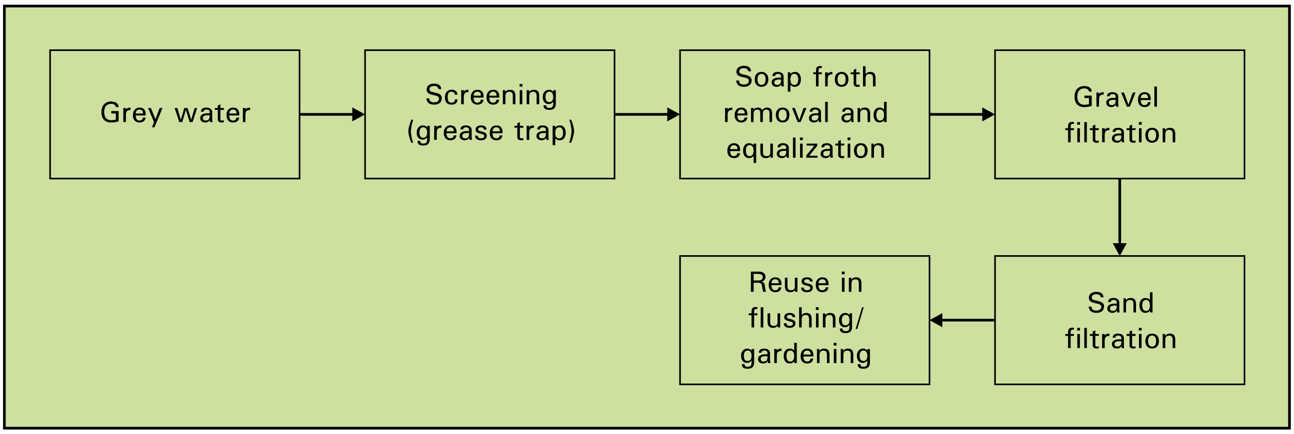
- Soakage pit is not suitable for rocky terrain
- It will over flow if wastewater flow in the pit exceeds the design flow
- If suspended solids get into the pit, the choking of the pit will take place earlier.

7.2.5 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.

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

1. 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.

2. Applicability

household.

3. Action

Individual households may construct and operate this system.

4. 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 storage tank:	Size: 40cm x 60cm x 50cm Brick masonry in 1:4 cement mortar & cement plaster 1:4 with neat cement finis

Construction of greywater treatment system

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.

5. O&M

- 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.

7.3 Technological Options for Community Level Management at Public Places-On Site

Community level greywater can be divided in two types:

a. Greywater in rural areas in public places like public stand posts for water supply, wells, hand pumps, schools etc
b. Greywater from houses 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.

On site management of community greywater:

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.

7.3.1 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.

7.3.2 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.

7.3.3 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.

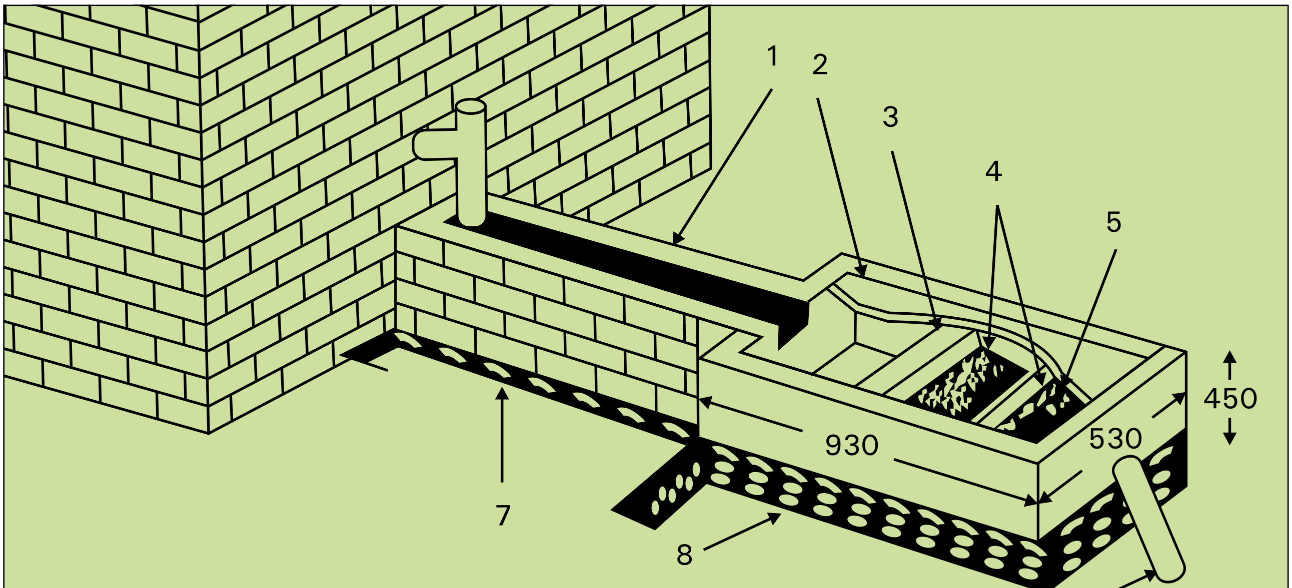
Description
The system has two major components:
a. Sludge Tank
b. Soakaway Channel.

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.

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



Sketch of sullage tank

1. 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

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 soakway channel through the pipe provided at the end of this chamber. This water is well cleaned.

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.

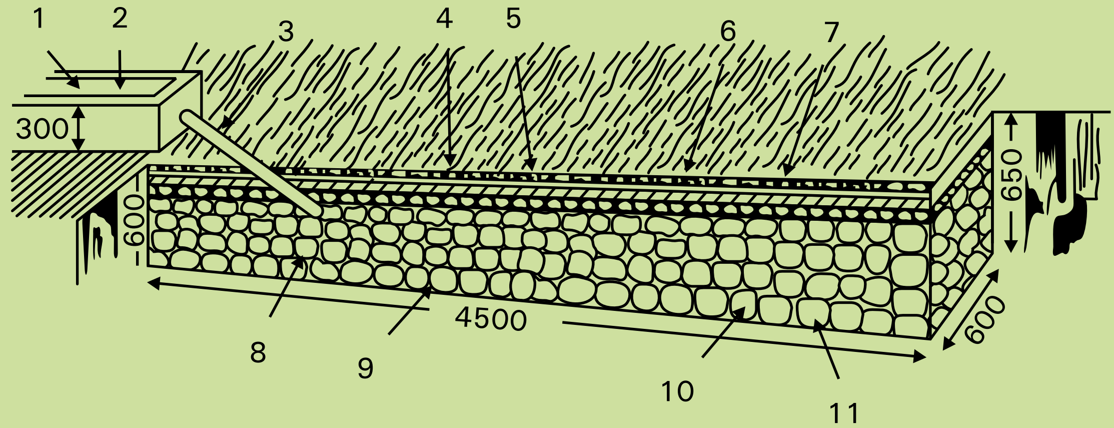
If drainage channel is long, smaller tanks may be constructed or colored containers be kept in the passage to intercept the sullage, mud etc. If the soakaway channel is far from the sullage tank then also a tank should be built in between.

b. Soakaway 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.

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.



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.

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

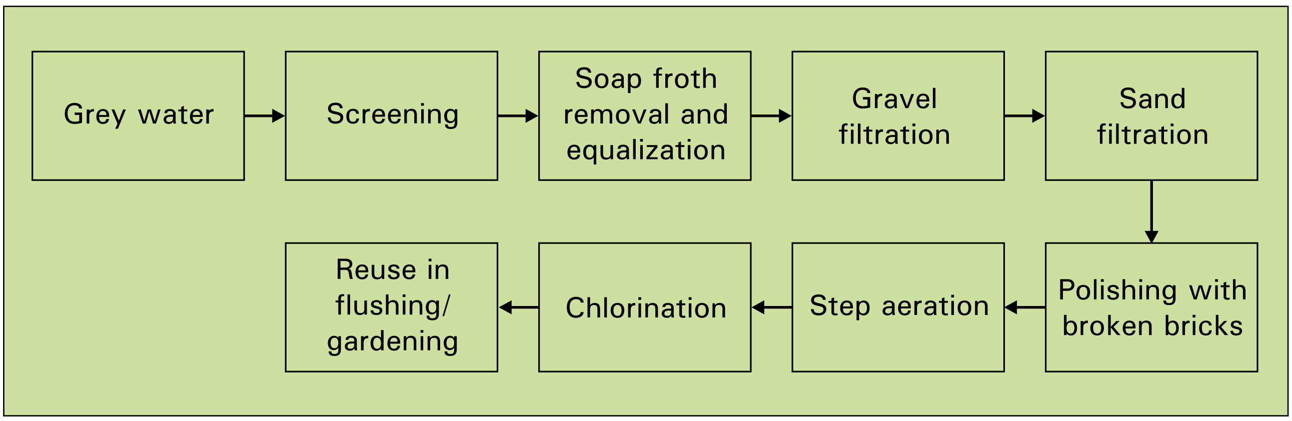
As per design for community soakaway channel system and detailed estimate with the support of available technical personal.

7.3.4 Reuse of Greywater

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:

Greywater treatment for reuse in school/community



2. 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.

3. Advantages

- 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.

4. Applicability

Community and schools.

5. 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.

6. 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):

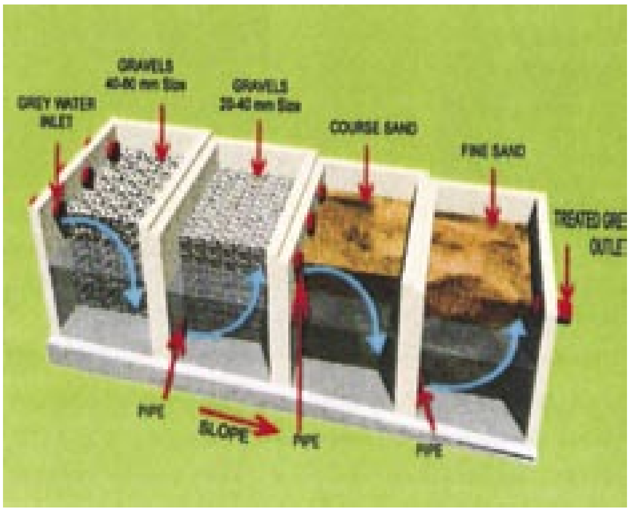
- Inlet pipe (4kg pressure PVC pipe, size and length will depend on quantity of flow of greywater; for an individual household of 5-6 members: 63mm, 4kg pressure PVC will be sufficient)
- Inlet chamber (30cm x 30cm x 10cm in brick masonry cement plaster for an individual household of 5-6 members and 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)
- 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.



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.

7. 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.

8. Limitations:

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

9. Materials required for and cost

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

7.3.5 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

Table 13

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 m^3 1.9 m^3	Made available by Ashram	0 0
Cement plaster and punning	38 m3	40	1520
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/-

- 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.

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

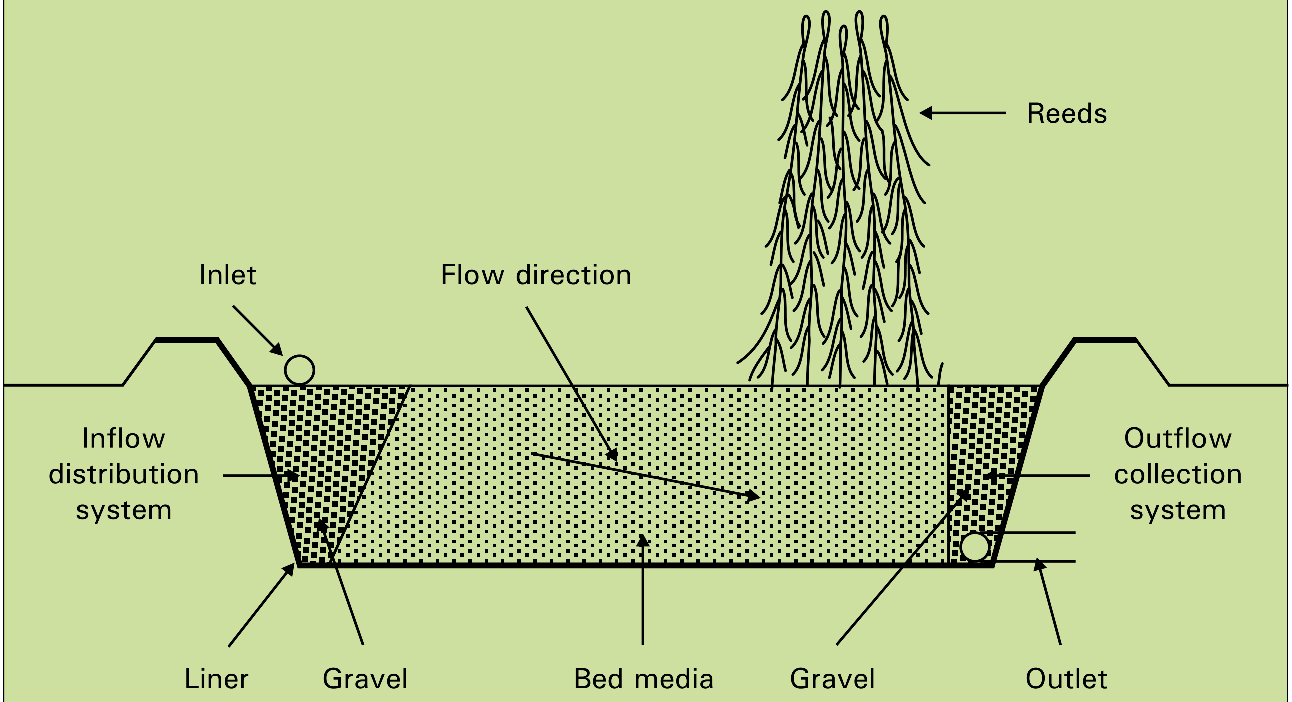
- Planted gravel filter module requires a large area per user (2sq.m. per person). Design should be more space effective by integrating with anaerobic filtration system
- Application of this technology need appropriate technical support to the Gram Panchayat.

