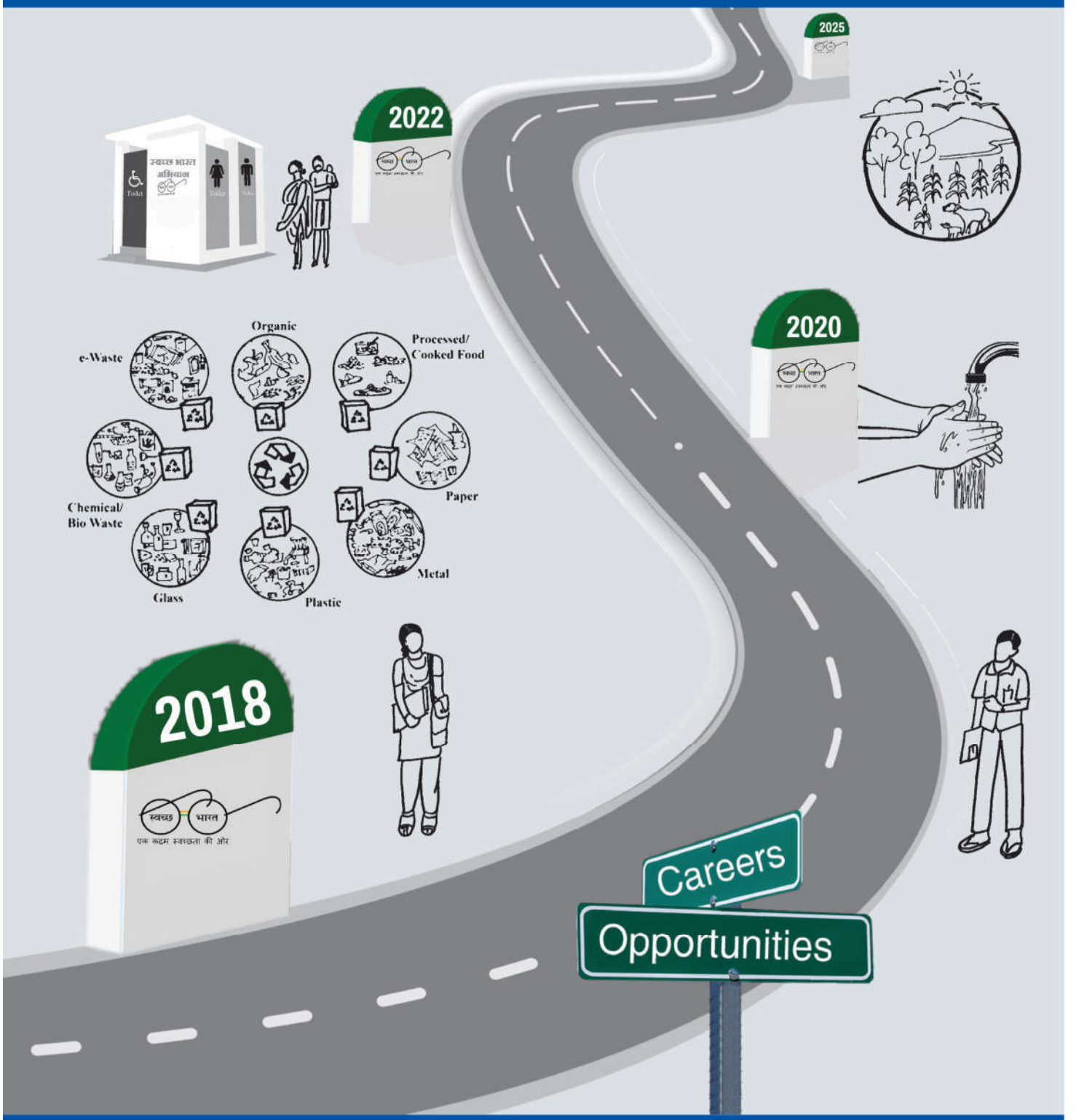
Environmental Hygiene, Sanitation and Waste Management

An Elective Course for all Undergraduate Programmes



सत्यमेव जयते

Mahatma Gandhi National Council of Rural Education
Department of Higher Education
Ministry of Human Resource Development Government of India

Where there is Rural Wellbeing there is Universal Prosperity

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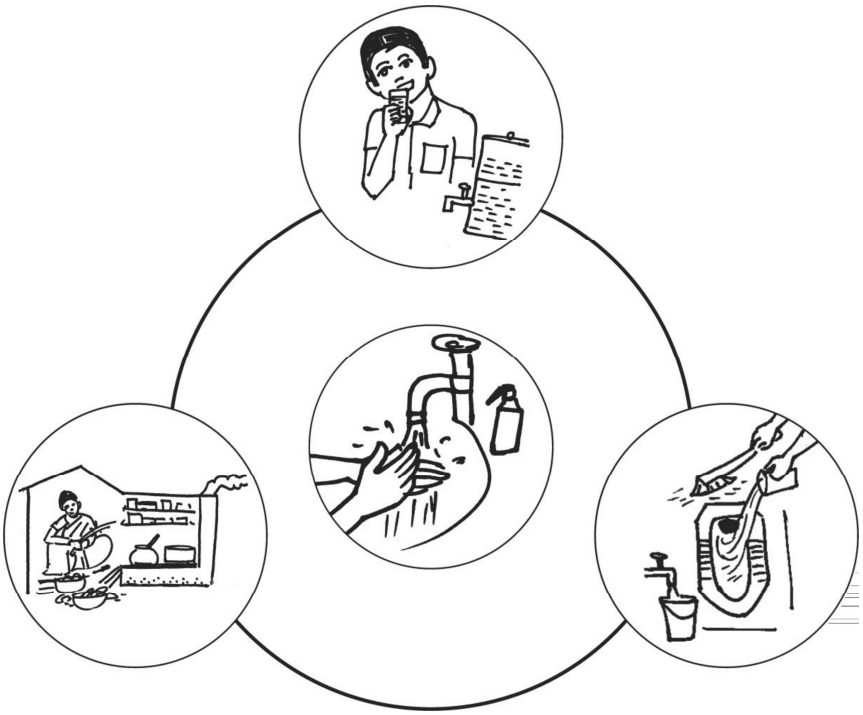

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Contents

Foreword

Environmental Hygiene, Sanitation and Waste Management are key methods to make 'Swachhta' a way of life. These vital operatives also create a wealth of opportunities for the youth of India, when ably backed by government support, community awareness and concerted efforts by one and all.

Over the last few decades, centralised waste collection, 24 hour water supply, uninterrupted power supply, water-based flushing systems, availability of disposable items and many other amenities have brought in their wake many new challenges especially in terms of handling large quantities of waste. To bring focus to the issues concerning waste management and sanitation, the Ministry of Environment, Forests and Climate Change, Government of India, promulgated the Solid Waste Management Rules 2016. This was preceded by the clarion call of the Prime Minister for a "Swachh Bharat" in 2014, associating this with Mahatma Gandhi as he was a great champion of the cleanliness cause in the country and throughout his life was involved in activities related to sanitation and hygiene. Further, the Ministry of Urban development rolled out Swachh Survekshan to usher in a spirit of competitiveness amongst urban local bodies in the country. These steps have brought in a sense of participation by all concerned to achieve the larger objectives of a Clean India.

A clean and healthy environment is our fundamental right (Article-21 of the Indian Constitution). Conversely, it is the fundamental duty of every citizen to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures (Article 51-A (g) of the Indian Constitution). Rights and responsibilities go hand in hand and there is wave of enthusiasm towards achieving the goals of a Clean India as envisaged by Mahatma Gandhi.

The objective of this elective is to make students aware of their immediate surroundings and think on lines of environmental hygiene, sanitation and waste management. Students and young people need to take the initiative in curbing open defecation, constructing toilets, eradicating manual scavenging, bringing about behavioural changes in people, creating general public awareness about health and hygiene, and building operative systems to design and execute operations related to cleanliness. Apart from this, students need to handle waste management techniques, scientific processing of waste, waste disposal methods, and reuse and recycling of waste.

By choosing this elective course you, the youth of the country, have chosen a cleaner way of life. It is our attempt through this course to guide you in the right direction with concepts as well as practical knowledge to empower you as harbingers of a Clean India. After all, knowledge without application is waste!

Dr. W G Prasanna Kumar
Chairman, MGNCRE

Be the change that you wish to see in the world.
- Mohandas Karamchand Gandhi

Curriculum

The curriculum is for one semester. It is interdisciplinary in nature and more practice oriented.

S. No	Module Title	Module Content	Teaching/ Learning Methodology	No. of classes
1	Environmental Hygiene (EH), Sanitation, Solid Waste and Wastewater: Perspectives	Prevailing scenario in EH, Sanitation, Waste and Wastewater- Urban and Rural- Risk Factors, Challenges & Work Opportunities in the District, City and State in India	Checklists, Classroom, Reports, Group Exercise	4
2	Environmental Hygiene and Sociology of environmental hygiene management, solid waste and waste water and impacts	Community Consciousness and Engagement on Sanitation Aspects, Roles & Responsibilities, Job Charts, Frequency, Schedules and Timelines in Swachhta Management, Culture of Cleanliness (Swachh Bharat Abhiyan), Behaviour Change Communication, Role of Habits and Attitudes in Environmental Hygiene Management, Waste and Wastewater Disposal; Change Management.	Checklists, Case Studies Lecture, Field Visit, Participative Learning and Action, Preparation of Aids and Coaching for Awareness Programmes	6
3	Sanitation /EH, Waste, and Wastewater Management as Participatory Learning.	**Sanitation / EH:** Sanitation infrastructure Status evaluation **Waste** : Social Mapping, Resource Mapping of Waste Infrastructure **Wastewater:** Audit and Feasibility Study for Management Practices.	Checklists, Field Visit, Mapping, Demonstration, Participation, Interaction with Adjunct Faculty (NGOs, Industry, ULBs, Private Sector Service Providers)	8
4	Sanitation Audit	Evaluation of Construction and Maintenance of Community, Public, Institutional and Individual Sanitation Infrastructure Toilets- Proportion and Number of toilets, Gender Sensitive Sanitation Facilities, Ramps for Differently Abled, Types – Indian and Western Faecal Sludge treatment- Single / Twin pit, Eco San, Septic Tank and Formal Sewerage.	Checklists, Class Room, Survey Formats, Field Visits, Web Tools	6
5	Waste & Wastewater Audit	**Waste Audit** Environmental Impact Assessment, Waste characterisation, Quantity Determination, Primary Collection Methods, Secondary Transportation **Wastewater Audit** Water Budget, Types of Wastewater, Survey of Distribution Network and Feasibility of Various Wastewater Treatment Methods	Checklists, Neighbourhood Field visit, Classroom Interaction and Group Exercise	8

6	Technology for Toilets and Sanitation; Construction and Maintenance, Recovery of Resources from Waste and Treatment of Wastewater	**Toilets** Latest Technologies in Toilet infrastructure with Emphasis on Feasibility of Usage, Maintenance and Sustainability Waste Robust Decentralised / Centralised Solutions Including, Source Segregation, Composting and Recycling (3R), Zero Waste Institution Wastewater Technologies to Separate Black and Grey Water, Wastewater Treatment Methods, Quality of Treated Water (3R) Soil Soil Restoration and Night Soil Management	Checklists, Case Study, Films, Interview, Field Visits Adjunct Faculty(NGOs, Industry, ULBs, Private Sector Service Providers)	8
7	Management and Administration of Environmental Hygiene, Swachhta, Waste to wealth programmes and Wastewater treatment programs	Management of Collectives (Kutumbasree Kerala and Swachh Pune), IHHL Procedures, Community Sanitation , Maintenance of Community Toilets, Waste Management Methods and Techniques, Government Priorities, Local Involvement, Political Will, Community Mobilization, Resolving Bottlenecks, Addressing Environmental Hygiene and Safety.	Checklists, Classroom Teaching, Case Studies, Interviews, Research. Adjunct Faculty(NGOs, Industry, ULBs, Private Sector Service Providers)	8
8	Internship	Participative Life Cycle Analysis of Wastewater Management Participative Cradle to Grave Approach to Solid Waste Management Operations of a Facility in the Neighbourhood	Checklists, Engaged Learning and Field Placement	1 Month

Introduction

This course is designed specifically for the students interested in becoming change harbingers and ushering in a clean and new India. The sectors of Environment Hygiene and Sanitation offer several opportunities for employment as well as social entrepreneurship thereby enabling careers making a living out of sanitation and waste management sectors. It is for those who are enthusiastic about bringing a positive change in society by employing and incorporating Environmental Hygiene, Sanitation and Waste Management as a way of life.

The format of the material is prepared accordingly. Some current information on most of the topics is presented in a comprehensible and easy to read manner. Unlike other traditional text books which are supports for classroom teaching, this book is the foundation or stepping stone to classroom teaching. Traditionally, students attend lectures, take notes given by their teachers and the conventional textbooks work as reference books at the time of revision, prior to the examination.

In contrast, this course has been designed for hands-on knowledge and gaining work experience. Students are expected to prepare on the aspects given in the relevant chapters before participating in the class. With background understanding and self-study of several relevant study materials, the participants will be better prepared to transact in the field.

Practical field work is the mainstay of this course. All exercises in the course of this study include field work at grassroots level. It is suggested that the fieldwork be done in pairs or manageable groups of 4-6 members. All field work needs to be carried out with prior approval and in consultation with the allotted guide or faculty.

Textual knowledge will provide the right backdrop for contrasting with ground realities. Several interesting case studies pepper this course book to make it relevant and appealing.

Emphasis is laid on knowledge sharing. Participative learning and action, verbal and written communication skills, interviewing techniques, primary and secondary data collection methods, filing reports and making classroom presentations will be honed during the course. It is essential for students to discuss and debate on their findings to keep the learning process vibrant.

Unit 1

Perspectives: Environmental Hygiene, Sanitation and Waste Management

Approach Methodology

Step 1: Have a 10 minute open-ended discussion to gauge students' level of understanding of environmental hygiene.

Step 2: Traditional classroom teaching using the contents of this chapter.

Step 3: Students plan out interesting activities for Oct 15 and Nov 19.

Step 4: Field visit to a Primary Health Clinic (PHC)/ Guest lecture by Resident Medical Officer (RMO) to throw light on the prevalent communicable diseases in your area.

Step 5: Learn about Swachh Bharat Mission

Introduction

The current Indian population is 135.70 crores, equivalent to 17.74% of world population. Urban population constitutes 33.2% of the population (44.93 crores), and is expected to increase to about 60 crores by 2030. About 8% of urban households practice open defecation, about 9% use community toilets, while about 14% households use shared toilets. About 19% households do not have access to proper drainage network, while about 40% of households are connected to open drains. India's rural statistics reveal that about 70% of the rural population defecates in the open.

Based on this backdrop, this text book on Environmental Hygiene, Sanitation and Waste Management provides vital information, key statistics, knowledge inputs, and practical exercises. The curriculum prepares aspiring students to take on this much needed subject and become contributors to society.

The vision for India is that all Indian cities, towns and villages become totally sanitized, healthy and livable.

Swachh Bharat Mission (SBM) emanates from the vision of the Government articulated in the address of The President of India in his address to the Joint Session of Parliament on 9th June 2014: "We need not tolerate the indignity of homes without toilets and public spaces littered with garbage. For ensuring hygiene, waste management and sanitation across the nation, a "Swachh Bharat Mission" will be launched. This will be our tribute to Mahatma Gandhi on his 150th birth anniversary to be celebrated in the year 2019."

SBM is being implemented by the Ministry of Housing and Urban Affairs (M/o HUA) and by the Ministry of Drinking Water and Sanitation (M/o DWS) for urban and rural areas respectively. These guidelines are for the implementation of Swachh Bharat Mission (Urban).

Introduction: According to Census 2011, India's urban population is 377 million or 31% of the total population. These numbers are expected to increase to 600 million by 2031. The Census 2011 also showed that in 4,041 statutory towns, close to eight million households do not have access to toilets and

defecate in the open (7.90 million). Weak sanitation has significant health costs and untreated sewage from cities is the single biggest source of water resource pollution in India. This indicates both the scale of the challenge ahead of the Indian cities and the huge costs incurred from not addressing them.

Mission Objectives

- Elimination of open defecation
- Eradication of Manual Scavenging
- Modern and Scientific Municipal Solid Waste Management
- To effect behavioral change regarding healthy sanitation practices
- Generate awareness about sanitation and its linkage with public health
- Capacity Augmentation for ULB's
- To create an enabling environment for private sector participation in Capex (capital expenditure) and Opex (operation and maintenance)

Duration of the mission

The Mission will be in force till 2nd October 2019

Mission components

- The Mission has the following components:
- Household toilets, including conversion of insanitary latrines into pour-flush latrines
- Community toilets
- Public toilets
- Solid waste management
- IEC & Public Awareness
- Capacity building and Administrative & Office Expenses (A&OE)

By Public Toilets, it is implied that these are to be provided for the floating population / general public in places such as markets, train stations, tourist places, near office complexes, or other public areas where there are considerable number of people passing by. By Community toilets, it is implied that a shared facility provided by and for a group of residents or an entire settlement. Community toilet blocks are used primarily in low-income and/or informal settlements / slums, where space and/or land are constraints in providing a household toilet. These are for a more or less fixed user group.

Read more: https://www.ircwash.org/sites/default/files/guidelines_for_swachh_bharat_mission_-_urban.pdf

The widespread open defecation in rural India can be attributed to age old beliefs, values and norms. People reject affordable latrines, deeming it ritually polluting and impure. Weak sanitation has significant health costs and untreated sewage from cities is the single biggest source of water pollution in India. This indicates both the scale of the challenge ahead of the Indian cities and the huge costs incurred from not addressing them.

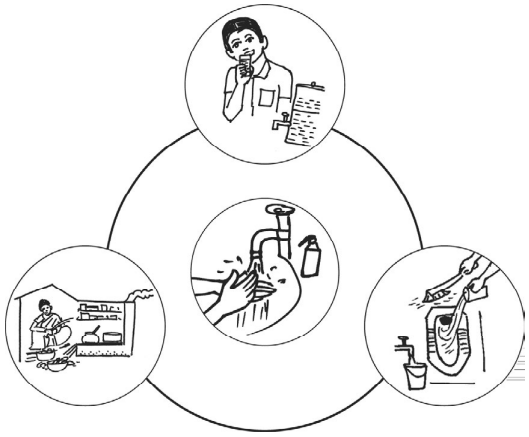
To start with, students must learn about Environmental Hygiene, Sanitation and Waste Management with a wider perspective.

Environmental Hygiene

Conditions or practices helpful in maintaining the basic healthy environmental conditions for human and for preventing diseases, especially through cleanliness. For example clean water supply, proper human and animal waste disposal, protection of food from contamination, and clean home , all of which are concerned with the quality of the human environment (IUPAC Glossary of Terms Used in Toxicology, 2nd Edition, 2007).

Benefits of Environmental Hygiene: Good sanitation and waste management have direct impacts on the local environment.

- Sanitation is, defecation in properly constructed latrines. This ensures that land is not contaminated with human waste and water sources no longer act as sewers. This allows plant life, fish and other aquatic organisms to flourish.
- Good waste management leads to less litter in the streets and in the neighbourhood of waste disposal sites. It also reduces the smell and flies from decomposing wastes.
- Environmental Hygiene leads to good health, making people more productive, which brings economic benefits to them and to the wider community.



Sanitation

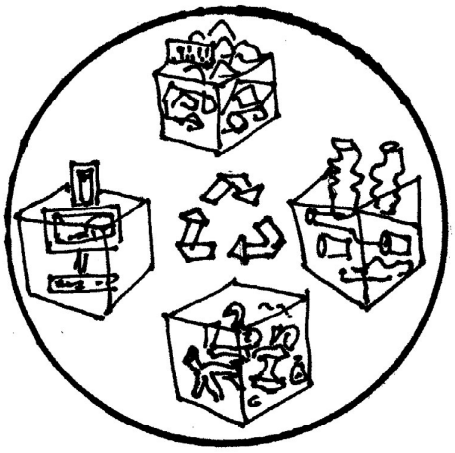
Sanitation is the process of keeping places clean and healthy, especially by providing a clean water supply and proper sewage system to prevent human contact with faeces. All human excreta and liquid wastes from all sanitation facilities including toilets must be disposed of safely. Maintaining network-based sewerage systems, recycling and reusing of treated waste water, promoting proper disposal and treatment of sludge from on-site installations (septic tanks, pit latrines), ensuring safe collection of all human wastes and their subsequent disposal after treatment are some of the measures for good sanitation.

In terms of medical health care the term environmental hygiene encompasses effective cleaning of surfaces

using appropriate products, decontamination of medical equipment and devices used in patient-care procedures, safe and appropriate handling of sharps, blood and body fluid spills, waste and linen, which essentially means the careful handling of bio-medical wastes. This is a very important part of a medical worker's life, as the maximum variety of germs enters the hospital premises along with sick patients.

Waste Management

Waste Management encompasses the process of collection, transportation, and disposal of garbage, sewage, and other waste products. It includes proper handling of waste materials, from maintenance of waste transport trucks and dumping facilities to compliance with health codes and environmental regulations. India faces massive waste management challenges with rapid urbanisation, generating 62 million tons of municipal solid waste per annum. Only 43 million tons (MT) of the waste is collected, 11.9 MT is treated and 31 MT is dumped in landfill sites (government sources). Solid Waste Management (SWM) is one of the basic essential services to keep urban centres clean. Solid waste deposited haphazardly makes for a flawed system of waste disposal and management.



The Health Perspective

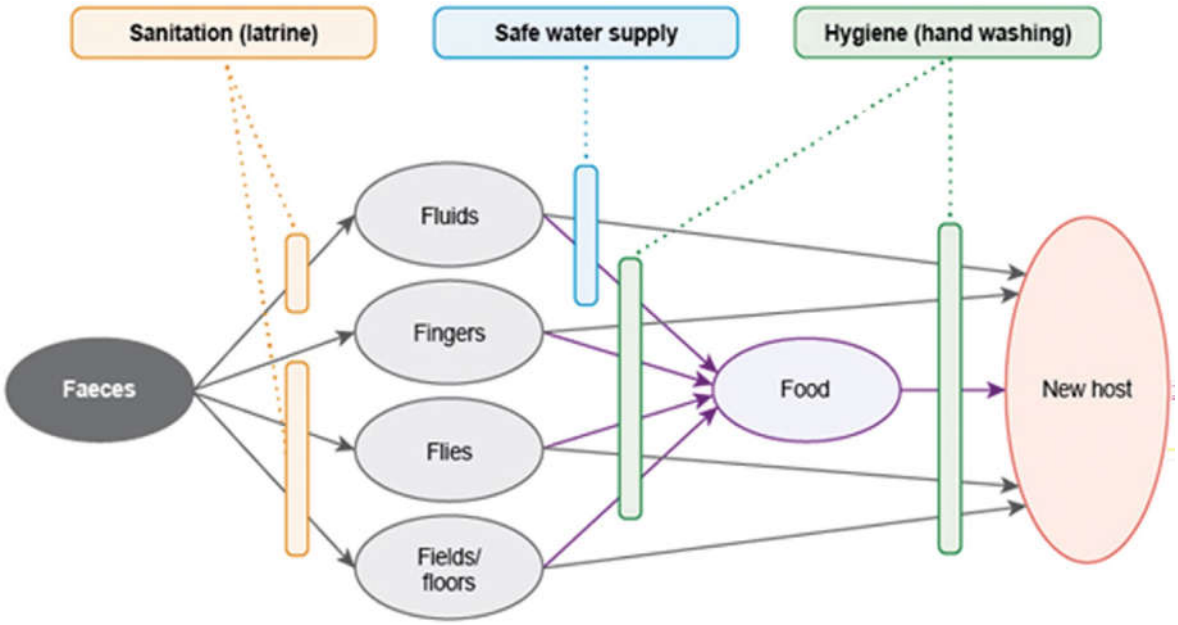
Urban and peri-urban areas are characterised by poor sanitation conditions, indiscriminate dumping of wastes and open urination and defecation. Urban and peri-urban pollution and overcrowding create significant vulnerabilities for the overall urban population, particularly the poor. Environmental impacts of poor sanitation and waste management at a local level include pollution of land and water sources, the visual impact of litter, and bad odours. Inadequate sanitation, particularly in the context of urbanization, allows for sewage or waste to flow directly into streams, rivers, lakes and wetlands, affecting coastal and marine ecosystems, fouling the environment and exposing millions of young people to disease.

Lack of safe water, inadequate excreta disposal facilities, poor hygiene, poor living conditions and unsafe food can all cause diarrheal diseases. Diarrheal disease is one of the leading causes of morbidity (illness) and mortality (death) in developing countries, especially among children below five years. Human excreta have been implicated in the transmission of many infectious diseases including cholera, typhoid, infectious hepatitis, polio, cryptosporidiosis, and ascariasis. Climate can affect disease transmission in a variety of ways. The distribution and population size of disease vectors can be heavily affected by local climate.

Health problems associated with poor sanitation and management of wastes

Disease-causing agent	Disease	Description
Bacteria	Shigellosis	Causes abdominal pains and diarrhoea
	Typhoid	Mild to severe fever lasting from a few days to several weeks
	Cholera	An infection of the intestines that can cause watery diarrhoea leading to dehydration
	Diarrhoeal diseases (note these can also be caused by viruses)	Production of frequent watery faeces that can lead to dehydration. Can be fatal, particularly among young people Diarrhoea is a symptom of several other diseases in this table
Viruses	Hepatitis A	An infection of the liver that can cause pain, diarrhoea and jaundice
	Polio	Can cause temporary or permanent muscle weakness, and sometimes death.
Protozoa	Amoebiasis (also known as amoebic dysentery)	Infection that can occur up to several years after exposure to the protozoa. Can cause mild to severe diarrhoea and liver damage
	Giardiasis	Infection of the small intestine. It is usually symptomless but can have a variety of intestinal symptoms, such as chronic diarrhoea, abdominal cramps, gas production and frequent loose, pale and greasy stools
Parasitic worms	Ascariasis (roundworm)	One in four of the world's population has this infection, which can lead to weight loss, malnutrition and anaemia
	Hookworm infection	Two species of nematodes that inhabit the small intestine, from where they suck blood, leading to anaemia
	Tapeworm infection	A worm that normally lives in the intestines which can cause anaemia and malnutrition. This is usually spread through eating improperly cooked food that contains the worm or its eggs
	Bilharzia or schistosomiasis	A disease caused by the Schistosoma worm that can cause diarrhoea and blood in the urine and faeces. In the long term, it can lead to liver and kidney damage

Schistosomiasis is caused by a parasitic worm that has a complicated life cycle. Its primary host is humans, but its secondary host is a type of freshwater snail. The disease is linked to poor sanitation because it is caused by the faecal contamination of water. However, the worm gets into the body not by the faecal-oral route, but by penetrating through the skin when someone washes, swims or stands in water inhabited by infected snails.



To promote better methods of Environmental Hygiene, Sanitation and Waste management, a number of international and national organisations have come together to observe specific days.

World Toilet Day19th November looks beyond achieving sanitation by all as an end. It aims to make access to safe and improved sanitation and hygiene sustainable for all. Good management of human waste, Faecal Sludge Management (FSM), is the safe collection, transport and treatment of human waste from sanitation installations. Governments, NGOs and Public Enterprises need to focus on FSM. Human waste can be converted to biogas and solid fuel. It can be converted to agricultural compost, organic fertilizer and soil conditioner. Water can be extracted from human waste - 75% from excreta and 95% from urine. Bill and Melinda Gates Foundation is working on this ground-breaking research. 'Toilet Board Coalition' is an example of a group driving proactive dialogue which encourages self-sustaining businesses and investments in sanitation.

Student Activity: Conduct awareness program by visiting neaby villages and surrounding colonies.

October 15, declared by WHO as Global Hand-washing Day, is a global advocacy day dedicated to increasing awareness and understanding about the importance of hand-washing with soap as an effective and affordable way to prevent diseases and save lives. Global Handwashing Day is an opportunity to design, test, and replicate creative ways to encourage people to wash their hands with soap at critical

times. Many institutions are spreading awareness among young people in educational institutions about the correct methods of hand wash. Also understand that the intent of washing hands is to kill pathogenic bacteria. However, our skin is home to a variety of good bacterial that are important for our skin health. Excessive washing, use of strong soaps and detergents, and strong chemical additives like triclosan can cause more harm to our skin and the environment. By adding anti-bacterial chemicals in large volumes in our waste streams can cause germs to become immune to these, as they get exposed to the chemicals in diluted forms and could potentially lead to 'super-bugs'. Hence, "When to wash, how to wash and with what to wash" are three important aspects of washing handsStudent Activity : Students need to learn the proper technique of washing hands and demonstrate it in class. Conduct awareness programs in neighborhood villages or colonies.

Menstrual Hygiene Day : May 28, declared asMH Day by WHO, is a global platform to bring together non-profits, government agencies, the private sector, the media and individuals to promote Menstrual Hygiene Management (MHM).

In a large part of a women life about once a month, females who have gone through puberty will experience menstrual bleeding. If pregnancy does not occur, this thickened lining is shed, accompanied by bleeding. Bleeding usually lasts for 3-8 days. For most women, menstruation happens in a fairly regular, predictable pattern.

