Annexure-I

MUNICIPAL SOLID WASTE MANAGEMENT IN DEVELOPING COUNTRIES

Name of the Organization:

COURSERA

Submitted in partial fulfillment of the requirements for the award of degree of

Bachelor of Computer Application

Submitted to

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PHAGWARA, PUNJAB

From 27/05/20 to 28/06/20

Submitted by

Name

Registration number:

1234567890

Signature of the student:

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Annexure-II:

STUDENT DECLARATION

To whom so ever it may concern

I **Puspadip Chandra Thakur**, **Registration Number 11909022**, hereby declare that the work done by me on **"Municipal Solid Waste Management in Developing Countries"** from **May, 2020 to June, 2020** is a record of original work for the partial fulfillment of the requirements for the award of the degree, **BCA.**

Name of the student (registration number)

Signature

Signature of the student:

Academics Team: CGPA Booster
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INTRODUCTION OF THE PROJECT UNDERTAKEN

1. OBJECTIVE OF THE WORK UNDERTAKEN:

Extreme growth challenges are currently facing both emerging and least developed nations, which will be reinforced if the same old conventional development policies remain in effect. As a result of the recent occurrence of global economic crises, the growth problems are projected to escalate because of the detrimental effects on the capacity of developed countries to provide emerging countries with the requisite assistance. Recently, the United Nations issued a study revealing that both emerging and least developed countries are far from meeting the 2015 MDG goals (UN, 2010). It is predicted that the impacts will outweigh the continuous worsening of the divide between developed and emerging countries to the degree that sustainable growth may be seriously affected. Since the Rio Earth Summit in 1992 and the implementation of the Rio Declaration and Agenda 21 afterwards, and since the Millennium Development Goals (MDGs) were announced and adopted in 2000, conditions have not changed dramatically on the ground. After more than two decades since the introduction of the idea of 'sustainable growth,' it may be argued that by compared developed countries to developing countries, the notion has been portrayed in various ways. Sustainable development is regarded by developed countries as an environmental philosophy that emphasizes inter-generational equity with a focus on potential needs (Carter, 2001), while most developing countries prioritize intra-generational equity with a focus on current needs, which are both social and economic. Such different representations have played an important role in shaping the ability of emerging countries to address the demands of global development they face and thus in widening the divide between developing and developed nations.

Urban Development Series

Produced by the World Bank's Urban Development and Local Government Unit of the Sustainable Development Network, the Urban Development Series discusses the challenge of urbanization and what it will mean for developing countries in the decades ahead. The Series aims to explore and delve more substantively into the core issues framed by the World Bank's 2009 Urban Strategy Systems of Cities: Harnessing Urbanization for Growth and Poverty Alleviation. Across the five domains of the Urban Strategy, the Series provides a focal point for publications that seek to foster a better understanding of

(i) The core elements of the city system,

(ii) Pro-poor policies,

(iii) City economies,

(iv) Urban land and housing markets,

(v) Sustainable urban environment,

(vi) Other urban issues germane to the urban development agenda for sustainable cities and communities.\

WASTE COLLECTION

Waste collection is the collection of solid waste from point of production (residential, industrial commercial, institutional) to the point of treatment or disposal. Municipal solid waste is collected in several ways:

1. **House-to-House:** Waste collectors visit each individual house to collect garbage. The user generally pays a fee for this service.
2. **Community Bins:** Users bring their garbage to community bins that are placed at fixed points in a neighborhood or locality. MSW is picked up by the municipality, or its designate, according to a set schedule.
3. **Curbside Pick-Up:** Users leave their garbage directly outside their homes according to a garbage pick-up schedule set with the local authorities (secondary house-to-house collectors not typical).
4. **Self -Delivered:** Generators deliver the waste directly to disposal sites or transfer stations or hire third-party operators (or the municipality).
5. Contracted or Delegated Service: Businesses hire firms (or municipality with municipal facilities) who arrange collection schedules and charges with customers. Municipalities often license private operators and may designate collection areas to encourage collection efficiencies.

Collected MSW can be separated or mixed, depending on local regulations. Generators can be enquired to separate their waste at source, e.g., into “wet” (food waste, organic matter) and “dry” (recyclables), and possibly a third stream of “waste,” or residue. Waste that is un-segregated could be separated into organic and recycling streams at a sorting facility. The degree of separation can vary over time and by city. ‘Separation’ can be a misnomer as waste is not actually separated.