7.4 Community Level Management of Greywater from Households.

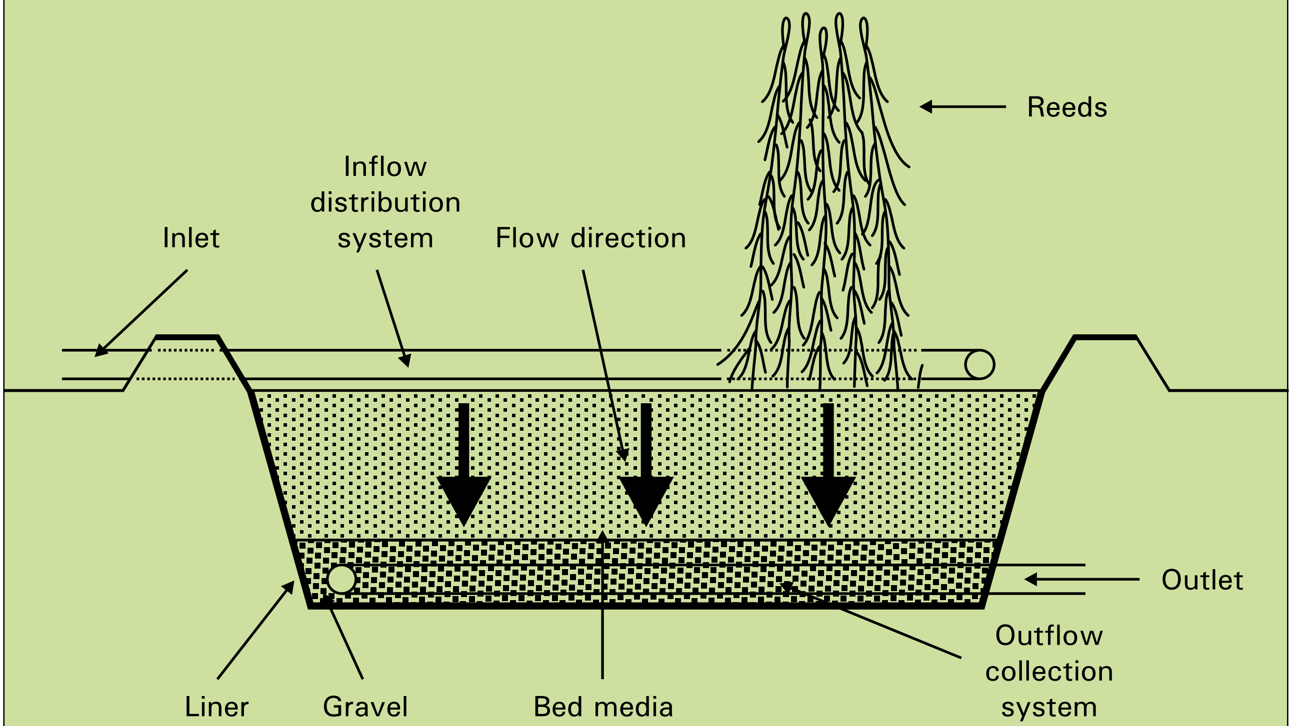
In very compact and very crowded village, effective greywater management at domestic level may not be feasible due to non availability of space around the house. In such cases domestic

Conceptual diagrams of rootzone treatment systems

A) Horizontal flaw system



B) Vertical flaw system



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.

7.4.1 '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

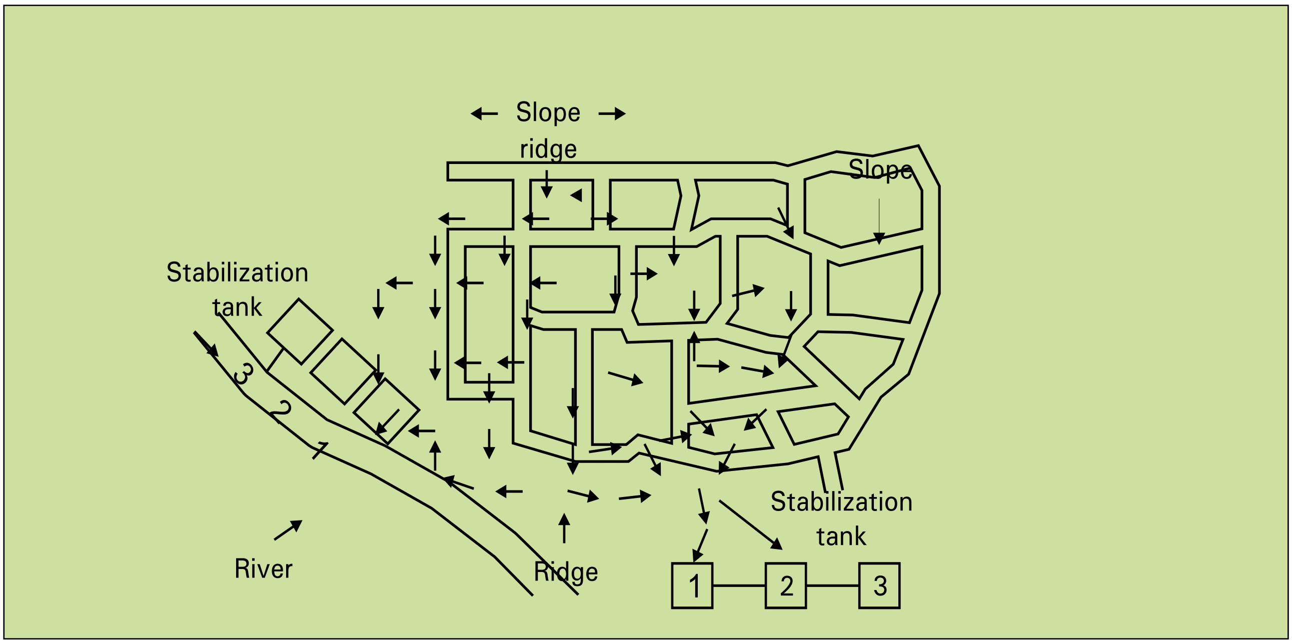
a. Open drain with technically sound design, involving semicircular base and trapezoidal cross section so as to maximize self cleansing velocity for carrying away silt in greywater
b. Closed drain-small bore greywater draining system with intercepting tanks at suitable points.

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.

7.4.2 Open or Surface Greywater Drainage System:

For collection and transportation of greywater flowing out from the houses, surface drain

Master plan for village



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:

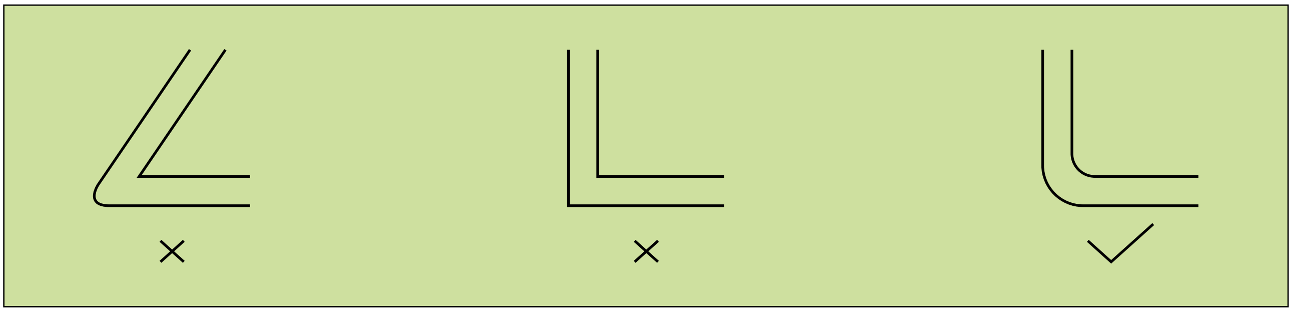
A master plan for the drainage lines will have to be prepared, taking into consideration, layout of the village, contour lines and available gradient for achieving gravity flow pattern as stated earlier.

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

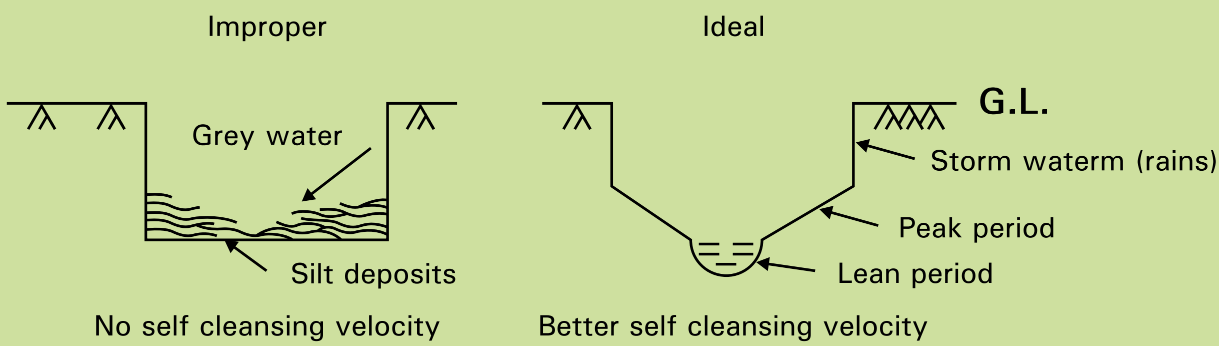
It would be necessary to see that nowhere the drainage line takes an acute angle. Sharp bends must be avoided. The turns in the drainage line should be gradually rounded.

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.



Cross section for surface drain



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. 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 can not 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.

7.4.3 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:

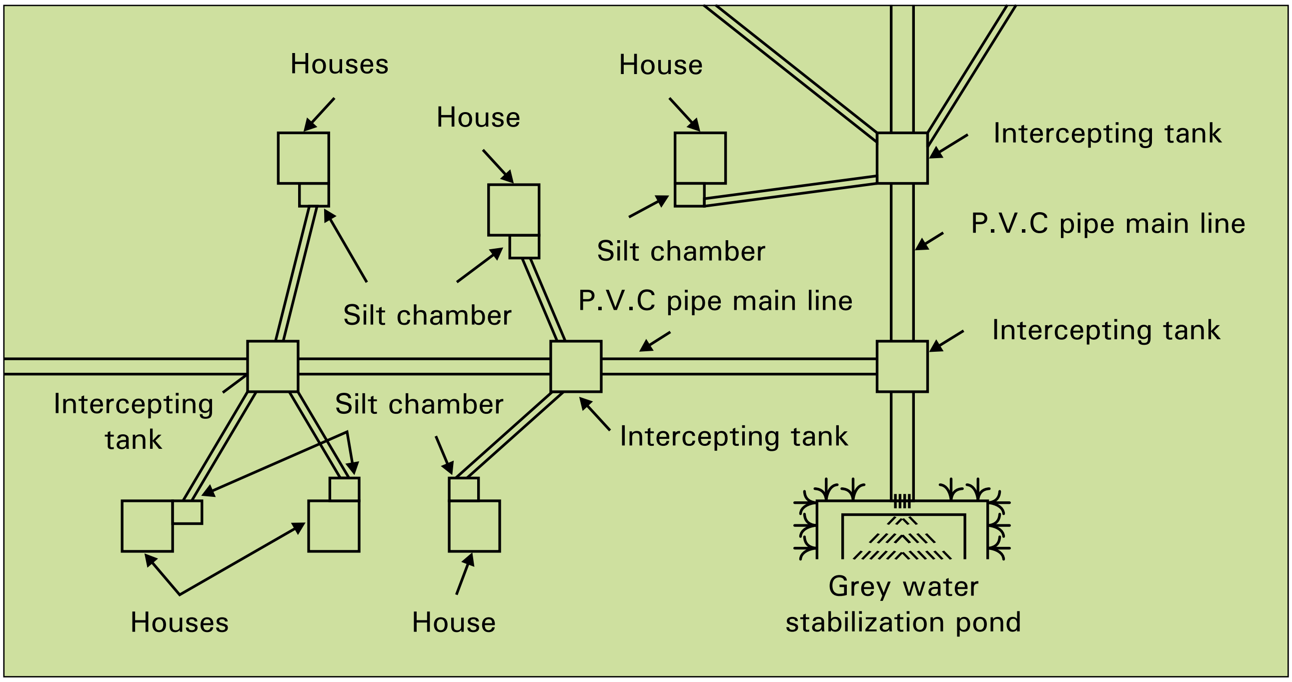
In this system, pipeline is laid taking into consideration land contours along the streets and lanes in the village. At intervals of 200 to 300 feet and at turnings, intercepting tanks are established for periodical, removal of sludge. Greywater from houses is led to the intercepting tanks, through connections 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.