Menstrual Hygiene Day will help to break the silence and build awareness about the fundamental role that good menstrual hygiene plays in enabling women and girls to reach their full potential. It catalyses a growing global movement for MHM and supports partnerships at global, regional, national and local levels.

Student Activity:

Study and understand the Menstrual issues faced by every woman, how she copes with the various related issues of anaemia, cramps, improper hygiene, odour problems, home and societal culture around menstruation, taboos and social norms. Improper menstrual hygiene not only puts her at risk of discomfort and illness, but also poses health risks for the people around her. Disposal of menstrual hygiene products need to be handled responsibly. Students need to talk freely and find out all the latest and best approaches to menstrual hygiene, types of materials used- cloth, disposable sanitary pads, reusable cloth femme pads, tampons, and menstrual cups. Find out the pros and cons of each method. Students need to interview women from different strata of society to understand their problems regarding this. It needs to be done in pairs or groups. Students need to break their own inhibitions and teach them to express their ideas clearly and without causing offence.

Case Study:

World Toilet College, Rishikesh, Uttarakhand:

World Toilet College India begins its journey in March 24, 2016. World Toilet Organisation (WTO) started the world's first World Toilet College to build capacity in toilet design and maintenance, cleanliness, and sanitation technologies in both urban and rural contexts. In order to tackle poor sanitation, we need to ensure that professionals are trained in the required skills and knowledge, including the design of toilets, technology, building toilets, cleaning and maintenance, eco-sanitation, waste management, and setting up sanitation social enterprises.

In 2015 World Toilet Organization (WTO) teamed up with the Global Interfaith Wash Alliance (GIWA), and Reckitt Benckiser (RB), to launch World Toilet College (WTC) in India. WTC was initially set up by WTO in Singapore, in response to the growing concerns and demands for better restroom maintenance, improved hygiene and service standards. WTC has conducted training courses in Singapore, China, Indonesia and India.

WTC's existing proven model is adapted to suit Indian needs keeping the audience in mind. The courses offered by WTC aims to address both the urban and rural toilet needs in a holistic approach. In an attempt to combat a sanitation crisis persistent in most parts of India, the Swachh Bharat Mission was launched in October 2014. This was a firm resolution to a "Clean India" by 2019. Unlike previous programmes on sanitation, the Swachh Bharat Mission (SBM) aimed at eradicating open defecation amongst both rural and urban population in India in 5 years. In order to achieve this massive feat, training of a more sensitised and empowered workforce is essential.

Aims: WTC India aims to build capacity to develop the skills needed to achieve the Clean India Mission. The program caters to the capacity-building needs of people working at different levels in the sanitation value chain, from middle management government officials to educational institution representatives and childcare-centre workers, to local sanitation workers and community members. Its mission is to empower sanitation workers, with an aim to build capacity for professionals ranging from policy makers, engineers, NGO professionals and sanitation workers, to target different stakeholder levels.

Objectives: The objective at heart of this training programme is aligned with the mission of the college itself, which is to predominantly empower the sanitation workers. Following on this model, the next planned session would be a Training Of Trainers, to impart and promote professional toilet cleaning methods, basic maintenance and repair. The students trained under this course would be equipped to later conduct similar trainings in India.

Training:

Training courses are delivered by Wash and EcoSan experts and certified trainers who have earned their certification and skills at WTC. WTC continues to empower individuals to invest in their professional and personal development by being part of a supportive network of sanitation stakeholders.

The first class of WTC was held at its Rishikesh campus in India in March 2016, with nearly 50 students in attendance! The class focused on "Community Training of Sanitation Ambassadors". The main topics included: why toilets are important for your home and community, provision of the Swachh Bharat Mission, how to access government funding for toilets, a DIY toilet-building plan for your home and community, and how to influence others to embrace the concept of toilets.

(Ref: http://washalliance.org/world-toilet-college-training-of-trainers-class/#iLightbox[gallery15131]/0 http://worldtoilet.org/world-toilet-college-india-begins-its-journey/)

While every effort is being made to bring in systemic change to improve the overall scenario in sanitation related issues several factors define the speed and reach.

Work Opportunities in Environmental Hygiene, Sanitation and Waste Management

- The fields of environmental health, sanitation and solid waste management are rife with opportunities. Work opportunities are available at every level for committed and passionate people.
- Opportunities can be sought in a variety of enterprises including community engagement, recycling, and waste management. Today, waste is also available in volumes large enough to achieve the economy of scale, thus making waste management profitable.
- The attention on sanitation and hygiene is subject to diverse political dispensation at various levels. In order to prioritize sanitation at all levels of governance, the Swachh Bharat Mission is taking steps to make the journey competitive and progressive, with a fixed deadline in sight. Leaders are required at various levels, from ward to city. There are huge opportunities to work with the over 4500 ULBs (urban Local Bodies) with Swachh Bharat Mission and Swachh Survekshan, besides other agencies.
- There is a vast scope for innovative approaches in the field. Scientific and technological advances have made it easier to deal with waste than ever before.
- Self-employment opportunities are in plenty. Creativity and job-satisfaction are all assured in the fields of Environmental Hygiene, Sanitation and Waste Management. Talented and capable individuals are working in the field of Environmental Hygiene, Sanitation and Waste Management.
- There are some stark examples of business houses which look at their waste as an opportunity to recover material and at waste disposal as their social responsibility. Nevertheless, industries all over the world are waking up to the business opportunities in transforming waste to wealth.

Some examples of Top Waste Management Companies in India:

1. EcoWise ISO certified Indian waste management company. It was founded five years and offers round the clock services. Ecowise is based in Noida, UP and each day they manage to dispose of at least 10 tons of plastic. EcoWise ISO certified Indian waste management company. It was founded five years and offers round the clock services. Ecowise is based in Noida, UP and each day they manage to dispose of at least 10 tons of plastic.
2. Antony Waste Handling Cell Private Limited is a Mumbai based Indian waste management company. AWHCPL was founded in the year 2001
3. Synergy Waste Management Private Ltd was established in 2006.
4. VermiGold Ecotech Private Ltd a Mumbai based company,
5. Hanjet Biotech Energies is turning solid waste into fuel to run power plants. The company was founded by Irfan Furniturewala.

   Ref: https://thetechpanda.com/2014/04/09/12-waste-management-startups-in-india/

1 Exercises:

1.1. How does poor sanitation affect the community?

1.2. Explain Faecal-oral route of infection.

1.3. Name a few infectious agents with examples.

1.4. Prepare charts and presentations regarding Global Handwashing Day, Toilet Day and Menstrual Hygiene Day. Prepare short plays (nukkadnatak), flash-mobs or other unique ideas to spread awareness about the three topics. Present these before the general public or at spots within your campus to spread awareness.

"Is cleaning only the responsibility of the karamcharis? Do citizens have no role in this? We have to change this mindset."
-Narendra Modi, Prime Minister of India

Unit 2:

Participatory Learning for Environmental Hygiene, Sanitation and Waste Management

Approach Methodology

Step 1: Students draw a map of their department on the board. They take turns to add one feature each. Discuss features of a map -scale, contour lines and legends.

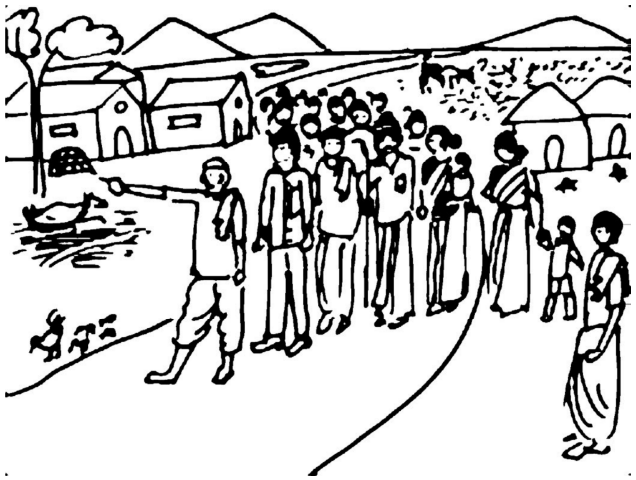
Step 2: Classroom teaching

Step 3: Conduct Role play to train students on how to interact with the local community. Add local language, common courtesies, dressing sense, behaviour.

Step 4: Students create questionnaires and data tables. Refine them. Teach them to consolidate information for easy data entry and analysis.

Step 5: Organize a field visit for secondary and primary data collection. Students form groups as per the topic they are collecting data for.

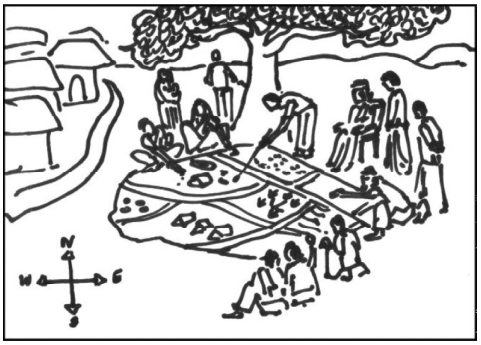
PARTICIPATORY LEARNING:



Participatory learning involves the first step in reconnaissance of an area. To understand the finer aspects of the lives of the residents in an area and the facilities they have around them, we need to have a first-hand experience of:

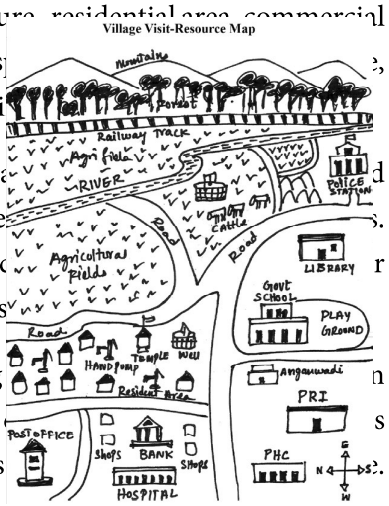
- Human resources and level of development
- Sanitation related infrastructure
- Behavioral perspectives towards sanitation
- Prevalent social fabric of the society
- Natural resources available around them

The most effective method of understanding the set-up is to befriend a local guide, a friendly and knowledgeable person from the area, who is willing to show you around the area and answer some of the simpler questions.



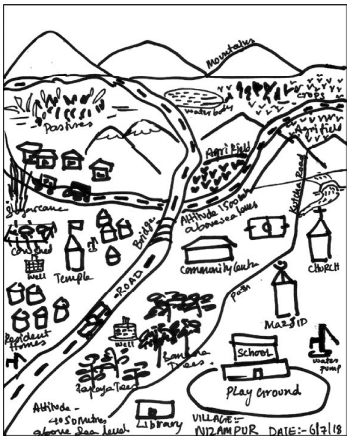
The second important aspect is a map of the area. This may be a physical map to scale available at hand, or at worst, a hand-drawn map. Depending on availability, it could be a political map, physical map or a contour map.

A human resource map depicts the location of all prominent infrastructure, residential area, commercial area like markets, institutions like post office, panchayat building, hos , veterinary hospital, agricultural office training centres and educational i

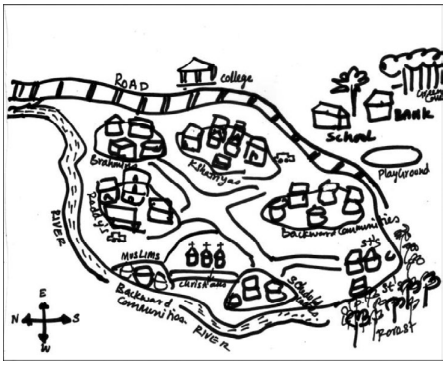


A social map depicts the location of different communities within geogr d town, people of different castes, trades, economic status and religions ge . This helps them to enjoy shared interests and cultures. These area demarc r situation and waste management culture. Hence, this is an important as

An EH and Sanitation map showing the infrastructure pertaining n management is necessary to undertand the existing scenario. This will s and understand ways and means to strengthen the infrastructure. This is .



The third is the natural resource map. Rivers, lakes, hilltops, forest patches, wastelands and wetlands are marked on this map. Most often these natural resources are soft targets for point and non-point pollution. Legal and illegal dumping takes place here, causing irreparable damage to flora and fauna. It comes to the notice of the authorities much later, after the carrying capacity of the natural body has exceeded and it starts showing visible signs of degradation. By then it is usually too late to reverse the damage.



Surveying the entire population is not possible. Begin with secondary data collection from Panchayat/ Municipal Office, old Census records, Primary Heath Care centre, old reports. Next, use the robust sampling methods, selecting sample size to represent the entire population, dividing the area map into quadrants and ensuring that sampling is done from all quadrants or grids on the map. Sampling is called primary data collection. This is raw information which needs to be collated and processed to derive usable information. Gathering information from old reports from various sources is called secondary data collection. This means that the data was collected by someone else at a previous time for a different purpose. Hence it cannot give you the exact information that you seek. It is supportive in nature. Always remember to note the source of the secondary data for easy reference. (e.g. name of the book or report, relevant page number, name of the agency from where data was collected and the date of the report).

For participatory learning it is important to:

- Work in pairs or small groups, with one person making notes while others are interviewing the people.

- Dress and behave appropriately to blend in with the community. It is a cornerstone of gaining acceptance and cooperation.
- Know the local language and dialect. This is a need to. Else, a dependable bilingual or multilingual guide from the community may be used for translation. Without this the responses could be wrongly reported or interpreted.
- Filling up questionnaires at every interview is a tedious, but important process. Using a tape recorder/ video recorder with permission, or writing the new responses while coding the more common responses could help ease the form filling. At the end of the day the reports need to be compiled, or else there is every chance of missing out on a few points. Any doubts arising in your mind need to be clarified immediately, or the very next day. Important contact numbers need to be noted, for further clarification.

- At the outset itself, make it clear that the interviews are strictly for education purposes. Do not hold a promise of improvement/ development, as sometimes it may cause misreporting or exaggerations in the hope of benefits.
- Accept the welcoming gestures of the community with grace and reciprocate suitably. (e.g. numerous cups of black tea would be offered during the course of the survey. Strategize in advance how to deal with the situation without causing offence). Respect and follow their customs.
- As the interviews progress, the topics may deviate from the questionnaires prepared before the data collection. Provide for this.

- At times a group of individuals can be questioned at once, for example at a panchayat meeting. The inputs of the entire team can be garnered at once.
- Males and females need to be interviewed in separate groups. At times, presence of the other gender restricts free talk. Preferably the interviewer and interviewee need to be of the same gender.
- Both group interviews and individual household surveys are equally important.
- Strategize the interview such that by turn each of you gets a chance to visit the home/ toilet to check on-ground status.

- Spend a few minutes of the visit to observe the natural resources in the vicinity of the location being surveyed. This may be done overtly or covertly, depending on the situation.

The objective of participatory learning is to give the students a big picture of the scenario. This exercise will help with the subsequent exercise of audits, which is discussed later in this book.

2. Exercise:

2.1 2.1 Conduct a survey of 1 sq km area in an area near your home or institution. Work in teams of 4 to conduct the survey using the techniques discussed in this chapter.

Prepare maps of human resource, sanitation infrastructure, identification of hot spots, social structure and natural resources present in the area.

Using secondary data, and participatory learning techniques, write a report on status of the population in terms of:-

a. Health
b. Education
c. Sanitation
d. Gender issues

"When we heal the earth, we heal ourselves."

-Al Gore, Former Vice President of USA

Unit 3

Sociology of Environmental Hygiene, Sanitation and Waste Management

Approach Methodology

Step 1: Students find out the challenges they have come across in using toilets in strange places. Issues faced and experiences in open defecation for locals and visitors. The discussion could be led on with required humour and seriousness in the relevant mix.

Step 2: Classroom teaching covers the topics in this chapter.

Step 3: Students conduct an internet study of the Swachh Bharat portal. http://swachhbharatmission.gov.in

Step 4: Discussion on the exercise at the chapter end with required preparation.

Step 5: Students do fieldwork as per Exercises 3.1 and 3.2

The number of people defecating in the open in rural India had reduced to less than half of what it was in 2014, according to the Economic Survey, claiming success in rural sanitation due to Swachh Bharat Mission (SBM), the flagship scheme of the Centre.

"As per baseline survey conducted by Ministry of Drinking Water and Sanitation, the number of persons defecating in open in rural areas, which was 55-crore in October, 2014, declined to 25-crore in January, 2018, at a much faster pace compared to the trend observed before 2014," the Survey said. "So far, 296 districts and 3,07,349 villages all over India have been declared as Open Defecation Free (ODF).

In the Swachh Bharat mission one of the primary objectives is construction of toilets. Ever since the SBM was launched in 2014, the toilet infrastructure at individual and community level has shown tremendous improvement. The technological intervention of geo-tagging has ensured that there is no misappropriation.

Open Defecation:

Open defecation (OD) is the human practice passing stool in the open environment including fields, bushes, forests, ditches, streets, canals, rivers and other open places. People get accustomed to it due to traditional cultural practice and others due to lack of access to toilets.

Habits and attitudes towards waste: With open defecation being a major problem in India, there is a very high risk of microbial contamination (bacteria, viruses and amoeba) of water which causes diarrhoea in young people. Also, diarrhoea and worm infection are two major health conditions that affect young people in educational institutions impacting their learning abilities. According to the UNICEF, water-borne diseases such as diarrhoea and respiratory infections are the number one cause for child deaths in India. Young people weakened by frequent diarrhoea episodes are more vulnerable to malnutrition and opportunistic infections such as pneumonia.

Belief: OD persists because there is a common belief that defecating in the open is natural and healthy. Hence there is an unwillingness to change the habit among rural folk. As a result, several toilets built before are being used for storing tools, grain, or building materials.

Dean Spears, an economist and visiting researcher at the Delhi Educational institution of Economics, writes, "Open defecation is everybody's problem. It is the quintessential 'public bad' with negative spill-over effects even on households that do not practice it."

NSSO Report on Swachhta Status

A Rapid Survey on Swachhta Status was conducted by the National Sample Survey Office (NSSO) during May-June 2015. The survey aimed to give a snapshot of the situation on the availability/accessibility of toilets, solid waste and liquid waste management at sample village/ward and household levels. Some major findings of the report are given below:

- In rural areas, 45.3% households reported to have sanitary toilets. In these households, the percentage of persons using household/community toilet was 95.6%.
- In urban areas, 88.8% households reported to have sanitary toilets. For the households having sanitary toilet, the percentage of persons using household/community/public toilet was 98.7%
- In rural areas, 50.5% of the households kept the garbage at a specified place outside their own house, 24.4% households disposed of the garbage in the nearby agriculture field, 5.5% households kept it at the common place outside the house, 4.4% households disposed of the garbage in the biogas plant or manure pit whereas 15.1% households threw it around the house.
- In urban areas, 64.2% wards were found to have a dumping place for solid waste.
- 36.7% villages had pakkinali and 19.0% villages had katchinali as drainage arrangement for waste water coming out of the rural households. 44.4% villages had no drainage arrangement.
- 56.4% wards reported to have sewer network for disposal of liquid waste.

The Culture of Cleanliness

Swachh Bharat Abhiyan: The Govt of India took up a pledge to make India 'Open Defecation Free' by 2nd Oct 2019, by constructing 12 crore toilets. The efforts started in 2014. By February 2018, 11 states/ UTs, namely Sikkim, Himachal Pradesh, Kerala, Uttarakhand, Haryana, Gujarat, Chandigarh, Daman and Diu, Arunanchal Pradesh, Chattisgarh and Meghalaya have been declared ODF, with people from2.5 lakh villages joining the crusade.

The Swachh Bharat Abhiyan has the following goals:

- Totally eliminate open air defecation.
- Build pit latrines in all homes of those living below poverty line, with 80% cost subsidy.
- Total eradication of manual scavenging.

- Recycling and processing of solid waste into energy and other by-products like fertilizer.
- Improve people's awareness for proper sanitation and on the importance of personal hygiene.
- Involve people, with the help of private sector and various NGOs, to spread the need to pro-actively adopt and promote the goals of the Abhiyan.

According to UNICEF, India has revamped its national sanitation program to focus less on subsidized toilet construction and more on helping the population understand the benefits of toilets. This could not have been possible by force alone. Collective behaviour change was needed by Community Approaches to Sanitation (CAS) that would trigger communities to demand sanitary facilities. 36 Key Resource Centres (KRCs) were empanelled by Ministry to assist States and Districts for local level capacity building besides administrative and technical experts in IEC and BCC, capacity building, technical supervision, SLWM and Monitoring and Evaluation.

Community–led total sanitation(CLTS): CLTS is a demand-driven method to make an area open-defecation free (ODF), focussing on not only construction of toilets but also on making communities use those toilets, maintain them and stop defecating in public. A time-tested model is given below:

Before toilet construction:

- Explain the purpose of the visit
- Establish rapport
- Conduct a 'walk of shame' where visitors stand in the area of OD, taking in the unpleasant smell and sight during daytime along with community members.
- Defecation mapping- Agencies working on CLTS: Taking a village map marking field, rivers, educational institution and houses. The villagers are asked to mark with yellow chalk the places where villagers defecate. With white chalk they are asked to mark the places where other animals defecate. This leads to self- realization of the extent of the problem.
- The facilitator helps them calculate the total volume of faeces generated per day and per year (in truckloads).
- S/he also demonstrates how water gets contaminated by flies sitting on faeces and then contaminating food & drinking water. By dipping a strand of hair in night soil and dipping the same in a glass of drinking water, and then offering to the villages, the message of polluted water is conveyed.
- Communities usually react strongly and show willingness to construct toilets. They are encouraged to construct kuccha toilets, as a preliminary exercise.

This generates a demand for sanitary facilities in houses, educational institutions, anganwadis, places of community congregation, and for Solid and Liquid Waste Management activities.

After Toilet Construction:

Identifying the natural leaders, both men and women, an array of innovative penalties are devised for OD.

Nigrani Samiti/ Watch Committees: A team of observers is appointed to keep watch. For instance, in Singrauli, Madhya Pradesh, a gang of 13 year olds, call themselves the 'Dabba gang'. They scout the OD areas every morning and as soon as the offender squats, they spring out whistling and topple the dabba of the offender. This courageous act is an attempt to stop people from going outdoors and encouraging the use of toilets.

After trying persuasion and shaming, if still people are practicing OD, coercive action is being taken. In some districts where toilets are being resisted, the community is being denied ration through the Public Distribution System (PDS). This can cause rage and strife among the poor.

One of the issues being faced is the shortage of masons, especially when villages have targets to complete toilet construction. Secondly, delay in payment by Govt to the masons.

Sometimes, the houses do not have space for toilet construction. This is especially the case in slums. In such situations, community toilets are being constructed.

Encouraging Public Toilets: There are many public pay-and-use toilets. Some of the toilets have been made free –of-use. Still several people, especially young people are reluctant to use toilets due to unfounded fears like witches and young people getting kidnapped. At Chandoliya in Ahmedabad, young people are being offered Re.1 per visit to the public toilets. Their visits are recorded on a card and the young people receive money at the end of the month. "The idea is to reward good behaviour", says Commissioner of Ahmedabad Municipal Corporation.

Drawbacks of Public Toilets: In most areas toilet cleanliness and odour are foremostimpediments. At some places, young people are discouraged from entering because they waste water. A long queue at public toilets in the morning hours is another major deterrent. Insufficient number of toilet blocks, eve-teasing, safety issues, distance from home, unavailability of toilets at night-time, class and caste issues are a few other barriers in the use of public toilets.

In Kenya, an educational institution created child-sized toilets which adults cannot use. This discourages adults using educational institution toilets and leaving them messy, and encourages the young people to use educational institution toilets instead of heading to the fields.

Acceptance of Manure from Human Excreta:

There are psychological/ religious taboos associated with using human excreta as manure. However, tests have revealed that the content of a leach- pit or Ecosantoilet is almost free from pathogens when taken out after two years of resting period. To make it completely pathogen free, digested sludge is sun dried for 2 to 3 weeks. During drying of sludge big lumps are formed making it difficult to mix in soil homogeneously.

Sulabh developed a technology to granulate such dried lumps into small size graded granules which look like processed tea leaves. Before granulating, it is processed in a ball mill to break it into small pieces. Then it is passed through the mass mixer where the moisture content of manure is regulated by adding water. Such manure has a good percentage of plant nutrients. Besides, it increases humus and water holding capacity of the soil. All experiments to monitor effects of human manure on different vegetables and flowering plants have been very encouraging.

All members of the community need to be made aware that the decomposed pit material from a twin-pit latrine or Ecosan toilet is safe to handle after about two years of closing the pit and can be used as compost/manure for agricultural purposes, and that switching of pits and taking out pit manure is safe and not a `dirty' chore, nor is it solely the responsibility of the women in the family.

3. Exercises:

3.1. Take a map of your city/ town. Divide it into a grid of 1 km x 1km. Divide the class into pairs or teams of 4, depending on the strength of the class. Assign different quadrants (squares) on the map to each team. Together the class need to survey at least 50% of the town or if the city is large, 25% of the city area. The division of quadrants need to ensure that all major socio-economic zones have been covered by the class.

Each team need to survey their quadrant to map public toilets. Public toilets could be in market places, streets, shopping malls, railway station/ bus stand/ airport/ hospital complex/ tourism site. Visit each toilet and find out the following:

a. Where is the toilet located, when was it built, who does it cater to?

b. How many individuals visit the toilet each day?

c. Who manages the toilet?

d. How is the toilet constructed?

e. Are there separate toilets for ladies and gents?

f. Is there a ramp for the handicapped? Are there low seat toilets and wheel-chair accessible wash basins and arrangements for young people?

g. Are the toilet seats, flushes, water taps, door latches and wash basins running in good condition?

h. Is the toilet clean? Is there a covered dustbin present in every cubicle, or in a central prominent place?

i. Is there odour, wet or slippery floors, sufficient lighting availability of soap, presence of mosquitoes, graffiti (drawing/writing on walls etc by public)?

j. Are there messages regarding toilet cleanliness?

k. Interview the caretaker of the toilet. Is there supervision of the toilet-cleaning? How many people are employed for the maintenance of the toilet block? What are the problems the staff faces in maintaining the toilets?

l. What are the timings of the toilet? Is it a paid toilet or free? Are any segments allowed free access (e.g. young people)? Are certain people restricted entry?

m. Conduct random interviews with the users. Ask them if they are frequent visitor? Take their opinion on the best toilet in their area. Find out why. Ask the drawbacks of the toilet being surveyed. Take their suggestions on how the service can be improved.

n. Walk around the toilet block and observe the sanitation. Observe or find out the method of confining night soil. Is it put to any use (e.g. biogas).

o. What steps are taken to make the toilets appealing (e.g.lighting, green plants, visible board and attractive decor)?

Present your findings team-wise. Consolidate your data as a class and map the public toilets. Create a mechanism of ranking them depending on their hygiene, cleanliness, quality of service provided, choice of customers and complete the mapping and ranking exercise together as a class.

3.2 Survey open defecation in your area.Using the same maps, quadrants and teams, survey the area for open defecation, open urination and letting out of untreated black water (e.g. overflowing septic tanks, broken pits and unlined pits). Consolidate team-wise findings to create a complete picture. Find out the measures being taken by the municipal authorities to put a stop to these unhygienic practices.

Unit 4

Infrastructure for Sanitation- Part 1

Approach Methodology

Step 1: Open discussion: 'What happens to your waste after you flush the toilet?'

Step 2: Explain sanitation value chain.

Step 3: Classroom teaching: toilet types.

Step 4: Class discussion- Exercise 4.1

Step 5: Field visit- Exercise 4.2

In the previous chapter we discussed the sanitation choices that communities make and the sociological aspects behind them. We also learnt how to bring a change in their choices and habits.

This unit will explain the stepwise process of collection, confinement, and treatment of human waste.

This is known as the sanitation value chain. Wherever this chain is incomplete, it leads to problems related to pollution and disease and a drop in living standards.

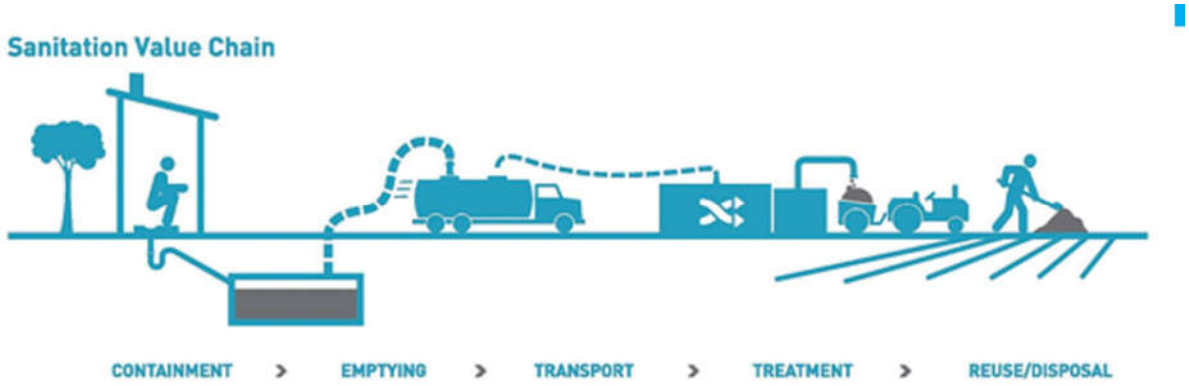
Step 1- CONTAINMENT- Preparing a Toilet

Factors to consider while planning the toilet:

The following conditions as factors to be taken into account for toilets to become household and community-friendly:

- Affordability
- Space in the home
- Geographical conditions – soil/water table etc
- Cultural habits
- Availability of water/scarcity of water
- Availability of skilled or semi skilled manpower

Almost 50% of households, even in big cities like Bangalore and Hyderabad, do not have sewerage connection. Only 21% of waste water is treated, as compared to 57% in South Africa.