WASTE DUMPS:

Old issue and new problem A waste dump is a place where people have thrown rubbish away. In ancient times, our ancestors ate shellfish and threw shells away somewhere near their residence. That place, in other words a shell heap, became the first dumpsite in the history of human beings.

Our ancestors disposed only things that were of no use, but we, sometimes considered as more "advanced," often dispose of things which are still quite usable and have value. Because most materials do not vanish immediately, we must keep them somewhere even if we do not need them anymore. There used to be few materials that did not degrade naturally. When people threw away banana skin, for example, it would degrade quickly and became a part of the nature. Many artificial materials are available now to make our life convenient. Unfortunately, most of them do not easily decompose and will stay as they are for a long time.

When materials are thrown away and left uncovered, they will start decomposing and generate bad smells, and act as a breeding ground for flies, mosquitoes, and other vectors. Those wastes that do not easily decompose remain scattered as they are. Some light materials will fly away under strong winds. Scavenging can also serve to spread the waste around. Uncontrolled open burning can also add to the nuisance impacts and potential health risks. This overall situation is called open dumping and poses significant environmental and health risks to the public and the surrounding environment. It is a common and typical problem in Pacific island countries.

We all generate waste. Some types of waste, such as organic matter (e.g. plants and leaves), decompose easily and quickly but others do not and remain as they are for many years. There was no word describing waste in the Pacific a long time ago because people utilized the natural resources very well and did not waste them. As artificial materials are produced to make our life more convenient, people tend to forget the importance of saving resources. The idea of mass production and mass consumption contributes to mass disposal of waste.

DUMPING:

Open dumping is a state where loads of rubbish are dumped and left uncontrolled in an open space with such conditions as:

- No soil cover,

- No leachate collection/control,
- No drainage,
- Poor access to the tipping area, especially in a wet season,
- Open to scavenging,
- Uncontrolled open burning.

✦ **No soil cover –** It allows for flies, mosquitoes, and other vectors to breed, generates unpleasant smells and is a potential fire hazard. There may be a high disease risk for the nearby residents. It also attracts human and animal scavengers to the dumpsite to look for foods and useful materials.

✦ **No leachate collection/control** – Where there is no proper control of leachate, it sometimes overflows to the plantations or farms downstream and will damage crops. Leachate also seeps into the ground and may pollute the groundwater that is one of the most important sources of drinking water in Pacific islands.

✦ **No drainage** – Surface water quickly accumulates at lower locations and deteriorates the site conditions. Runoff water damages the road surface as well as slopes if there is no drainage facility. Any surface/runoff water entering the waste deposited area will end up as leachate.

✦ **Poor access** – When the access road is in poor condition, collection vehicles cannot reach the tipping area and may therefore offload the waste in a disorganized way alongside the access road. This sometimes blocks the road and makes even more difficult for following

vehicles to find the proper place to unload the waste. Landfill operation and maintenance will also be hampered by the poor access.

- **Open to scavenging** – Scavenging activities by people and animals to look for foods and valuable materials not only disrupt the landfill operation but are considered very dangerous to the scavengers themselves. In some countries, for example, health-care waste from hospitals and medical institutions is mixed with solid waste and is disposed of at the same dumpsite. Such waste contains needles, syringes and infectious materials and is harmful to the people on site.
- **Uncontrolled open burning** – Exposed rubbish easily catches fire whether this is a deliberate act or not. Uncontrolled open burning is potentially hazardous and dangerous to the surrounding community and the environment as well as landfill workers. Once a fire breaks out, it sometimes requires weeks to extinguish.

LANDFILL:

A landfill is like a big rubbish bin. Imagine a life without a rubbish bin at home. Let us suppose you live in a small room and generate waste every day. You most probably will start throwing your rubbish at one of four corners of your room. If one corner is filled up with rubbish, you will continue throwing the rubbish at the next corner and will go on to the next until all the four corners are filled up. The rubbish will invade your space and you will be eventually buried in it.

The story above teaches you two important lessons. One lesson is that you need to reduce rubbish as much as possible so as to save the space of your room. The other is that a rubbish bin must be placed to keep your room clean and neat. A rubbish bin clearly demarcates inside and outside, retains rubbish horizontally and vertically and is structurally stable. A landfill is of no difference except for its size and location.