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.

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.

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.

Out side 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.

7.4.4 Final Treatment of Community Greywater

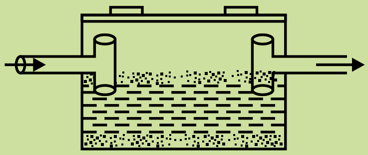
Once the community greywater is collected at one or multiple points outside the village, final treatment is required to convert it into harmless and reusable water.

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

Small bore sullage drain

Pipe dia 100mm to 150mm



Pipe dia 100mm to 150mm

Intercepting tank

- 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.

7.4.5 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.

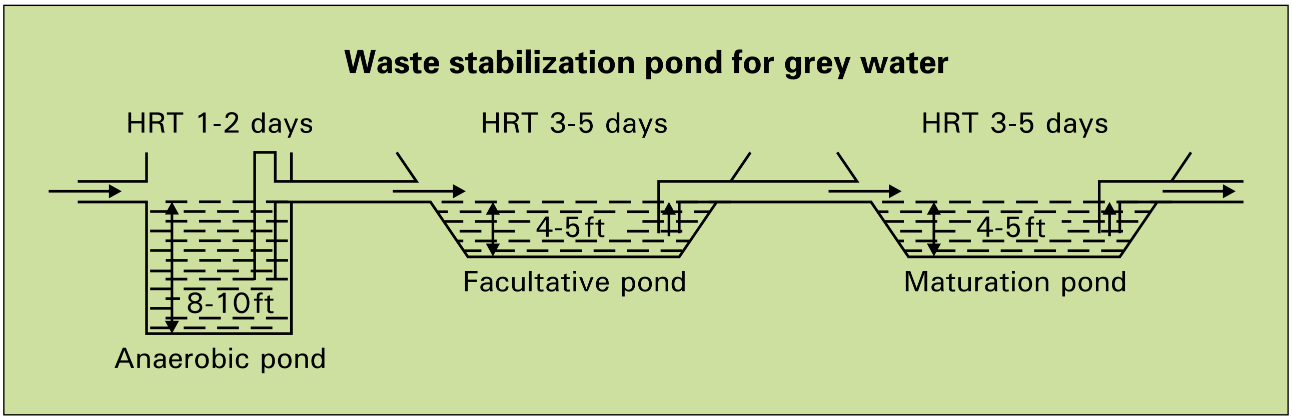
a. Anaerobic ponds

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.

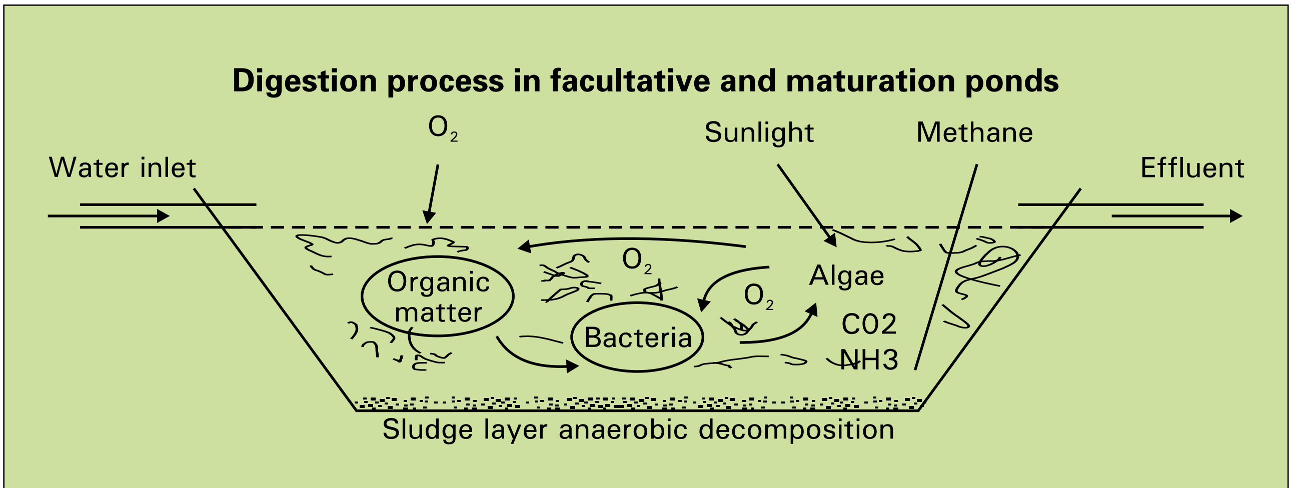
The sides and bottom of the pond need to be compacted. Masonry construction is not necessary. If the soil is very permeable, plastic sheeting topped with soil may be laid at the bottom.

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

Digestion process in facultative and maturation ponds



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.

Interpond connection

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

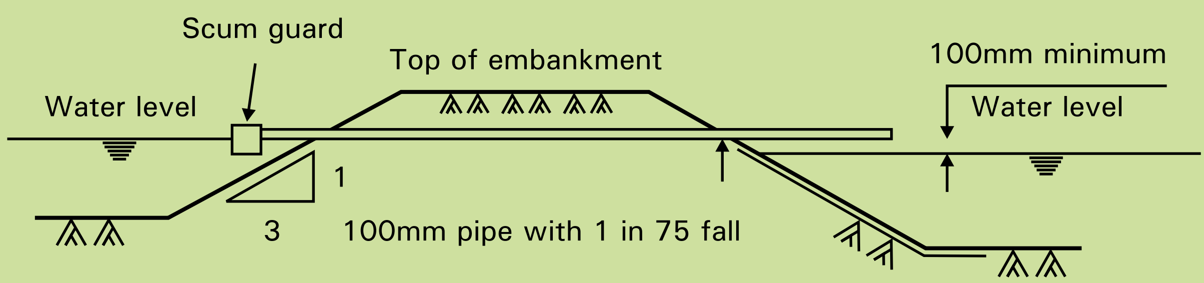
Depending on the land availability, a suitable layout can be planned. As an example one such layout is depicted here.

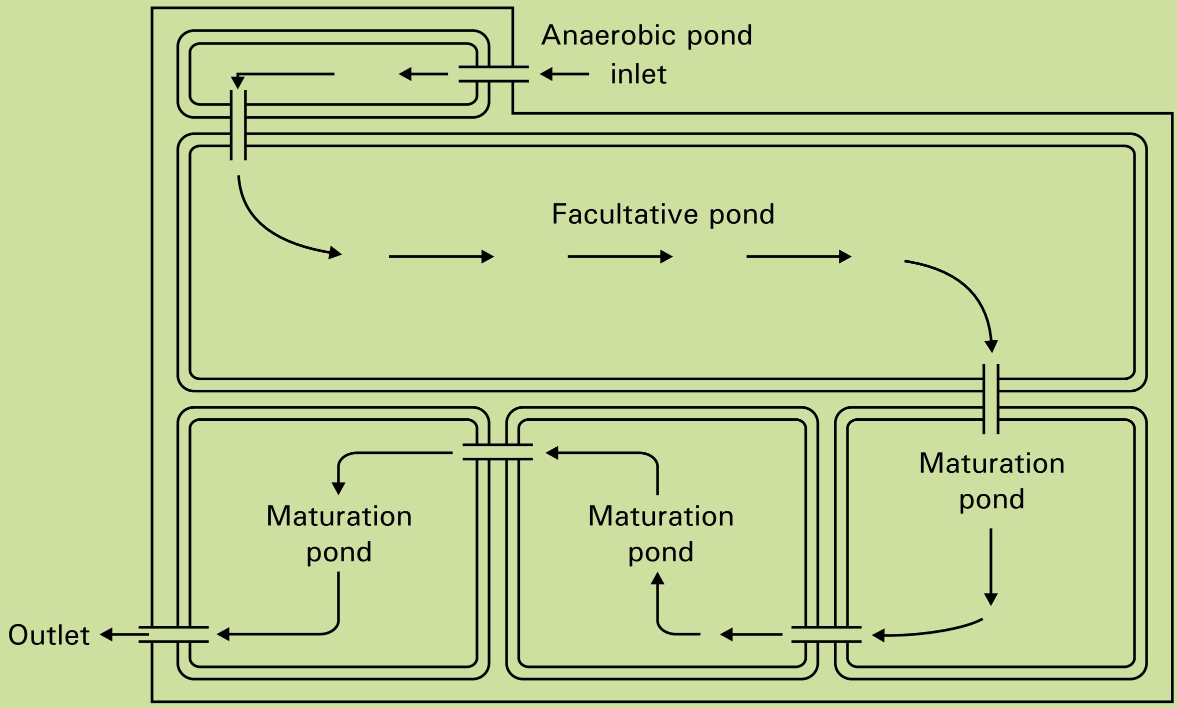
Use of nala or river bank

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.

Interpond connection





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.

7.4.6 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.

7.4.7 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.

7.4.8 Reuse of Stabilized Water

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.

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.

Part B

Compilation of Case Studies and Best Practices in Solid and Liquid Waste Management in Rural Areas

Overview

The initiatives around solid and liquid waste management are redefining the living pattern in rural India but in few places and spaces. Many villages though generate huge of amount solid and liquid wastes have not witnessed the gains of waste disposal and recycling technologies which not only help to keep the villages clean and green but also ensure sizable economic return if managed effectively. Some of these SLWM technologies we have discussed in the part A of this technical note in terms of design, process and use which may include vermin-costing or bio-gas plant or bio-culture or use of waste into recycling of paper. These technologies are developed and localized to suit the conditions, geography and re-usability.

The successful adaptation of these technologies have generated tremendous curiosity among watsan practioners who are faced up with demands from the community for the cost-effective and simple waste management and recycling technologies. This section attempts to document some of the best practices in waste management and recycling both from the technology and management aspects.

A set of 14 case studies on different aspects of solid and liquid waste management have been compiled in this section. Many watsan practioners have contributed in the documentation of these cases and we acknowledge and thank them for their efforts and hard work to make the cases accessible for other to replicate in their areas. We are providing their names and address for further contact and guidance. They are:

- Dr. S.V. Mapuskar, Director, Appa Patwardhan Safai W Paryawarna Tantraniketan, Dehugaon, Tal.Haveli, Dist. Pune, Maharashtra
- Mr. Srikanth Navrekar, Nirmal Gram Kendra, Nasik, Maharastra
- Mr. Ishwarbhai Patel Director, Environmental Sanitation Institute, Saugahd, Gandhinagar, Gujarat
- Dr. Sam Godfrey, Project officer (WES), UNICEF Bhopal Office, M.P.
- Mr. Purushottam Toshniwal, Secretary, Kanpur Gaushala Society, Kanpur (U.P.)
- Mr. M.M.Datta, Consultant, CGG, UAA, Nainital
- Mr. Chandi Charan Dey, Coordinator Sanitation, RKMLP, Narendrapur, West Bengal
- Mr. A.K. Singh, Dy. Director, PR, UP
- Mr. C.Srinivasan, Project Director, Exnora GreenCross, Vellore,Tamil Nadu
- Gram Panchayat Presidents of Fathepura, Amli village, Ahmed Nagar District, Maharashtra, Dhammer village, Satara Dist. Maharashtra, Fatehpura, Mehsana

Case Study-1

Practising Zero Waste Management in Vellore, Tamil Nadu

Urbanisation brings prosperity but at the same time creates environmental problems like pollution, accumulation of solid waste and poor sanitation. Use of tetrapacks, plastic plates, cups and bags, tin cans and similar throw-away items has increased in the last decade as has the amount of organic waste. In many Indian states, rural areas are fast catching up with urban areas in generating solid waste. Lack of proper waste collection, segregation and management systems and poor sanitary conditions in both urban and rural areas are aggravating health problems. In this context, solid waste management is an area of challenge and of innovation for urban planners and city corporations. Small and big pilots, with different degrees of sustainability and success, are operational in many parts of the country. A zero waste management (ZWM) project by NGO Exnora Green Cross and the District Rural Development Agency (DRDA), initially piloted with UNICEF, in Tamil Nadu's Vellore district is an example of a successful solid waste management programme and its benefits.

ZWM is a system of managing solid wastes that strives for maximum waste recovery through recycling and reuse, aiming at zero waste generation.

- The system's strength lies in segregation of waste at the source leading to maximum recovery of resources, minimization of waste and reduction in area required for storing and composting
- It minimizes pollution of ground water and air by doing away with disposal of wastes at dumpsites and landfills
- Zero waste management integrates the informal recycling sector (ragpickers and waste collectors) into the solid waste management system providing opportunities for income generation.