In about 80% of the rural households, the average water supply is less than 5 hours a day and over 70% of the household do not have access to toilets or sewerage system.Keeping this in mind, rural India is being provided with toilets that require least amount of water.

TOILET TYPES

Some toilet designs that can suit rural India:

1. Single-pit leach pit

In the single pit system, de-sludging has to be done almost immediately after the pit has been filled to enable its reuse. Fresh and undigested excreta would contain pathogens that are hazardous for health. Single-pit leach pit is appropriate only if mechanical de-sludging can be done by a vacuum tanker. If a deeper and larger single pit is provided, desludging operation will be difficult. Chances of pollution are high where the ground water table is high.Though popular and low-cost, a single lit leach toilet could lead to adverse environmental impact besides propagating manual cleaning, a human rights battle India has been fighting since Independence.

These toilets could have any of the following combinations: temporary superstructures with or without roof, walls of different materials, and toilet with or without an attached bath. A temporary superstructure costs about Rs. 1,500. Superstructure can be made from locally available materials such as banana leaves, bamboo sticks and gunny bags. It can be a simple solution for sanitation around festival places and during emergencies. As the quality of the super structure improves the price rises. On an average, a single-pit latrine need to cost about 5 to 8 thousand rupees.

The toilet structure is for the convenience of the user, while the pits are for the containment of waste.

Lining of Pits: In single-pit and twin pit designs, the leach pits need support to prevent collapse of walls. Lining could be in brick work, stones, laterite bricks, burnt clay or cement concrete rings. Lining could be done with treated bamboos, wooden logs, tar drums depending upon availability 50mm wide holes need to be provided in alternate brick courses by laying bricks 50mm apart. This allows for excess water and waste gas to escape into the soil directly, thus eliminating the need of a ventilating pipe. Above the invert of incoming pipes or drains, no holes need to be provided. Where the soil is sandy, sand envelope is provided or where there are chances of damage by field rats, the width of the holes need to be reduced to 12-15mm. Pit-lining is essential for both single and twin pits.

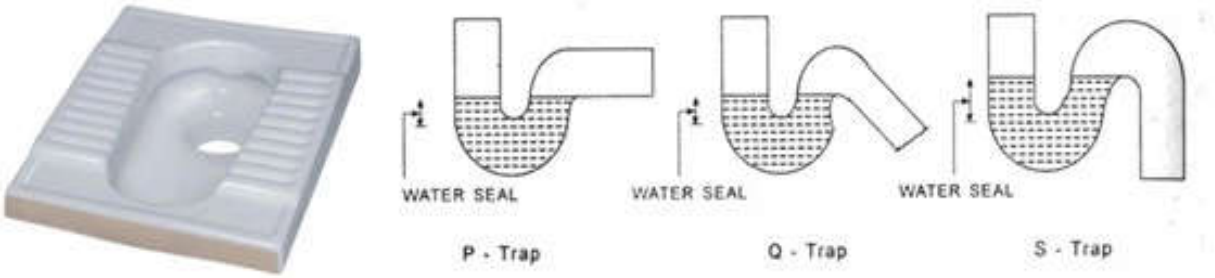
Placement of Leach-pit to Prevent Pollution: In homogeneous soil, bacteria are capable of moving up to about 3 metres horizontally and about 1 metre vertically. This varies with soil compaction. Therefore, leach pits can only be allowed in places which have water table 2m below the pit even during rainy season. To prevent pollution of water sources, the pits need to be located at a minimum distance of 3 m from open wells and shallow hand pumps.If soils are coarse, (effective size more than 0.2mm), a 50 cm thick sand envelope of 0.2mm sand has to be created all round the pit and the bottom of the pits need to be sealed by clay, polythene sheet, lean cement-concrete or cement stabilised soil to prevent contamination.

Pits in low-lying areas/ areas with high water table: Areas that are waterlogged, flood prone or having high subsoil water, the pits need to be raised so that the invert of pipe or drain is just above the likely water level. The raising of pits will necessitate raising toilet floor also. Earth need to be filled and well compacted all round the pit.

Pit Cover: The pits are covered air-tight with RCC slabs. They are strong enough to be used for different household purposes or even for running a small shop and so forth. The pit covers ensure that the premises are free of foul smell or the nuisance of flies, cockroaches or mosquitoes.

Fixing of Pan and Trap:

A toilet pan could be an Indian style squatting pan or a Western style commode.Squatting pans can be of ceramic, fibre glass, PVC, mosaic or cement concrete.



A trap is a device which has a shape that uses a bending path to capture water to prevent sewer gases from entering buildings, while allowing waste to pass through. Traps are used in various plumbings. Toilets may have S-traps or P-traps. With fibre glass pan, traps of HDPE are used. With ceramic and PVC pans, traps of the same material are used. For mosaic and cement concrete pans, traps are of cement concrete.

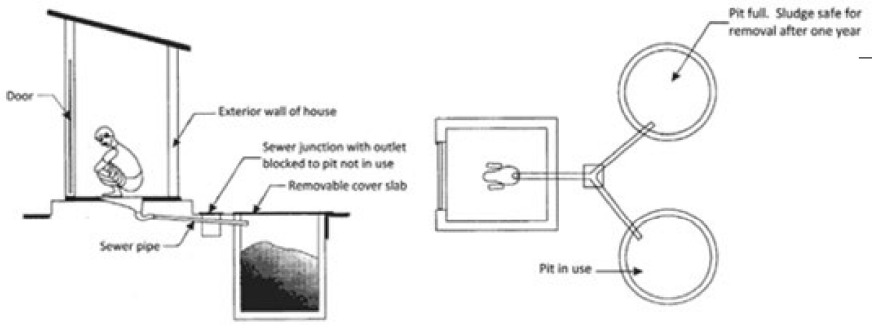
2. Twin-Pit leach pit

In the two-pit system, two pits are provided at a distance from one another or with an impermeable wall between them. One pit is used at a time. The filled-up pit kept closed for a 2 year period. The long period of microbial digestion makes the manure pathogen free, odourless and safe for handling. The pit can be manually emptied by the householder himself.

2 (a)Twin pit – Pour flush latrine

Slightly larger space may be needed to construct this toilet but the cost is still low.

This is the most popular model under the Swachh Bharat Abhiyan. It is described below in greater detail. Estimated cost of 1 toilet: Rs. 7257



Shape of Two Pits: As far as possible, separate circular pits need to be constructed as these are structurally more stable and the sludge is dry and safe to handle. If space is a constraint, pits of smaller diameter (not less than 750mm) can be provided, but the depth need to be increased suitably to provide required storage volume and infiltration surface area. The minimum space between the two pits need to be 1 m or equal to the depth of pits below the level of incoming pipe or drain, whichever is more.

If spacing is not possible, a combined oval, square or rectangular pit may be created which is divided into two equal compartments by a partition. The partition wall need to be taken 30 cm below the bottom of the pit and be plastered on both sides with cement mortar of 1:6 ratio to prevent pathogens from the active pit from entering the sealed pit. However the possibility of water from one pit finding its way to the other pit is very much there. Therefore the de-sludging of the filled up pit has to be done with care to avoid health hazards.

Sizes of Pits: The sizes of pits where ground water level is always below the bottom of the pit and infiltration rate of soil is 30 l/m2/day, for 3 years sludge storage volume works out as follows:

	Circular Pits	Combined rectangular pit divided by partition wall in two equal compartments. Size of each compartment			
No. of Users per day	Diameter cm	Depth cm	Length cm	Breadth cm	Depth cm
5	105	100	85	85	85
10	120	152	110	110	105
15	146	153	140	140	120

The above depths are from the invert of incoming pipes or drains to the bottom of the pit. These depths are to be increased by 225mm to provide free space above the invert of the pipes/drains.

Other criteria for constructing leach pit including lining, placement, pit covers, are given in the previous section of single-pit leach pit toilets.

Interconnection between trap and pits: The trap need to be connected to leach pits through 'U' shape covered brick drains or by PVC non pressure pipes of 75mm diameter. Where the drains bifurcate, a junction pit need to be placedwith internal size of 25 cm x 50 cm. The pipes of drains need to have a minimum gradient of 1:15.

One of the pits is to be used at a time by plugging the drain for the other pit.When the first pit in use is full, the flow need to be diverted to the second pit. A lever/ mechanism need to be provided for switching drainage between pits. The filled up pit need to be de-sludged after a 2-year rest period. The contents can be sun-dried for 15 days and used as manure. The first pit can then be put to reuse, when the second pit fills up.

2 (a) Twin-pit Pour Flush toilet:

Environmental friendly two-pit, pour-flush compost toilet is also known as 'Sulabh Shauchalaya'. That toilet is socially acceptable, economically affordable, technologically appropriate and does not require scavengers to clean the pits and implemented in more than 1.2 million houses all over India. These toilets are easy to maintain, socially acceptable and can be constructed even on upper floors of houses. Design

and specifications can be modified to suit householder's needs and affordability.A low volume flushing cistern of 1.5 to 2 litre volume can be attached to avoid pour flushing.

2 (b).Anganwadi Toilets

Created under the 'Integrated Child Development Centres (ICDS) scheme' the anganwadi toilets are believed to be a platform for behaviour change for the young people by promoting hygiene behaviours from childhood. Child friendly door with a provision for opening from inside and outside of the toilet is available. Displays of pet animal pictures inside the wall create a friendly environment and hence young people don't fear using it. Smallest toilet pan with 14 inches can be used and to maintain one foot height of water storing tub. Water tub need to be easy to access for young people for cleaning and washing. Kerala, Himachal Pradesh and Tamil Nadu are among the states that have cleanest Anganwadi toilets.

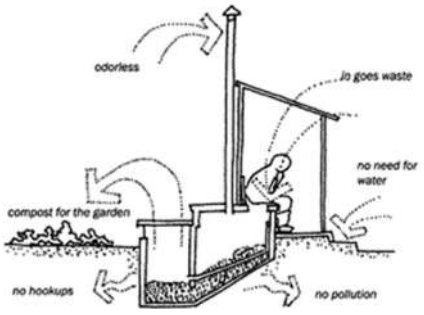
3. ECOSAN Toilets

This design is suited for areas where water logging and water scarcity is a concern. It is most effective in coastal and rocky areas, as it promotes soil fertility and crop production. Historically, such ecological methods of sanitations were utilized in Rome, China, Mexico, Peru and Yemen.

Ecosan was implemented in Haiti as part of the emergency relief effort following the 2010 earthquake.
In India, these designs are notably used in Tamil Nadu where the Tamil Nadu State Government provides subsidies.

Estimated cost of 1 toilet: Rs. 10,747. Unlike leach-pit toilets, emptying pits is not a requirement.This toilet prevents contamination of water sources and soil. Human waste can be composted and used as a natural fertilizer. The waste treatment technology of Ecosan is explained later in this book.

4. Bio-gas linked toilets



Conventional toilets are connected to either a septic tank or to the sewers. Septic tanks are equipped with an exhaust pipe that releases gases from the anaerobic digestion of wastes. The gases contain mostly methane (CH_4), carbon dioxide (CO_2), hydrogen sulphide (H_2S) and water vapour. Methane and carbon dioxide are greenhouse gases. Methane is a clean fuel.

A bio-gas linked toilet enables the collection of precious methane.The fuel generated can be used as local source for electricity, heat and light. Also, the waste can be composted to bio-manure which increases productivity and catalyses soil conservation. In 2012, UNICEF chose two districts in West Bengal to pilot this kind of

design in India and approximately 19,000 Kg of methane gas that was produced from waste alone each day was converted to produce biogas. UNICEF successfully piloted this program with a local NGO – Ramakrishna Mission Lokashiksha Parishad to implement this program at Medinipur district. Estimated cost of 1 toilet: Rs. 21, 167.

More details regarding bio-gas linked toilets are given later in the text.

5. Community Toilets:

In congested areas and slums, it is difficult to construct individual toilets. In such locations, public toilets of the pay-and-use model are most suited. Sulabh International was one of the first in modern India to bring about the trend of community toilets. Sulabh is maintaining over 8000 public toilet complexes spread all over the country. Community toilet blocks need to be separate for men and women. They need to have provision for sufficient water, soap, lighting, maintenance and safety. More details about community toilets are mentioned later.

Community toilets can use septic tank, sewerage system or anaerobic digester for processing the waste.

5(a) Child friendly toilets

These toilets encourage proper hygiene habits from childhood and provide privacy for young people. One can make it to look interesting with beautiful caricatures of pets and animals on the wall. Young people are not scared to use these kinds of toilets. All of them possess accessible and easy provisions for anal cleaning and hand washing facilities. As these are constructed adjacent to the community toilets, and maintenance is certainly easier. Estimated cost of 1 toilet: Rs. 18,000 – Rs. 22,000

5 (b) Educational institution sanitary complex

Educational institution Sanitation is a tool for promoting better sanitation and water management for young people. It aids in improving the educational institution environment and privacy for young people in educational institutions is certainly ensured. This complex promotes proper hygiene behaviours from childhood. Operation and maintenance is taken care by young people in educational institutions and separate facilities are provided for urination and defecation. Estimated cost of 1 toilet: Rs. 50,000

5 (c) Community Toilet Linked Biogas Plant:

Recycling and reuse of human excreta for biogas generation is an important way to get rid of health hazards from human excreta. Human excreta based biogas technology remained unnoticed for long due to the fact that the available technology was not socially acceptable, as it required manual handling of human excreta, which contains a full spectrum of pathogens. Sulabh is the pioneering organization in the field of biogas generation from public toilet complexes. After a series of experiments, the organisation developed a more efficient design of biogas plant that has been approved by the Ministry of Non-

conventional Energy Sources, Govt. of India, for its implementation through state nodal agencies. Based on the 'Sulabh Model' design, over 200 biogas plants of 35 to 60 cum capacity have been constructed by Sulabh in different states of the country so far.

The design developed by Sulabh does not require manual handling of human excreta and there is complete recycling and resource recovery from the wastes. The Digester is built underground into which excreta from public toilets flows under gravity. Inside the digester biogas is produced due to anaerobic fermentation by the help of methanogenic bacteria. The biogas, thus produced, is stored in inbuilt liquid displacement chamber.

6. Bio-toilet

Replacing conventional toilets in railway coaches with bio-toilets has been a boon for Indian Railways. Before the advent of bio-toilets, train tracks all over the country were littered with human waste, putting track maintenance workers at risk. In fact, Indian Railways was considered the world's largest open toilet!

The bio toilet system in railways utilizes anaerobic bacteria which consume the waste material and convert it into water and gas. The water is passed through a chlorine tank and is discharged as clean water on the tracks, while the gas evaporates. Foul smell and clogging issues plagued the bio-toilets until Natural Draft Induced Ventilation System (NDIVS) was introduced. Railways now targets fitting 80,000 bio-toilets by 2018 and 100 percent bio-toilets by 2019. Vacuum bio toilets will also be introduced in the near future.

The 'bio-digester' technology has applications not just in train toilets but also in various other fields such as rural areas, mobile toilets and high-altitude regions among many others.

The bio-toilets system works on Defence Research Development Organisation (DRDO)'s 'bio-digester' technology, which is used for sanitation in high-altitude military establishments such as Siachen. Many enterprises are now purchasing the patented technology from DRDO and popularizing it in the country. Cochin Shipyard is one such example. Slowly people are adopting the same in their homes as well. Bio-digester technology is explained later in this book.

Maintenance of Toilets: Traditionally, cleaning of toilets is looked upon as an `unclean job', often to be done by women of the household. Specifically promote the idea that everyone in the family, irrespective of gender, has an equal responsibility in keeping the toilet clean after use. As a workable solution, all members need to pour water/ flush after use and it need to be cleaned with a broom or brush once a day. The woman of the house can clean the toilet bowl with a suitable toilet cleaner and brush once or twice a week, or as required. This will ensure inclusivity in toilet use and maintenance. If the toilet is connected to a biogas plant, then extra care need to be taken to avoid strong disinfectants that can stop the methanation process, such as acids.

The following points need to be remembered while operating a flush compost toilet:

- Before use, wet the pan by pouring only a little quantity of water.
- After defecation, pour 1.5 to 2 litres of water in the pan for flushing.
- Pour about half litre of water in the pan after urination.
- The pan need to be cleaned once a day with a brush or a broom and with soap powder periodically.
- Kitchen, bathroom waste water or rain water need to not be allowed to enter the pits.

- Dirty diapers, condoms and sanitary pads also need to not be thrown in the pan.
- Other solid wastes like kitchen waste, rags, cotton, sweepings need to not be thrown in the pan, this could block the toilet.

Common sanitary facilities and shared toilets are a universal responsibility of communities. Factors like caste, need to not play a role in determining who cleans and maintains toilets within households, in educational institutions, health facilities and in other community places.

4. Exercises:

4.1: Classroom Exercise: Select the ideal toilet type and the ideal method of waste water management in the following set-up:

a) A new working women's hostel is being constructed. It is a triple storey building with 120 residents. A mess is run within the hostel.

b) A village is located amidst sugarcane fields. Mothers leave their young ones under the care of the anganwadi workers. There are 50 young ones who spend 8-10 hours a day at the anganwadi.

c) A dam is under construction. 500 workers are staying in a makeshift colony near the construction site. This site is located deep in the forest, in hilly terrain. Water is available in the river, but no pumping arrangement is provided. The colony is likely to remain for 4 years.

d) A small tribal hamlet consisting of 5 families is located in the hills of the Western Ghats in Maharashtra. They are farmers who practice rain-fed dry land cropping. They have 20 cattle and 60 goats with them, whom they take for grazing to the nearby forest land. Water is available through seasonal rain only, for which they rely on a river stream and a dug well. No drinking water or electricity is available.

e) The Government of India is planning on a fleet of elite long-distance buses that run on CNG. There is a proposal for adding a mini unisex toilet in the buses.

f) A slum is on the banks of a highly polluted river, amidst garbage and in low-lying, swampy conditions. People are used to squatting along the riverside.

4.2: In pairs or teams, visit a construction site to study how a toilet is created. Interview the engineer on site for better practical understanding about the various components and aspects to consider while creating toilets. Write a short report of your findings.

Unit 5

Swachh Bharat Mission and Inclusivity

Approach Methodology

Step 1: Students read chapter before the lecture

Step 2: Organize a debate on the topic: "Swachh Bharat (Rural) is a success (or not)".

Step 3: Open discussion on gender issues that today's generation faces.

Step 4: Class room teaching on community toilets and the social issues relating to them.

Step 5: Collage–making: Students collect news articles on community toilets. Prepare a collage.

Step6: Field visit- Conduct exercise 5.1.

Step 7: If a volunteering opportunity arises for Swachh survekshan, encourage students to participate as representatives of your institutes.

Sanitation infrastructure relates to the larger picture of sanitation across the land. It involves an understanding of actual facilities and systems pertaining to Environmental Hygiene, Sanitation and waste management in place. It is part of town planning, and involves an understanding of how the toilets in various locations contain the waste, connect through a sewerage system, how the black water is treated and finally released. India is taking its sanitation infrastructure seriously since 2014. Though efforts have been on for several years, they were sporadic and limited in reach. Now the sanitation infrastructure development has been taken up as part of Swachh Bharat Abhiyan, with target date of 2nd Oct 2019, coinciding with the 150th birth anniversary of the Father of the Nation, Mahatma Gandhi. Sanitation infrastructure for rural areas focuses on the basic human need of dignity in sanitation.

Swacch Bharat Mission (Rural):

SBM (Rural) targets an open defecation free countryside (ODF). ODF is a continuous process. Along with building infrastructure SBM envisages bringing about a transformational change in the behavioural attitude.

As per the Ministry of Drinking Water & Sanitation (MoDWS), villages are considered open defecation-free when "no faeces are visible and every household and public/community institution uses safe technology to dispose of faeces in such a way that there is no contamination of surface soil, groundwater or surface water; excreta is inaccessible to flies or animals, with no manual handling of fresh excreta; and there is no odour or unsightly condition".

It is important to remember that ODF declarations are self-reported. Ideally there need to be regular, third party evaluation in which they conduct their own independent surveys to ensure actual ODF. Centre for Policy Research (CPR), a think tank, observed that declarations often follow presence of toilets rather than actual ODF. It is further worrying to notice that once a village has been declared as ODF, most monitoring efforts come to a stop and there is no concerted effort to maintain the ODF status.

Subsequently, the Swachh Survekshan Gramin 2017 survey covering 140,000 households and 700 districts was conducted by the Quality Control of India (QCI), an autonomous government body. "In the criticism of the Swachh Bharat Mission, many have cited anecdotal evidence about toilets being used to store grains, but there is empirical evidence of a dramatic improvement in both coverage and usage

of toilets," Adil Zainul bhai, Chairman, QCI wrote in Sep 2017 adding, "Three years after the launch of the mission, a behavioural change is discernible, especially in rural India." 91.29% rural households with access to a toilet use it, reported the QCI survey.

Moreover, there is a need for Swachh Survekshan Gramin to look at toilet technology, solid and liquid waste management, adaptability and acceptance by villagers in its method of study and factors like availability of water, sensitisation, long-term affordability (based on soil type and groundwater level), cleanliness and maintenance. These factors may encourage toilet usage in the long term.

The focus need to shift to changing behaviour and convincing every rural Indian that they want to use a latrine rather than go in the open. Only then will we progress to making India free of open defecation by 2019.

Swacch Bharat Mission (Urban)

In the urban context, the focus of the Indian Government is on strengthening toilet infrastructure at individual and community level and also solid waste management. A lot of progress has been achieved on the toilet infrastructure front as well as Solid Waste Management.

States will contribute a minimum of Rs 2,667 per IHHL towards individual toilets to match Central Share of Rs 4,000 per IHHL. For UTs without legislature, Central share will be 100% (Rs 4000 per IHHL) and UT share of Rs 1333 will also be borne by the Centre. For UTs with legislature, Central share will be Rs 4,000 per IHHL and UT share will be Rs 1,333 per IHHL. For North Eastern and Himalayan states, the Central share will be Rs 10,800 per IHHL, and state share will be Rs 1,200 per IHHL.

According to SBM status report 2016

- 44,650 wards (of 82,725) have 100% door-to-door waste collection;
- 12,526 community toilets built in three years;
- 11,806 public toilets constructed
- 45% of rural households and 89% of urban households have access to sanitary toilets.

Only 53% of wards have 100% door-to-door collection of garbage, and only 23% of it is processed. Efforts are on to improve the collection, transportation, treatment and disposal of Solid Waste through promotion of better technologies and behavioural changes.

Of 73 cities that participated in Swachh Survekshan 2016, 54 cities have improved their score in overall municipal solid waste management in 2017.

Swachh Survekshan Urban also deals with community or public toilets in urban India. Public toilets are difficult to keep in good condition, but still might be a good solution for the urban context. However, effective and robust models under Build- Own- Transfer schemes are being practised.

Gender Issues in Sanitation

Women and girls bear the heaviest burden of poor sanitation and continued open defecation. Lack of privacy, fear for personal safety, sexual harassment and violence are faced by women and girls each time they defecate in the open (both in rural and urban India). In addition, the situation arising from

open defecation puts their health to risk through medical conditions such as urinary tract infections, chronic constipation and mental stress. Lack of safe, private spaces for women and girls to wash or tend to their personal hygiene needs when menstruating severely restrict their ability to fully participate in daily activities, including attending educational institution.

Issues Women face with Community toilets

A study conducted in 2017 by Centre for Urban and Regional Excellence (CURE) for USAID/India revealed the reluctance of rural and slum women in using community toilets. The interviewees candidly explained their reasons. It is the behaviour of the men which keeps them away from using the facilities. Men crowd around the community toilets, sometimes dress like women to gain access, stand in line and touch inappropriately, peep over walls and every day someone is misbehaved with.

The condition of the toilets is also a matter of concern. Most times the toilet has no soap for hand wash and the condition of the toilets is questionable. In slums and settlement areas, the pressure on each community toilet could be 1: 500 with 40 of community toilets catering for 25,000 people, which amounts to less than 3 minutes per person.

Walking long distance, standing in a queue, paying Re.1 each time for the use of poorly maintained toilets with inadequate security is not worth the effort. To make community toilets acceptable, the cleaning staff needs to be paid better and the security needs to be tightened.

Role of women in sanitation: Women are actively involved in the mobilization of communities through social and behaviour change communication for sanitation. However, their involvement in the actual implementation of the sanitation programme i.e. in planning, procurement, toilet construction and monitoring needs to be strengthened. Swachh Bharat Mission Guidelines (SBM(G))encourages active participation of women in community engagement, process of toilet construction (VWSCs, motivators, procurement committees), leadership of SBM(G) committees, WASH (eg: Nigrani) committees and Village Water Sanitation and Health Committees (VWSHCs).

Ownership by men: Women centric entry-point level messaging carries risks of lack of ownership by men and reinforcing gender stereotypes (eg: women need to not step out of the house, men as custodians of women's dignity). The message needs to be gender sensitive and target both men and women, particularly focusing on men who are often the primary decision makers in rural households where household expenditure is involved. Media coverage on these aspects raises public interest.

Gender stereotyping and portrayal of women as weak and passive compared to men need to be avoided. Rather, portray and popularize stories of powerful women and successful women Swachhta champions to inspire and motivate women across the country to take charge of their own fate, health and safety. Examples of this include women Self Help Groups (SHGs) who along with other activities, take on the responsibilities of Sani-

Marts (selling of sanitary napkins) and work as masons. Some adolescent girl leaders speak out and raise awareness about menstrual hygiene management. Men and women at the district level like DCs/DMs and other leaders to talk about the important role women have played in making their districts ODF.

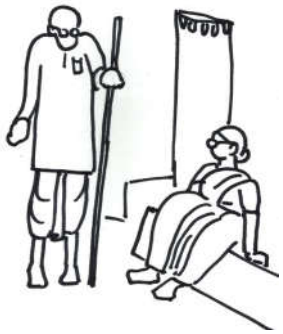
Inclusivity of the Third-gender: In many communities, people of the third-gender are dissociated from the mainstream. Third gender toilets ensure that they are recognized as equal citizens and users of toilets. They need to be allowed to use the facility of their choice (men or women) in community or public toilets.

Mysore city bus terminal of Mysuru and Mangalwara area of Bhopal host community toilets exclusively for transgenders. The toilet in Bhopal also has a 'change room/make-up room'. Different signs for men, women, handicapped and transgender people are emblazoned on the doors of the toilet.

There are also examples from around the country, where the third gender have become Swachhta champions and played a huge role in taking the message of Swachhta to households in the community. Where suitable, their support can be enlisted in engaging communities, and their efforts duly recognized and honoured to break any stigma around them.

Differently-abled/ Infirm:

Elderly people with age-related constraints, pregnant ladies, young people and people with physical disabilities should find it convenient to use toilets. The toilets need to be built in an inclusive design to ensure good ventilation, good lighting to prevent stumbling, handle-bar support, gently sloping floor towards the drain to keep the floor dry and to prevent slipping, and ergonomics to support people with stiff joints or difficulties in squatting position - raised toilet seats/ western commodes for the elderly, the young and the differently-abled are included in the design. Maintenance of such toilet facilities requires much more attention.



If there is a user fee in community/public toilets, concessions need to be provided for senior citizens, young people and the differently-abled to encourage them to avail of these services.

To ensure the success of any enterprise, we need to look at the triple bottom line- People- Planet and Profit. The same is true for community toilets. Many NGOs are looking at ways of making community toilets more acceptable to the community. Some experiments in this regard include harnessing bio-gas from the community toilets and supply it as cooking gas to the locals. Another way to draw the public is by expanding toilet complexes into community health care centres and day care centres. This could also help in maintenance and improve use.

5 Exercises:

5.1: Working in groups, survey the city/ town for public toilets. Map the same. Interview 5 users each and take down their comments regarding the toilet blocks. Also map areas where toilets are needed (identified by the smell of open urination).

Regroup in class to consolidate your findings and suggest methods to improve the current public toilet system. Forward your report to the Municipality.

Unit 6

Infrastructure for Sanitation - Part 22

Approach Methodology

Step 1: Revise sanitation value chain

Step 2: Show video film on human scavenging.

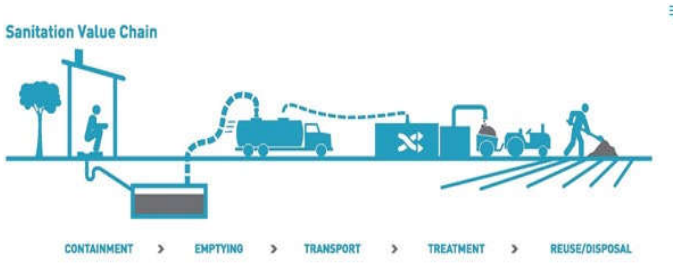
Step 3: Classroom teaching

Step 4: Students prepare sanitation audit- which needs further refinement including that of questionnaires. Form the groups, allot areas for survey and fix dates for survey

Step 5: Field visit- Conduct exercise 6.1. Consolidate findings and present in class/ in the form of a report.