Rubbish Bin

A Sanitary Landfill:

A simple rubbish bin can solve some of the problems of waste disposal, but that is not enough. If you want to make your life safer and cleaner, waste should be properly disposed of and contained safely for a long period of time. A landfill is the physical facility used for disposing of waste onto or into the land in a controlled manner. A sanitary landfill is a landfill where waste is disposed of without causing a nuisance to the environment and public health and safety.

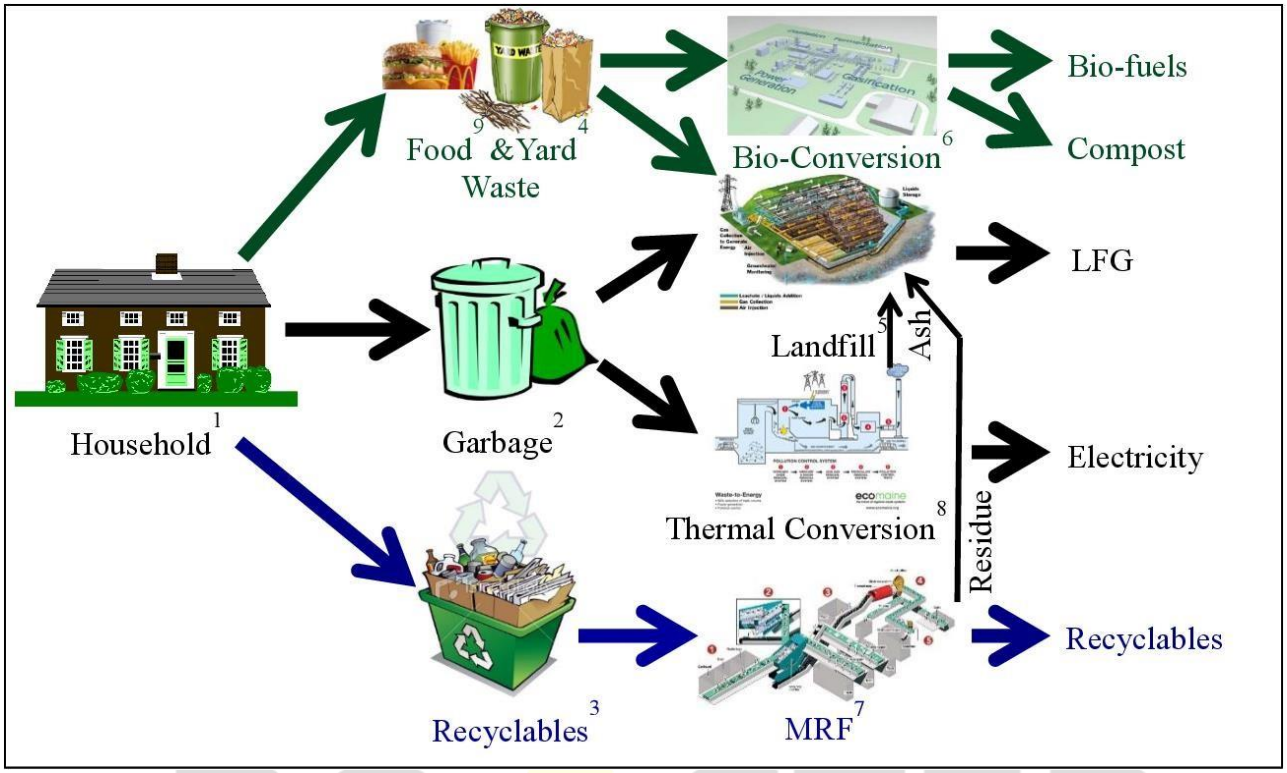
To upgrade an open dump to a sanitary landfill, you need to consider three important aspects of control. These three aspects are the waste, gas and water, and access. Proper control over these three aspects is a must for establishing and operating your waste disposal facility as a sanitary landfill.