Exnora Green Cross, supported by UNICEF, initiated a pilot project on solid waste management in a ward of Vellore municipality in 2000. The project was then piloted in rural areas of Kaniyampadi block under the Total Sanitation Campaign in 2002. The aim of the project, carried out in four villages (Palavanchattu, Selamanatham, Virupakshipuram, Kammavanpet and Virupakshipuram), was:

- to create awareness among people about environment-friendly waste management promoting source segregation and recycling
- organise local communities and decentralize solid waste management through people's participation
- generate wealth from waste through micro-enterprise opportunities for rural youth.

Exnora Green Cross provided technical inputs and guided implementation of the project along with local resident associations and self help groups (SHGs). The DRDA provided funds for construction of sheds, purchase of tricycles and tools and ensured the support of local bodies. A project team comprising a coordinator, supervisors and street beautifiers was formed for each village Panchayat. A public meeting was organized for the village residents and shopkeepers to explain the concept of zero waste management and how to differentiate waste for segregation. Pamphlets and video shows on waste classification and segregation were shown. Each household was provided with a set of red and green dust bins. The street beautifiers were trained on all aspects of solid waste management. Teams with two street beautifiers each were formed. Each team was allocated 300 households and provided a tricycle and a set of hand tools. The tricycle had two compartments, one green and the other red, to collect organic and inorganic waste respectively.

The street beautifiers collect domestic garbage in their allocated zones between 7.00 a.m and 11.00 am. The waste collected in the households in green and red dust bins are emptied in the colour-matching compartment of the tricycle and brought to the zero waste centre. Inorganic waste is separated into more than 25 items under categories like bottles, plastics, metals, cardboard, paper, PVC etc. They are then packed and sold to local waste collectors and recyclers every month. Mixed waste (10-15 percent), which cannot be recycled, is sent to land fills. The organic waste is composted and treated in two stages: (a) cattle dung/bio-dung composting (b) vermi-composting.

For cattle dung composting, the organic waste is laid in a composting yard in large compartments and spread in different layers. Each layer is treated with cattle dung microbial inoculums. When the height of a layer reaches 5 feet, it is covered with a polythene sheet. This first stage of composting takes 45 days. The polythene sheets trap the heat generated during anaerobic composting and increase the internal temperature to 70-75 degrees Celsius. This high temperature kills the pathogens. The moisture evaporates and condenses on the underside of the polythene. The cyclic movement of water also cycles the bacteria aiding rapid decomposition and reducing the volume to about one third in 15 days. After 50 days, the compost can be harvested, sieved and packed in bags for sale. Under the second method, the semi-decomposed organic waste is put into vermi-composting beds after 15 days. The vermi-compost can be collected after 45 days. The rich composted manure is sieved and packed for agricultural purposes and afforestation activities.

The Vellore solid waste management project[1] is now managed by village Panchayats supported by Residential Welfare Associations and SHGs. Each family pays Rs 20/- and each shop pays Rs 50/- as waste collection charge. The funds collected from monthly subscriptions and sale of inorganic waste and organic manure are used for paying the street beautifiers and supervisors. Gandhi Nagar village Panchayat generated an income of Rs 10,646/- during the financial year 2005-06 by selling organic waste and Rs 1,62,289/- from inorganic waste. The pilots in Vellore district are successful because informed communities are willing to pay for a clean environment managed by local youth who take pride in beautifying their street and get paid for it too. Equally crucial to the success is the full involvement of local bodies and their commitment to making a difference.

1 For further details, pls contact Mr. C. Srinivasan, Project Director, Exnora Green Cross, Vellore, Tamil Nadu

Case Study-2

Solid Waste Management-
Vermitank at Hari Mandir, Panchavati, Nashik[2]

Harimandir is a famous temple in Nasik. The temple has a big garden around it & a kitchen for preparation of 'Prasad'. The temple generates about 25 to 30kg of biodegradable waste which includes floral offerings, garden waste & kitchen waste. Since the temple is amidst dense locality, disposal of this waste was a big problem & it was expensive too.

A vermitank was constructed for the temple under the technical guidance of Nirmal Gram Nirman Kendra which is working satisfactorily till date. This has not only solved the problem of garbage but has added to the beauty & income of the temple.

Main features of vermitank

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. Salient Features are summarized below:

- *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

2 For Further details, pls contact Mr. Sriknat Navrekar, Nirmal Gram Nirman Kendra, Goverdhan (Gangapur) Nashik 422 222
Tel: (0253) 2231598
e-mail: nirmalgram@rediffmail.com

- *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 vermicompost. Accordingly the economics of the vermitanks would be as under.

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.

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 used:

- Eisenia foetida
- Eudrilus euginiae.

Operation & maintenance

Daily: Feeding of garbage
Weekly: Addition of dung – once or twice a week
Monthly: Harvesting of vermicompost
Care to be taken 1.maintaining moisture level.

Costing & economic viability

Total cost of erection: Rs 14000/-
Recurring expenses per annum (Labor, water etc): Rs 5000/-
Average annual income from vermicompost: Rs 13000/-
Maximum payback period: 2 years.

Case Study-3

Vermi Composting from Solid Waste by KGS, Kanpur in U.P.

This case study is about round the year production of vermi compost by reuse & recycling of cattle dung and cow dung slurry from Gaushla and Biogas plants and its successful management through a low cost technology at village Bhounti; promoted by Kanpur[3] Gaushala Society (KGS), Kanpur, Uttar Pradesh and is a good example of income generation from solid waste management by using a very low cost technology.

Main features

Vermi composting involves the stabilization of cow dung through earthworms, which converts cow/ cattle dung into worm castings. Vermi composting is the result of combined activity of microorganisms in cow dung and earthworms (Acena phalida). Microbial decomposition of biodegradable organic matter occurs through these earthworms culture activities of primary decomposition. Ingested feed substrates are subjected to grinding in the interior part of the worms gut gizzard resulting in particle size reduction.

The technology consisting of a tripartite system that involves biomass, microbes and earthworms, is influenced by factors such as temperature, moisture, aeration etc. Microbial ecology changes according to changes in these factors in the biomass. Hence processing of waste like cow dung as well as providing favorable environmental conditions necessary for vermi composting. Conditions such as particle size of biomass, the extent of its decomposition, very high temperature (May to July in Kanpur), anaerobic conditions, toxicity of decomposition products etc. influence activity of worms and production of manure. The technology has been used for composting of organic agriculture waste, cow dung and its adoption in solid waste management in rural and urban areas in India is of recent origin.

For the Vermi Culture Technology application an appropriate site selection for vermi culture, construction of appropriate shed (thatched roof on bamboo poles with proper slope to drain rain water, earthen floor, kutcha walls with local available material, natural light and ventilation are required. The process comprises of following steps:

- Make a basic bed of size 24 cu.ft (L = 8ft, B = 3ft, Ht = 1ft) with one brick

3 *For further details, pls contact Mr. Purushottam Toshniwal, Secretary, Kanpur Gaushala Society, Bhounti, Kanpur, U.P. Ph: 09936794565*

(9 inch x 4 inch x 3 inch) size containment all round (5 kethch:S-1) the bed, paste with a larger of cow dung slurry

- 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 (gobar/biodegradable organic matter leaves, kitchen waste) for earth worms in the ration of raw cow dung: organic waste = 1:1
- Prepare feeding material (9 inch) by mixing 50% raw cow dung & 50% organic waste & keep the mixture inside the bed for one month at least. Sprinkle water 5 to 6 time to cool the mixture and each time slowly turn up and down to cool and reduce the temperature of the mixture, during the month
- Put the feeding material over the 2 inch thick hard organic waste on the prepared bed for minimum period of 1month. Put 4 to 5kg Earthworms (Acena phalida) over the feeding materials in the vermi culture bed (0.5kg earthworms in one ft length of feed bed. To maintain moisture sprinkle water on alternate day/every day in summer, 3 days intervals in winter
- Cover the entire bed with gunny bags to reduce light penetration and create dark environment and maintain required moisture, for better performance of the earthworms
- After 1 month remove the gunny bags collect the top 2 inch larger of earthworm compost by slow & smooth scrapping of the top layer of the compost bed till you observe the earthworms; stop scrapping to send the earthworms down into feeding materials bed
- After 2 to 3 days put 1/2 of the uncapped materials from the bed on one side and add fresh feed materials on the empty side of the culture bed. This activity doubles the number of worms in the bed; repeat this practice every month. Vermi composting process completion is indicated by accumulation of granular size of the manure on the top
- Collect and store the granulated earthworm compost from the bed and store in an appropriate place in the shed for 15 days to allow the development and maturing of the remaining earthworm eggs to baby earthworms, remove the top layer of the stored earthworm compost. Then transfer the baby/young earthworms to an open sunlight bed. Lower layer of this bed should contain feeding materials 2 to3 inches thickness (Cow dung: Agriculture waste = 1:1) over the feeding materials, now put 6 inches of compost containing young earthworms, and keep the compost with baby/young earthworms open for 4 days. Then remove the adult earthworm by straining (2 times a day within one day) strained adult earthworms are collected for sale. Use the remaining materials with new adult earthworms in new feed beds for replication of process.

Economic viability

The project benefits in both quantitative and qualitative terms. On an average 50kg earthworms produce 50kg manure per day; thus, monthly yield about 4000kg. Manure packets of 20 and 5kg are sold at the cost of Rs 50/- & Rs 20/- respectively. The average yield is 4,000kg per month and 1000kg waste which is again reprocessed. Gross sales turnover from the Vermi Culture compost is 4000kg x Rs 5/- = Rs 20,000/- per month. Also the un-reprocessed waste is selling @ Rs 2.50 perkg i.e.1000kg x Rs 2.50 = Rs 2500/- per month making the total earning of Rs 22,500/- per month from the vermi culture compost.

The cultivated earthworms are also sold @ of Rs 300/- per kg During the last two years, the society sold 200kg of earthworms to the farmers and earned Rs 60,000/- against the total initial expenditure e.g. purchase of 50kg of earthworms @ Rs 500/- perkg = Rs 25,000/- + Rs 5,000/-. This had been recovered at the end of the 1st year of operation of the plant. The annual average gross earning from the vermi composting pilot project at KGSS is:

S.No.	Item	Amount (Rs)
1	Gross earning from the sale of 60,000kg vermi compost manure (48,000kg @Rs 5/- perkg and 12,000kg @2.50 perkg from rejected low grade material annually.	2,75,000.00
2.	Gross earning from the sale of earthworms) to farmers (100kg annually @ Rs 300/- per kg)	30,000.00
	Grand total	**3,05,000.00**

Precautions

Proper covering of feed bed. Only sprinkling the water, protect the shed area and the beds from red ants, cockroaches etc. by using Turmeric, and flour around the perimeter of the shed and the bed. Keep the feed beds away from birds/chicken/ducks from eating the worms.

Constraints

Lack of organized marketing, lack of awareness with farming community, of benefits of EWC. Seasonal variation of composting process & production due to temperature and moisture differences. Lack of institutional arrangements for dissemination of information for vermi composting technology.

Case Study-4

Making Nightsoil-based Biogas Plants viable in Maharashtra's Pune District

Biogas generated from nightsoil serves a dual purpose of providing energy and helping manage human waste. However, nightsoil from 25-30 persons per day is required for generating 1 cubic metre biogas. While biogas generated from nightsoil of community toilets, which are used by larger numbers of people, has proved viable, gas produced from individual toilets used by 5-10 persons is inadequate for any practical use. Keeping this in mind, a new strategy has been evolved in Dehu village of Maharashtra's Pune district, where some families allow their neighbours to use their toilets for a nominal maintenance charge making attached biogas plants economically viable. Currently, there are about 75 family-owned human nightsoil-based biogas plants in Dehu providing kitchen fuel for villagers. The strategy has also eased the village Panchayat's responsibilities for human nightsoil management and reduced environmental pollution due to open defecation[4].

Innovative efforts:

- The processing animal and human excrements in biogas systems naturally improves sanitary conditions for the plant owners, their families and the entire village community
- The initial pathogenic capacity of the starting materials is greatly reduced by the fermentation process
- Each new biogas system eliminates the need for one or more waste/manure/latrine pits, thereby substantially improving the hygienic conditions in the village concerned
- From a medical standpoint, the hygienic elimination of human excreta through the construction of latrines located in direct proximity to the biogas systems constitutes an important additional asset
- In addition, obnoxious odours are avoided, because the partially decomposed slurry stored in such pits is odourless
- Since biogas systems do not attract flies or other vermin, the effect is to reduce the danger of contagious diseases for human and animals alike. Further more, eye aliments and respiratory problems attributable to soot and smoke from the burning of dried cow dung can no longer develop.

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4 *For further details, pls contact, Dr. S.V. Mapuskar, Appa Patwardhan Society, Pune Maharashtra, Ph: 020-27697204*

Area of work: Recycling of slurry and human waste as kitchen fuel.

Objective:
- Use cow dung and human excreta for fuel for kitchen
- Prevent unhygienic surroundings
- To save fossil based fuel
- To provide clean, healthy and cheap fuel from waste.

Present scenario in the country:
- Much of the human excreta from toilets is contaminating the water bodies and soil.

Consequences
- Health hazard caused by faeces, which carry dangerous disease carrying pathogens
- Breeding of mosquitoes and flies, carriers of diseases.