Step 6: Group discussion: Ideal way to contain, empty and transport human waste.

The first step in sanitation infrastructure was to build toilets. This has been explained in the previous chapter. The second step is the containment and further processing of excreta.



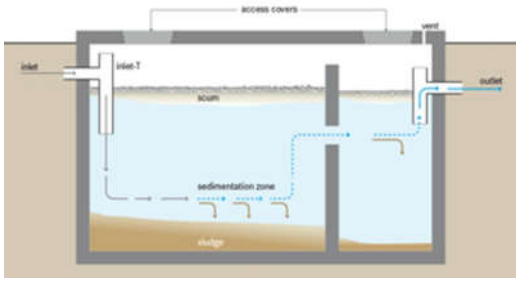
STEP 2- Further processing of excreta from toilets:

All toilets are provided with some kind of storage unit for the waste matter. Leach pits, Ecosan chambers, contain the waste in mostly solid form, while septic tanks and sewers carry it in more wet forms.

Conventional toilets are connected to either a septic tank or to the sewers. Sewerage systems will be discussed in the next chapter. Methods of emptying septage/ night soil from each type of container are explained in this segment.

Septic tank

A septic tank is a chamber between 4,000 and 7,500 liters in capacity, made of concrete, fiberglass, PVC or plastic, through which domestic wastewater flows for primary treatment. Settling and anaerobic processes reduce solids and organics, but the treatment is only moderate.



The term 'septic' refers to the anaerobic bacterial environment that develops in the tank which decomposes or mineralizes the waste discharged into the tank. However both aerobic and anaerobic bacteria act to digest the waste. One end of the septic tank is connected to an inlet wastewater pipe and the other to a septic drain field. Generally these pipe connections are made with a T pipe, allowing liquid to enter and exit without disturbing any crust on the surface. Today, the design of the tank usually incorporates two

chambers, each equipped with a manhole cover, and separated by a dividing wall with openings located about midway between the floor and roof of the tank.

Wastewater enters the first chamber of the tank, allowing solids to settle and scum to float. The settled solids are anaerobically digested, reducing the volume of solids. The liquid component flows through the dividing wall into the second chamber, where further settlement takes place. The excess liquid, now in a relatively clear condition, then drains from the outlet into a soak pit and then into the septic drain field, also referred to as a leach field or seepage field, depending upon locality. A percolation test is required prior to installation to ensure the porosity of the soil is adequate to serve as a drain field.

The remaining impurities are trapped and eliminated in the soil, with the excess water eliminated through percolation into the soil, through evaporation, and by uptake through the root system of plants and eventual transpiration or entering groundwater or surface water.

Once in about 10 years, accumulated sludge (septage, also known as fecal sludge) is pumped out of the tank by a vacuum truck.

To maintain a septic tank, the following things need to not but flushed in the toilet: oil, grease (could clog the inlet), non-biodegradable solids like cigarette butts, menstrual pads, condoms etc, food waste(they overload the system), bleach, caustic soda, pesticides, herbicides (they are toxic to microbes) and waste water from water softner (high total soluble solids could harm the bacteria). Roots, high water table, excessive water, structural damage, a thick bio film within the pipes (biomat failure) could cause septic tanks to malfunction.

Septic tanks cannot be placed in areas where there is insufficient drain field. Sulphates in the waste produce hydrogen sulphide, a foul smelling gas. Nitrates are not digested by the bacteria. This could lead to ground water or surface water pollution from the outlet.

The advantage of septic tanks over leach pits is that the digested waste does not need frequent emptying, and it usually does not need manual removal. Hence it is more acceptable in India.

There are some practical difficulties in designing a workable septic tank in India, where usually the mason designs it as per his experience, without any municipal guidelines. Ideally septage needs to be regularly emptied, once in 8-10 years. But often people wait very long, which causes sludge to settle as a hard mass at the bottom of the tank and can no longer be pulled out by vacuum. The mason also gives the contact of the persons who will conduct the manual scavenging to remove residual sludge if it is too dried to be removed by vacuum suction. Often the septic tank is constructed without a partition wall, thereby allowing unsedimented waste to exit. This interferes with the treatment process.

Soak pit: This is the simplest unlined pit to collect toilet waste. When the pit fills up, it is simply closed and a new pit is dug elsewhere. This is not recommended as it has the greatest chance of contaminating the water and soil around it.

Leach-pit: Many urban dwellers in developing countries (in Sub-Saharan Africa, often more than 90%) have no access to a sewer system, or the running water needed to make it work. In such a scenario, leach pits are a viable option. Leach pits are lined with cement rings, uncemented bricks or hollow bricks with

spaces. The waste from toilets is collected below the ground. Leach pits are designed to have a layer of fine sand around them and are created at a distance from sources of water or other leach pits. The concept is that once a leach pit fills up, usually in 6 months to 1 year, it is shut tight and the waste within is allowed to compost. Meanwhile the family uses the alternative leach pit. Within 1 year the waste completely composts. Then it can be easily removed. The spacing between leach pits is maintained to prevent germs from one pit from entering the next pit. The construction of leach pits has already been discussed in detail before.

However, the problem of emptying the leach pit is a hindrance. The problem is worse when there is provision of a single leach pit, which means the toilet waste needs to be removed as soon as the pit fills up, i.e. before the waste has a chance to decompose. This is dangerous as it increases the chances of spreading disease causing germs.

Ecosan: Ecological sanitation is a concept of on-site excreta and urine disposal whose basic principle is to close the nutrient loop between sanitation and agriculture through recycling/ allowing for manuring. Ecosan has the advantage of using less water, of the possibility of construction over high water table and rocky soils, as a raised toilet. The collection system of Ecosan toilets is different from the one used in conventional and modern flush cistern toilets. The night soil and urine are collected separately, and after each use the night soil is covered with a handful of ash or sawdust to allow the water to be soaked up quickly. This dried form of waste is allowed to breakdown into usable manure. Like the twin-pit leach pit, there are two chambers provided, so that when one pit fills up, it is sealed off and the other pit is used. It takes over a year for the waste to be ready for removal.

Initially, Ecosan toilet users feel uncomfortable with the new system where urinating, excreting and cleaning take place in different areas. But over time, the discomfort changes to comfort. It takes longer to make older people use the toilet but the young people quickly learn how to use the toilet.

The advantages of using Ecosan are that:

- It prevents contamination of ground water
- It can be placed on hard rocky surfaces, water logged regions.
- It does not need a sewerage system for composting or disposal of waste.
- It improves the soil fertility when applied to lands.
- Therefore it saves farmers the cost of fertilizers.

The drawbacks of the Ecosan toilets are that:

- Ecosan is expensive. It needs two pans and the water seal waste collection chamber. Therefore, compared with pit latrines and double toilets, the cost is often prohibitive.
- Ecosan needs a different type of pan which is not easily available on local markets.
- It requires users to be aware of how to use such toilets as night soil and urine have to be separated. It can be a more serious problem when visitors use the Ecosan toilet.
- It is difficult to master the use of Ecosan toilets. One has to defecate in one place and has to move

to another position for anal cleansing. Indians clean themselves with water after toilet. Ecosan does not allow water to enter the collection chamber.

- There is a problem of social acceptance of using human waste as fertilizer. People do not easily accept touching human waste.
- The Ecosan toilet is mostly suitable for farmers. There is no central collection system that allows people to sell the human waste to farmers or to those having larger farms. There is generally a lack of information regarding Ecosan among stakeholders such as the general public, politicians and policy makers, and there is no academic course for students. In fact, wider sensitization and integrated approaches are needed to promote such interventions.

Anaerobic digester

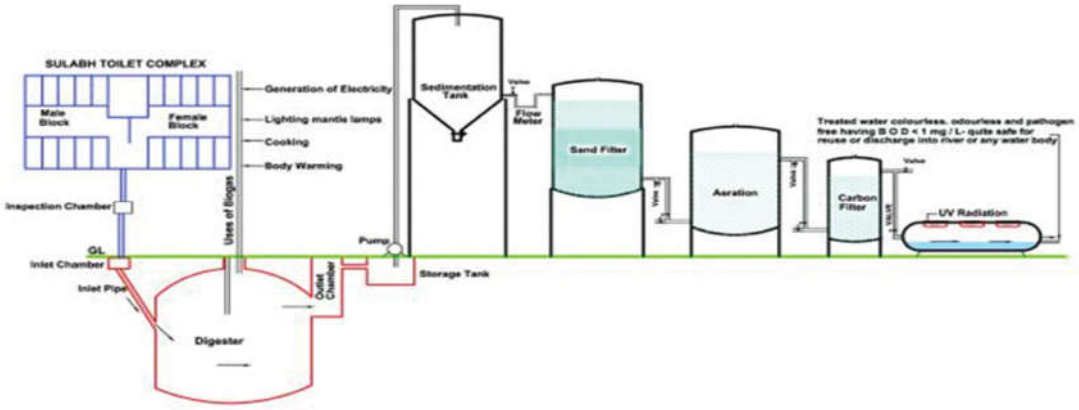
All the containment methods explained till now work on a similar principle. Microorganisms breakdown human waste. Some of it done by aerobic bacterial and most of it is done by anaerobic bacteria, which release gases - mostly methane, carbon dioxide, hydrogen sulphide and water vapour. Methane and carbon dioxide are greenhouse gases (GHGs). As a GHG, methane is roughly30 times more potent as a heat-trapping gas than carbon dioxide. From septic tanks the gases are let out through a flue pipe, while in leach pits it gets absorbed into the surrounding soil.

But, methane is also a clean fuel. Methanogenic bacteria are capable of turning 1 kg of human waste (i.e. waste from 2-3 people) into 0.4 m3 Biogas/day. 1m3 of biogas can give light as a 60-100 Watt bulb for 6 hours, cook 3 meals for a family of 5 or 6, equal 0.7 litres of petrol for a car and generate 1.25 kilowatt hours of electricity. A small biogas can reduce 9.7 metric tons of CO2 and produce Rs1,00,000 /year carbon credit. Human excreta-based biogas contains 65-66% methane, 32-34% carbon dioxide while the rest the hydrogen sulphide and other gases in traces.

Human excreta also contain a full spectrum of pathogens. Most of these pathogens are eliminated due to anaerobic condition inside the digester. Besides using biogas for different purposes, biogas plant effluent can also be used as manure after processing. This effluent contains a good percentage of nitrogen, potassium and phosphates. There are anaerobic digesters available for individuals homes to generate biogas for household needs. Similarly, a larger amount of bio-gas can be produced through community toilets. Since, Sulabh is maintaining over 8000 public toilet complexes spread all over the country, out of which 200 are linked with biogas plants, it was an important task for the organization to make the effluent free from odour, colour and pathogens, to use it safely for agricultural purposes. After a series of experiments, the organization has developed a new and convenient technology (Sulabh Effluent Treatment (SET) System)based on sedimentation and filtration of effluent through sand, aeration tank and activated charcoal followed by ultraviolet rays.

The filtration unit makes it colourless, odourless and free from organic particles and the UV eliminates the bacteria. It reduces BOD and COD of the waste water drastically. Since such wastewater is from human wastes, its BOD (Biochemical Oxygen Demand) which is around 200 mg/l, comes down to <10

mg/l after treatment – safe for aquaculture, agriculture gardening or discharge into any water body. It can also be used for floor cleaning of public toilets in drought prone areas.



Thus, biogas technology from human wastes has multiple benefits — sanitation, bio-energy and manure.

Advantages of Decentralized System of Biogas Plant with SET Technology

- Cost of collection of sewage and operation & maintenance of the system are very low.
- No manual handling of human excreta is required.
- It is aesthetically and socially accepted.
- Biogas is used for different purposes.
- Treated effluent is safe to reuse for agriculture, gardening, or discharge into any water body.
- In drought prone areas treated effluent can be used for cleaning floors of public toilets.
- If discharged into the sewer, pollution load on STP will be much lower.

Thus, the decentralized system of sewage treatment through biogas technology is more effective for minimizing financial burden to combat pollution.

Bio-Digester:

At the heart of the 'bio-digester' technology is a cocktail of cold-loving bacteria patented by DRDO which have the natural capacity to survive on waste.The bacterium has its origin in Antarctica and can survive extreme conditions. When added to the septic tanks, this suspension speeds up degradation of bio-waste. The process converts septic tanks into 'bio-tanks' that do not contaminate groundwater.

To set up a bio-digester, a certified bio-digester providing company needs to be contacted. Pre-fabricated septic tanks 9 called Bio-Digester Tank -BDT) in 750l to 1000l capacity septic tanks are fitted in the compound, either below or above ground and connected to the toilet outlet with a small chamber to trap

any non-compostable solids that may have accidentally been flushed. A regular cemented septic tank may also be created, but with advice from the AMI providers. The entire bio-digester chamber is filled to 40% of its volume with a special microbial mix named 'AMI- Anaerobic Microbial Inoculum' or 'DRDO bacteria'. The cost of the tank with the microbial mix costs around 40 to 60 thousand rupees. The zero-waste process breaks down human waste into water, carbon dioxide and methane gas. The gases leave the chamber from an outlet at the top, while the recycled water can be used to water the garden and for other non-potable use.

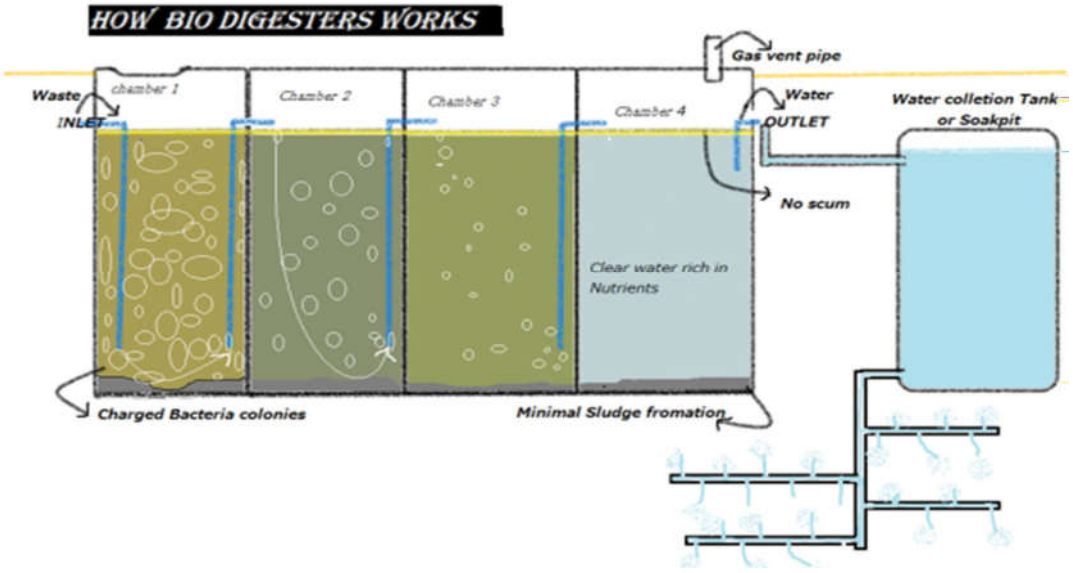
The bio-digester tank is maintained at a temperature of 5oCto 30 oC, though it can withstand -5oC ton 55 oC. On the basis of dry waste weight, 90% of the solid waste is reduced. The gaseous effluent (bio-gas) is continuously let off to the atmosphere. This is too low in pressure for effectively using for cooking. Experiments are ongoing to utilize this biogas. Liquid effluent can be drained to any surface or soak pit without any environmental hazards.

The Pollution Control Board prohibits the letting out of any effluent, treated or untreated, from toilets into the rainwater drainage system. In areas not connected to the city sewer lines, the water from the BDT need to be used for gardening.

The AMI needs to be fed regularly on waste. In case the toilets are not being used, cow dung slurry needs to be fed to them at least once in 3 months. A 750 l tank is sufficient for a 5 member family, while 1000 l tank can support an 8 member family. Fluctuations in numbers can be sustained for short durations. If by chance the AMI needs topping up, the inoculum is available for around Rs. 25 per litre or so.

The advantages of the bio-digester are:

- 99% reduction in pathogens and organic matter.
- Odour-free, non-toxic effluent usable for gardening and irrigation
- Commercially available toilet cleaning liquids can be used.
- There are no moving parts and hence zero maintenance.
- No desludging or cleaning is required
- No infestation of cockroaches and flies.
- Needs one-third the space required by a septic tank.
- Bacteria conditioned to remain unaffected by cleaning agents upto a certain limit.



6. Exercises: Sanitation Audit

6.1 Survey a 1 sq km area around you. It could be urban, rural, residential, commercial/ institutional. Work in pairs.

Write your findings in the following format:

Student's names: Roll Number: Date(s) of survey:

Name of the area:

Commercial/ residential/ institutional:

Approximate population density:

Resident population/ moving population:

Number of buildings:

Number of toilets:

Number of household with private toilets:

Number of households sharing toilets:

Number of households without access to toilets:

Methods of containment of waste with numbers and percentage:

Septic tank:

Single leach pit:

Two-pit:

Biogas:

Others (name them):

Main challenges faced by the people:

Unit 7

Wastewater

Approach Methodology

Step 1: Open discussion on drains in your locality.

Step 2: Scan newspaper reports on drainage / sewer maintenance issues faced in your area. Students need to make a collage.

Step 3 : Classroom teaching

Step 4: Students take up Exercise 7. Refine their questionnaires, form into groups, areas allotted for survey, dates fixed for survey.

Step 5: Field visit- Conduct exercise 7. Consolidate findings

Step 6: Seminar

Sewage

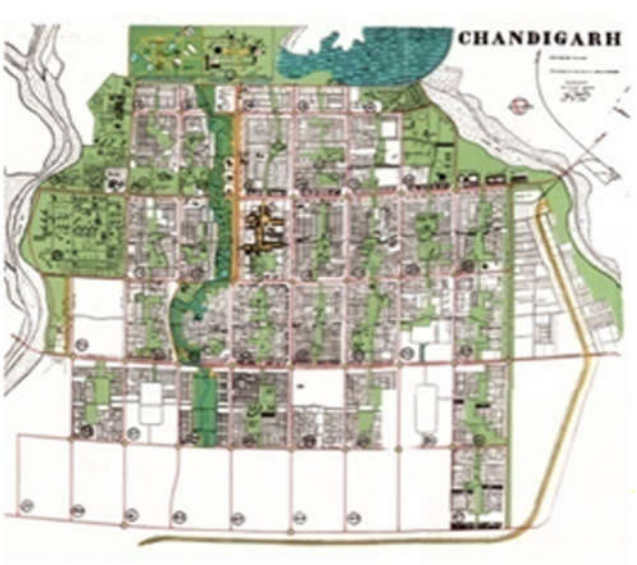
The most commonly accepted solution for urban sanitation is piped sewerage with centralized wastewater treatment. And many engineers, politicians and city managers regard it as the only legitimate solution.

Sewerage is the infrastructure to convey sewage through sewer lines. Sewerage ends at the entry to a sewage treatment plant or into a point of discharge. Lines are different from rainwater drains.

Planned cities, which were carefully planned, since their inception, would often have a drainage system. In contrast, settlements that evolve into towns in an ad-hoc manner do not have sewerage systems in place. Apart from the historically best planned cities of Harappa and Mohen-jo-daro civilization there are also modern best planned cities in India like Chandigarh and Gandhinagar.

Mohenjodaro – Ancient Sewerage System

The haphazardly located cities like Gurugram, with 2 million residents living in skyscrapers, but without paved roads, citywide system of water, electricity and public sewers. In congested urban environments of Gurugram, Mumbai, Delhi, Hyderabad and Chennai it is often observed that septic tanks drain out directly into sewers. Often, apartment buildings have functional–looking sewers, but they do not connect to a sewerage system, but are transported by tankers into the nearest nala or river or dumping ground. Disposal of sludge is a nuisance due to population pressure and paucity of land. The usual practice of dumping sewage and industrial sludge on land or oceans is highly dangerous and has been banned in several countries.



Even the best–planned city of Chandigarh faced utter chaos in Aug 2017 when 3 hours of downpour choked the arteries of the tricity. The reason is that Chandigarh's natural storm drain water channel has not been cleaned in more than 20 years.

Importance of Keeping our Freshwater Clean

Ironically, though India has several water resources, gross mismanagement of fresh water and the extreme pollution of rivers is the cause of India's water woes.

The following examples demonstrate that with willpower, community support and proper planning and maintenance, unpolluted freshwater can be made available to all.

Case study 1 : Rajendra Singh, 'Waterman of India', has successfully built 8,600 'Johads' or traditional earthen dams to store water along with the villagers and brought back water to a thousand villages in Rajasthan's Alwar district. For his commendable dedication, he has won the Stockholm Water Prize and Ramon Magsaysay Award. Now his focus, and of many other community and spiritual leaders has shifted to cleanup of rivers.

Rivers are the lifeline of our country. Today, the proportion of dirty water is higher than the clean water in majority of our rivers. No intervention in the name of development need to obstruct, pollute, erode or result in adverse impact on ecology and bio-diversity.

Case study 2 : 163 Ponds Revived In 60 Days: People of Ernakulam District, Kerala, are giving a second lease of life to ponds

In Ernakulam district of Kerala, there used to be close to 3000 ponds, but over a period of time majority of the ponds dried up and now there are some 600-700 ponds.

Due to urbanisation and other activities people began to neglect natural water resources. Slowly and gradually, ponds, lakes and other water bodies became waste dumping yards. Eventually, the ponds dried up and people began to face acute potable water shortage in the district, especially during summer season. To give a second lease of life to the ponds, District Collector started a project 'Entekulam Ernakulam' (my pond Ernakulam) under the government's Haritha Keralam (Green Kerala) Mission in 2016 after severe drought in Kerala.

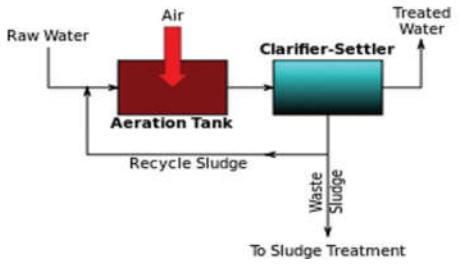
Ponds are not only a source of water, but ground water recharge as well. Disappearing of ponds was a big challenge.Pond water is majorly used for agriculture, drinking and in water stress, for household chores. People needed water and could not get piped water everywhere. So, the administration decided to clean and maintain the existing ponds- the target was to revive 100 ponds within 50 days. With the support of 5,000 volunteers from different walks of life, the target was achieved on the 43rd day. Individuals from different voluntary group like Anbodu Kochi, social groups like NSS (National Service Scheme), NCC (National Cadet Corps) and Nehru Yuva Kendra (NYK) restored 163 ponds within 60 days.

To revive the ponds the administration along with volunteers created a team to evaluate the existing condition of the pond- depth, purpose, manpower and machinery required to clean the pond and then chalk out the plan. After evaluation, locals are made aware about the pond and when the cleanup drive is scheduled. The cleanup drive usually takes place on weekends or on public holidays so that more and more residents can participate. From mud to plastic to dry leaves, all kinds of waste are removed from the pond. It is local people who have taken the leadership. The idea is to sustain the efforts- to maintain the cleanliness of the pond and revive the discipline of keeping water bodies clean and it will happen only when people re-establish their bond with the ponds.

This case study also demonstrates that it is easier to clean water bodies that are not already polluted by sewage or industrial effluents.

Domestic water:

Conventional Sewage Treatment plants use bacteria under aerobic conditions to break down non-toxic organic waste. 1mg of carbon needs 2.26 mg of oxygen to break down. Organic load is first calculated in BOD (Biological oxygen demand). BOD values are around 165 for domestic sewage, 22 for industrial waste water, 372 for paper industry, 747 for food industry and 13 for metals industry. A eutrophied lake also needs an STP to maintain water quality.

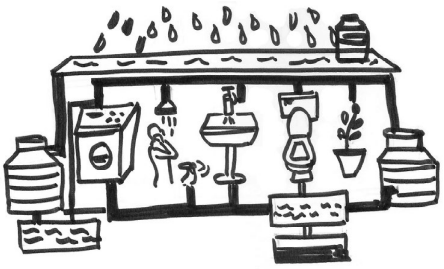


First solid waste is screened out. Next, sludge is allowed to settle. Water alone is sent through a bed of microbes in activated sludge for organic matter removal. This sludge too is sedimented. Lastly, the microbes are killed with chlorination. This is primary treatment.

The sludge residues are difficult to dispose of. Sometimes sludge is dumped in landfill, incinerated or let into the ocean, none of which is safe. The best method is to treat sludge anaerobically to produce biogas (methane CH4) If the sludge is free of toxic material, it can be used for fertilizing crops. Treatment of sludge is secondary treatment.

The effluent (waste water) remaining after water treatment also needs further treatment to remove excess phosphate (by adding slaked lime), nitrogen (ammonia stripping) and adsorption of organics on activated charcoal and finally chlorination. This is called tertiary treatment. It is expensive. Using a combination of nitrifying and denitrifying bacteria can be used for removing excess nitrogen is a cheaper alternative.

STPs are good for low strength waste water treatment. Upflow Anaerobic Sludge Bed (UASB) Reactors are better for medium to high strength effluents (COD 1500mg/l). UASB is cheaper and combines waste water treatment with recovery and reuse.



Nowadays many cities are insisting on apartments treating their waste water before discharge, or for reuse to reduce water consumption. The average waste water generated per head is 131l/per capita per day. In reality it is 250-450 lpcd.

Points to remember:

- STP never is to be located in the basement. The oxygen pumped into the STP will suck out all air from the basement.
- Never allow rainwater to mix with sewage, all water will get contaminated.
- Never allow wastewater from RO plant and water softener to enter STP, as the Total Dissolved solids will rise. At TDS >15,000ppm, STP stops working.

A good alternative for disposing excreta where sewage systems are absent, such as in villages, UNICEF recommends Ecosan toilets which are very effective for coastal regions with high water table and for dry/ rocky/ water scarce areas.

Industrial Waste Water:

In India, about 70% of freshwater is used for agriculture and nearly 30% of freshwater is used for industries. Less than 2 % is used for municipal purposes.

Fresh water used in agriculture can cause pollution through agricultural runoff that contains pesticides and chemical fertilizers. This water cannot be easily treated. The other large segment, i.e. fresh water used in industries, also contributes substantially to water pollution.

Inorganic pollutants like iron, copper, cobalt, zinc, mercury, arsenic, nickel, cadmium, lead, alkalis and acids, etc exist in industrial waste water. Heavy metals can cause cancers, birth defects and permanent nerve damage. Effluent treatment plants take care of the waste water from the industrial sector. Filtration by activated charcoal or synthetic resins, or by membrane techniques are the preferred methods.

Activated charcoal is fine black powder made from coconut shells, bone char, saw dust and coke. It is heated at high temperatures in the absence of oxygen (450–900 °C) after saturating char with phosphoric acid/ slaked lime to make is highly porous and adsorbent. Then repeated washing to wash away the chemicals gives us highly porous activated charcoal. It is very effective in cleaning chlorinated hydrocarbon and other organic molecules. Membrane techniques include ultra filtration, reverse osmosis and electro dialysis.

Establishing effluent treatment systems in small-scale industries is a problem, since a large number of them are located in residential areas, where space is a constraint. Moreover, the small-scale industries lack adequate resources to establish treatment systems. Such industries need to establish common effluent treatment plants (CETPs). A number of such facilities have been established across the country. It is expected that establishment of CETPs would reduce the pollution load in the aquatic resources of the country to a large extent.

Recovery of metals from chemicals sludge is easier from individual effluent sludges. Sewage sludge is also an excellent scavenger of metals, such as 9000ppm of Zn, 6000ppm of Cu, 800ppm of NI, Therefore sludge need to be looked at as a resource for recovery of metals. Care need to be taken to prevent health hazards. Aerobic digestion at 35oC, anaerobic digestion at 35oC and lime treatment followed by high temperature composting at 45-65oC need to be done before resource recovery from sludge.

Some streams of industrial effluent are high in BOD, such as food industry waste water. This can be treated in a conventional STP.

In spite of having technology, communities and industries are incessantly pushing their untreated wastes into the rivers. Indian rivers have reached a level of exhaustion after being ill-treated for years with inflow of raw sewage, septage, industrial effluents and agricultural runoff. The country is struggling to clean up its most important river Ganga and her tributaries at a very high cost, but to no avail.

The remedy is to treat the waste stream- be it sewage or industrial effluent- in a systematic manner, bringing down its characteristics within permissible level before letting them into the rivers. Better still; the clean water can be put to alternative use, thus reducing our demand on the rivers.

This brings us back to the treatment of waste water. In this course we will restrict ourselves to municipal waste water, which is usually sewage, septage, grey water or contaminated storm water. The most important course of action is faecal sludge treatment.

Faecal Sludge Management

There are 7,000 towns in India with a population under 1 million. 95% householdsin these towns are exposed to water contaminatedwith faecal sludge.

Faecal Sludge is the undigested or partially digested slurry or solids resulting from storage or treatment of blackwater or excreta. The residue removed from a septic tank is called septage and needs the same treatment as faecal sludge.Faecal sludge comes from onsitesanitation technologies, i.e., it has not been transported through a sewer. It can be raw or partially digested, a slurry or semisolid, and results from the collection and storage/treatment of excreta or blackwater, with or without greywater.