- **Control over waste:** This could be done by establishing a physical boundary just like a rubbish bin. The waste should be safely contained in an orderly fashion. Deposited waste should be covered with soil or other suitable materials to eliminate fly breeding and odor emissions from the waste. The first important thing you need to do is to take control of rubbish and not the other way around.
- **Control over gas and water:** Gases are generated as by-products of the natural decomposition process occurring at a landfill. Such gases include methane (CH_4), carbon dioxide (CO_2), nitrogen (N_2), hydrogen sulphide (H_2S), ammonia (NH_3) etc. Methane and carbon dioxide are the two principal gases generated from the anaerobic decomposition of biodegradable organic waste. Some of these gases may cause fires and/or explosions at landfills. Landfill gases need to be controlled to prevent unwanted movement into the atmosphere so that any accidents can be avoided.

Water control has two targets, one for surface water and the other for leachate. The control of surface and storm water can prevent water from entering the landfill and as a result it contributes to reducing the amount of leachate. The control of leachate is essential for preventing pollution and protecting groundwater quality since leachate may percolate through the underlying soil. The idea of control over leachate is to collect and drain leachate as

quickly as possible from the disposal area and keep it in a retention pond. It is be much easier to control leachate when it is confined to one location.

- **Control over access:** The control of access means the securing and proper maintenance of an access road and the restriction of unauthorized entry to a landfill. The access road needs to be constructed and maintained to allow all-weather tipping. This means that the road leading up to the dumping area can be driven on even during a heavy wet season. Unauthorized entry of vehicles and people may lead to illegal waste dumping, fires, and vandalism of landfill facilities. It also allows uncontrolled scavenging at the tipping area. To take control of site access, the perimeter of the landfill needs to be fenced or ditched and the gates should be locked after operating hours. Gate control also needs to be established to record all the vehicles and people entering the landfill. All the above are requirements for a sanitary landfill, but, in the Pacific region there exist only few landfills satisfying these requirements. In the following chapters, you will learn the basic concept of the semi-aerobic sanitary landfill and how to upgrade the existing landfill and its operation.


Food &Yard Waste
9
4
Bio-Conversion
6
Bio-fuels
Compost
LFG
Household
1
Garbage
2
Landfill
5
Ash
Electricity
Thermal Conversion
8
Residue
Recyclables
Recyclables
3
MRF
7

Aerobic Decomposition

Organic substances in municipal solid waste, such as carbohydrates and fats, are broken down by an aerobic metabolic process into fatty acids and alcohol. This process works in the same way as animals and plants utilise respiration. In addition, after organic nitrogen has been oxidized into ammonia, it is stabilised by being changed into nitrite-nitrogen or nitratenitrogen by the action of nitrite-oxidizing bacteria. Aerobic decomposition of solid waste is generally faster than anaerobic decomposition and its end products are simple and nonodorous substances such as carbon dioxide, water, and nitric acid. Anaerobic decomposition produces pollutants with high BOD (Biochemical Oxygen Demand) such as fatty acids, inflammable gases such as methane and odorous gases, such as hydrogen sulphide (H2S), sulphurous oxides (SOx) and nitrous oxides (NOx).

A particular type of semi-aerobic landfill was developed as a joint project of Fukuoka City and Fukuoka University. Staff at the university undertook research over three years in the early 1970s which showed that decomposition and therefore stabilisation of waste in a landfill increases when oxygen is present due to a greater level of microbial activity. Additionally, the quality of leachate was improved at a much faster rate, and the generation of methane, hydrogen sulphide and other gases was reduced significantly. The semi-aerobic landfill method was first tested at Shin-Kamata Landfill with close collaboration between Fukuoka University and Fukuoka City in 1975. After proving its positive effect on the environment, it was officially accepted in Japan as the 'Fukuoka Method' and was adopted as a national standard technology by the Ministry of Health and Welfare.

Leachate Collection and Supply of Air

Leachate is collected in a leachate collection pond through pipes cut with properly sized holes and laid in graded rocks. As the outlet of the main leachate collection pipe is always open to air, fresh air is drawn into the waste layers. This process introduces an aerobic condition around the pipes. Since leachate is removed as quickly as it forms, the inside waste layers have lower water content. Also, as the leachate level is kept low, the chance of groundwater contamination is reduced.