Why use human faeces and cow dung?
- To prevent health hazards
- The soil is fast losing its fertility due to indiscriminate use of chemical fertilizers
- The manure coming out of the biogas plant is excellent for improving soil fertility
- It is very cheap, since both cow dung and human faeces are available easily in rural areas
- The use of the gas for cooking reduces drastically the time needed for cooking and thereby enables women to spend their time more usefully.

Salient features:
- The cow dung obtained from two milch animals (10kgs per day) is made into slurry by mixing it with water and then fed into the inlet of the biogas chamber
- The flush out toilet faeces is led into the biogas chamber by connecting the flush out outlet pipe to the slurry inlet
- The gas generated from five persons using the toilet is sufficient to cook food (breakfast, lunch and dinner) for the family
- It reduces cooking time drastically, saves fuel cost

- The biogas plant also provides rich manure for improving the fertility
- The fully digested organic manure which comes out after 45-50 days is excellent for promotion of soil fertility and restore the land which has lost its productivity due to continuous application of chemical fertilizers
- The maintenance of the plant is very simple, which can be learnt by any one even in the village. The only technical point to be remembered is that the cow dung slurry is neither too thick nor thin
- The night soil from the flush out toilet will move down smoothly from the biogas plant when the toilet is flushed.

Technical replicability
- Biogas plants are built in almost all parts of the country and it requires a basic training to ordinary masons to link the toilet pipe into the biogas plant
- Already 20 such toilets are functioning in the small locality close to the training center
- Farmers who have the plant are very happy with use of manure.

Constraint
- Not enough flush out toilets in rural areas and with increased availability of LPG, people prefer the same to biogas.

Case Study-5

Solid Waste Management-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".

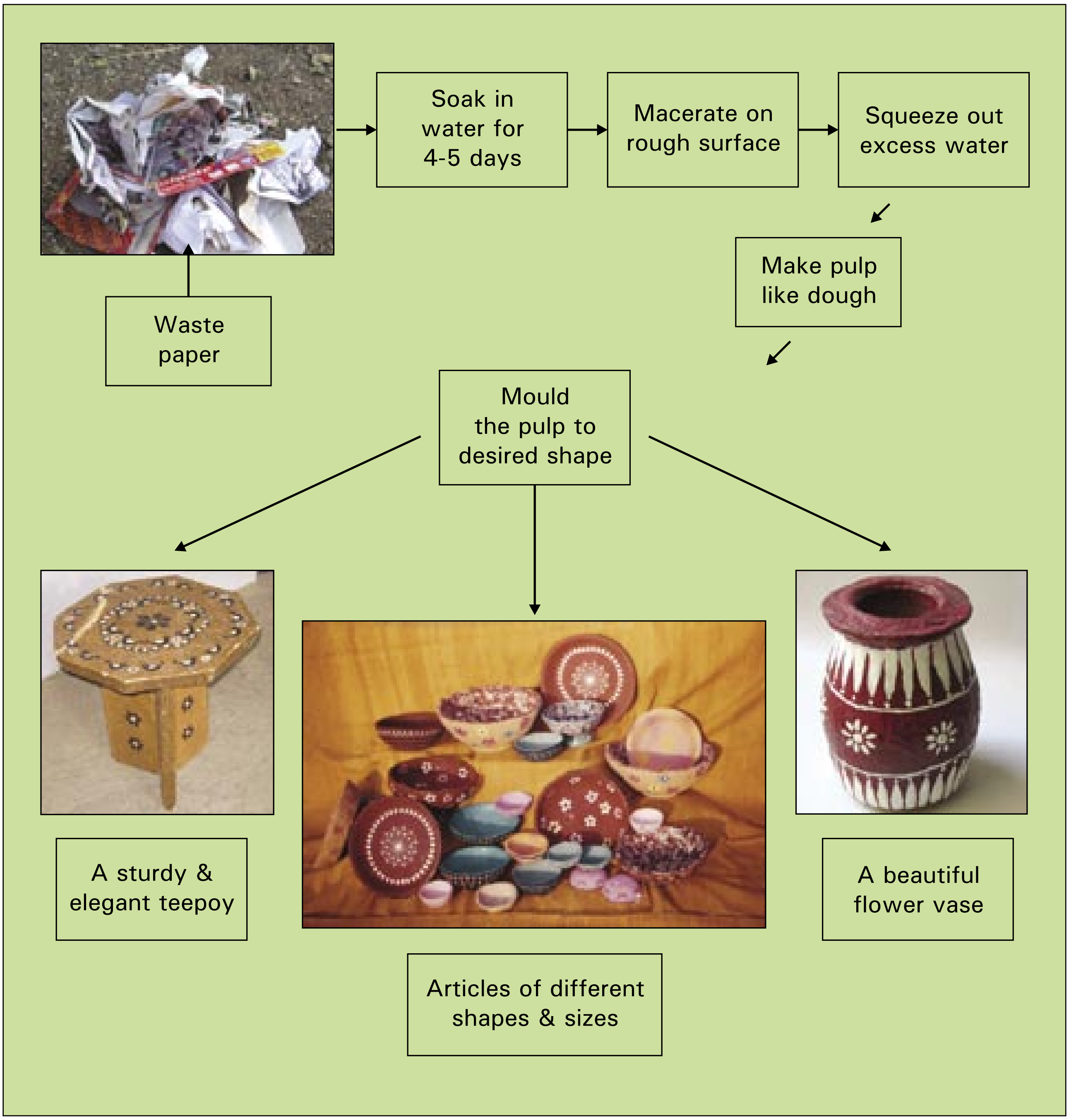
Main features of the technology

- 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 Kendra[5]

- 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



5 *For Further details, pls contact Mr. Sriknat Navrekar,Nirmal Gram Nirman Kendra, Goverdhan (Gangapur) Nashik 422 222 Tel. (0253) 2231598 e-mail: nirmalgram@rediffmail.com*

- The articles are painted artistically as per customers' choice
- The product is ready for marketing.

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.

Reaplicability

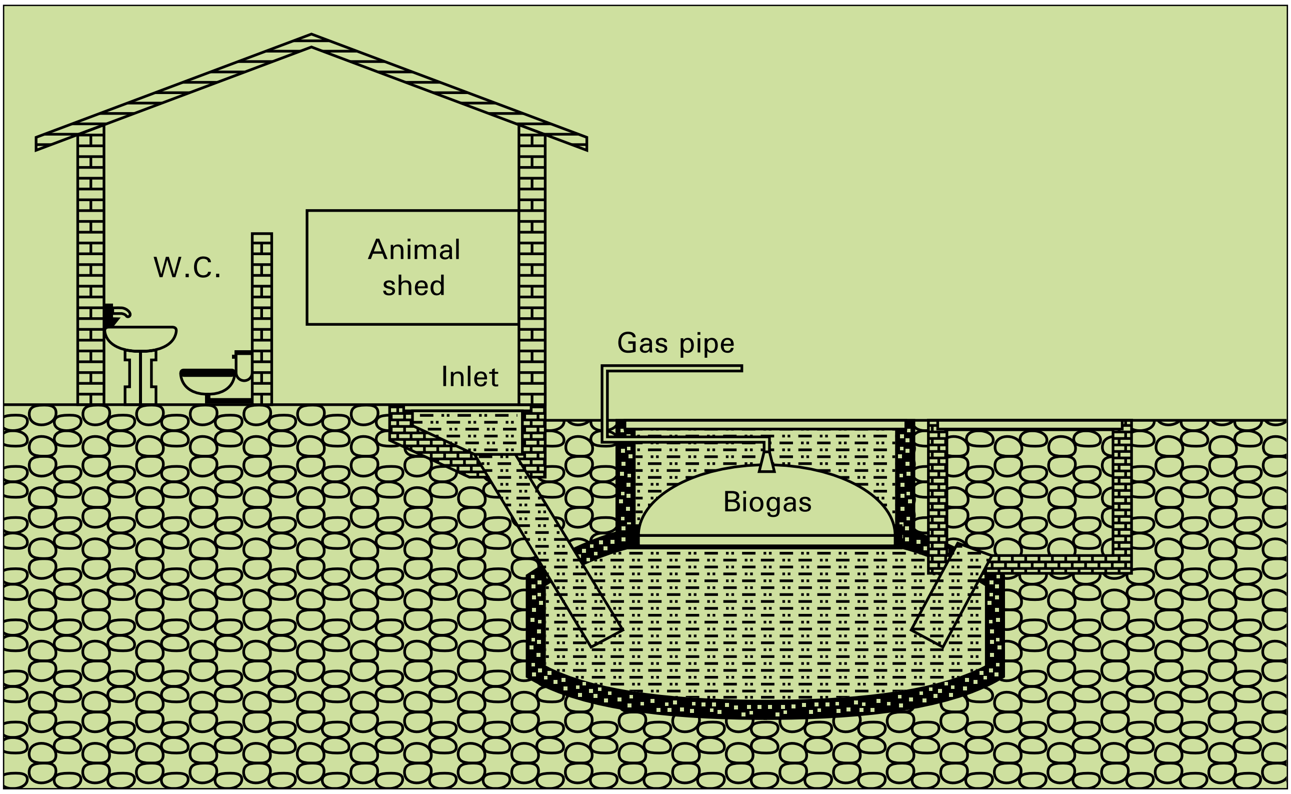
The technology is available for replication & generation of employment.

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

Case Study-6

Biogas Technology at KGS, Kanpur

The Balaji model for generating biogas from cow/cattle dung and agro wastes is a unique technology that has been promoted by the Kanpur Gaushala Society (KGS) at Kanpur in Uttar Pradesh, working in the area of research, development, manufacturing, installation & supply of agricultural equipment and biogas plant[6].



6 *For further details, pls contact Mr. Purushottam Toshniwal, Secretary, Kanpur Gaushala Society, Bhounti, Kanpur, U.P. Ph: 09936794565*

Main features of the case

The Balaji Model comprises three main parts, i.e. the concrete digester, the gas holder and the neck & covers.

Concrete Digester is the stomach (digester) of the plant, made with the help on scaffolding (steel mould) by casting the concrete (mixture of cement, smashed stone, sand).Hence it is stronger than the other types of plants with brick or stonewall.

Gas Holder is the gas holder is made up of reinforced glass fiber, which 100%air and watertight. The diameter of the gas holder is 1.6m and the volume varies with height of it. The volume of gas holder for 10 cu m plant is 2.6 cu m. The gas holder always remains below the water level and is fixed in the neck part of the plant.

The round part above the Digester is known as neck. This is also made with the help of steel frame, the neck is essential for fixing the gas holder. The neck is covered with five concrete covers which make the plant attractive and utilization of the plant area.

KGS is using and promoting three types of biogas plants of different capacity biogas plants. Out of these, the plants of 45M3 and 85M3 capacity are of floating dome type and the 10M3 plant is of fixed dome type biogas plant.

Costing and economic viability

The capital cost of the Balaji Models of different capacity as reported by KGS is presented in the table.

It is demonstrated “Gobar is really Ganesh” and how cow dung and urine (primary raw materials from cattle wealth in the country) can be used for manufacturing ayurvedic medicine, pharmaceutical and veterinary products to generate productive employment in rural areas. In addition water, fire & radiation proof “Tiles” have been prepared from cow dung and paddy husk. It has been claimed that these tiles can be used particularly for construction of superstructures for latrines under TSC. A handsome earning by the society from the export of these products was reported. The society has installed a vermi compost pit for reuse of biogas slurry and kitchen waste in the campus through which the society is earning (net) around Rs 60,000/- per year from the sale of vermi compost and earthworms to he local farmers. The benefit of ready availability of bio fertilizer to the agriculturists is also a big benefit.

Advantages

- Easy and fast technology, which is used to make the plant of strong strength with larger volume than other models. This biogas plant is completely submerged in the ground, so it is very attractive than other plants
- An alternate renewable source of energy at low capital and maintenance costs and provide employment generation
- Durable, safe, produces odourless gas and easy to repair technology. Plant does not require daily water addition because it is completely submerged below water. The feeding material takes the required amount of water
- Solid organic materials like grass, and straw can be used as feeding material, while the slurry from the plant is perfectly digested as it consists of 90% of water
- Suitable to address Solid Waste Management in rural areas in the country.

Limitations

- Selection of land site for installation of the Biogas Plant, sub-soil water level has to be below 20ft

S.N.	Particulars	10 M3	45 M3	85 M3
1.	Operational cost for one year	5 Rs/day	20 Rs/day	50 Rs/day
2.	Maintenance cost for one year	400/year	1000/year	1500/year
3.	*Total cost excluding O&M	30,1000/-	4,00,000/-	5,40,000/-

- Leakage of gas due to lack of alignment of the gas holder
- Marketing constraints for sailing of digester sludge
- Lack of awareness of the benefits among villagers/people may lead to improper extension of technology
- The toilets have not been connected to the biogas plant. The night soil for the human excreta enhance the availability of the methane generated and also improve the pressure in the tank even during the winter month, when the biogas generation activity usually remains slow. The social stigma for connecting toilets to biogas plant has also been noticed a constraint.