Septage is usually collected only if the septic tank is filled, which is indicated by an overflowing toilet. A truck-mounted or tractor-mounted vacuum tanker is called upon to clear the tank.

Once collected, the sludge is often dumped illegally into urban watercourses, open drains and rivers. This has significant public health and environmental consequences with the whole community potentially being exposed to untreated human waste.

Faecal Sludge Management is an important component of waste management. Often micro, small and medium-sized enterprises are engaged informally or by the municipality for this critical sanitation service in cities and towns. It is usually an on-the-call service, though ideally it need to be a scheduled service.

Emptying the septic tanks: If faecal sludge is liquid enough, it is usually collected by using vacuum pumps or centrifugal style booster pumps. A variety of manual and motorized devices designed to excavate thick and viscous sludge and accumulated trash are also available in the market.

After sitting for years in septic tanks and pit latrines, the accumulated sludge becomes hardened and is very difficult to remove. It is still common that workers enter pits in order to desludge them, even though this practice is generally unsafe and undesirable. In India, this practice is called "manual scavenging". A number of low-cost pumping systems exist to remove this hardened sludge hygienically from the ground surface, although many of them are still in the experimental stage (e.g. Excavator, Gulper and e-Vac)

The collected faecal sludge need to preferably be processed at dedicated faecal sludge treatment plants, instead of being co-treated with sewage in municipal sewage treatment plants. Septage has very high BOD, suspended solids, total dissolved solids, pathogens as well as high nitrogen and phosphorous content which can overload an STP and cause its breakdown.

Processing technologies include constructed wetlands, anaerobic digestion, and waste stabilization ponds. The treatment process can produce useful products such as treated effluent that can be used for irrigation. Another possibility is to use the treated faecal sludge after composting as a soil conditioner or for the production of biogas, charcoal, biodiesel, powdered industrial fuel and electricity.

In India FSM is the missing link which prevents the country from reaching its goals of sanitation and prevention of pollution. To complete the link requires a private-public sector partnership. This is a viable business provided it is managed well, has appropriate technology in place and proper regulation guidelines. For containment, emptying and collection of faecal sludge, septic tanks need to be built following standard specifications and guidelines. The Government bodies need to conduct scheduled desludging of septic tanks, contracting out the task to private operators. The facility of treatment of faecal sludge was unavailable in India till recently. The following case study throws light on the management of an FSM system which can transform the face of sanitation in India within 5 years.

Case Study : Devanahalli

Devanahalli in Karnataka, with a population of 30,000 has set up the first successful pilot Faecal Sludge Treatment Plant (FSTP). This was done by CDD Society in collaboration with the Devanahalli Town Municipal Corporation.

The treatment plant has an anaerobic digester where the solid sludge is deposited. Biogas is produced and then it is stabilised in anaerobic reactors before being dried in the drying beds and co-composted with municipal solid waste to prepare soil manure.

FSM is a 5 step process:

Step1: Assessment: How much faecal sludge is generated? This can be calculated by a sanitation census that collects data on number of toilets, number of pits and septic tanks, number of septage managing private desludgers, frequency of desludging. Irregular/ delayed desludging makes the operation difficult. Operators have to travel far to empty their tanks and there are no designated disposal points for the desludging operators. Initially people protested against the building of the FSTP. They were convinced with house-to-house consultations. The FSTP looks aesthetic, is odour-free and acceptable to the community.

Step2: Land allocation: Planning and Zoning Authority approvals, ownership, legal access, road access and approvals from SPCB

Step3: Create a Regulatory Environment: with regulations for sustainable Faecal Sludge Management. Proper regulations regarding containment for new houses, licensing and regulation of private operators, outsourcing the operations of the treatment plant to private operators, raising property taxes to support the cost of the treatment plant.Practical interventions for effective implementation include calls routed through a call centre, GPS devices and cameras trucks for monitoring desludging and disposal, monitoring the treatment plant for input and output parameters to meet standards, training tanker operators about method of safe emptying of septage, and proper depositing in the FSTP.

Step4: Financial Model: FSTPs have a low operating cost, affordable by most municipalities. Only one operator is needed to manage the FSTP, since it runs on gravity and does not need electricity for operations. 50 % of maintenance cost comes from Property tax, the rest from sale of manure, collecting fee for desludging and a small amount from advertising costs. Farmers are getting good quality manure at a cheap rate.

Step5: Community Engagement – Farmers are supportive. Previously they were using cow dung supplied by the Government, which was problematic to use and store and labourers were reluctant to handle it this made them switch to chemical fertilizers. The manure produced by the FSTP is convenient for farm labour to use. It is odour free, and of good quality and giving double the yield. Women's Self-help group works with every stakeholder in the Sanitation Value Chain, educating them about FSM as well as larger sanitation messages. Overall the community is contented by the presence of a FSM.

The mountain town of Leh, in Jammu and Kashmir has established a Faecal Sludge Treatment Plant at an altitude of 11,400 feet, one of the first in the world at such a high altitude. This will be instrumental in treating faecal sludge from commercial establishments which were gradually polluting Leh's groundwater.

Similarly, Ambikapur Nagar Palik Nigam of Jabalpur, MP has also created an FSTP that uses a different set of technological interventions to achieve clean water from septage.

The states of Andhra Pradesh, Rajasthan and Tamil Nadu have expressed an interest in adopting this technology. FSM is an important link that can get sanitation to a majority of the people quickly.

Innovations in Faecal Sludge Management

1. Research is on at the London Educational institution of Hygiene and Tropical Medicine to use the larvae of black soldier fly (BSFL).- a non-disease spreading, non-nuisance fly species (Hermetiaillucens) - to feed on pit latrine waste. As the larvae develop on the faecal material, they increase in size, reducing the mass of the waste, and converting the dangerous pit material into a potentially useful soil conditioner or fertiliser. Once the larvae have developed into pre-pupae, they can be harvested. These pre-pupae are high in fat and protein and have an economic value as a suitable replacement for conventional protein sources in animal feeds.
2. GenRobotics, a Kerala based tech start-up has launched an Iron-Man style semi-automatic robot named 'Bandicoot'-the first of its kind exoskeleton robot in the country that cleans manholes without the need for human beings having to enter the pits. Their invention made waves in the state due to its huge potential social impact against manual scavenging – a practice banned in India nearly two decades ago, yet actively practiced in almost every state. Thanks to the Bandicoot, sanitary workers would be able to stop endangering their lives on a daily basis. They no longer have to enter clogged manholes filled with hazardous gases. Many municipalities in Kerala are now using this robot.

1. Exercise: Conduct a Wastewater Audit in your locality

Working in pairs or groups of (max) 6, students conduct a wastewater audit to assess the current wastewater management practices in different parts of your locality or area of study.

Step1: Mapping:

Conduct a discrete and detailed survey of the study area. Find out demography and composition of the area. On a map, mark locations of waste outlets, sewage treatment plants, septic tank opening, drainage lines, nallahs with garbage thrown in and water bodies which are used to dump waste in liquid or solid form, if any. Mark the inlet and outlet of the drainage system of your area on the map.

Is storm water allowed to mix with black water or grey water? Trace the drainage lines on a map and mark the areas which need attention from authorities in terms of maintenance.

Conduct interviews with people from different walks of life to understand issues regarding smell or change in taste of water or ground water that would indicate pollution and any other issues faced by the people, e.g. mosquito menace, water hyacinth, vanishing migratory birds, news of polluted waters unfit for sports and reporting of fish kills.

Step2: Wastewater characterisation:

Find out the types of waste water leaving the following establishments- commercial, industrial, residential, medical and institutional. Find out, if any of it is treated or recycled for alternate purposes.

Step3: Quantity Determination:

Note the volume of water used by each establishment. Assume that 80% of the water consumed is turned into waste water. Note the method of waste water disposal.

Step4: Disposal methods and testing of water quality:

In case of a sewage treatment facility, find out the quality of water being let out after treatment. If possible, get it tested in a local laboratory to check its BOD, COD, pathogenicity, TDS, TSS. Is it within norms? Where is the waste water let out? Collect secondary data from relevant municipal water and sewerage department. Visit the Pollution Control Board and enquire about the situation in your study area. Take notes.

Check the map for the inlet and outlet of the drainage system of your area on the map. Check the water at the inlet point and outlet point. Is the water quality substantially different? How so?

Step5: Social and work conditions of the waste water maintenance staff:

Arrange an interview with the people in charge of drain cleaning. Find out the maintenance routine and conditions under which they work.

How many workers are engaged in cleaning and maintenance of drainage systems in the city?

What are the problems and what are the facilities provided to them. Make note.

Is there a formal or informal group of people working in the area for cleaning of septic tanks? How and where do they dispose their wastes?

Step6: Environmental Impact Assessment:

Based on the first 5 steps, prepare a report on the methods of waste water generation, processing and disposal in your study area. Add your map on the sources of point pollution and the direction of the waste stream.

Analyse your findings with the best practices in waste water treatment that you are aware of and give suggestions for improvement.

Any issues of public apathy, public involvement and health-link to wastewater need to also be discussed.

Suggest the practices which need to be avoided. Give alternatives.

Highlight any best practices (if any) that you have found in the course of your research.

Suggest methods to improve the wastewater management of the study area.

Present the findings in a seminar before your class and teachers.

Unit 8

Technology for Recovery of Resources and Treatment

Approach Methodology

Step 1: Reading of case study- self-flushing e-toilet.

Step 2: Classroom teaching of bioremediation

Step 3: Field work: Plant collection from local polluted water bodies, and their identification.

Step 4: Visit to a biogas plant. This could be of any scale.

Step 5: Visit to a local enterprise that sets up biogas plants. Or, a guest lecture by them.

Step 6: Project: Exercise 8.2

Step 7: Exercise 8.1

The world's first electronic solar public e-Toilet has been put up in Pulluvila, a village in the Thiruvananthapuram district of Kerala in May 2018. It generates power as well as fertilizer from the waste. The toilets have been set up in. The village boasts of having the world's first e-toilet, which utilizes technology to turn waste into fertilizer, generate power, and even produce potable water. The innovative agency behind the initiative is Eram Scientific Solutions.

The E-toilet flushes itself before as well as after every use with the minimum quantity of water required. On average, every flush uses only 1.5 liters of water, as compared to a normal flush which uses around 8 to 10 liters of water. The floor gets automatically washed after every tenth use. Even the lights turn on automatically and they draw power from an in-built solar panel. Electronic equipment monitor everything through GPRS telemetry including the frequency as well as volume of usage, together with water and electricity consumption. There are also provisions for waste treatment through the use of a large bio-digester or anaerobic biodegradation.

A user needs to insert a coin to open the door. The eToilet's sensor-based lighting system automatically turns on once the user enters. The system is also capable of directing the users with audio commands. In order to conserve water, the eToilets are programmed to flush around 1.5 liters of water after every 3 minutes of usage and about 4.5 liters is discharged if the usage is longer than the above period. The 'smart' eToilet also cleans the platform automatically. Instructional notes are put up outside the eToilet in order to guide the user about its functioning. There are She-toilets put up in educational institutions, equipped with coin-operated sanitary napkin vending machines as well as incinerators. A service team periodically conducts visits to the eToilets for maintenance as well as repair. The eToilets are being put up at easily accessible points for the public.

Similar self flushing eToilet (using concept of pay & use toilet scheme) have been placed in Delhi Mumbai for footpath and slum dwellers wherein the toilet flushes itself on entry and exit with a drop of coin!

The basic eToilet costs Rs. 2 lakhs while specialized models cost 4 to 5 lakhs a piece.

Bio-remediation:

Using the power of microorganisms and plants to clean waste streams is proving extremely successful. Septic tanks, oxidation ponds, filter beds and root zone technology are all examples of bio remediation.

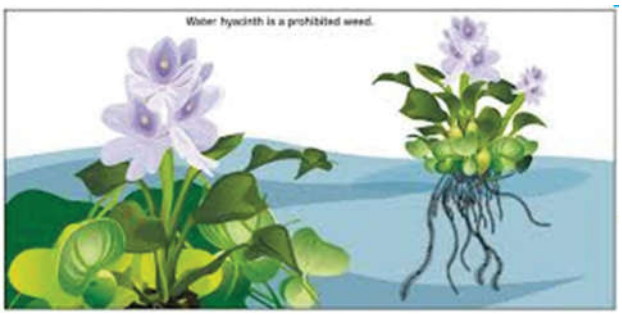
Today Indian researchers have isolated salt- and alkali-tolerant bacteria capable of detoxifying tannery and textile effluents within 12 hours.

River-cleanup

Indian rivers are facing heavy damage due to non-point and diffuse sewage pollution. The major river systems of Ganga and Yamuna are polluted beyond repair. Yamuna is the most polluted river in the country, with the maximum load of pollution coming in from the 20km stretch of the river flowing through Delhi, and further down in Mathura and Agra. Several attempts at STPs have failed to give good results. The Uttarakhand High Court has ruled in a judgement that both Ganga and Yamuna are living entities and implies that the rivers have basic human rights.

The problem of rivers being heavily polluted due to untreated domestic sewage load from the cities could be solved effectively by recycling and reuse of sewage for biogas generation. Sulabh International has developed an efficient design of biogas plant that has been approved by the Ministry of Non-Conventional Energy Sources, Government of India.

Innovative Uses of Aquatic Weeds



Water hyacinth (Eichhorniacrassipes) is an aquatic, seasonal and problematic weed of national concern. The Government of India formulated a Task Force to get rid of this weed. But it is difficult to process by other means. It is not good for incinerating or composting. It also contains high heavy metal content. However, it is a good substrate for biogas generation. Since this weed is seasonal, biogas plant based on this feed becomes non-functional during summer due to unavailability of this weed. Latest research has demonstrated that by harvesting, drying and pulverising the weed, it can be transported with ease and used for biogas generation throughout the year.

Water hyacinth is also being turned into durable handicraft bags, yoga mats, laptop bags and commodities. Andhra Pradesh, Kerala and Assam are leading this trend. In North-East India alone over 3,500 artisans are earning their livelihood from hyacinth based craft. Water hyacinth grows during July-November. The raw material is prepared by sun drying its stems; stems of 24-30 inches are preferably picked. They are sun-dried for seven to eight days. The stems are then flattened to prepare them for weaving. For non-framed products like bags, the stems are braided and stitched to give the desired shapes. For framed products like furniture, bamboo and cane frames are used. These are even weaved in looms to make products like yoga mats. For colouring, natural dies are preferred. Colours, mostly brought from Bangkok, are mixed in hot water and salt. Prepared stems are then boiled in the colour and dried for permanent colouring.

For a glossy look, products are burnished with melamine. Finally, they are smoked to protect them from insects and fungus.

Researchers from Kerala have been able to produce L-Glutaminase - a medically and industrially important enzyme - using lignocellulosic material found in water hyacinth and water moss (Salviniamolesta) under solid-state fermentation. The weeds could be efficiently used to make biomass briquettes, disposable plates and as a bedding material for mushroom cultivation and modified hydroponics. In Africa, hyacinth is being used to manufacture sanitary pads as well.

Innovative use of Human Urine:

Advantages of separate collection of urine from excreta at source:

The fundamental principle remains that to conveniently reuse or recycle wastes as resources we need to avoid mixing of waste streams- be it solid waste with sewage, effluents from different industries, or even urine and faeces.

Research shows that it is far more useful to collect urine separately. The advantages are that faeces takes less time to decompose and will smell less foul.

Urine as fertilizer:

People across the globe and in India are researching on the alternative uses of human urine. One piece of research from University of Agricultural Sciences states that if 40%of people in India stored their urine to use it on crops, the country's farmers could save 1.2 billion rupees in fertilizer expense.

A long-term study in Finland reveals that urine can be used as a substitute for chemical fertilizers "without posing any microbial or chemical risks." The urine-fertilized plants had a surprising increase in protein content- 35–37% higher protein compared to mineral and ash fertilized, without any difference in taste or smell. One litre of urine contains 11 gm of nitrogen, 1 gm of phosphorus and 2 gm of potassium. Urine mixed with wood ash (collected from a wood stove) reduces the acidity of the soil. The wood ash also adds extra potassium which encourages more fruit. Urine from a 'healthy' person is sterile, free of bacteria and viruses as long as it is uncontaminated by faeces. Only diseases of the urinary tract contaminate urine so those with a urinary tract infection need to not use their urine for fertilizer. Those taking antibiotics or medications need to abstain from contributing, and those who consume excess salt need to consider reducing their salt intake. After collecting the urine, store it in an air tight container otherwise it will smell, lose its nitrogen, and become ammonia.

Apply fresh urine as fertilizer when plants are 2 weeks old. Stop fertilizing two weeks before harvest as mature plants do not need the extra nutrients. Use 4 litres per 10 square feet of garden, diluted 1:4 with water. For very young plants, dilute 1:10 with water. Fertilize only twice a week. If the leaves look yellow, the nitrogen is excess. Restrict fertilizing for a few weeks. Undiluted urine can be used as a weedicide. Brinjal, Celery, Cabbage, Cucumber, Corn, Leafy greens, Onion Garlic, Chillies, Potato, Radish, Spinach, Squash, Tomato, Banana, Citrus, Grapes, Melons, Pineapple, Alfalfa, Barley, Millet, Sorghum, and Wheat. It is not of much use to beans, since they are legumes and can capture their own nitrogen. Nitrogen in urine turns to ammonia when exposed to air, giving a foul smell. The nitrogen will no longer be available

for plants. To prevent this, one need to store urine in an airtight container. Within about 10 days, the bacterial activity will grow and then die down, leaving the urine fit for use again.

Biogas from Animal Dung:

Anaerobically digesting farmyard waste seems a good idea on paper and is being practiced in many farms in India. But sometimes it fails. The dung from cows, goats, sheep, etc is low in nutrients. Generally it does not digest well in anaerobic digesters. This can be set right by adding kitchen waste, rotting vegetables from supermarkets and farmer's markets.Food scraps from restaurants can be added if they are not very oily. In Europe, a farmer with 800 heads of cattle found success by offering to collect the waste of a local green grocer, for a fee. With this vegetable waste added to the anaerobic digester he successfully generated biogas for his heating needs and good quality farm yard manure for sale. This process is called co-digestion.The beneficial effects of co-digestion are mostly related to a balanced availability of macro- and micronutrient required by the microbial community, optimal moisture content, buffer capacity and dilution of inhibitory or toxic compounds.Hydrolysis rates also increase when food waste and manure are co-digested compared to mono-digestion resulting in 26% higher methane production than the sum of digestions of individual substrates.

Anaerobic co-digestion technology allows concurrent digestionof different organic wastes, like animal manure, food waste, organic fraction of municipal solid waste and sewage sludge.Manures provide a wide range of nutrients, while the addition of other organic wastes increases the methane yield of the process.Compared with cattle manure, the concentration of micronutrients was obviously fewer in food waste,in plant-based material and waste, higher in fresh leachate and sewage sludge. Appropriate mixing strategies need to be applied depending on the substrate to get the highest biogas yield.

Mixing substrates for co-digestion have many advantages including environmental, technology and economic benefits.The substrate (organic waste)-to-inoculum (anaerobic bacteria) ratios between 2 and 6 are typically used at the laboratory scale, while on industrial scale the ratio between 2 to 4 works best.

Bio-methane: Energy from human/ animal waste and raw sewage:

Biogas is the name for the gas produced by anaerobic digestion, where microorganisms convert biomass, plant and animal material to biogas in the absence of air. Biogas from a digester is roughly 60% CH4, 29% CO2 and trace elements of H2S.It is not suitable for use as fuel gas as the H2S causes corrosion inside the burners. Biogas from landfills is used to fuel reciprocating gas engines and generate electricity. But raw biogas results in high maintenance cost. Hence biogas need to be upgraded to nearly pure methane, which can now be injected into the national natural gas grid or substitute compressed natural gas as a 'clean' transport fuel. In other words, bio-methane is cleaned/ upgraded biogas.

To remove CO2, pressure swing adsorption, chemical solvent scrubbing (amine gas treatment) and water wash (pressurized water scrubbing), membrane separation, are used. Technologies like physical solvent scrubbing (using glycols), membrane separation and cryogenic distillation, supersonic separation industrial lung technology rotary water scrubbing, and can lower operating costs and compact process deigns. To remove H2S, desulphurisation can be achieved with water scrubbing, caustic scrubbing and

Solid Chemical Absorption wherean 'iron sponge' consisting of ferric oxide and wood shavings is made to react with gas in a dry scrubber. Else, molecular sieves are preferred as they help to remove both carbon dioxide and hydrogen sulfide. Microbial methods Molecular sieves made of natural zeolites maybe economic, efficient and simple.After upgradation, bio-methane is compressed and injected into the grid. Bio-methane can be liquefied at -161oC and conveniently stored in cylinders.

In theory biogas generates no net carbon dioxide. Hence it is a clean fuel. In reality inefficient processes and the energy needed to upgrade lead to net carbon emissions. Unlike solar, wind or wave energy, bio-methane provides continuous 24/7 energy availability. Bio-methane can also be used to produce all the plastics which are currently manufactured from petroleum products.

Compressed Natural Gas contains more than 90% of methane and 3–4% of ethane. Bio-methane can be stored in CNG cylinders in compressed for and used for running vehicles. The comparative price of comparable fuels is: 550 Kilo joules/ rupee for petrol, 700kj/Rs for commercial LPG, 1485 kj/Rs. for bioCNG and 1238kj/Rs. for CNG. This proves that bio-methane is not only an eco-friendly fuel for vehicles, but also economical.

In July 2018 Bharat Petroleum Corporation (BPCL) announced that it is venturing into the biogas sector by setting up a captive use plant for a food outlet in one of its petrol pumps at Bazargon, off the Nagpur-Amravati highway. An entire logistics supply chain would need to be developed before the scale-up of biogas in India could take place. The biggest challenge is ensuring availability of bio-waste at a large scale. This will require the involvement of civic bodies, NGOs and other government agencies to collect bio-waste which can be converted into gas. Nevertheless, the business can be financially viable with around 12% return on investment, predicts BPCL.

According to the International Energy Agency, bioenergy (biogas and biomass) have the potential to meet more than a quarter of world demand for transportation fuels by 2050.

Waste water treatment plants can anaerobically digest sewage into biogas, which can be stripped off CO2 and H2S to run the fleet of waste collection vehicles. This is the most efficient way to use a digestor. This is being done for many small scale waste water treatment plants across America.

The calorific value of biogas is about 6 kWh/m3, what corresponds to about half a litre of diesel oil. Recently Sulabh has modified the genset which earlier required 20% diesel and 80% biogas. It does not require diesel and runs on 100% biogas. This has made electricity generation from biogas more sustainable.

In Germany and other industrialised countries, power generation is the main purpose of biogas plants; conversion of biogas to electricity has become a standard technology.

Constructed Wetlands: Aerobic methods of wastewater treatment

In contrast to anaerobic digestion, aerobic treatment of waste water can be done with the help of terrestrialnatural systems. This is gaining popularity in New Zealand. Aerobic waste water treatment in STP has already been explained. Mechanical aerating wastewater systems are water-based where energy-intensive aerators to pump oxygen into the wastewater and its many moving parts can be unreliable and

expensive to repair. High maintenance costs, running costs, and high potential for odour. In nature, most decomposition takes place in land-based, oxygen-rich humus. This highly efficient decomposition of waste is by a complex range of soil organisms. Without this, decomposition would cease and we could no longer live on this planet. Letting nature do the aeration on a typical on-site wastewater system eliminates more than 1000kWhours per year.

If one observes the polluted wetlands around India, one notices that nature is cleaning the system through root-zone technology. The same can be scientifically achieved with a few simple systems in place. This is a low-cost system which can be very effectively applied in small towns and villages to achieve water treatment. Its advantages include:

- Low capital cost
- Simple construction, no mechanical and electrical equipment.
- Little or no maintenance.
- Robust process and is able to withstand wide variation of operating conditions.
- Consistent quality of treated water.
- Potential for bird sanctuary and wildlife habitat.
- Potential to develop into a beautiful landscape.
- Works on a wide range of organic and inorganic contents in the effluent.
- Works economically for capacities as low as 1 m3/day to 10,000 m3/day and for COD input as high as 50000 to 60000 mg/l.
- Lasts for more than 50 to 60 years without any major maintenance.
- Treats effluentsincluding sewage,dairy mill waste, Sugar mill waste, food/ fruit processing, agro-based industry, meat and fish processing industry, auto service station's effluent petroleum refineries, chemical industries, textile industry, pulp and paper, steel plants, coal mines and distillery spent-wash.
- No sludge
- No need for skilled operators.

The essential components of the systems are:

(i) The reed type of wetland plants: cattail, reed-phragmites, bullrush, sedge and various plants in grass family, phalaris, spartina and carex are some of the plant types used in wet land systems. Care need to be taken to avoid alien invasive species of reeds, giving preference to native species.

(ii) The soil bed: The water is fed through the stone aggregate channel which normally takes care of uniform flow distribution over the entire cross section of the reed bed. Due to the slope deliberately provided in one direction, the effluent percolates through the porous soil bed towards the other end horizontally and comes out through a perforated under-drain pipe system provided at the outlet end of the reed bed.

(iii) Micro-organisms of different type: 2500 to 3000 naturally occurring bacterial strains of aerobic as well as anaerobic type along with fungi and yeasts that also help in treatment particularly in colour removal. The bacterial activity is maximum at pH 6 to 8 but bioconversion takes place from 4 to 10 pH in Root zone systems. The resistance to heavy metal toxicity is developed in bacteria by increasing impermeability of cell and biochemically transforming the metal. Aerobic type of bacteria on the upper parts of the soil biodegrade the organic matter from the effluent to CO2, N2 and H2O and elemental sulphur thus leaving practically no sludge behind. The soil bed area where roots do not reach has anaerobic bacterial population and also biodegrades the organic matter reducing the COD and BOD of the effluent as it flows furtherdown through the bed. During the percolation, there is a very fine filtration which arrests the suspended organic matter along with some inorganic colloidal matter. During the percolation, there is a very fine filtration which arrests the suspended organic matter along with some inorganic colloidal matter. Porosity reduced by such particles getting trapped is compensated by increased porosity caused by crevices created by decay of old roots. The special chemicals added to the bed react with some of the products of bio-reaction to neutralise the effects by precipitation and adjusting the pH.

The engineered Root zone bed is shown below. As seen from this figure, the bottom and side bunds of system are compacted and made impermeable using either plastic liner or certain clays. The bottom has a slope in one direction which depending upon the hydraulic load and organic load is varied between 0 to 0.2 per cent.

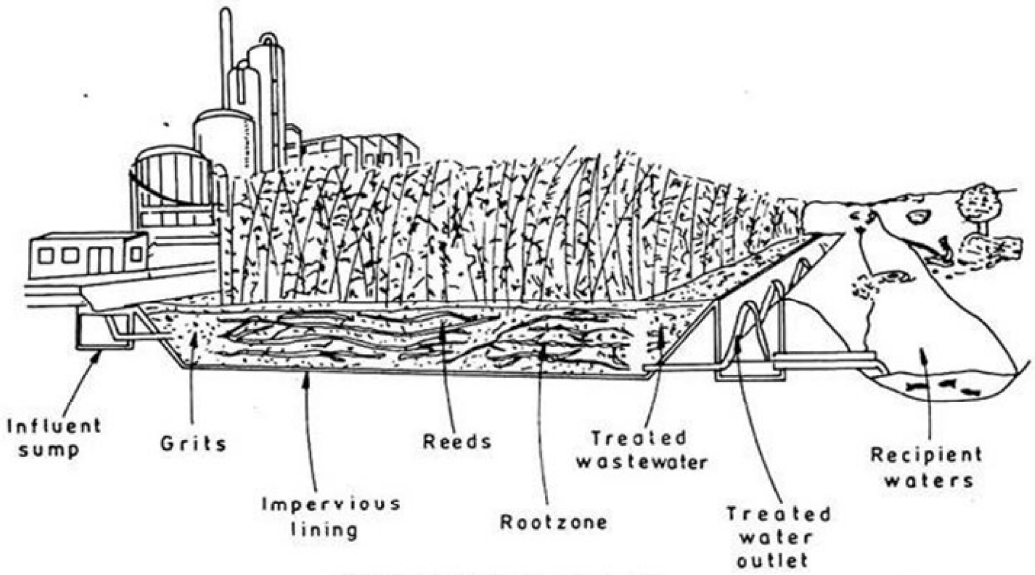


Fig. 4.25 Typical Rootzone installation

There is an under-drain pipe system at the bottom with a provision to vary the water level in the bed as required. The soil bed is especially prepared to achieve the hydraulic permeability required for a particular effluent as well as for required output quality. The addition of certain chemicals in powdered or granular form is determined to take care of the constituents in the effluent and also for pH correction (only if pH falls below 3).

Types of Constructed Wet Lands:

There are two principal types of constructed wet lands:

(i) Free water surface systems with emergent plants: Free water surface system consists of basins or channels with subsurface barrier of clay or impervious membrane to prevent seepage to soil or other suitable medium. This is present to support the emergent vegetation and water flowing through at a shallow depth. Cattails and bull rushes are commonly used in free water surface wet lands.