In a semi-aerobic landfill, the leachate collection system consists of a central pipe (main collection pipe) with branch pipes on either side of it laid at a suitable spacing (holes with approximately one inch in diameter are cut into the pipe to allow leachate to enter). The pipes are placed in graded rock (5-15cm in diameter) and laid with a slope to allow collection. The main collection pipe ends in an open leachate collection pond. The pipes are designed and laid so that only one-third of the section is filled with leachate, leaving the rest of the pipe to be remaining free for air to flow. At each intersection of the main collection pipe with the branch pipes and at the end of each branch pipe, vertical gas ventilation pipes are installed. Those gas venting pipes with punched holes are enclosed in used drums filled with graded rocks. The heat produced by microbial activity in the semi-aerobic landfill causes the temperature inside the landfill to rise. Convection currents generated by the temperature difference between the landfill and the outside air make it possible for air to enter the waste layers through the main collection pipe (Fukuoka City Environmental Bureau,1999).

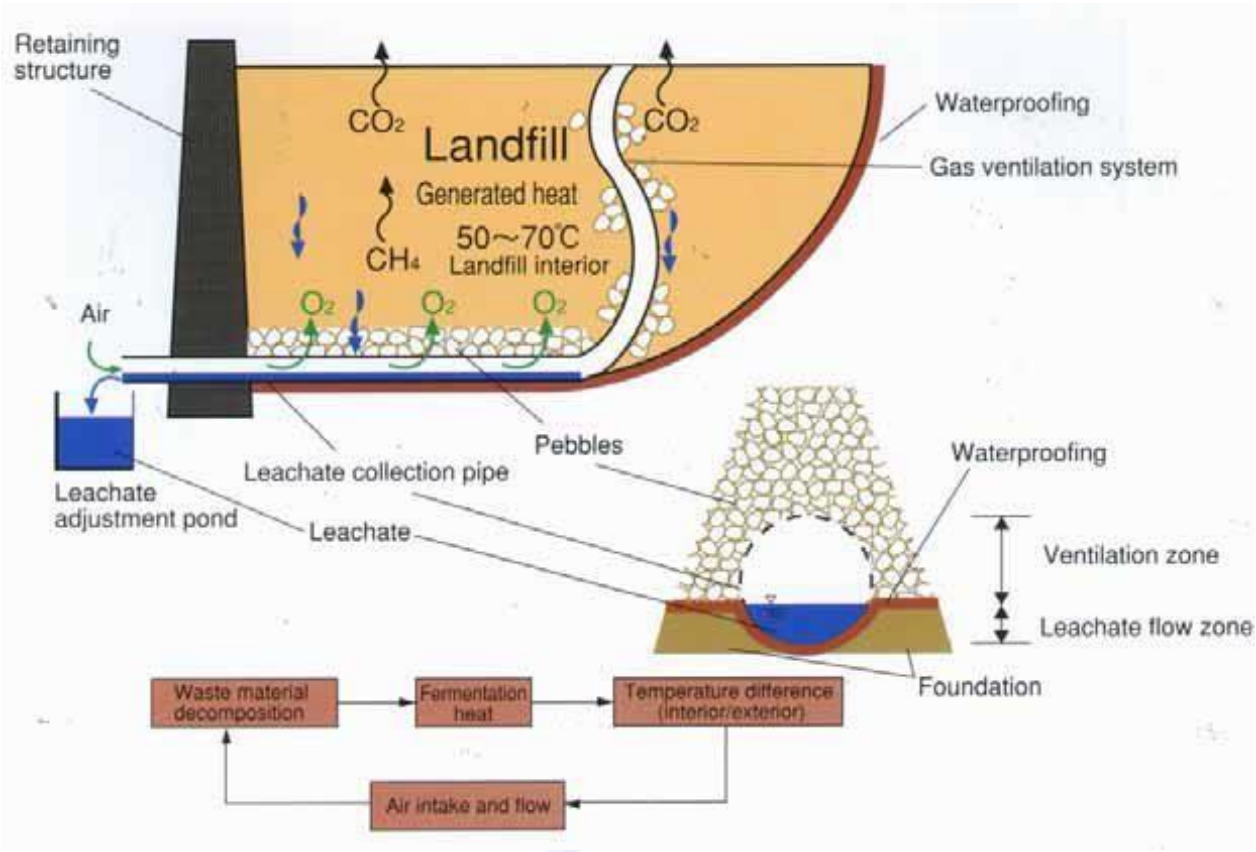


Diagram of a semi-aerobic landfill

The overall effectiveness of semi-aerobic landfills depends on the ability to continuously monitor various performance parameters such as quality of leachate (BOD, COD, pH, color, suspended solid, etc.), gases, settlement, etc.