Case Study-7

Liquid and Solid Waste Management in Dhamner Village, Dist. Satara in Maharashtra

Underground drainage for reuse of gray water and effluent from toilets and vermi composting for solid waste management and generation of biogas using human night soil as raw material with aims at:

- Avoiding the unhygienic and in sanitary surroundings in village (Dharmner) road arising out of liquid waste disposal problem
- Generating wealth from waste through scientific management of solid waste and human excreta with the adoption of vermi compositing and biogas plant (human night soil based).

Background:

In 2005 Dharmner village in Satara Dist. (having pop. 2756, HHs: 488 Nos. received Nirmal Gram Puruskar from RGDWM, the Ministry of Rural Development, Govt. of India.

Liquid waste management:

Gray water (waste water from bathrooms, kitchen, washing of cloths, hand washing) from 488 households and effluent from a few septic tanks are collected and transported through underground drainage system (cover drains in the inner roads and uncovered drains on the surrounding roads of the village) with adequate slop (gravity flow) at a point outskirts of the village where waste water is treated with provision of a screen chamber followed by stabilization tanks in series 2 nos. each of size: 3et(W) x 4ft (L) x 10ft (D) and one number out let chamber of size 2ft (W)x 4ft (L)x 6ft (D) From the outlet chamber waste water is

taken by gravity through underground pipes and disposed off in a soakage pit (16ft dia and 10ft depth).

From second stabilization tank, as per requirement, treated waste water is pumped through (One H.P.) centrifugal pump and recycled for use and maintenance of a beautiful children's park in the village.

In some houses greywater from kitchens are utilized for growing vegetables in kitchen gardens.

Waste water from hand pump platforms are connected to the underground drainage system.

Thus every drop of gray water is treated and reuse/recycled in Dharmner village. No where in the village water stagnation observed.

A healthy drainage system in the village has created a soothing environment in the village and its health impact has been observed.

Solid waste management

Individual households dispose of their domestic solid waste (without segregation) in to a community Kutchara Kundi. GP has provided a kutchra kundi for every 5 to 15 households. Community kutchra kundis are placed at appropriate locations in the village. From kutchra kundis, solid wastes are collected by safari karmacharis (2nos. recruited by GP by paying salary Rs 1500/- p.m. to each safai

karmachari who works daily from 8 am to 12 noon and in the evening as per requirement by the GP and transport garbage through a kutchra gari (cart) to a common treatment plant site (vermi composting).

Segregation of waste:

Wastes are segregated at treatment plant site (vermi composting). Non-biodegradable waste is sorted out in a pit of size 7ft (L) x 7ft (W) x 3ft (D) and biodegradable solid waste in an adjacent pit of same size.

Vermin composting:

Bio-durable wastes are treated in 2 Nos. Vermin compost plants and each of size 20ft (L) x 3ft (W) x 3ft (D).Initially5kg. Earthworms were added in each vermi compost pit GP purchased the earthworms @Rs 400/- per kg. Effluents from each vermi compost pit is collected separately in a pit of size 2ft (L) x 2ft (W) x 1ft (D). Vermi water is collected and used for agriculture by the farmers.

Vermin compost:
On an average 10 tons/year vermi manure is available from this vermi compost treatment unit (2 pits). During the last four years about 40 tons of vermi manure produced from this treatment unit 50% of the produced (20 out of 40 tons) were used for gardening in the village and the balance 50% i.e. 20 tons were sold @ Rs 10/- per kg and from this, GP earned about Rs 20,000/- from the sale of vermi compost.

Biogas plant 15m3/day:
2 x 7 nos. (male) toilets + 3 Nos. (femals) toilets i.e. 17 nos. toilet sets are connected to the Biogas plant of capacity 15m3/day.

8 households have been given connections in their kitchens to utilize the biogas.

Each household is paying Rs 100/- per month to the Gram Panchayat for utilization of biogas in the kitchen. The biogas is utilized through two burners for ½ hour in the morning and ½ hour in the evening by a family of 5 members for preparation of food for the family.

GP is earning Rs 800/- per month from eight household connections. GP has been utilizing the money (Rs 800/-) by paying wages to the safai kramachri for maintenance of community toilets in the village, once in a month. The slurry from the biogas plant is collected in a stabilization tank adjacent to the plant. So far no slurry has been disposed off from the stabilization tank. It is observed that the full capacity generated (15m3/day) is yet to be utilized. It is not known whether utilizing human excreta from 17 nos. of toilets generates adequate quantity of biogas. Generated capacity can be fully utilized either by connecting more toilets to the plant or by adding cow dung slurry as would be required to utilize the full capacity[7].

7 *For further details, pls contact, Dr. S.V. Mapuskar, Appa Patwardhan Society, Pune, Maharashtra Ph: 020-27697204*

Case Study-8

Greywater Management- A Case Study of Mehsana, Gujarat

The Fathepura in Meshana district of Gujarat is a village having a total human population of 1200 in 214 households and also cattle population of 1400. This village, which is being headed by Sri Jai Singh Bhai K.Chaudhary (Gram Pradhan) has presented a unique example of **greywater** management in the village[8].

Main features

The village has a deep bore tube well of 8″ diameter and 800 feet depth. Water is pumped through a 35hp pump to a overhead reservoir of 40000 lt capacity, four times in a day, i.e. 160000 lt per day water is being used by the village. Out of this, about 40000 lt is being consumed for the cattle population. Though, the actual quantity of greywater production is not calculated, however it can be assumed that 80% of the total water use will come out as greywater. Thus, the estimated quantity of greywater generation in the village would be around 96000 lit per day.

The Gram Panchayat has implemented a pilot project on use of greywater for farming. The Gram Panchayat got the technical support of a consultant by paying Rs 15000 for preparation and assistance in implementation of the project. The project was completed in 45 days. Greywater of the village has been chanalized to a pond located at the outskirts of the village.2700 fit of total length of RCC pipes (12-15-18″ have been laid in seven zones of the village).

Economic viability

The village pond is 7 feet below the ground level of the village and the depth of water reported in 12 feet. Areas of the pond reported 3 acre. A project completed 2 years back. Expenditure on the project reported 12.76 lacs (GP share 2.70 lacs and funds from 11 Finance Commission) against estimated cost of Rs 15 lacs for house connection GP spent Rs 1 lacs (Rs 25000 for paying to 30 labourers and Rs 70000 for purchase the materials. The GP collected Rs 4 lacs, Rs 1 lac each from milk dairy, sale of mud from the pond, collection of 1 lac people contribution during Nav Ratri and from the 200 beneficiary household @ Rs 500.Out of Rs 4 lacs

8 *For further details, pls contact Mr. Ishwarbhai Patel, Safai Vidyalaya, Sughad, Gandhinagr, Gujarat, email- safai@ice.net*

thus collected, Rs 2.5 lacs were shown as GP contribution to the gray water project making a saving of Rs 1.5 lacs of which Rs 50,000 were shown as GP contribution for construction of school building at accost of Rs 4 lacs to mobilize 11th Finance Commission fund for the project and the balance 1 lac again invested to mobilization of 11 Finance Commission fund for construction of a GP building in a village. By the sale of the gray water after retention in the pond the GP earns Rs 12,000 per year. During the contract period of 3 years by the sale of gray water (after retention in the pond the GP is expected to earn Rs 36,000 in three years).

The village received **Nirmal Gram Puraskar Award in 2006** from the Ministry of Rural Development, Govt. of India.

Advantages

Community of village Fathepura in Meshana district of Gujarat has proven, where there is a will there is a way and gave an example to the adjacent villages. Community becomes aware and they have the sense of ownership in the community driven programmes. The main advantage of closed drains is that they don't take up surface space and they also reduce the risk of falling into polluted water and odour problems.

Constraints

The success of this particular project depends upon the involvement of community in decision making process and transparency in functioning and budget expenses, hence any dispute may lead to failure. Therefore, it is important that proper avenues should be created about such government schemes for better acceptance and impact.

Case Study-9

Liquid Waste Management through Root Zone Treatment at Community Level, Sughad, Gandhinagar, Gujarat

Environmental Sanitation Institute (ESI), Sughad in Gandhinagar in Gujarat has established an effective demonstration of the sustainable built environment, where architectural design is primarily governed by the concerns for energy efficiency, resource conservation, and environmental management. The institute has adopted various technology options on liquid and solid waste management in the campus for training and demonstration purposes. The management of waste water from toilets through "Root Zone Treatment Method is one amongst the successful demonstrations of the institute[9].

Main features of the case

Under the liquid waste management practices at community level, the waste water from toilets is being treated naturally through "Root Zone Treatment Method (Natural plant based system)". The treated water (5500 liter per day for 50 person's occupancy) is recycled for toilet flushing and landscaping purposes. Thus the campus has become self sufficient in its water demand.

Under this technology, the plant: is grown in a specially designed bed through which greywater is passed. Initially after 40 days totally clean water is discharged to be reused for toilet flushing, washing etc. (Capacity 5000 liters/day for 50 persons). Afterwards every day recycled clean water is available for toilet flushing, washing, etc.

9 *For further details, pls contact Mr. Ishwarbhai Patel, Safai Vidyalaya, Sughad, Gandhinagr, Gujarat email- safai@ice.net*

Root zone treatment plant at ESI consists of two parts of 34ft x 14ft x 3.5ft and 13ft x 6ft x 3.5ft size respectively and one treated water collection tank in between. The plant has been designed for treatment of greywater generated from 50 person in a day of the order of 135lpcd x 50 = 6750lpcd. Assuming 80% of the consumption will come out as a greywater from 50% would of the order of 0.80 x 6750 =5400lpd. This treatment plant expected treat per day whereas the plant has been reported to be designed 6750lpcd.

First greywater from students' hostel in the campus is being discharged in the intake tank wherein settable solid get settled down in the bottom of the settling tank and effluent from the settling tank has been discharged into the root zone treatment plant connected in series through 50mm dia. PVC pipes having number of perforations at suitable intervals for percolation of gray water into the route zone of the plant in the treatment plant.

It is reported that smaller size of such treatment plant for family size of 5 people takes about 40 days for filtration/treatment to clean the gray water. Afterwards treated gray water is available every day which can be reused in the toilets for flushing and gardening purpose.

Costing and economic viability

Reported project cost of this plant is Rs 35,000/-. Material used for the treatment plant were brick masonry work, pebbles, PVC pipes and special plant namely *Australis phragmatis.*

Advantages

Treated greywater can be recycled, atleast 5 times, for reuse in the toilets and after that it can be used for gardening purpose. Smaller size of such treatment plant for family size of 5 people can also be constructed for greywater treatment and reuse. Only HDP sheet and stone pitching is sufficient for such small size greywater treatment plant.

Limitations

The filtration by percolations through the bed material is the reason for the very efficient reduction of pathogens, depending on the size of grains of the bed material and thickness of filter, thus making the treated effluent suitable for suitable for reuse. So it is advisable that the bed material should be laid in the proper way.

Case Study-10

Liquid Waste Management in Maharashtra

An innovative Effort[10] in the greywater (bathroom, cloth washing) management especially in the reuse of greywater in a hygienic manner in Wadgaon village (Ahmed Nagar) was initiated with objectives:

- To avoid unhygienic and insanitary surroundings on village road arising out of poor drainage system
- To avoid mosquito breeding &foul odour
- To reuse treated greywater (bathroom, cloth washing waste) for irrigation and gardening.

Background:

Wadgaon Amli village having 1200 souls in 188 households (of which 51 belong to BPL families) was a tanker fed village. With the improvement of W/S, water scarcity problem was solved. 100% households covered with latrines. Sant Gadgebaba Abhigan work started in the village in 2003. With the improvement of W/S, the problem of drainage system cropped up. GP decided to take up a drainage scheme in 2003, subsequently mobilized *Panchayati Samiti* and its engineeres to approve the project to the tune of Rs 1.53 lac for preparation of an underground drainage system for collection, treatment and reuse of greywater for irregation and gardning purpose.

The salient feature and items proposed by GP and approved by ZP under this scheme are as follows:

Status:

- GP executed the scheme as sanctioned by ZP and spent Rs 1.53 lac out of sanction amount of Rs 1.54 lac
- In addition, the GP mobilized Rs 60,000/- (60% of the prize money as received under Nirmal Gram Purskar and 40% from public contribution varying Rs 500/- to Rs 1000/- per family came forward to support the GP) for providing 3 Nos. filters for treatment of greywater

10 For further details, pls contact, Dr. S.V. Mapuskar, Appa Patwardhan Society, Pune, Maharashtra Ph: 020-27697204

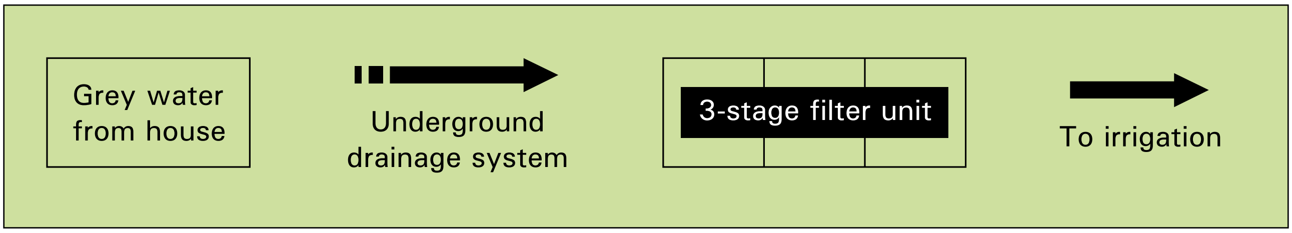
- GP has been selling greywater after treatment from 2 Nos. filters to the farmers for irrigation. GP has been earning Rs 200/- per year from 2 farmers for one time withdrawal of the treated greywater in a year
- Greywater after treatment from one filter is used by GP for gardening purpose
- The system comprises of following components:
  - 605m underground drainage system (8 to 9 inches dia. RCC pipe) for transportation of greywater (bathroom, cloth washing waste) to 3 Nos. filters located in 3zones
  - Provided 37 Nos. (square manholes)
  - 3 Nos. filters
  - 95 Nos. house service connection to drainage system
- Filter unit cleaned every 4 months (pre monsoon & post monsoon).