The shallow water depth, low flow velocity, presence of plant stalks and litter regulate flows, specially in long narrow channels, ensuring good flow conditions. This system may produce H2S odour, if wastewater contains more than 50 mg/l of sulphate, due to presence of sulphate reducing bacteria. Due to surface flow, mosquito problems may occur when the system is overloaded and anaerobic conditions develop.

(ii) Sub surface closed systems with emergent plants: Free Subsurface flow system lined or unlined trenches or basins are filled with permeable packing medium and placed with emergent plants. Rootzone method and rock reed filter are two main categories of subsurface flow systems. To grow plants, a soil medium in Rootzone method, rock and sand are used in a rock-reed filter system.

Sizing of Beds is done on two considerations (i) Hydraulic flow capacity (ii) Organic load to be degraded and higher of the two area values is selected.

Formula normally used is: Ac =K x Qdx (Ln-Cl)

where,

Ac = Active bed area

K = is a constant depending on the nature of organic matter and can vary between 4 to 10.

Qd= Daily average flow rate in m3/day

Co =Daily average BOD5 of feed in mg/l

Ct =Required average BOD5 of treated water in mg/l

Based on hydraulic flow:

Ac = Qs/Kfx dH/dS

where,

Qs= Average flow rate of sewage in m3/sec

Kf= an imperial number based on soil porosity and structure

dH/dS = slope of bed in m/m

Areas calculated by these two formulae are considered and higher area is taken for designing.

Soil and Growth Medium:

Proper selection of soil considering permeability, inorganics and organic contents are most important and determination of proper admixtures and their proportions is complicated and propriety information to be given here.

Plants and Plantation:

Being very hardy and robust and having high root density for most of the treatment plants of subsurface nature, phragmitesaustralis has been very useful. For quick growth, clumps of the plants are planted with a plant density of 1 to 2 per m2, though propagation through seed and seedlings is also practiced. Multiplication using Tissue Culture method has been found most scientific as the health of the plant is uniform.

Under-Drain System:

Plastic pipes not less than 100 mm diameter with or without perforations are used in the under-drain system. Depending upon the length of the bed, two or more intermediate drains are provided in the bed. A sump or manhole is provided in the outlet channel or outside where all drains are connected. By increasing or lowering the outlet level of the pipes in the outlet manhole, the water level in different zones can be altered during the operation and primary growth period.

In a vertical flow system, cut channels with serrations are installed on the top of the bed and effluent is fed by gravity/overflow combination for uniform distribution. Using a pressurized flow and spraying the effluent over the entire bed also practiced.

With the proper residence time which could range from few hours to few days, the required extent of treatment is achieved. The treated water gets accumulated in the outlet channel and with the help of suitable piping network is taken out and can be pumped the tertiary treatment to remove undesired inorganics to the extent required for reuse. Technologies like RO, ED, Ion exchange, demineralising, nanofiltration, and ultrafiltration are employed depending upon the treatment level required for reuse.

Limitations of Rootzone System:

(i) Highly advanced treatment requires relatively larger area.

(ii) Biological and hydrological complexity and lack of full knowledge of nature's treatment know-how makes it difficult to design for unknown effluents.

(iii) Possible problems relating to steep topography, shallow soils, high water table and susceptibility to floods.

Hydroponics

Effluent from a biogas digester has a good plant nutrient valuefor irrigating grass lawns, flower beds or even for agricultural purposes.

Hydroponics i.e., soil-less culture of plants can be done as follows: the effluent is first dried in earthen pots kept in sunlight where owing to the evaporation of the liquid, the concentration of nutrients increases. It is filtered with a thin plastic mesh. Some trace elements are added in the filtered effluent. Such effluent is completely odourless. Various plants have been grown exclusively on such an effluent when mixed (5 to 10% by volume) with tap water. Plants can be grown in glass bottles or any other jars and kept inside or outside the room. Such technology is useful for the culture of rare plants like cactii and other ornamental plants.

Biogas Chullah and other uses of biogas:

Methane is the only combustible constituent, which is utilized in different forms of energy. Its calorific value is 24 MJ/cum or about 5000 Kcal/cum. A one thousand cft. (30 cum) of biogas is equivalent to 600 cft. of natural gas, 6.4 gallons of butane and 5.2 gallons of gasoline or 4.6 gallons of diesel oil.

Biogas is utilized for cooking, lighting through mantle lamps, electricity generation and body warming during winter.

Cooking is the most efficient use of biogas. Biogas burners are available in a wide ranging capacity from 8 cft to 100 cft biogas consumption per hour. It burns with a blue flame and without soot and odour. The biogas mantle lamp consumes 2-3 cft per hour having illumination capacity equivalent to 40 W electric bulbs at 220 volt.

Motive power can be generated by using biogas in dual fuel internal combustion (IC) engine. Air mixed with biogas is aspirated into the engine and the mixture is then compressed, raising its temperature to about 350°C, which is the self-ignition temperature of diesel. Biogas has a high (600°C) ignition temperature. Therefore, in order to initiate combustion of the charge, a small quantity of diesel is injected into the cylinder just before the end of compression. The charge is thus ignited and the process is continued smoothly. At optimum condition only 20% diesel is required, rest (80%) is substituted by biogas. Biogas consumption by engine is 15 cft/BHP/hour.

A public convenience used by about 2,000 persons per day would produce approximately 60 cum of biogas which can run a 10 KVA genset for 8 hours a day, producing 65 units of power. Sulabh has developed a novel technology to run dual fuel genset on biogas alone i.e. without any diesel. Under the system ignition of compressed biogas is done through battery operated spark system. It is a new method to make biogas based electricity generation sustainable.

8 Exercise:

8.1 Based on the report of waste water audit and the water map of your study area (done in the previous chapter), explore the feasibility of various wastewater treatment methods in your study area. Mark the areas where intervention is required. Specify the intervention you recommend, with proper reasoning.

Present your findings before a guest expert on the subject and take their feedback. If the study and recommendations are found robust, the same may be forwarded through your institution to the Municipality/ District Collector/ Mayor.

8.2 Project: Students need to prepare a small-scale constructed wetland near a small drain on campus, using locally available plants. Students need to make it as aesthetic, functional and economical as possible. Check the quality of water at the entry and exit after it stabilizes.

Never doubt that a small group of thoughtful and committed citizens can change the world; indeed, it's the only thing that ever has.

- Margaret Mead, American cultural anthropologist

Unit 9

Solid Waste Management

Approach Methodology

Step 1: Classroom activity. Self-assessment: Students need to list on the blackboard the different kinds of wastes generated in their households. Each student need to add one new item to the list till the list is complete (or has 50 items). Conduct an activity of segregation, by putting the items into lists of recyclables, reusables, landfill material, toxics,

Step 2: Classroom teaching on solid waste disposal and management. Supported by video/ short film.

Step 3: ExplainSwachhSurvekshan in class.

Step 4: Exercise 9.1

Step 5: Field Visit to a recycling unit.

Step 6: Project: Survey composting methods prevalent in your area. Work in groups, divide the city in grids. Prepare a report.

Step 7: Project: 9.2

Swachh Survekshan:

Ministry of Housing and Urban Affairs, Government of India concluded its third survey 'Swachh Survekshan - 2018' covering 4203 Cities including 61 Cantonment Boards to encourage cities to improve urban sanitation. This annual event kick-started in January 2016 with the rating of 73 cities followed by 'Swachh Survekshan-2017' ranking 434 cities in a bid to scale up and encourage cities to actively implement mission initiatives in a timely and innovative manner.

The 2018 Swachh Survekshan declared Indore as the cleanest city with Bhopal and Chandigarh as runners up.

The three main areas in which Indore has excelled over the years are:

- 100per cent waste segregation at source
- Treating waste on the same day
- Utilizing the waste within the city effectively.

Currently, Indore generates 1100 metric tons of waste daily, out of which 600 is the wet waste and 500 is the dry waste. In Indore, waste is collected in three bins format – wet waste, dry waste and domestic hazardous waste that includes medical waste, sanitary/diapers waste. The collection of waste is done on a daily basis from households and it is on the same day treated effectively. Two centralized recovery centres in the city with more than 500 rag-pickers treat the dry waste. One centralised unit treats wet waste besides 274 decentralised channels hat include top hospitals, banquet halls, hotels, and educational institutions, which have composting units within their area and are treating their wet waste on their own. Moreover, 636 gardens in the cities compost their green waste. Indore is also successfully converting its waste into bio CNG gas which is further being used to run 20 city buses. The fruit and vegetable mandi in the city has a system of treating waste into bio CNG gas with 20 metric tons of waste converted on a daily basis into 1000 kgs of CNG gas. By the end of the 2018, Indore will be able to produce 4,000 kgs of CNG gas which will further help in running all the city buses.

Greater Mumbai is the Cleanest State Capital. Vijayawada, Andhra Pradesh is the cleanest city with a population over 10 lakh (as per 2011 census) and Mysuru, Karnataka is the Cleanest City with 3-10 lakh Population. Nagpur received the best city in innovation and best practices, while Navi Mumbai proved best in solid waste management. Bhalso in Punjab, Bundu in Jharkhand, Kakching in Manipur, Siddipet in Telangana and Panchgani in Maharashtra won from their respective zones.

Ratings of Swachh Survekshan are based on category wise assessment of open defecation free (ODF) progress, collection and transportation of solid waste and processing of solid waste. Swachh Survekshan 2018 involved data submitted by civic bodies on cleanliness and sanitation, as well as feedback from the citizens. The survey takes places in 3 steps:

1. Service level progress based on data provided by Municipal Body,

2 a. Independent validation- based on step 1 and negative marking if discrepancy found,

2 b. Direct observations, and

3. Collection of direct citizen feedback.

Solid Waste Management:

Waste Management

Visible cleanliness of any public space is essential requirement for public hygiene. This requires efficient waste management. Such exercise encompasses reducing, reusing, recycling waste material which will improve the economic and environmental performance of the Institutions. The simple steps along with scoring system in this section will help you to map out your existing waste management practices.

Waste Management includes		
1. Segregation of Waste		
2. Collection of Waste		
3. Reuse and Recycling of Solid Waste		
4. Disposal of Waste		
5. Waste Management Initiatives		
6. Bio Medical Waste Managed as per Rules		
Total		

Solid waste is an issue that needs to be addressed both in rural and urban area. Until a decade ago, solid waste in rural areas was a bare minimum. The lifestyle they led ensured that most of the materials they used, and therefore most of their waste was biodegradable. However, in recent times, packaging waste has started to appear in the waste stream in the form of processed food, toiletriesand tobacco packed in small sachets and its volume is growing exponentially. Rural India is embracing plastic as a symbol of

modernity. Since villagers do not know how to deal with plastic, it is often burned with their other dry waste. Village outskirts now resemble open garbage dumps. Rivers, ponds, farmlands and forests are all getting affected.

The issue of solid waste is much larger in urban areas. Urban India is the third largest garbage generator in the world, where 1 lakh tonnes of waste is being generated every single day. Population pressure and lack of land are making garbage heaps unmanageable. Cities are buckling under the weight of solid waste. The repercussions of this can be seen in the following ways: -

- Unsightly and malodorous heaps which bring down the real estate value in the neighbourhoods of garbage depots.
- an increase in ground water contamination, through leaching
- an increase in the population of scavenging animals including crows, dogs, cows and pigs
- increased deaths of stray animals, whose post-mortem reveals chocking due to plastics in stomach

Under the Swachh Bharat Abhiyaan, urban solid waste management has been taken up on war footing.

The urban Indian citizen generates nearly 700 grams of solid waste per person per day which is nearly 250 kg in a year. About half of this is biodegradable. To make these projects most effective, citizens of India need to practice proper segregation of waste at source. Simply translated, it is the separating of wastes into three categories- compostable, recyclable and hazardous. The three categories of waste need to be handled separately throughout their journey till the end. Properwaste segregation is the secret of success for cities like, Alleppey, Mysuru, Panaji, Indore, Chandigarh, Bhopal and Vijayawada. Source segregation is the key to effective SWM. However to sustain source segregation and maintaining the process through collection, transportation and treatment requires a peoples movement with fundamental changes in behavioural attitudes and total overhaul of the existing SWM in terms of infrastructure and manpower. This course it is expected will sow the seeds for the development of an improved and modified waste management system. Trained, skilled and committed manpower is the need of the hour.

An effective system of SWM essentially comprises of :

- Collection- Source segregation, primary waste collection
- Transportation- Primary and secondary
- Treatment- Composting, recycling
- Disposal- waste to energy, Land fills

All of the above have undergone a transformational change since the advent of Swachh Bharat Abhiyan. Swachh Survekshan, a competition based on sanitation issues has evoked a new wave of enthusiasm towards a Clean india. This has to be sustained. This course will endeavor to do exactly this with a practical, to do approach and finding innovative, implementable solutions to legacy challenges.

Internationally, the cleanest cities are Singapore, Hamburg in Germany, Chicago, Honolulu and San Francisco in USA, Copenhagen in Denmark, Helsinki the capital of Finland, Reykjavik, the capital of Iceland, Vienna the capital of Austria. The reason these cities are the cleanest is because the people make a conscious effort to keep them clean. There is zero- tolerance for litteringand irresponsible handling of waste is not tolerated. Without public support, even the cleanest city cannot stay clean. Though Geneva in Switzerland is among the cleanest, it is the public money that runs the show, not the community with dustbins being cleared up to 10 times a day. This attitude of the community is upsetting the city's civil engineering and disposal department.

To beat clean cities like Mysuru and Chandigarh two years in a row, Indore has worked really hard with their campaigns, stringent fines for urinating in public, public shaming for OD and littered courtyards, street plays and awareness drives at educational institutions. Systematic door-to-door waste collection; first mixed waste, but later segregated waste is collected every day. Read the story at https://www.businesstoday.in/magazine/columns/the-curious-case-of-a-clean-clean-indore/story/254144.html

Passion, systematic planning and public-spirit are the three human qualities which can get any city clean.

Waste Audit:

Waste audit is an exercise that prepares the foundation of solid waste management. After a round of participatory learning, an environmental audit related to solid waste need to be conducted. It includes identifying :

- the different kinds of waste generated in a particular area,
- the quantity of waste generated of each variety,
- studying the collection method, and
- the prevalent methods of disposal.

Colonies, organizations and support groups involved in scientific and best practices in waste management need to be identified and encouraged to expand their area of work and to provide transfer of knowledge to poorly managed neighbourhoods.

The theory and a few practical aspects of solid waste management are presented here: -

Classification:

In 2016 rules have been promulgated by the Ministry of Environment, Forests and Climate change on Solid Waste, Plastic waste management, Bio medical waste, E-waste and Construction and demolition waste. The rules empower the Urban Local bodies and describe the road map towards sustainable environment. Solid waste can be classified into different types depending on their sources:

a. Municipal Solid Waste (MSW): Waste consisting of everyday items that are discarded by the public.

b. Hazardous Wastes: Waste that has substantial or potential threats to public health or the environment. Waste that is ignitable, reactive, corrosive, toxic or pathogenic falls in this category.

c. Industrial Wastes: Material that is rendered useless during a manufacturing process or industrial activity such as that of factories, industries, mills, and mining operations.

d. Agricultural Wastes: Waste produced as a result of various agricultural operations. It includes manure and other wastes from farms, poultry houses and slaughterhouses and harvest waste.

e. Bio-Medical Wastes: All the waste that visually appears to be of medical or laboratory origin, containing infectious (or potentially infectious) materials including used (and unused discarded) needles, scalpels, lancets and other devices capable of penetrating skin. Biomedical waste may be solid or liquid. discarded blood, sharps, unwanted microbiological cultures and stocks, identifiable body parts (including those as a result of amputation), other human or animal tissue, used bandages and dressings, discarded gloves, other medical supplies that may have been in contact with blood and body fluids, and laboratory waste.

f. Construction and demolition waste: Thisis a large component of MSW which often goes into dump-yards unprocessed, creating dust. Sometimes it is used for raising lands and filling foundation for new construction. In Burari, North Delhi, 2000 tonnes of construction and demolition rubble is recycled daily to recover construction grade materials. Segregation, grinding and washing with recycled water creates raw material for pre-cast products like pavers, tiles and curb-stones. Washing the rubble substantially reduces the particulate matter in the atmosphere.

The present course is limited to municipal solid waste. Every year, about 55 million tonnes of municipal solid waste (MSW) and 38 billion litres of sewage are generated in the urban areas of India. 94% of municipal solid waste is dumped on land, while only 5% is composted.

Methods of Solid Waste Disposal and Management

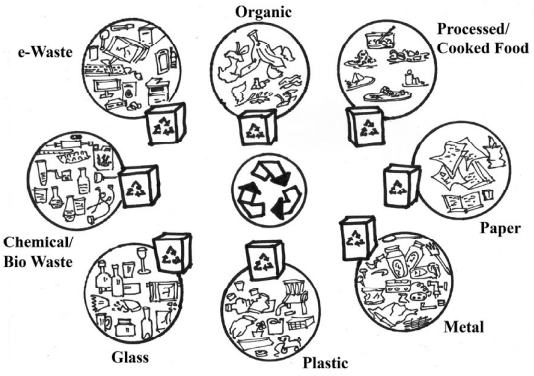
Managing waste is a cyclic process. Waste management is a complex process that covers

many different activities. Each of these activities need to be addressed with care and diligence in order to prevent any adverse effects on the environment and achieve a more effective and sustainable use of all resources.

1. Assessment:

The first step in properly managing waste is monitoring. This includes identifying and assessing the needs of the entity – be it a household or a commercial organization, and identifying all opportunities for recycling and minimizing waste output. After closing the cycle, the monitoring process also includes evaluating the results of the waste minimization efforts and making corrections in the waste collection and disposal methods used in order to improve the environmental friendliness and efficiency of the entity.

2. Segregation:



Throwing our kitchen waste tied in a plastic bag along with other dry waste is the greatest crime many of us commit every day. Due to poor source segregation, Municipalities in India are currently able to compost only 0.21 % of the wet waste we throw away. The result is that neither is the plastic fit for recycling, nor can the food waste be composted. Moreover, stray animals attracted by the smell of food are put in danger. If biodegradables do not enter the city's dump yards, issues like flies, odour, for the neighbourhood will no longer be present.

Three-bin culture is the most effective model for segregation at source.

- Wet waste- biodegradable waste including kitchen waste
- Dry waste-including recyclables and non-decomposable waste
- Domestic hazardous: includes used sharps, sanitary pads, diapers, bandages,

To keep a city clean, it is important that segregated waste is collected every day. However, the every household need to diligently segregate their waste at source. For this they need to be made aware, the process needs to be explained properly and repeatedly until it becomes instilled in them. They need to also be given proper colour-coded bins that are convenient to use and easy to move to the serviceable locations.

A study byCSE has revealed that in 2017-18, only four of 20 forum cities have more than 90% segregation. These four are Indore (MP), Panchgani and Vengurla in Maharashtra and Alappuzha(Kerala). Of these, in Vengurla, there are 3 basic categories of segregation- dry, wet and domestic hazardous. In Indore, all households, establishments and bulk generators practice segregation at source. Panchgani, Vengurla and Indore use their plastic waste for road construction. Other cities with over 50 % waste segregation include Thiruvananthapuram, Mysuru, Gangtok, Muzzafarpur, Bengaluru, Bhopal, Bobbili and Vaijapur.

The right thing would be for every city to adopt 100% waste segregation for waste minimization.

3. Collection

Garbage collection involves organizing the logistics so that waste is collectedon time and there are no bad smells or overspills resulting from waste sitting uncollected for too long. Garbage disposal bins need to be handled by trained and authorized personnel only in order to prevent public hazards and injuries.

There is a need for separate, clearly marked bins which are available for collecting different types of waste – recyclable plastics, metal, paper, glass and general rubbish.

Based on a waste audit and assessment, different cities can set up strategies for convenient waste collection. For instance, Allepuzha only collects dry waste from homes, encouraging residents to treat their wet waste at source. Dry waste is further segregated in the next step. Composting bins are provided to many households at a nominal price to encourage composting.

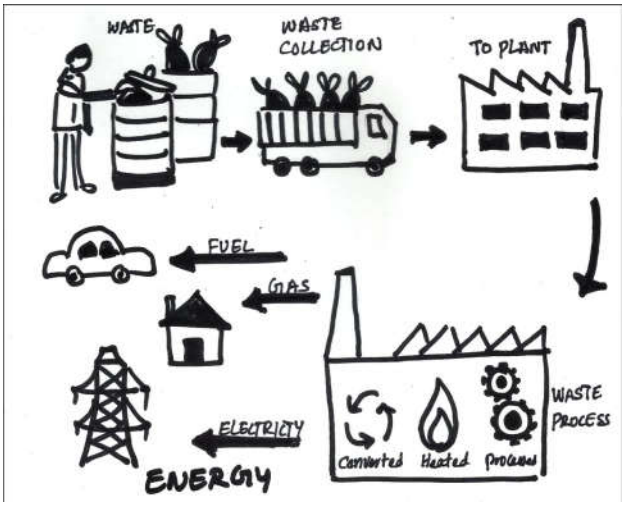
4. Transportation

This step involves transporting the waste from the collection point to a processing plant or landfill. Only vehicles designated for carrying waste need to be used for the purpose. The waste management company need to be a certified waste carrier and their vehicles and drivers need to be approved, licensed and insured so at to comply with all governmental regulations and follow all safety standards.

To make collection easier, the right kind of vehicle is required to effectively access every household, and the right height for citizens/ waste collectors to drop waste without spillage are points to be kept in mind.

5. Processing:

For effective management and disposal, after the waste is collected and transported to a reprocessing plant, for further treatment. Recyclable items are separated from non-recyclables. Recyclables are further categorised into different types of recyclable materials that require different methods of reprocessing. In Vengurla, dry waste is further segregated in 20 different categories. In Mysuru , it is 24 categories. Each category has a market. The waste is sold to the scrap dealers who send it up the chain to recyclers.



Many waste collection units collect different recyclables (glass, paper and metals) on different dates for ease of processing and disposal. Hazardous waste including batteries and e-waste need to be sent to specialized treatment facilities to be safely reprocessed.

6. Recycling/Disposal:

After processing the rubbish, the waste carrier needs to see to its efficient and safe recycling and disposal. Non-recyclable materials need to be taken straight to the landfill for waste disposal. The landfill sites used for the purpose have to be licensed and approved by the authorities. This guarantees that waste will be buried at the right depth and there will be no seepage into the ground waters or soil contamination. Recyclables, on the other hand, need to be reprocessed in the relevant recycling plants to create raw materials which can then be sold for sustainable production of new items without depleting the natural resources.

Final disposal of waste takes place in many different ways across the world. Some methods, though popular due to convenience or cost, may be extremely polluting and dangerous. The list of disposal methods is described here:

- Open burning: This is a very prevalent, highly polluting method. Not recommended.
- Dumping into the sea: In coastal cities garbage is taken in barges sufficiently far away from the coast (15-30 km) and dumped there. It is very costly and extremely harmful to aquatic life. Highly avoidable.
- Ploughing in fields: Agricultural waste including straw, animal dung, weeds, old jute sacks are ploughed into the field. Though not widely in use, this is practiced by a few farmers in India. The advantage is that soil microbes break down the waste and make it available for the next crop. Spreading the waste out reduces its concentration and exposure to direct sunlight accelerates the composting. Care need to be taken to avoid ploughing in of non-biodegradable waste, potentially toxic waste and sharps, as these can harm soil quality and affect the crop.
- Hog feeding: Though not popular in India, it has recently entered the Indian markets. A grinder is attached at the base of the kitchen sink. Vegetable peels, other kitchen waste including chicken bones are ground and discharged into sewers. This can increase the BOD (biological oxygen demand of the waste water by 30% and total suspended solids by 25-30%. Therefore it is not recommended. However, if waste water from the kitchen is allowed to drain into a digester, then this kitchen waste can be turned into biogas.
- Sanitary Landfills: This is a simple, cheap, and effective method, where a deep trench (3 to 5 m) is excavated. Waste is laid in layers, depth is generally limited to 2m, which are then compacted with mechanical equipment and covered with earth, leveled, and compacted. The landfill takes a few months to settle. Organic waste is decomposed by facultative bacteria hydrolyze complex organic matter into simpler water soluble organics. These diffuse through the soil where fungi and other bacteria convert them to carbon dioxide and water under aerobic conditions. Aerobic methanogenic bacteria utilize the methane generated and the rest diffuses into the atmosphere. Sanitary landfills need to be small. Large landfills can be a fire hazard. Moisture content need to not less than 60% for good biodegradation. Temperature in the initial stages of decomposition – as high as 70 degree C – then drops. Reclaimed areas may be used for other purposes. Much land in Mumbai has been reclaimed from the Arabian Sea through sanitary landfill. On the other hand, Mysuru, Panaji and Allepuzha are zero landfill cities.
- Engineered Landfills: In this method, the bottom of the trench is lined with impervious material (Geo-synthetic clay liner) to prevent the leachate from contaminating groundwater. The black liquid contains organic and inorganic chemicals, heavy metals as well as pathogens; it can pollute the groundwater and therefore represents a health risk. A well-designed and laid out leachate collection mechanism is provided. Leachate so collected is treated and then disposed off.

Landfill gas created from such landfills typically has the following components by dry volume: methane (45-60%), carbon dioxide (40-60%), nitrogen (2-5 %) and traces of oxygen, hydrogen and ammonia. Technology is available to extract, purify and use this landfill gas as biomethane. Engineered semi aerobic landfills with facilities for leachate collection and venting of the gases from the biodegradable matter dumped are best suited for countries like India.

Methane and leachate are the two major pollutants that are produced in a landfill. This makes landfills polluting. To avoid leachate from being highly toxic, batteries and other toxic material, biodegradables, radioactive wastes and e-waste need to be prevented from entering the landfill. There is a need for leachate treatment plant to be located along many of the landfills.

If biodegradables, toxics and recyclables are removed from the waste, the resultant landfill is called an inert landfill.

- Incineration: This is a method suited for combustible refuse which is burnt. Incineration is able to reduce waste mass by 70% and volume by up to 90%. A primary chamber is designed to facilitate rapid drying of garbage and volatile gases. A secondary chamber – between the primary chamber and the stack burns the waste at temperatures above 700-11000C. Maintenance of this temperature is most difficult. When the temperature is not maintained it may release toxic gases like furans. An incinerator is expensive to build and operate. Incineration is suited in crowded cities where sites for land filling are not available. Usually it is used for residential complexes to reduce cost. The stack height needs to be scientifically designed, tall enough to allow the fumes to efficient dispersal. The two problems with incinerators are the waste of heat and the dirty fumes. The exhaust gas exceeds the acceptable inlet temperature for electrostatic precipitators and therefore particulate emission cannot be controlled in incinerators.
- Waste to Energy Combustors: To overcome the drawbacks of incinerators, modern combustors have been introduced which combine solid waste combustion with energy recovery. Combustors have the following components:

a. Storage pit – for storing and sorting incoming refuse.

b. Crane – for charging the combustion box

c. Combustion chamber consisting of bottom grates on which combustion occurs

d. Grates on which refuse moves

e. Heat recovery system of pipes in which water is turned to steam

f. Ash handling systems

g. Air pollution control systems

Grates provide turbulence so that the MSW can be thoroughly burned. They also provide under fire air to assist in combustion as well as to cool the grates. The operating temperature of combustors is 980oC to 1090oC.

According to the Ministry of New and Renewable Energy (MNRE), there exists a potential of about 1700 MW from urban waste (1500 from MSW and 225 MW from sewage) and about 1300 MW from industrial waste. When high temperatures are used to decompose organic non-biodegradable matter with low moisture content matter to produce either heat energy or fuel oil or gas, the process is called Thermo-chemical conversion e.g. Pyrolysis and Gasification.The products of these processes (producer gas, exhaust gases etc) can be used purely as heat energy or further processed chemically, to produce a range of end products.

India's first EURO norm compliant Waste to Energy plant was set up at Gazipur, New Delhi with a 7-stage pre-processing which prepares refuse derived fuel (RDF) which has a calorific value of 3,000 kcal per kg. 550 tons per day of Refuse Derived Fuel (RDF) are burned at a furnace temperature of 1,100 oC thereby eliminating carcinogens and furons. The flue gas moves through a semi wet reactor and a bag filter. EURO norm compliant gases are discharged through the chimney. Emission data is monitored on site and made available online. A steam turbine generates 12 MW of power at 11 kV.