Recirculatory Semi-aerobic Landfill:

The quality of leachate can be improved through recirculation. The leachate recirculation in semi-aerobic landfills returns leachate to the landfill to quicken the purification (treatment) of the leachate. In aerated landfills, there is a rapid reduction of organic components (i.e. BOD) and a slow reduction in nitrogen components. In recirculating landfills, there is a higher population of nitrifying and denitrifying bacteria to reduce the nitrogen components in the leachate thus reducing the pollutant load. This method is particularly suitable for landfills in developing countries where leachate concentrations are high.

In an anaerobic landfill, the concentration of BOD in leachate becomes as high as several thousand ppm (parts per million) and is very difficult to treat using conventional treatment facilities. By recirculating leachate into the landfill and trickling through the rocks in the vertical gas venting pipes, a combination of biological treatment and coagulation of sediment takes place effectively.

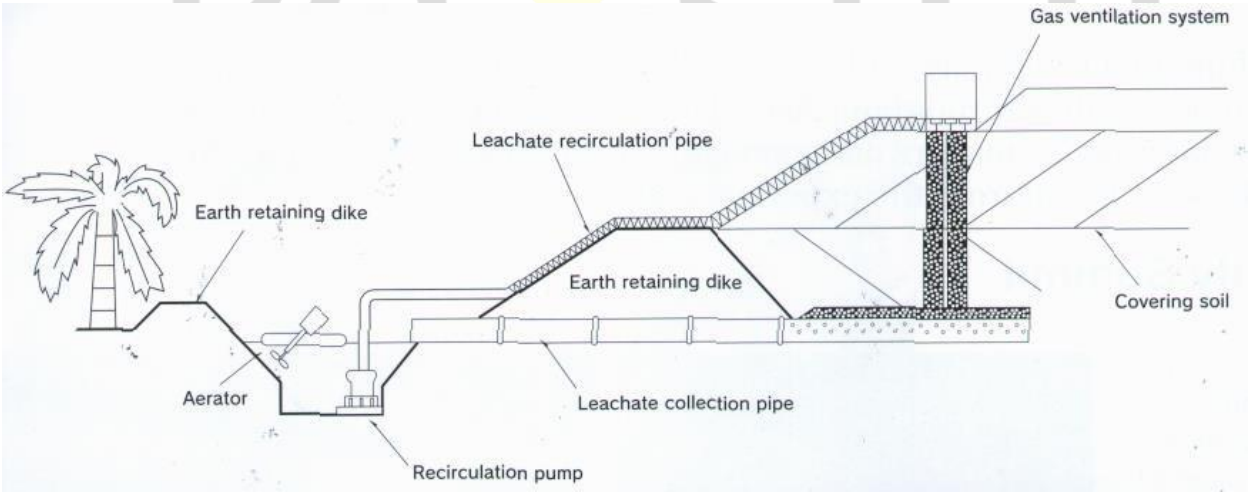
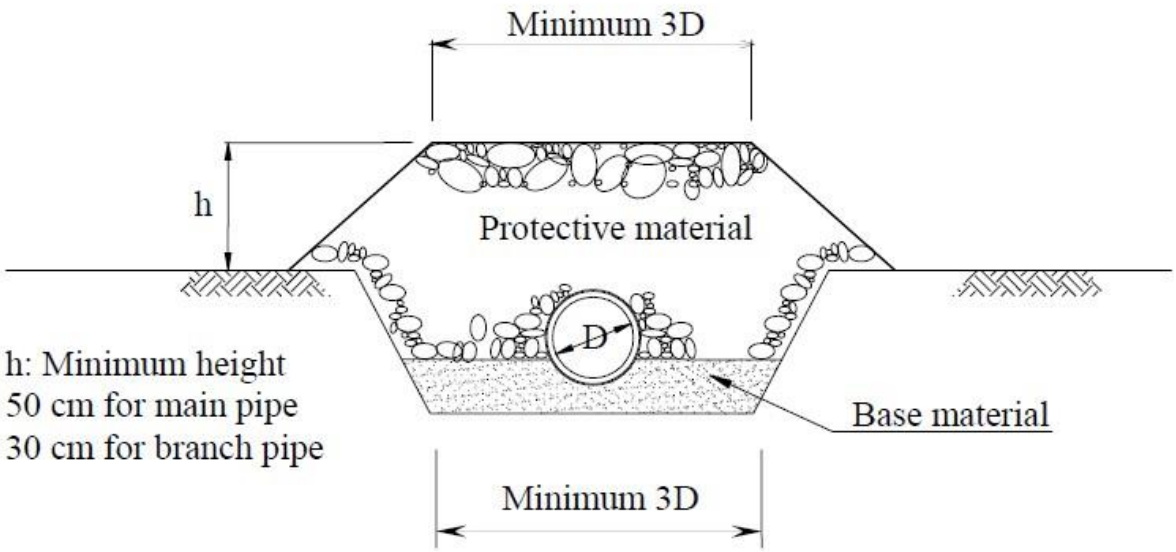