Benefit accrued:
- Clean village road
- Mosquito problem solved
- Odour problem solved
- No mosquito borne disease in the village due to improved sanitation.

Beneficiary satisfaction:
Very High.

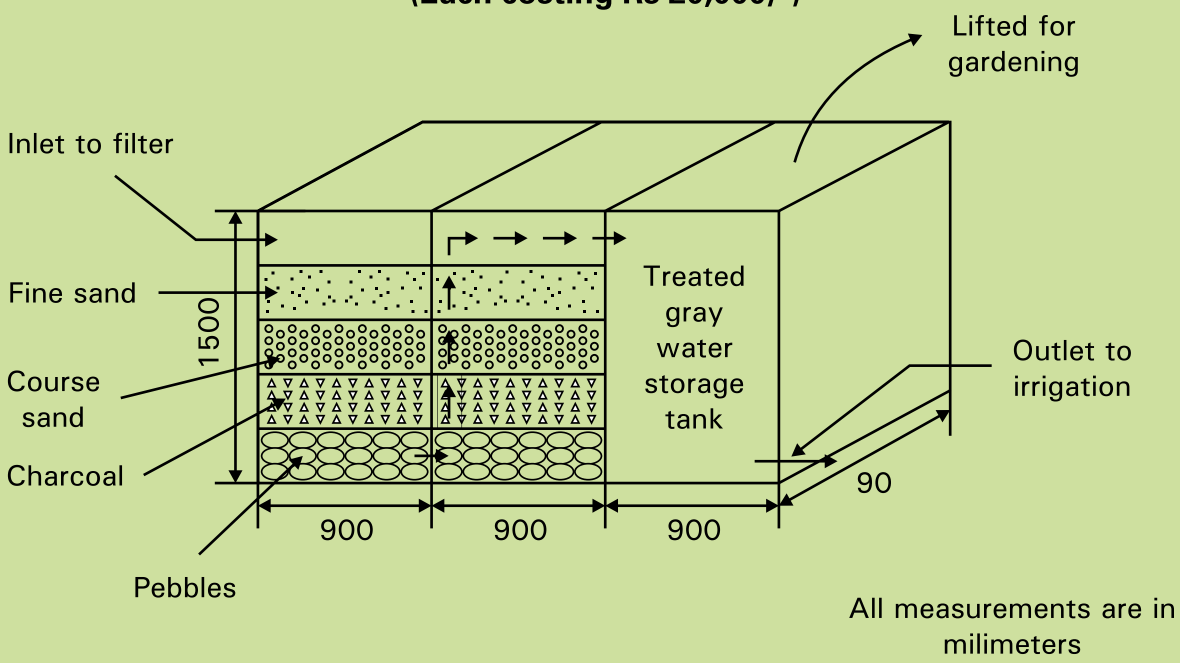
Replicability:
Possible with provision and implementation of safety plan for greywater reuse after treatment.

S. No.	Item	Proposed by GP	Approved & sanctioned by Z.P.
1.	Underground drainage system by using 8 to 9 inch dia. R.C.C pipes	1200m	605m
2.	Manholes	60nos. (circular)	37 nos. (square)
3.	Filters	6 nos.	Nil
4.	No.of house connections	170	95 (of which BPL30)
5.	Estimated cost	Rs 3.00lac	1.54 lac
6.	Funding pattern	10% GP contribution 90% Yashwant Gram Sammridhi	100% Z.P. cess fund

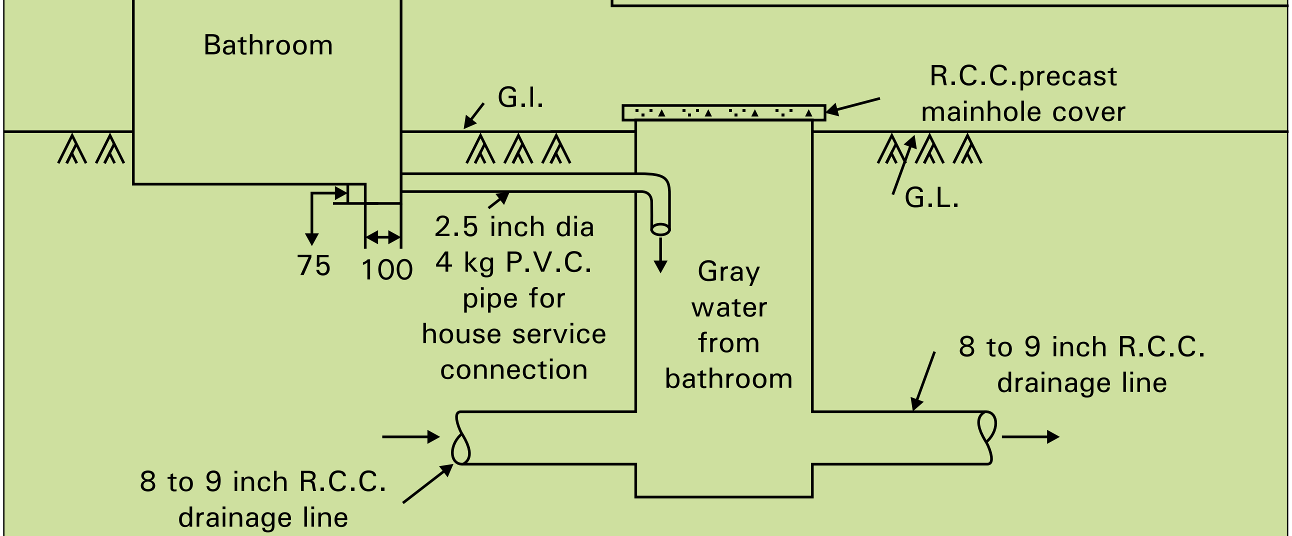


Greywater pumping by cycle pump and its use for gardening

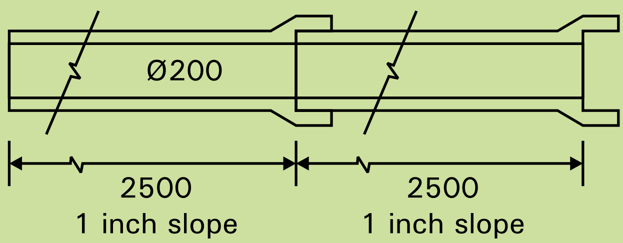
3 Stage filter unit
(Each costing Rs 20,000/-)



Mainhole (House sewage connection to drainage system)



R.C.C.pipe



Case Study-11

Black Water Management from 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 M^3 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.

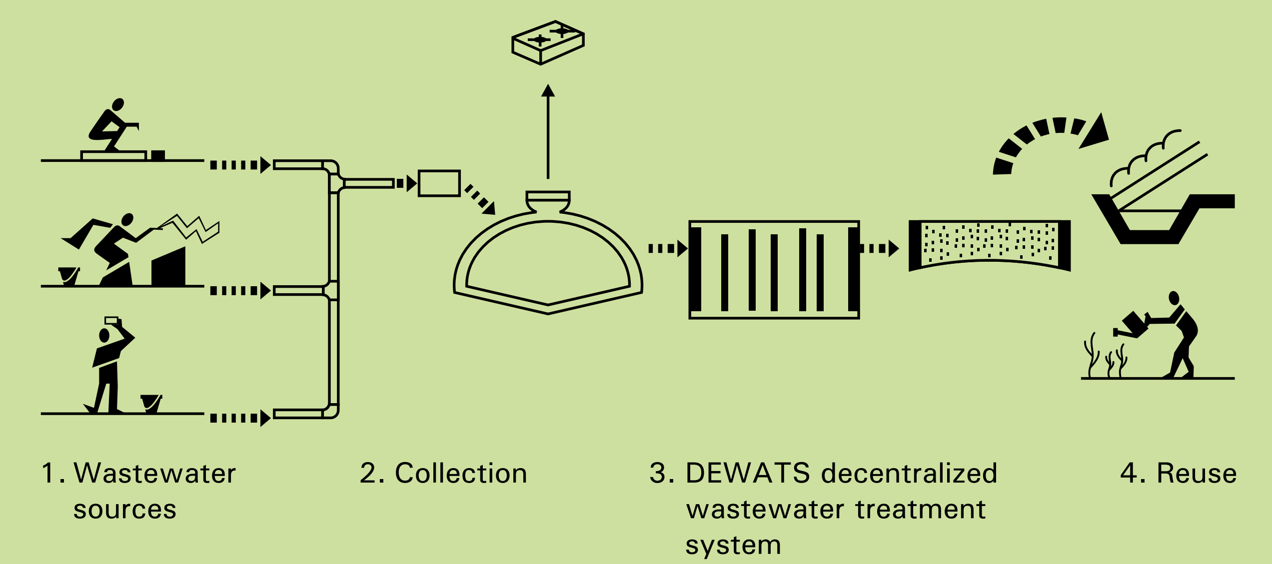
DEWATS in tiruchi city corporation community toilet

- 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 m^3 of water and generates three m^3 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.

DEWATS-linked sanitation components



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.

Case Study-12

Covered Drainage System in Banthra Village Uttar Pradesh

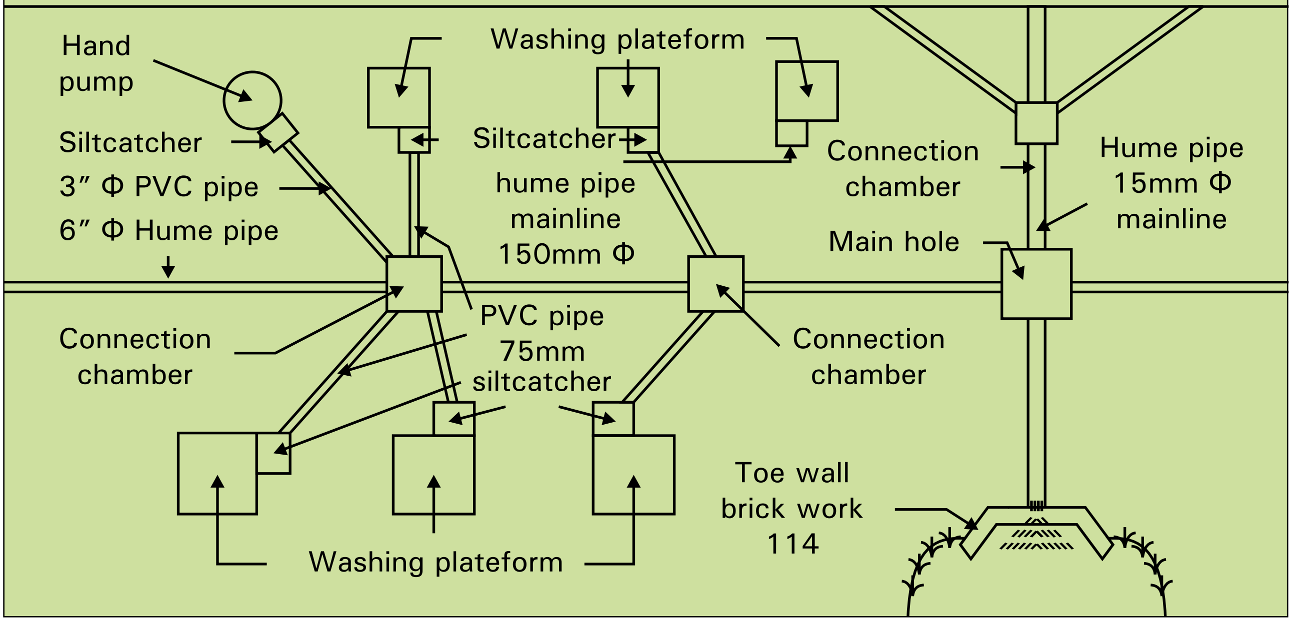
In this field an exemplary work done in 1971-72 in Ambarpur majra, village Banthra of district Lucknow, Uttar Pradesh. Department of state planning, Government of Uttar Pradesh was involved to pilot this project. Every household's waste water connected with covered drainage system.

These designs were the out comes of successful implementation of so many experiments. This design is also known as low cost sewerage system[11].