- Fermentation and biological digestion: Bio-chemical conversion is another waste to energy model. This process is based on enzymatic decomposition of organic matter by microbial action to produce methane gas, and alcohol This process, on the other hand, is preferred for wastes having high percentage of organic, bio-degradable (putrescible) matter and high level of moisture/ water content, which aids microbial activity. The major technological options under this category are anaerobic digestion (bio-methanation) and fermentation. Of the two, anaerobic digestion is the most frequently used method for waste to energy, and fermentation is emerging.
- Electrochemical conversion: Electrochemical conversion in the context of waste to energy refers typically to microbial fuel cells (MFC). These systems are developed to trap the energy from wastes, where the reduction-oxidation machinery of immobilized microbial cells is catalytically exploited, for the accelerated transfer of electrons from organic wastes, to generate electricity and bio-hydrogen gas. However this methodology needs extensive evaluation studies on bulk scale liquid waste treatments and stands at a nascent level in India as well as worldwide.
- Composting: This is popular in developing countries. Composting need to ideally be done at household level. Still, there are many municipalities that collect biodegradable waste and centrally compost it. Government has also offered a subsidy on compost produced by empaneling fertilizer companies to buy compost at a cost of Rs 1,500/- per tons.

a. Composting at source:

A pit is dug and decomposable organic matter is separated and composted. There are many modern methods of decomposing, Composting organisms require 4 four conditions to create compost:

- Carbon from brown organic matter like dried leaves, sawdust, straw, paper
- Nitrogen that comes from fruit and vegetable waste, coffee grounds

- Oxygen which comes from air
- Moisture in the right amounts

Composting needs collection of kitchen waste in a container, and dry or brown decomposable waste in another. Any large container, with holes drilled at various heights can be used for composting. Line the bottom with a layer of soil. Add kitchen waste and dried waste alternately. When it fills up, cover it with a lid. Turn the mix every few days for aeration. If dry, sprinkle some water. Readymade composting buckets and bacterial mix are also available for hastening the process. Composting yields a stable end product –a good soil conditioner that may be used as a base for fertilizers. Municipalities sometimes have schemes for collecting the end-product i.e. compost. By segregating, recycling and composting, a family of 4 can reduce their waste from 1000 Kg to less than 100 kg- a 90% reduction- every year!

Several municipalities offer subsidies on various instruments for wet waste composting, such as pipe composting. Communities using pipe composting need hand-holding support till they learn to use it properly.

Stack composter or 'khamba', is a set of three earthen pots with a lid and air vents. It can be kept in a balcony, or a terrace, but away from direct rain and danger of being toppled over. They come in attractive colours to suit the decor of homes. The lowest container is filled halfway with dry leaves or coconut fibre. The top two bins are lines with newspaper. Daily kitchen waste is added, and a layer of dry mix of soil and old compost is added. When the pot fills, a layer of microbes (available in market) are added. Humidity is adjusted by sprinkling water. The second pot is put to use. The cycle continues, using the bottom pit for the final decomposition. A contraption of this kind costs Rs.3000 or so and serves a nuclear family well. The compost can be used for home gardens or neighbourhood trees.

b. Aerobic Composting : Open Windrow

In places where wet waste is collected from homes, the municipality or other waste collectors use open windrow composting and mechanical composting methods. For composting to occur well, bacteria need a substantial quantity of waste to create the right humidity and heat conditions. This suits municipal and agricultural waste. Biodegradable waste is placed in piles called 'windrows', about 1.5m high and 2.5m wide at about 60% moisture content. Heat builds up in the refuse piles due to biological activity – temperature rises to about 70oC. The pile is turned up twice a week for cooling and aeration to avoid anaerobic conditions. Moisture content is adjusted to about 60%. Then it is piled again. This operation is repeated for 7-10 weeks till the temperature stabilizes to atmospheric temperature, indicating that the compost is ready.

Aerobic composting is a dynamic system in which facultative and obligate aerobic forms of bacteria, actinomycetes and fungi are most

active. Thermophilic bacteria are mainly responsible for breakdown of protein and other readily biodegradable organic matter. Fungi and actinomycetes play an important role in the decomposition of cellulose and lignin. The relative predominance of one species over other depends upon the constantly changing available food supply, temperature and substrate conditions. If turning is not carried out frequently, increased growth of actinomycetes and fungi in the outer layer lends a typical greyish white colour.

Success Story:

Composting : Today, composting is one of the easiest and best ways to manage the wet or kitchen waste. One can either choose to go for traditional composting option, where waste needs to be added with soil/cow dung on a daily basis, or can simply opt for an automatic composting unit, where one is only responsible for adding waste in a composting unit on a daily basis and the manure will be generated automatically. A leading example of this practice is the Centre for Science and Environment (CSE) office in New Delhi, the office premise in the last 15 years has successfully become waste neutral in its operation. The office premise where food for around 200 people is cooked daily is successfully converted into 18-22 kgs of manure daily.

For optimum results the particle size in the range of 25-75 mm. Composting time can be reduced by adding partially decomposed compost (1-5%) or sewage sludge. To prevent drying, caking and air channeling, materials in the process of being composted need to be mixed or turned on a regular schedule. The optimum temperature for biological stabilization is between 45-55° C. The initial carbon: nitrogen ratio between 35 and 50 and pH less than 8.5 is optimum for composting process. At lower ratios and higher pH levels nitrogen is in excess and will be given off as ammonia and smell bad. At the end of composting process temperature need to be maintained between 60 and 70°C to destroy pathogenic organisms.

Mechanical composting: The process of stabilization is accelerated by mechanical devices of turning the compost. The machine works to keep turning the food waste to reduce particle size and allow aeration. After2 – 5 days itbecomes humus, though it is not completely composted yet. This method of composting is carried out in different vessels: - horizontal plug flow reactor, vertical continuous flow reactor or rotating drum.

The rest of the composting is similar to traditional composting. To enrich compost – night soil and cow dung are added to the refuse. Arrangements for draining of excess moisture are provided at the base of the pit. Compost is stabilized in about 1 to 2 weeks. At the bottom of the pit, a layer of ash, ground limestone, or loamy soil is placed – to neutralize acidity in the compost material and providing an alkaline medium for microorganisms. The pit is filled by alternate layers of refuse (laid in layers of depth 30 – 40 cm) and night soil or cow dung (laid over it in a thin layer). Material is turned every 5 days. This is a good method for large establishments to process their waste and hasten composting. Excel Industries of Ahmedabad treats around 300 tonnes of MSW per day through mechanical composting.

Mechanical aerobic composting of MSW at Okhla in Delhi is another good example, where 200 MT of waste is processed daily. This is the first municipal composting plant in the world to be issued carbon credits. The waste is treated on covered windrows followed by mechanical sieving to get high quality organic manure. The manure is sold in Mother Dairy outlets across the city.

Indore city also does aerobic composting, in brick pits of 3m x 3m x 1 m dimension for up to 8-12 weeks. Materials are turned regularly in the pits and then kept on ground for about 4-6 weeks. In this period, a total of 6 to 8 turnings are required.

Anaerobic composting: This is popularly known as the Bangalore method as it was invented at IISc Bengaluru and is being used successfully for the city. 5000 metric tonnes of MSW are generated each day. 50- 60 % of this is biodegradable. Waste is treated in decentralized dumps. An anaerobic method is carried out in pits. Brick lined earthen trenches 10 x 1.5 x 1.5 m are created. A layer of coarse municipal solid waste is placed at the bottom of a pit to a depth of 15 to 25cm and is made 7.5cm thicker for 25cm width towards both the edges of the pit. Night soil is put in the depressed portion to a thickness of 5cm and the elevated edges prevent it from draining to the side.

A layer of solid waste is put on top so that the night soil layer is sandwiched between the two layers of municipal solid waste. Solid waste and night soil are put in alternate layers till it rises to a height of 30cm above the pit edge. The final layer of solid waste is at least 25 to 30cm thick. The top of the deposited material is completely covered with soil or grass clippings to make it air tight and to avoid rain water entering into the pit. After 4 to 6 months of decomposition the material is stabilized and is taken out and used as compost. The advantage is that turning of waste is not required. It saves water. The disadvantage is that germs and seeds of weeds are more in the compost. The decomposition method is difficult to control and needs more experience.

Vermicomposting: Use of earthworms for composting is ideal for biodegradable wastes from kitchens and hotels. At the household level, a vessel or tray more than 45 cm deep and 1 x 0.60m may be sufficient. A hole shall be provided at one end in the bottom for draining the leachate out into a tray or vessel. Lay a 1" thick layer of baby metal or gravel at the bottom of the tray. Above that lay an old gunny bag or a piece of thick cloth, a layer of coconut husk upside down over it and above that a 2" thick layer of dry leaves and dry cow dung (powdered). Lay the biodegradable waste over it. Introduce good quality earthworms into it (~ 10 g for 0.6 x 0.45 x 0.45 m box). If the waste is dry, sprinkle water over it daily. Rainwater need to not fall into the tray or vessel or box. Cover with a gunny bag to prevent birds and ants from attacking the earthworms. If the box is kept under bright sun, the earthworms will go down and compost can be taken from the top. Compost can be dried and stored. Continue putting waste into the box. Add little cow dung at interval. The leachate collected is called vermiwash. It is very nutritious for plants if diluted in the ratio 1:10 with water before applying to root zone of plants. Vermicomposting takes 2-3 months.

Salvaging: Materials like paper, metal, glass, rags, certain types of plastic can be salvaged, recycled, and reused. This is prevalent in India where waste collectors scour through dump-yards to retrieve recyclables

and sell to scrap collectors. Sometimes old vehicles are sold directly to scrap dealers and they break them apart and salvage valuable material. This is an informal recycling method prevalent in India. Salvaging of e-waste is the latest trend. Apart from natural and health concerns, casual e-waste recycling also raises concern of the protection of recycled electronic items. This sort of recycling also affects the running of formal recyclers. There is a need to diminish improper recycling exercises by creating awareness in the informal scavenging sector.

Fermentation or Biological Digestion: To convert organic matter into energy, the biodegradable part of MSW can be sent for anaerobic digestion, which has been explained in detail in the previous chapter.

From the above description of the methods of solid waste disposal and management it will be easy for you to analyse the kind of waste management practices prevalent in your area. Once the waste is segregated into different streams, the logical treatment of the waste is as given below.

- Biodegradable Waste – convert to compost.
- Recycle whatever is possible.
- Hazardous wastes – dispose it by suitable methods.
- Landfill or incinerate the rest.

The entire process of solid waste management is a continuous, cyclical, labour intensive and expensive. It is the civic responsibility of every citizen to support this process and respect the labour force involved in this process. An appropriate fee need to be paid by every citizen for the services provided in this regard.

Government bodies do not have sufficient staff for handling solid waste of ever-expanding cities and towns. Often waste collection is outsourced to private agencies. It is the municipality's responsibility to ensure that the vendors contracted for this crucial service are following the norms and collecting waste systematically on a daily basis. If any laxity is found in the service provider, they need to be immediately set right to prevent the waste management schedule of the city from going out of control.

Waste Minimization:

Waste minimization is a set of processes and practices intended to reduce the amount of waste produced. By reducing or eliminating the generation of harmful and persistent wastes, waste minimisation supports efforts to promote a more sustainable society. This begins with source reduction and environmentally-sound recycling methods prior to treating or disposing of wastes. Waste minimization means to reduce the production of waste at society and individual level.

Adelaide city in Australia focuses on recycling to keep the city clean. The government encourages citizens to give quality, unwanted items to charity and to rely on recycling services for reduced landfills and minimized waste. Their suggestion is to:

- Set aside another garbage can or container for items that can be recycled instead.
- Repurpose items.
- Donate items instead of putting them in the trash.
- Recycle old batteries and electronics.
- Purchase items made from recycled products.

Success Stories: Battle to Control Plastic Waste

Plastic roads, the brainchild of Dr. Rajagopalan Vasudevan, need one tonne of shredded plastic (or, 10 lakh plastic bags) to lay one kilometre of durable, pot-hole free and hardy road. The Indian Road Congress has also recognized the technology. Since 2015 the Indian Government has made it mandatory for all road developers in the country to use plastic waste, along with bituminous mixes, for road construction. Urban areas with more than 5,00,000 people are now required to construct roads using waste plastic.

Indian Institute of Petroleum (IIP), a constituent laboratory of the Council of Scientific and Industrial Research (CSIR) in 2014, developed a unique process of converting plastic waste like polyethylene and polypropylen(both together account for 60 percent of plastic waste) into either gasoline or diesel, converting one kg of plastic to 750 ml of automotive grade gasoline. IIP's technology has been approved from the Indian Railways in April 2015, and the Railways would set up plants to manufacture diesel from plastic, which would be used for mechanical traction with technology patented by scientists at the CSIR-Indian Institute of Petroleum (CSIR-IIP).

Inspiring Strategies to Maintain A Clean City:

Most cities that regularly rank on "cleanest cities in the world" lists have organizations working hard to prioritize efficient and effective cleanliness measures.

In Singapore they prioritize avoidance of littering. Stickers are placed in bathrooms and small reminders are put up in strategic locations for the public to avoid dropping wrappers on the street. Heavy littering fines and a ban on chewing gum sale have gone a long way in keeping the streets of Singapore litter-free.

Zurich, the largest city in Switzerland, takes air pollution as seriously as municipal solid waste. Their strategy is to provide cleaner public transport. Clean, dependable public transport decreases individual cars in transit daily. Car pooling is encouraged.

Reykjavik, the capital of Iceland, implements green cleaning programs in the government to make environmental efforts a more attractive proposition in the local economy.

There is much to learn for India, and inspirations lie all around us. It is up to us to practice clean living to make our country one among the cleanest in world.

1. Sanitation and Hygiene

Every public place has the right as well as duty to basic facilities such as clean and functional toilets, safe drinking water, clean surroundings and basic information on sanitation and hygiene. This creates

an enabling environment which secures human dignity, safety, health and overall well-being. Increasing awareness about good sanitation practices supported by enabling and reinforcing factors will lead to desirable changes in environment. This stresses the importance of combining sanitation and hygiene education and practical implementation of these aspects involving the communities. Wastes left unattended and untreated lead to unhygienic surroundings which lead to infections and chronic diseases.

How can students contribute to safe and clean surroundings?

The basic principles of sanitation and hygiene include accessible infrastructures to suit different types of needs. Specific approaches and sanitation management practices need to be adhered to.There is a need for equal participation and collaboration among all groups. The methodologies adopted need to be for long term benefits.

- Public places need to promote technical options (EcoSan, pit toilets, toilets with bathing spaces)
- Leadership development to steer the movement from within
- Activities need to influence and develop (local, rural and urban governments, water and sanitation committees, and frontline workers) to lead, own and manage the processes and change
- Need to engage with communities in villages and urban neighbourhoods to empower communities while developing and implementing local level WASH micro plans

Overall, sanitation and hygiene initiatives need to include:

1. Physical Appearance and Overall Ambience
2. Adequacy of Toilets (Student/Toilet Ratio)
3. Gender Balance of Toilets (Male: Women) self certifiable
4. Disabled-Friendly Toilets
5. Water Taps and Sanitation Plumbing, Adequacy and Efficiency
6. Water Efficient Toilets
7. Dedicated Staff for Hygiene Maintenance
8. Dedicated Staff for Hygiene Inspection
9. Kitchen Staff Apparel and Hygiene
10. Canteen Hygiene
11. Kitchen Hygiene
12. Cutlery, Crockery and Utensils Hygiene
13. Dining Hall Hygiene
14. Cleaning Equipment and Consumables

Waste Management

After conducting a detailed study on the segregation of, students can discuss how best to categorize waste. They can keep aside old newspapers, batteries and bottles at source, until it is a substantial volume. Later give these items to waste collection team at intervals (e.g. once in 3 months), to reduce the burden on the waste collectors and segregators during secondary and tertiary segregation.

Plan for waste handling

1. Compost structure
2. Biomedical wastes, if any, must be securely and properly sent to biomedical waste treatment and disposal facilities as per the procedures laid out by the Pollution Control Board.

3. Bio-methane plant for wet waste.

4. Set up an incinerator for hazardous dry / waste. Strict rules need to be implemented to prevent littering.

6. Declare areas as 'No Plastic Zone'.

7. Water dispensers need to be set in several locations at public places with durable and reusable cups (bottled water as well as sale point of soft drinks and water in pet bottles need to be banned).

8. Reusable tableware and eco-friendly parcelling need to be enforced in all food joints.

9. Small land areas to be earmarked to set up four separate waste processing units: one for organic waste (biogas plant/ compost), one for secondary and tertiary segregation of dry wastes, yet another for shredding and incinerating, and a fourth one to store recyclable wastes, construction rubble and waste residue intended for municipal landfill and e-waste

10. E-waste is to be deposited with designated contractor duly authorised by the Pollution Control Board. Refurbished computers, monitors, scanner and printers may be donated.

11. Avoid paper pamphlets and flex banners. Instead, use reusable cloth banners and notice boards.

12. Wet waste can be treated at source itself for the benefit of other organisms. The wet waste from the kitchen and the canteen is to be collected at a place so that birds, cows, dogs, goats and small animals can feed on it. If unused food is in large quantity and not spoiled, it can be channeled to the needy through 'Food Bank' system.

13. When institutes and offices become paperless, a lot of trash can be reduced. Hence use emails, SMS, WhatsApp and Facebook and other social media platforms and online resources to a certain extent.

9. Exercise

9.1 Conduct a Waste Audit in your locality

Working in pairs, or groups of (max) 6, conduct a waste audit to assess the current waste management practices in different parts of your locality or area of study.

Step1: Mapping:

Conduct a discrete and detailed survey of the study area. Find out demography and composition of the area. On a map, mark locations of waste collection points, garbage transit points, waste recycling

units, composting units, official garbage dumps and unofficial places which are regularly trashed, and biomedical waste management plants, if any.

Conduct interviews with people from different walks of life to understand the practical aspects of waste collection and disposalissues and any issues faced by the people.

Step2: Waste characterisation:

Find out the types of garbage collected from each category of establishment- commercial, industrial, residential, medical and institutional. This can be found from interviews with Public Relations Officers of some organizations, or from published data of the Municipality.

Step3: Quantity Determination:

Visit the important dumpyard and interview the supervisor to understand the quantity of waste generated, types of waste and the methods used for processing and landfill. Identify any areas of pollution due to dumpsite

Step4: Collection methods:

Find out form the group in charge of waste collection the details regarding the number of persons involved in waste collection, the mechanisms and frequency of waste collection, segregation and disposal practiced in the study area. This need to include primary collection methods, secondary transportation, health and safety measures taken during the process.Interview formal and informal groups of garbage collectors as well as waste collectors. Find out their work ethic and work life. List out the problems they face in their line of work.

Step5: Environmental Impact Assessment:

Based on your findings, prepare a report.

Analyse your findings with the best practices in solid waste management that you are aware of and give suggestions for improvement.

Any issues of public apathy, public involvement and health-link to waste management need to also be discussed.

Highlight any best practices (if any) that you have found in the course of your research.

Suggest methods to improve the waste management of the study area.

Present the findings in a seminar before your class and teachers.

9.2 Project: Map the areas where waste is illegally dumped (along roadsides, into open drains, etc). Conduct a clean-up drive in any one area, with active support of locals. Beautify the area with art, slogans and plants to prevent recurrence. Take Municipality support and advice before starting the activity.

"Change will not come if we wait for some other person or for some other time. We are the ones we've been waiting for. We are the change we seek."

- **Barack Obama,** former President of USA.

Unit 10

Management of collectives

Approach Methodology

Step 1: Classroom reading of the chapter.

Step 2: Discussion on the difference and commonality in these two models.

Step 3: Field visit- Exercise 10.1 To a local collective body working in waste minimization, waste-to-wealth,

Step 4: Survey/ Project: Exercise 10.2

For a proper management and administration of waste and waste water treatment across the length and breadth of a vast nation, it is not possible to depend entirely on the government machinery. It becomes an individual and collective responsibility of all citizens to bring about a positive and ever-lasting change.

Many Municipalities and Gram Panchayats have joined forces with a variety of non- governmental entities in different models to achieve the common goals of cleaning the county.

A collective is a group of entities that share or are motivated by at least one common issue or interest, or work together to achieve a common objective. Collectives can differ from cooperatives in that they are not necessarily focused upon an economic benefit or saving, but can be that as well.

For the urban poor in developing countries, informal waste recycling is a common way to earn income. There are an estimated 1.5 million to 4 million waste pickers in India, who pick up, clean, sort and segregate recyclable waste and sell it further up the value chain. For instance, Indian recycles 70% of all PET bottles (water bottles and soft drink bottles) as compared to 31% in the USA. This is largely owing to the informal chain of recycling that exists in all of our cities. This chain starts with the waste pickers, who sell waste to scrap dealers, who in turn sell to aggregators and eventually the waste goes to recyclers. By working singly or in unorganized groups they remain underpaid, undervalued and face public apathy. 94% of the 150 waste pickers interviewed in the Jawahar Nagar landfill in Hyderabad, stated that they chose this job since there were no other alternatives available to them. There is no dignity of labour, and certain castes and communities are deliberately made to this menial job of scavenging and cleaning of sewers and septage. They often experience physical abuse and harassment on a daily basis. Caste-based slavery still exists quietly in India.

There is no quantifying the economic and environmental impact of the services that waste pickers and scavengers render to society as long as they keep working anonymously. Their services remain largely unrecognised and uncompensated by the system.

When organized and supported, waste picking can spur grassroots investment by poor people, create jobs, reduce poverty, save municipalities money, improve industrial competitiveness, conserve natural resources, and protect the environment.

Three models have been used to organize waste pickers:

- microenterprises,
- cooperatives, and
- public-private partnerships.

These can lead to more efficient recycling and more effective poverty alleviation. Where Municipalities often consider waste pickers a problem, two successful collectives in India, Kudumbashree from Kerala and SWaCH from Pune, Maharashtra stand out as pillars of support for the municipalities of their area.

Kudumbashree

Kudumbashree is the poverty eradication and women empowerment programme implemented by the State Poverty Eradication Mission (SPEM) of the Government of Kerala. The name Kudumbashree in Malayalam language means 'prosperity of the family'.

Founded in 1997, Kudumbashree has a three-tier structure for its women community network, with Neighbourhood Groups (NHGs) at the lowest level, Area Development Societies (ADS) at the middle level, and Community Development Societies (CDS) at the local government level. The Kudumbashree network has a total membership of 43,06,976 women by 15th March 2017, with 2,77,175 NHGs affiliated to 19,854 ADSs and 1073 CDSs. Kudumbashree membership is open to all adult women, limited to one membership per family. Its main features include democratic leadership, and support structures formed from the 'Kudumbashree family'. The elected body consists of a chairperson, vice chairperson, and committee members.

Some of the work that the Kudumbashree members are involved in include: Green-bites (providing cut fruits and vegetable), ABCD (to control stray dogs), Kalaripayat training unit (to teach women martial arts), crèche (for IT professionals), Women cab drivers, mushroom cultivation, paper carry bag units, agro consulting teams engaged in terrace farming, bio fertilizers and seedlings, preparing nutrimix for young people below 3 years, women welfare centres, Hashram, a geriatric care service, Kudumbashree Women Construction groups where cement bricks are made and homes are constructed by women in partnership with Pradhan Mantri AvasYojana. Many innovative projects including plastic shredding units, kitchens and takeaway counters, supermarkets, laundry service, soap manufacturing are also being run successfully by the women entrepreneurs.

The most noteworthy activity of Kudumbashree has been door-to-door waste collection. Their effort has been a major cause for clean Kerala, with nearly 90% of citizens depending on their relentless work. This activity takes place through an agreement between the Municipality and Kudumbashree. Smaller women's groups form Sanghams (groups) which take up this work in different areas. The Municipality provides them with all necessary equipment, vehicles and safety gears. The members collect a nominal fee from customers, for door to door waste collection. Fuel and maintenance cost of the vehicles is borne by the Kudumbashree unit. Wet/ biodegradable waste is collected once in two days, dry waste is collected once a week and glass and other recyclables are collected once in 1- 6 months, depending on the availability. The waste thus collected is delivered at designated transfer points. From then on, Municipality takes responsibility of its further processing and disposal. The Kudumbashree workers are volunteers who do not get any direct monetary benefit from the Municipality. However, they are given periodic health check-ups and free medical treatment facilities in Municipal hospitals. The workers collect the monthly fee from consumers and after deducting maintenance cost\, and any soft loans from the micro finance,

they share the profits among themselves. They are encouraged to use a savings bank account for the purpose.

From March 2018 Kudumbashree will gradually withdraw from biodegradable waste collection in Kozhikode, as the corporation is promoting home-based garbage processing. They will instead focus on plastics and recyclables. This may be replicated in other districts too. 71-83 % of the waste from Kerala homes is biodegradable. By managing this waste themselves, households can help solve the solid waste management problems of cities to a great extent. Further 15% is recyclables. This can be handled by Kudumbashree units.

To run the Kudumbashree programmes successfully, a Management Information System (MIS) has been put in place, which includes information on farming groups, micro enterprises, Balasabhas, Ashraya families,

Since this is a poverty alleviation programme, the thrust area of the programme is micro-financing. The thrift and credit programme pools together the small regular savings of neighborhood groups and given out as internal loan to the most deserving member of the group. These loans acted as a leveler to address the immediate financial shocks of the group members. To form strong bank linkages NHGs are given matching grants of upto Rs.5000/-.

Swachh, Pune

Swachh is a 9000 member team which evolved from a waste pickers and itinerant waste buyers union in Pune and Pimpri Chinchwad named 'Kagad Kach Patra Kashtakari Panchayat (KKPKP)', a membership-based trade union created way back in 1993.A case study conducted by KKPKP demonstrated that Pune and Pimpri Chinchwad Municipal Corporations save to the tune of several crores of rupees in waste handling costs due to the labour of ragpickers.

The Municipal Solid Waste Management rules, 2000 gave rise to the concept of door-to-door waste collection. However, the Municipality had no provision for employing Safai Karmacharis. At this point, the Union stepped in and offered their help. For this, Swachh, a wholly-owned workers' cooperative as a pro-poor Public Private Partnership for door-to-door waste collection (DTDC) work came into existence in 2005. The members of the cooperative were also members of the KKPKP union. An MoU/ agreement was signed between the Swachh cooperative and the Municipalities, allowing them to conduct a door-to-door waste collection. The Swachh team created zones, and a two-member team is assigned for each area, collecting waste from 150-250 households per day. Prabhag (electoral ward) Workers are dedicated field staff who are on the ground everyday making sure that the waste collection takes place efficiently. Each of the 76 prabhags has a coordinator who liaises between the citizens and the waste pickers as well as the PMC staff for the smooth collection and disposal of garbage. They are supported by 15 ward coordinators and 4 zone coordinators. The coordinators work with the Swachh waste pickers and liaise with the PMC staff and the citizens in order to ensure that the system runs on oiled wheels.

To participate in this activity, the worker need to join the union as well as the cooperative and contribute a small sum each month to a corpus fund, which intends to safeguard their financial condition with a promise of a minimum wage guarantee, in case of an adverse condition.

For the waste pickers' contribution to Solid Waste Management, KKPKP worked for granting waste pickers their rights and dues. The Swachh DTDC model was based on recovery of user fee from service users and provision of infrastructure and management support from the municipality. This enabled 1500 waste pickers to become service providers for the door-to-door collection of waste from 1,25,000 households in Pune city. They have been provided with proper uniforms, gloves, masks and equipment which prioritized their health and safety.

Though they have not yet received the status of Safai Karmachari, they do receive 'dhan-batta' or welfare from the municipality for undertaking a potentially hazardous job. Thecooperative is able to provide social security benefits, insurance and a fixed amount of fellowships of the young people of waste pickers. The Municipality/ Government pays them their entitlement through their KKPKP Union, which in turn uses their 'Pattedi' or credit system to pay their earnings into their individual bank accounts. These accounts were opened in nationalized banks through the 'Jan –Dhan' Yojana. Each worker pays out 5% of his earnings as membership fee to the Swachh cooperative society. The Union is trying to persuade the municipality to pay a pension to 60+ year old workers, and to those workers who are unfit to work in this field after putting g in long years as waste pickers. The struggle continues in this regard.

Meanwhile, with fellowship benefits the young people of waste pickers are an educated lot, capable of handling value added services like composting, and allied services. For them a separate legal entity named Swachh Plus has been launched. Swachh Plus which is involved in livelihood upgradation and income enhancement activities such as V-Collect events where citizens can dispose of their unused household items, furniture and clothes (they are suitably repaired and reused or dismantled and recycled); composting; e-waste collecting and disposing through the correct channels; making and selling ST Dispo bags (or red-dot bags) and awareness raising events.

Swachh also provides internship opportunities for 1-6 months for undergraduates who are willing to work in challenging environments. Students able to speak the local languages, namely Marathi and Hindi will be assigned field work. Students who can converse mostly in English are assigned work in the offices, looking at the bureaucracy aspects of SWaCH. Students can communicate via email to: swach.outreach@gmail.com. Moredetails are available on their website.

10. Exercise:

10.1 Working in pairs, Locate an organization in your locality which is a collective. It may or may not be functioning in the arena of sanitation and waste management. Find out the details of how it functions, namely:-

How many members

How are the members enrolled

Past history

Nature of work

Revenues made

Distribution of earnings among members

Administrative goals, etc

Interview a few members of the collective; also interview their clients to understand the value of the service the collective provides.

10.2 Find out the informal, unorganized sectors in which there may be a scope to develop collectives in your town or study area. Collect information on all informal sectors of labour in your community. Find out which unions are functioning. Interview a few individuals from the poorer strata of society and take their opinion on the kind of work environment they would like to have.

Based on your findings, write a short note about the viability of creating a new collective.

Unit 11

Change Management

Approach Methodology

Step 1: Identify areas of Change.

Step 2: Identify partners in Change Management.

Step 3: Match the commitment of top management with those in operation

Step 4: Introduce the process of change at identified levels.

Step 5: Monitor the process of change for interim corrections

Step 6: Evaluate the benefits of change

Step7: Prepare future interventions.

Introduction

Rapid urbanisation, and high rate of population expansion, are forcing India to experience massive challenges in management of environmental hygiene and sanitation including solid waste management and waste water management. It is believed that more than 377 million urban people live in 7,935 towns and cities and generate 62 million tons of municipal solid waste per annum. Out of this only 43 million tons (MT) of the waste is collected, 11.9 MT is treated and 31 MT is dumped in landfill sites. Most waste management activities managed by the Municipal Corporations have been handled in an unsystematic and haphazard manner. The waste management rules in India are based on the principles of "sustainable development", "precautionary" and "polluter pays", wherein municipalities and commercial establishments have to act in an environmentally accountable and responsible manner. Several subordinate rules made for regulating the manner of disposal and dealing with generated waste have been issued under the umbrella law of Environment Protection Act, 1986 (EPA), but they have several difficulties in implementation.

The key to efficient waste management whether from domestic sector or health care sector or commercial sector or industrial sector is ensuring proper segregation of waste at source and ensuring that the waste goes through different streams of recycling and resource recovery. The reduced final residue is to be deposited scientifically in sanitary landfills. Sanitary landfills are the ultimate means of disposal for unutilised municipal solid waste from waste processing facilities. They are also final destination for other types of inorganic waste that cannot be reused or recycled, but this procedure is costly and has many logistical challenges.

A study by IIT Kanpur (2006) found the potential of recovering at least 15 per cent or 15,000 MT of waste generated every day in the country. This, the report said, could also provide employment opportunities to about 500,000 rag-pickers. The report added that despite immense potential in big cities in this area, participation from local not for profit agencies or community collectives has been limited.

In this context we are trying to study change management. It has been found that most of new initiatives like installing new technology, downsizing, restructuring, or trying to change organisation culture has had low success rates in waste management. The brutal fact is that about 70% of all change initiatives fail in the initial stages.

Most organizations in their rush to change their systems, processes and managerial techniques end up immersing themselves in a muddle or confusion. They lose their initial focus and are overwhelmed by all the advice available in print or on-line about why organisations should change, what they should try to accomplish, and how they should do it. Too many expert recommendations often lead to confusion or disorientation of efforts. This leads to huge human effort and economic cost.

Change Management Process

Change management is a set of processes, tools and mechanisms that are designed to keep organisational changes under control (Kotter, 2013). It is an effort to get individuals and groups ready and willing as well as capable of implementing and sustaining the new ways of working. In 1995 Kotter introduced his 8 step model that outlines eight critical success factors that could be used in change management. According to Kotter (1995) the most general lesson in this area is that the change process goes through a series of phases that may require considerable time. Skipping steps never provides satisfying results and critical mistakes in any of the phases can have serious impact. Changing is always about changing the behaviour of people, and behaviour change happens mostly by speaking to people's feelings (Kotter & Cohen, 2002). According to Jones et al (2013) communication is the key in change management. Leaders need to realize that others often do not feel the need to change, do not understand the issues or see the new direction. The best change methods reinforce core messages through regular advice that is both inspirational and practicable. In change management people matter. It is important to face up to the human issues and to master the soft side of change management. Kotter (1996) stresses the importance of not letting up once the implementation phase is over. He argues that resistance is always waiting to emerge once the project seems to be accomplished. The new behaviours and practices need to be driven into the culture to ensure long term success.

Effective Change management process acts as a gatekeeper ensuring minimum risk and impact to the ongoing Infrastructure & Operations. Change management includes pre-release activities such as roll out, back out planning and scheduling of changes. It performs quality control checks ensuring planned change and release activities.

Objectives

Change Management primarily enables mitigation of risk and impact. Change Management process auhorises and approves any deployment of change. It safeguards the production environment and productivity, while executing change. Objectives of Change management process are:

- Reduction of risk and impact
- Maintenance of current working state
- Communication and approval management
- Effective planning of change with optimum resources
- Reduction in number of disruptive incidents while executing the change

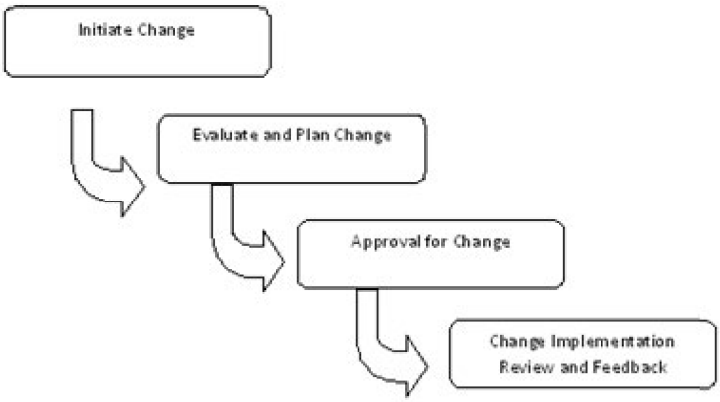
Scenarios

1. New rules and new acts

2. New demands from the customers
3. Technological evolution
4. Process reviews
5. Crisis situations
6. Consumer habit changes
7. Pressure from new business entrants
8. Acquisitions and mergers
9. Organizational restructuring

Change Management Process Flow

Change management process includes different steps. These steps capture every detail about a change request for future tracking. These processes ensure that the change is validated and tested before deployment. Change release management process is responsible for successful deployment. Change Manager handles planning and evaluation. Change Release Manager takes care of the actual implementation of the change. The change management process flow:



Initiate Change

Request for Change (RFC) is submitted to the change management team for validation and approval. Change requests emanate from:

- An Incident that causes a change
- An Existing problem that results in a change
- An user requesting for a new change
- Change as a result of an ongoing maintenance An RFC template is used to record the change

Reason for change - Justifies why change is needed along with risk/benefit analysis.

Impact & Risk assessment - Potential Impact and risk are calculated and documented including configuration items, CIs.

Cost benefit analysis - Estimated cost versus potential benefits are compared.

Implementation planning - Steps for implementing change that includes project members, timelines and methodology.

Evaluate and Plan Change

This stage handles change evaluation and planning activities. It includes prioritization and planning activities to minimize risk and impact.

- Prioritization - Determine the type of change and prioritize the requests accordingly.
- Scheduling - Check the Release schedule to get an estimated time frame and fix the planned start date and end date
- Roll out plan - Plan out the implementation activities
- Back out plan - Back out plan in case of unexpected setbacks

Approval for Change

Any change request that comes in, needs to be approved. The Change management team handles end to end communication and approvals from Change Advisory Board (CAB). Change approval is crucial to eliminate any execution failure and downtime. Approval process varies according to the change type. For example, a major change like ERP solution replacement requires approval from CAB as well as management whereas a standard change like patch deployment does not require any CAB approval as they are pre-approved. Change request is approved only if all the CAB members approve it. Upon rejection, reassessment review is done and submitted again for CAB approval.

Change implementation, Review and Feedback

Change implementation is handled by Release Management Team and Post Implementation Review (PIR) is taken care of, by the Change Management Team. Release Management Team follows its own processes that involve planning and testing. Change review happens once the implementation is completed to ensure that everything has gone according to the plan. The existing change management process is constantly reviewed and updated wherever necessary.

Key Steps for successfully managing change

Research suggests there are two theories of change. They are based on very different and often unconscious assumptions by senior executives—and the consultants and academics who advise them—about why and how changes should be made. Theory E is that of the change based on economic value. Theory O is that

of the change based on organizational capability. Both are valid models. Each theory of change is capable of achieving some of management's goals, either explicitly or implicitly. The costs involved in both these models may be different. The ideal way to success of managing change is to amalgamate both theories E and O into practice in the right mix. Steps on how change mix is achieved:

*Source: https://hbr.org/2000/05/cracking-the-code-of-change

Exercise: Case Discussion: Set direction from the top and engage people below

From day one, Norman set strategy without expecting any participation from below. He said ASDA would adopt an everyday-low-pricing strategy, and Norman unilaterally determined that change would begin by having two experimental store formats up and running within six months. He decided to shift power from the headquarters to the stores, declaring: "I want everyone to be close to the stores. We need to love the stores to death; that is our business." But even from the start, there was an O quality

Dimensions of Change	Theory E	Theory O	Theories E and O Combined
Goals	maximize shareholder value	develop organizational capabilities	explicitly embrace the paradox between economic value and organizational capability
Leadership	manage change from the top down	encourage participation from the bottom up	set direction from the top and engage the people below
Focus	emphasize structure and systems	build up corporate culture: employees' behavior and attitudes	focus simultaneously on the hard (structures and systems) and the soft (corporate culture)
Process	plan and establish programs	experiment and evolve	plan for spontaneity
Reward System	motivate through financial incentives	motivate through commitment—use pay as fair exchange	use incentives to reinforce change but not to drive it
Use of Consultants	consultants analyze problems and shape solutions	consultants support management in shaping their own solutions	consultants are expert resources who empower employees

to Norman's leadership style. As he put it in his first speech: "First, I am forthright, and I like to argue. Second, I want to discuss issues as colleagues. I am looking for your advice and your disagreement." Norman encouraged dialogue with employees and customers through colleague and customer circles. He set up a "Tell Archie" program so that people could voice their concerns and ideas.

Making way for opposite leadership styles was also an essential ingredient to Norman's—and ASDA's—success. This was most clear in Norman's willingness to hire Allan Leighton shortly after he took over. Leighton eventually became deputy chief executive. Norman and Leighton shared the same E and O values, but they had completely different personalities and styles. Norman, cool and reserved, impressed people with the power of his mind—his intelligence and business acumen. Leighton, who is warmer

and more people oriented, worked on employees' emotions with the power of his personality. As one employee told us, "People respect Archie, but they love Allan." Norman was the first to credit Leighton with having helped to create emotional commitment to the new ASDA. While it might be possible for a single individual to embrace opposite leadership styles, accepting an equal partner with a very different personality makes it easier to capitalize on those styles. Leighton certainly helped Norman reach out to the organization. Together they held quarterly meetings with store managers to hear their ideas, and they supplemented those meetings with impromptu talks.

Focus simultaneously on the hard and soft sides of the organization.

Norman's immediate actions followed both the E goal of increasing economic value and the O goal of transforming culture. On the E side, Norman focused on structure. He removed layers of hierarchy at the top of the organization, fired the financial officer who had been part of ASDA's disastrous policies, and decreed a wage freeze for everyone—management and workers alike. But from the start, the O strategy was an equal part of Norman's plan. He bought time for all this change by warning the markets that financial recovery would take three years. Norman later said that he spent 75% of his early months at ASDA as the company's human resource director, making the organization less hierarchical, more egalitarian, and more transparent. Both Norman and Leighton were keenly aware that they had to win hearts and minds. As Norman put it to workers: "We need to make ASDA a great place for everyone to work."

Plan for spontaneity.

Training programs, total-quality programs, and top-driven culture change programs played little part in ASDA's transformation. From the start, the ASDA change effort was set up to encourage experimentation and evolution. To promote learning, for example, ASDA set up an experimental store that was later expanded to three stores. It was declared a risk-free zone, meaning there would be no penalties for failure. A cross-functional task force "renewed," or redesigned, ASDA's entire retail proposition, its organization, and its managerial structure. Store managers were encouraged to experiment with store layout, employee roles, ranges of products offered, and so on. The experiments produced significant innovations in all aspects of store operations. ASDA's managers learned, for example, that they couldn't renew a store unless that store's management team was ready for new ideas. This led to an innovation called the Driving Test, which assessed whether store managers' skills in leading the change process were aligned with the intended changes. The test perfectly illustrates how E and O can come together: it bubbled up O-style from the bottom of the company, yet it bound managers in an E-type contract. Managers who failed the test were replaced.

Let incentives reinforce change, not drive it.

Any synthesis of E and O needs to recognize that compensation is a double-edged sword. Money can focus and motivate managers, but it can also hamper teamwork, commitment, and learning. The way to resolve this dilemma is to apply Theory E incentives in an O way. Employees' high involvement is encouraged to develop their commitment to change, and variable pay is used to reward that commitment. ASDA's senior executives were compensated with stock options that were tied to the company's value.

These helped attract key executives to ASDA. Unlike most E-strategy companies, however, ASDA had a stock-ownership plan for all employees. In addition, store-level employees got variable pay based on both corporate performance and their stores' records. In the end, compensation represented a fair exchange of value between the company and its individual employees. But Norman believed that compensation had not played a major role in motivating change at the company.

Use consultants as expert resources who empower employees.

Consultants can provide specialized knowledge and technical skills that the organisation doesn't have, particularly in the early stages of organizational change. Management's task is figuring out how to use those resources without abdicating leadership of the change effort. ASDA followed the middle ground between Theory E and Theory O. It made limited use of four consulting firms in the early stages of its transformation. The consulting firms always worked alongside management and supported its leadership of change. However, their engagement was intentionally cut short by Norman to prevent ASDA and its managers from becoming dependent on the consultants. For example, an expert in store organization was hired to support the task force assigned to renew ASDA's first few experimental stores, but later stores were renewed without his involvement.

Implementation Checklist

Success of Change Management is closely associated with managing situations such as unforeseen or unpredictable incidents, day to day problem management, new process release management and communication within the organization for updates and dissemination of information. This is essential to maintain information consistency. Checklist in change management process:

- Define change process and share it with internal teams
- Define change workflows to automate change processes
- Include members from Release Team in Change approval
- Communicate clear roles and responsibilities to every Change Management Member
- Use change templates to pre-fill standard changes thus saving time
- Define success factors and Key Performance Indicators(KPIs) for Change Management. i.e. change executed successfully vs failed changes
- Continuous review is crucial to improve change management process outcome

Unit 12

Internship

Approach Methodology

Step 1: Prepare an internship strategy and action plan.

Step 2: Faculty Members need to identify different organisations and agencies working in relevant field and take their consent for training interns.

Step 3: Match students to institutions based on their areas of interest and capability.

Step 4: Communicate in writing with the guide offered by the agency.

Step 5: Introduce the intern to their guide.

Step 6: Monitor the process of internship with concurrent and terminal reporting

Step 7: Evaluate the benefits of Internship

Step 8: Ensure commitment of various officers in the organisation or agency through further collaborations and scientific publications.

Step 9: Review and prepare future strategy

Internship exposes participants to the everyday ground realities of their subject area in an employment scenario, replete with the myriad challenges faced by professionals. Being an interface with relevant communities and stakeholders, the opportunity helps participants learn about various aspects of hygiene, enterprise, communication, education, health, livelihoods, economy, polity and the interplay between institutions.

Internship provides an opportunity to the participants to:

- Apply their learning
- Use their management skills in real time
- Have a flavour of the current business practices and perform realistic assessments
- Strengthen exposure to grassroot Swachhta issues
- Have practical engagement and develop interactive skills with the community and grassroots organizations
- Experience first-hand, the challenges faced by primary producers/socially oriented organizations

Internship enables participants to blend their understanding of theories of development interventions, managerial skills and tools and techniques with the problems experienced in their implementation and come up with viable solutions in the interests of all stakeholders in managing Swachhta.

The internship projects could cover areas of solid & liquid waste management, rural sanitation, soil conservation, livelihoods, communication, community education, rural entrepreneurship, community mobilization, capacity building of primary producers, health and education interventions, poverty alleviation, environmental safety, employment generation or other initiatives with a clear objective of achieving social good. The location of internship would be either in Municipalities, Gram Panchayats, hospitals, hospitality sector etc. where hygiene is a major variable. It would be the responsibility of the educational institution to tie up the internship.

The participants choose their project and a guide is allotted to each project. The participants consult and communicate with the Reporting Officer and the Faculty guide during the Internship period. The Reporting Officer would be from the internship unit and he would both assign work to the intern as well as observe progress. The participants submit the final report and make presentations to the faculty at the end of the Internship. The Reporting Officer evaluates the participant's performance and reports it to the Institute.

One needs to know the roles and responsibilities in the field, how to interact non-intrusively with the community, orient the stakeholders, motivate them to utilize the facilities, and how to identify key concerns related to Swachhta, health, sanitation, water and malnutrition. Faculty members are trained to guide interns on conducting surveys, and finding simple yet practical solutions to issues faced in Swachhta such as initiating government processes to sanction toilets in the adopted areas at various levels.

Aspects that need attention during Internship:

1. **Formation of Groups and Buddy System:** Groups formed on the basis of common interests and functioning as per the buddy system help in achieving goals. Buddy system is a cooperative arrangement whereby individuals are paired or teamed up and assume responsibility for one another's welfare. The synergistic effect of the team will also be significant.

2. **Translate instruments into local talking language:** It pays to adopt the local parlance for all forms of communication. This includes modifying the language of the instruments used in the process.

3. **Personal aspects and precautions: Appearance counts.** Looking formal, clean and neat is essential. Care must be taken to ensure that one's personal problems and issues do not affect work in any manner.

4. **Preparation and reading:** One must prepare well before taking up internship. It is important to know about the organization, its activities, management team, and key functionaries and how the interns fit in. Reading about these aspects is essential.

5. **Relationships dos and don'ts:** Cultivate good inter-personal skills to build strong relationships. Being close does not mean that one needs to forget the superior-subordinate relationship. Never cross your limits.

6. **PRA on select aspects of the community and organization:** Incorporate the knowledge and opinions of local people in the planning and management of projects intended for the community

7. **Networks and groups in the community and organization:** Know and tap all networks and groups in the community, whether formal or informal, to stay updated on all happenings.

8. **Important Achievers of the community and organization:** Most people crave for recognition and rewards. So, give all achievers their due, be it in the community or the organization.

9. **Important aspects of the community and organization:** Identify all that is required to take the community and the organization to the next level. Start working on them immediately.

10. **Challenges in the community and organization:** Challenges need to be addressed in a positive manner by creating the confidence that all obstacles can be surmounted with collective efforts.

11. **Excellent responses from the community and organization:** When the responses are good, encouraging and positive, place them on record. Let everyone know that they have contributed.

12. **Entrepreneurship in the community and organization:** Not all would want to take up a job. Some may want to venture into their own dream project with some support. Find support for those having the entrepreneurial spirit.

13. **Communication in the community and organization:** Communication needs to be clear and direct within the community and the organization. There should be no room for ambiguity or miscommunication.

14. **Educational community in the community:** In a community, every person who is in a position to contribute in the field of education is important. They all need to work together, not in isolation.

15. **Health, health centre and health issues in the community:** Apart from seasonal diseases, some of the health issues in the community may have something to do with local soils, water sources etc. If the local health centre can't handle certain types of diseases, help find higher centres.

16. **Collecting information:** For obtaining any type of information, much depends on the manner in which the questionnaire is structured and worded. In any case, it needs to be localized to glean full information.

17. **Important learning from organization:** Internship is not complete unless the learning that takes place at various stages is internalized for practical application.

18. **Photography and documentation of the process of internship:** Make and document records of the entire process of internship, along with speaking pictures and vivid visuals. After all, we need permanent records of good memories!

19. **Important quotes and stories from the organisation and community:** Whenever you come across statements that encapsulate beautiful thoughts or stories that are timeless and can be retold; put them in writing.

20. **Daily diary:** Journaling or the habit of writing daily in a diary helps in crystallizing one's thoughts. It also helps in understanding how we are evolving as persons, as the entries in a diary are true and unvarnished.

21. **Timelines:** Everything undertaken as part of internship needs to be completed as per timelines. There can be no lapse if planning is good. Even if there is a lapse, there is no reason why there should be a relapse. Mid-course correction can mend matters.

22. **Report:** Every participant, upon completion of internship, needs to submit a comprehensive report. The report needs to set out the purpose, goals, plans, targets and actual achievements, apart from individual as well as group learning and experiences.

23. **Payment of internship stipend:** The amount stipulated as stipend for internship will be paid upon successful completion of internship and submission of report.

24. **Certificate:** Interns completing their assignments successfully need to be given a Certificate of Appreciation.

Some of the communities and organisations would be quite remote and the students will be challenged by heat, biting insects, water shortage, lack of toilet and bathing facility, as well as lack of electricity. Undaunted, the students, along with some accompanying faculty members, need to manage. After the internship they will be able to pinpoint some key problems, and in some places they will also be able to address the challenges. Some of the projects could include upgrading facilities, upgrading community status to qualify for improved infrastructure, demonstrating innovations and healthy habits, cleanup campaigns, repairing a fault, career counseling and tutoring community leaders.

Probable Agencies/Organisations for Internships

From the perspective of the student, an internship assists with career development by providing real work experiences. This provides students with opportunities to explore their interests and develop professional skills and competencies. After studying, learning and figuring out the correct career path, doing an internship is a crucial way to understand the practical issues in career opportunities, which enables all learning to be put into action.

The following are suitable types of agencies/organisations where students can apply for internships

1. Healthcare Establishments

Public Hospitals/Nursing Homes

Private Hospitals

Institutional/Campus Hospitals

Township Hospitals

2. Local Bodies

Urban and Rural Local bodies

Municipal Corporations

Municipalities

Urban Development Authorities

Water Supply & Sewerage

3. Board and Authorities

Zilla Parishads

Cluster of Panchayats

4. Outsourced Waste Management Agencies

Waste Water/Sewage Treatment Plants

Solid Waste Management Agencies/facilities

Recycling Agencies

Refuse Driven Fuel (RDF) - Development & Agencies

5. Public Facilities

Railway Stations

Bus Stands

Market Places

Vegetable market places

Fruit market places

Agriculture market places

Cattle markets

Slaughterhouses

6. Industrial Municipalities

Industrial areas/Notified Industrial Estates/areas

7. Educational Campuses

Universities

Technical Institutes

Colleges

Appendix 1: Career Opportunities

Career Prospects in Solid Waste

The launch of Swachh Bharat Abhiyan in 2014 and subsequent evaluation under Swachh Survekshan and grading under Star rating system has made Urban Local Bodies (ULB), numbering more than 4500 in the country look at sanitation in a more organized manner. Given the limitations of ULBs, there is a need to have trained and skilled manpower who can deliver the objectives of a Clean India.

Great amount of opportunities await the prospective students of this course since there is large amount of work across municipalities, Nagar Palikas and Gram Panchayats in the country.

S. No.	Operations	Opportunities
1.	Segregation at source	Community engagement Documentation
2.	Collection	Planning and design Mapping – Ward sanitation Plan, City sanitation plan Different streams – biodegradable (home composting), non biodegradable, domestic hazardous waste Optimization Community/ULB/liaison
3.	Transportation	Fleet management, operation research, route mapping, GPS technologies, and management of primary and secondary transportation.
4.	Treatment	Composting methods, recycling, waste to energy, management of landfills
5.	Disposal	Management of inert waste, sanitary landfills, capping and legacy waste handling

Waste Management, an emerging career prospect, presents a lucrative opportunity with attractive money and huge growth potential. Potential job positions include public works services supervisor, hazardous waste engineer, landfill operator, waste collector, recycling supervisor, recycling program specialist, environmental coordinator, e-waste professional, solid waste manager, waste minimization specialist, communications manager, environmental educator, environmental and sustainability consultant, industrial waste inspector and so on.

Popular employers are central and state governments and non-profit associations apart from some private companies. For instance, E-Parisaraa Pvt. Ltd. is India's first scientific e-waste recycling unit (on the outskirts of Bangalore). Setting up an own business like recycling of particular wastes (solid, hazardous, industrial, health care, electronic, etc.) can also prove very profitable. Those who are qualified in courses like Environment Hygiene, Sanitation and Wastewater treatment can look for rewarding and satisfying careers which will contribute to better both the natural environment and quality of human life!

Training and Capacity Building Opportunities

In view of the large requirement of man power as well as infrastructure planning, there are tremendous opportunities for training and capacity building in this sector. Some of them are listed below:

- Educating people about the sanitation issues
- IEC campaigns
- Impact on health
- Infrastructure management
- Community engagement
- Planning and management of resources
- Active liaison with government agencies
- Collaborative approaches with NGOs, RWAs, community groups, educational institutions.

Career Opportunities in Wastewater

Every effort possible must be made to conserve water. Treatment of wastewater can supplement the water supply needs. Different technologies and methods are on offer for treatment of wastewater.

This sector offers many opportunities in view of the scarcity of water as a resource.

- Separation of grey water
- Recycling of wastewater
- Technologies in waste water treatment
- Ward water management plan
- RWH plan for ward/city

Appendix 2: Teaching Resources

The area of Environmental Hygiene, Sanitation and Waste Management is an emerging field and different situations require different approaches. While this is true some standard methods have been benchmarked for teaching and training. The following websites offer several examples of case studies, videos and other material.

Some websites reference:

swachhbharatmission.gov.in/

https://www.india.gov.in/swachh-bharat-mission-gramin-portal

https://www.swachhsurvekshan2018.org/

https://zerowasteeurope.eu/

www.zerowasteindia.in/

www.indiaenvironmentportal.org.in/category/3902/thesaurus/unep/

www.indiawaterportal.org/questions/kitchen-wastewater-treatment

Some reference books:

- Water and Wastewater Treatment: A Guide for the Non-engineering Professional by Joanne E. Drinan and Frank Spellman
- Solid Waste Management: An Indian Perspective by M.S. Bhatt and Asheref Illiyan
- Solid Waste Management: Present and Future Challenges by Jagbir Singh
- Solid Waste Management: An Indian Perspective by M.S. Bhatt
- Management of Municipal Solid Waste by T. V. Ramachandra
- Solid and Liquid Waste Management: Waste to Wealth by Vasudevan Rajaram
- Wastewater Treatment: Concepts and Design Approach by Karia G.L
- Integrated Solid Waste Mgmt by Tchobanoglous
- Wastewater Treatment Plants: Planning, Design, and Operation by Syed R. Qasim

References

See http://www.un.org/waterforlifedecade/pdf/award_south_africa_eng_for_web.pdf

http://www.sulabhinternational.org

http://swachhbharatmission.gov.in/sbmcms/writereaddata/images/pdf/Guidelines/Complete-set-guidelines.pdf

http://www.thealternative.in

https://www.mapsofindia.com/my-india/government/understanding-swachh-bharat-cess

FSM video, Devanahallihttps://www.youtube.com/watch?v=WZgT2Vwfvwc

http://www.environmentalpollution.in/water-pollution/wastewater-treatment/application-of-rootzone-technology-for-wastewater-treatment/6499

https://theconstructor.org/environmental-engg/methods-of-solid-waste-disposal/4721/

www.eai.in/ref/ae/wte/wte.html

http://dailydump.org/shopping/index.php/composters/kambha3t-large.html#close

https://www.slideshare.net/arunimakt/refuse-disposal-area-level

F. Tufaner, Y. Avs, Effects of co-substrate on biogas production from cattle manure: a review,Int. J. Environ. Sci. Technol. (2016) 13:2303–2312 DOI 10.1007/s13762-016-1069-1.http://www.bioline.org.br/pdf?st16213

(http://blockbyblock.com/blog/5-cleaning-strategies-5-cleanest-cities-world/)

https://www.businesstoday.in/magazine/columns/the-curious-case-of-a-clean-clean-indore/story/254144.html

https://www.thenewsminute.com/article/oppressed-and-unrecognised-life-waste-pickers-crucial-india-s-sanitation-72426

Glossary

Biota: Plants and animals of a particular region, habitat, or geological period.

BOD (Biological oxygen demand): Biochemical oxygen needed for decomposing organic matter. It is measured in mg O2/ litre of waste water.

Faeces: Human or animal excrement, waste discharged from bowels after digestion.

Greenhouse gases: GHGs such as carbon dioxide and methane, contribute to human-induced climate change that is causing the overall warming of the Earth and changing weather and rainfall patterns.

Cess: A cess imposed by the central government is a tax on tax, levied by the government for a specific purpose. For example, the education cess of 3% on personal income tax of 30% is imposed as a tax on the prevailing 30%. As a result, the total tax rate goes up to 30.9% (30% basic rate + 3% (cess) of the 30%) But some cess like the Swachh Bharat Cess (SBC) is imposed as percentage tax on total value. e.g. SBC is 0.5% of the value of the services.

Cubic metres: 1000 litres

Peri-urban areas: the areas surrounding a town between the urban and rural areas. They are often settled in by migrants from the countryside who suffer from extreme poverty, overcrowding and a lack of sanitation facilities.

Picocurie: Measure of radionuclides in water. 1 picocurie =2.2 disintegrations per min. e.g. Sr-90 need to not exceed 10 picocuries / l, Ra-224 need to be below 3 picocuries/l

Sanitation: World Health Organization defines sanitation as the provision of facilities and services for the safe disposal of human urine and fecal matter and the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal.

Sludge: Activated sludge: bacteria and protozoa that clump together and eat containing carbon, nitrogen and phosphorous rich organic waste. As they grow, floc/clump size increases and they settle down.

Garbology: Scientific study to assess waste and figure out new ideas for waste management. Scientists are currently studying the floating mass of plastic trash in the oceans.

Windrow: Organic waste is formed into rows of long piles called windrows and aerated by turning the pile periodically by either manual or mechanical means. The ideal pile height, which is between 4 and 8 feet, allows for a pile large enough to generate sufficient heat and maintain temperatures, yet small enough to allow oxygen to flow to the windrow's core. The ideal pile width is between 14 and 16 feet.

स्वच्छ भारत
एक कदम स्वच्छता की ओर

सत्यमेव जयते

Mahatma Gandhi National Council of Rural Education (MGNCRE)
Department of Higher Education
Ministry of Human Resource Development Government of India

Where there is Rural Wellbeing there is Universal Prosperity