Main feature:

In this system waste water goes through

Model lay-out plan for under ground drain



11 *For further details, pls contact Mr. A. K. Singh, Deputy Director, Panchayat Raj Dept, Govt of UP, Lucknow, U.P. Ph: 09415447848*

underground covered cemented pipe line in place of open drainage system. After the success of these underground drainage systems and keeping in view the availability of PVC & Hume pipe in the local market, a slight change have been made for the safety point of view, the cemented pipe is replaced by PVC & Hume pipe. After the construction of **silt catcher** at household level it is connected with 3″ PVC pipe and finally connected with 6″Hume pipe with the main line. In house silt catcher should be constructed near the plate farm made for washing purposes and pipe slope should be kept approx 1:200. Instead of bends it is better to provide chambers in turning points of pipe lines. At the end of the drains hard Toe wall should be constructed. This is very important to keep construction quality in good and people's participation is necessary during planning, construction and maintenance of structure constructed.

For proper O& M the depth of underground drainage should be at least 60cm so that pvc pipe line is safe from any surface pressure. Silt catcher should be clean at least once in a weak. Time to time water should flow in the drains. The important aspect for the O&M is active people participation and awareness in the community.

Costing and economic viability:

Tentative estimated cost of underground drainage for 10 households having 100 mt. Hume pipe and 200 mt. PVC pipe is around Rs 49454.00 maintenance is done by users them self.

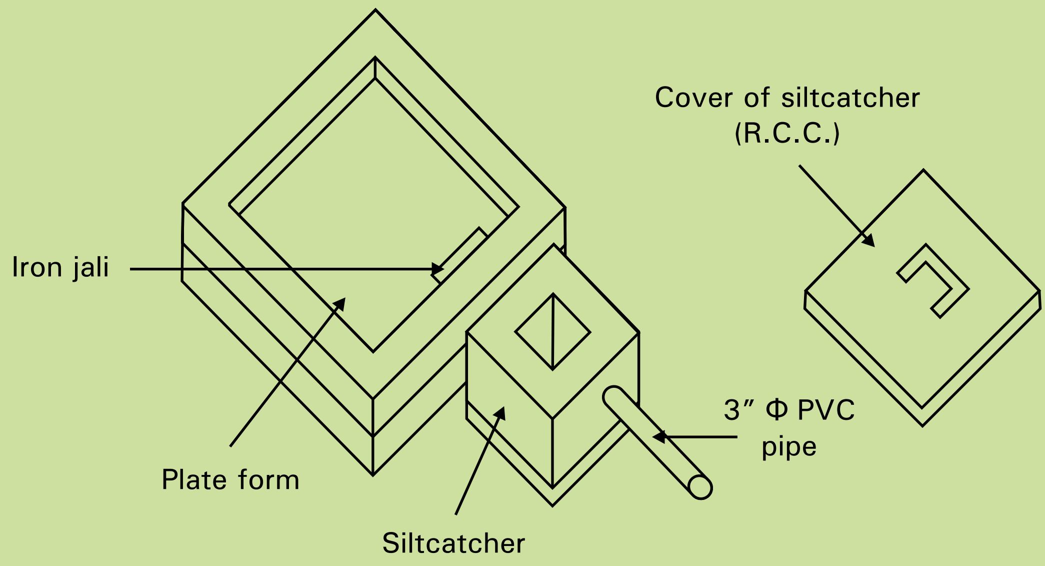
Advantages:

This pilot is very much appreciated by users because against open drain system, close drain system is more useful and due to low maintenance cost this system is economical viable. This system keeps surrounding environment more clean and safe against health hazards. Pipes were buried 60cm below the ground surface so this system is more sustainable than open drain system. Socially this system is more acceptable than any another because house holding using the system had developed participatory approach and developed more capacity of community in respect to economy, relationship and awareness.

Limitations:

Silt catcher needs regular cleaning and proper disposal of greywater coming from houses should be disposed safely otherwise this will create mosquito breeding spots in surrounding area and bad odour.

Plateform with siltcatcher for under ground drain system



Case Study-13

Eco Friendly Plastic Fuel (Conversion of Waste Plastic into Liquid Hydrocarbons/Energy)

A major breakthrough in the arena of Non-conventional sources of 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.*

2. 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.

3. 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

4. Test reports

a. Comparative data of various chemical properties of regular petrol and fuels extracted from plastic

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/m^3 max.)	40	36
Reactivity with SS, MS, Cl, Al, Cu	Nil	Nil

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)		

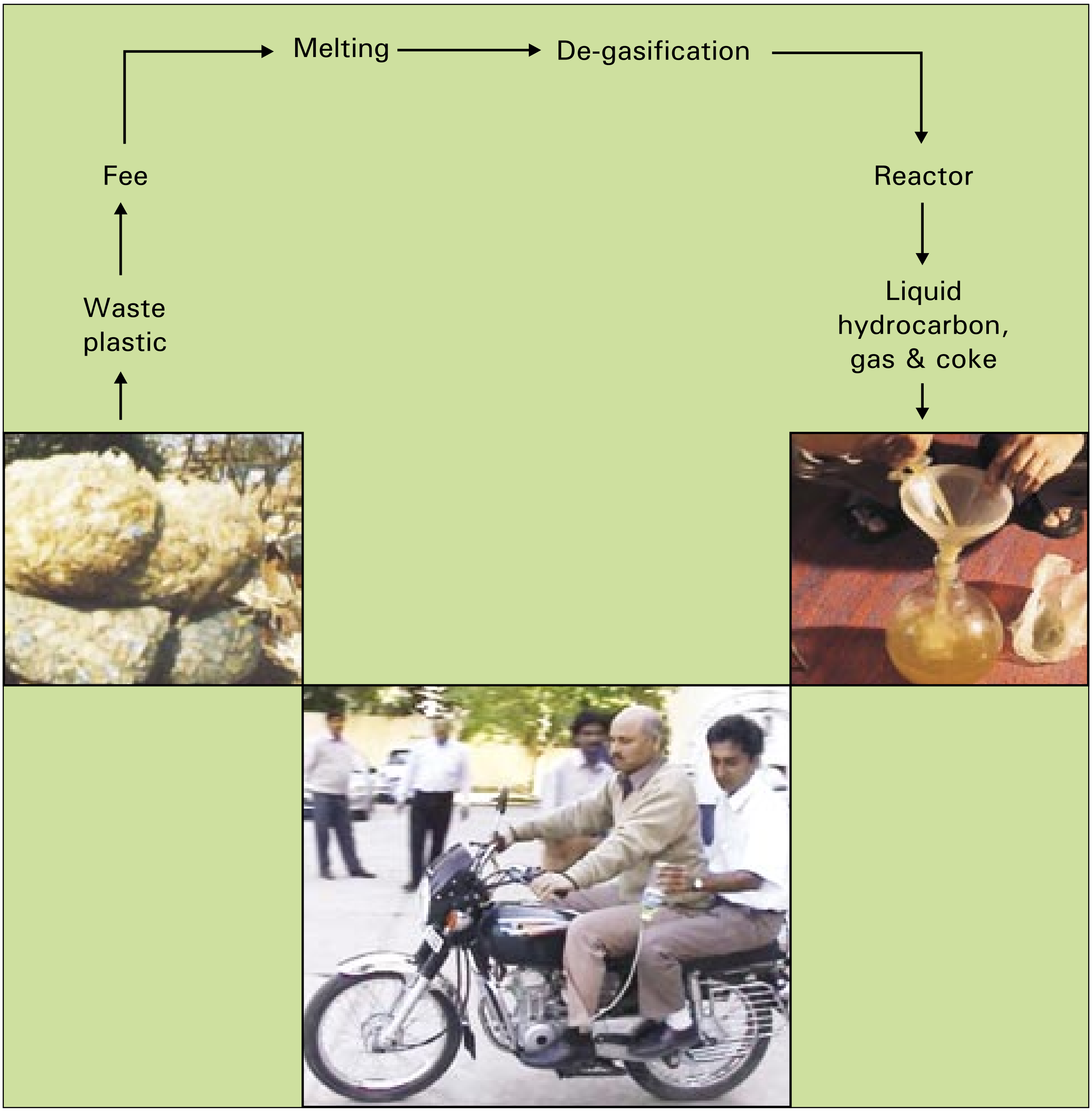
a specially designed Reactor in absence of oxygen and in the presence of catalytic additive. The maximum reaction temperature is 350°C.
It is a unique process in the world which converts 100% waste into 100% value added products[12].

Note: Above mentioned tests were carried out by State Bank of India's Technical team.

In spite of the above mentioned facts, the fuel extracted from plastic waste will be utilized strictly as Non-Motorized fuel to start with.

5. 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.



12 *For further details, pls contact Prof. Mrs. Alka Umesh Zadgaonkar, Head of Department of Applied Chemistry, G.H. Raisoni College of Engineering, Nagpur, Maharashtra*

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.

Commercial Plant at Butibori, Nagpur

Case Study-14

Gray Water Recycling with Piped Root Zone Treatment

Nirmal Gram Nirman Kendra has put forth a concept named as "Zero Waste House" which means that all the wastes generated in a household, can & should be recycled at household scale in an economic manner. As a part of this concept, some techniques have been developed to reuse/recycle greywater generated in a household. Greywater Recycling with piped Root Zone Treatment is one such technique.

Sixty percent of the incoming water in a house hold, goes out again as greywater (waste water from bathroom, laundry & kitchen) This water does not contain any pathogens, however indiscriminate disposal of the same gives rise to many problems such as 1) filthy & unhygienic surroundings & 2) vector breeding & consequent spread of vector borne diseases. At the same time water – the precious commodity of the time is totally wasted in the form of greywater.

In the system developed by Nirmal Gram Nirman Kendra, greywater from the household, after some treatment, flows directly to the root zone of the plants in a kitchen garden One such system is operational in a Zero Waste House of Shri.G.C. Bhatevara, Bajirao Nagar,Tidake Colony in Nashik City. This has resulted in saving of fresh water to the extent of 60%.
The treated greywater is being recycled & reused for growing flower, fruits & vegetables successfully for last two years[13].

Main features of the system

The waste water from bathroom, kitchen & laundry passes through a settling chamber, a filter & finally through perforated PVC pipes

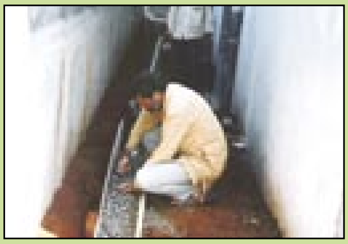
13 *For Further details pls contact Mr. Sriknat Navrekar, Nirmal Gram Nirman Kendra, Goverdhan (Gangapur) Nashik 422 222 Tel. (0253) 2231598 e-mail: nirmalgram@rediffmail.com*

which are laid at the root zone of the garden plants along the periphery of the plot. The flow of water can be controlled and diverted to desired area with the help of controlling valves. At the end of the pipe line there is an under ground leach pit which acts as a stand by arrangement when the water is not required in the garden (e.g. rainy season).

The greywater automatically flows from the point of generation to the end of the treatment unit & one does not see a single drop of dirty water. On the contrary the courtyard of Shri. Bhatevara is always flourished with flowers (roses, chrysanthemum, seasonal flowers), vegetables (Lady's finger, spinach, guar), & fruits (Papaya, Chikoo).

Grey water from house → Settling chamber → Three stage filter → Perforated pipes in the garden (underground) → Leach pit (stand by)

Three stage filter



Filling of trench with gravels

Laying of perforated pipes

Completed grey water recycling system

Salient features:

- Decentralized treatment of waste water
- Low cost option
- No foul odour
- No filthy sights
- Full utilization of waste water & saving of fresh water
- Easy to operate & maintain.

System components:

The System comprises of following components.

Operation & maintenance:

- Cleaning of silting chamber – once in a week
- Cleaning of Filter – once in a month or as per requirement
- Cleaning of pipe lines – once in a year.

Costing & economic viability

- Total plot size – 50ft x 70ft = 3500sft
- Total cost – Rs 15000/-
- Cost per sft-Rs 5/-
- Cost per rft – Rs 62/-
- Saving of fresh water-Sixty percent fresh water is saved
- Gain in the form of fruits & vegetables – Availability of pollution free fresh fruits, vegetables & flowers through out the year.

Limitations

Use of strong detergents may prove harmful to the plants. The house owner uses soft soap which has not shown any harmful effects so far.

Annexure

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Abbreviations

CCDU	Communication and Capacity Development Unit
DDWS	Department of Drinking Water Supply
GP	Gram Panchayat
MoRD	Ministry of Rural Development
NFHS	National Family Health Servey
NGP	Niraml Gram Puruskar
PRIs	Panchayat Raj Institutions
RNDWM	Rajiv Gandhi National Drinking Water Mission
SHG	Self Help Groups
SLWM	Solid and Liquid Waste Management
TSC	Total Sanitation Campaign
UAA	Uttaranchal Academy of Administration
WHO	World Health Organization
ZP	Zilla Parishad

Government of India
Ministry of Rural Development
Department of Drinking Water Supply
Rajiv Gandhi National Drinking Water Mission
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Lodi Road, New Delhi-110003

website: www.ddws.gov.in