Diagram of how leachate can be recirculated in a semi-aerobic landfill

Improving Existing Landfill Facilities:

In a situation that an existing landfill has become an open dump, people generally want to close the facility to cover up the mess as soon as possible and aim for a new clean landfill. It is however apparent that the new landfill will soon become another messy open dump. The reason is that the capacity to properly manage a landfill has not yet been increased or developed. Without increasing your ability to manage the existing landfill, you will never be successful in managing the new one, however clean it may be at the beginning. It is therefore strongly advised that the construction of a new landfill be postponed, even if you have financial resources, until such time you acquire enough knowledge and experience on how to properly manage landfills through the process of upgrading, operating and maintaining your existing landfill.

Upgrading existing waste disposal sites could be a difficult process for the first time. In this chapter, you will learn the process of upgrading your facilities. All sites are different and therefore an individual assessment is required on the problems of your landfill and the level of existing capacity, to achieve and sustain proper landfill operation.



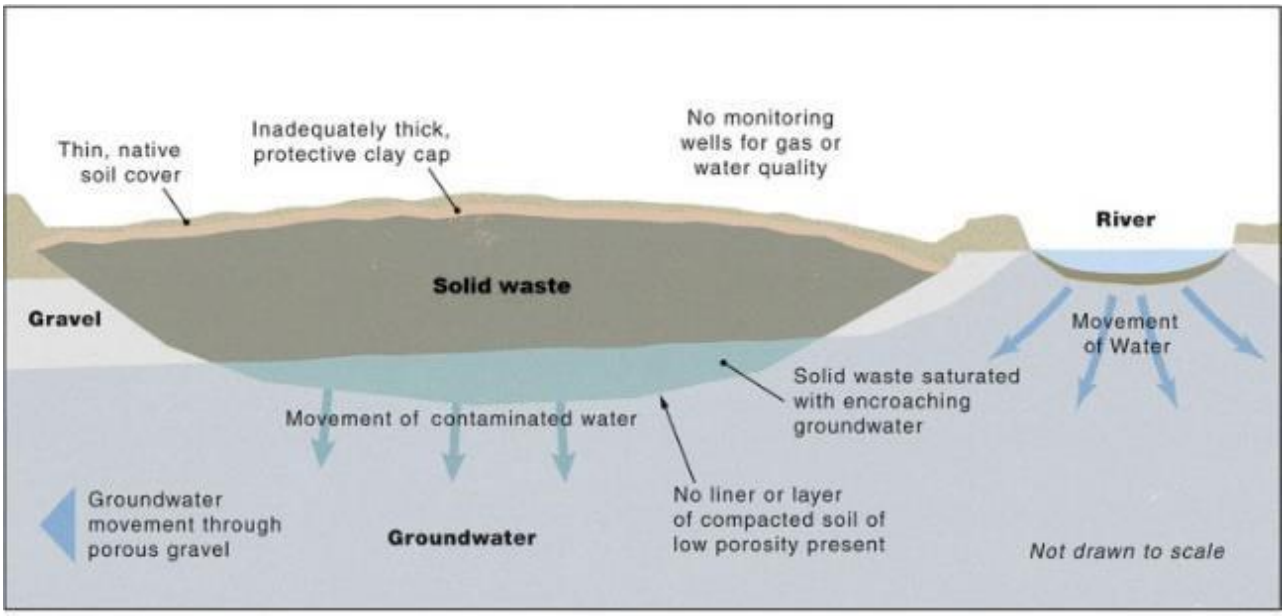
Improving Landfill Operations:

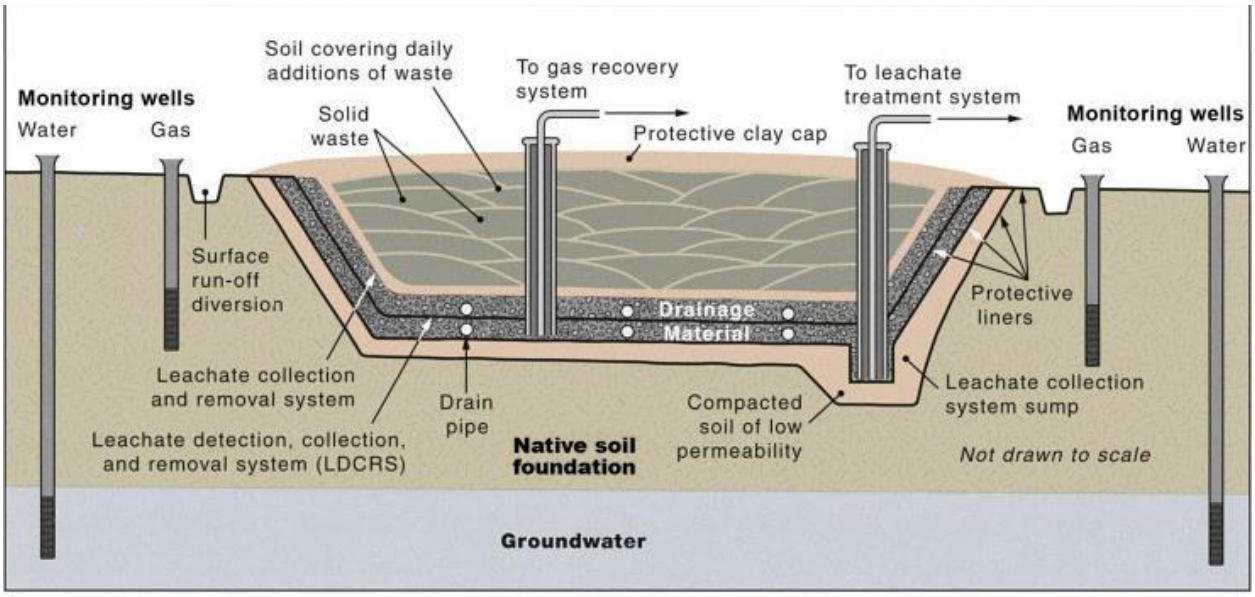
Upgrading an existing landfill facility may be a difficult task for you, but a real challenge is whether you can sustain the proper operation and maintenance after the landfill facility is upgraded. In this respect, physical upgrading work is relatively easy. You can improve the facility overnight. However, you must continue the operation at the landfill for many years in a sound and controlled manner.

Landfilling work includes the methods of landfilling, spreading and compaction, cover requirements and access roads. These items must be considered carefully before undertaking landfilling work as there is a close relationship between them.

To sustain proper operation and maintenance of the landfill, it is required to develop an operation & maintenance plan. In most landfill sites across the Pacific, either national or municipal government will be responsible for the management and operation of the landfill. Due to this, the relevant government agency should take ownership of the operation and maintenance plan at an early stage

and be very familiar with its contents. It will be more beneficial if as much of the operating and management practices are developed by the responsible body.





(B) *Modern sanitary landfill*

- **<u>Surface Water Quality</u>** - Landfill sites typically have a lot of exposed surfaces in which stormwater can become a significant source of sedimentation. A sedimentation basin or other soil erosion and sediment control measures may be useful so that water can be collected, and sediments be allowed to settle from the water prior to discharge from the site. Any measures constructed will need regular maintenance, particular after heavy rainfalls. Stormwater that has travelled across the site may become contaminated. If surface waters are contaminated, they may need to be directed for treatment along with the leachate (if a leachate treatment process is in place).
- **<u>Visual Impact</u>** - The visual improvement of a landfill site can contribute to reducing the NIMBY syndrome against rubbish dumps. Effort should be made to try to keep waste from view of the public employing such measures as building a buffer zone with trees, constructing bunds, installing wooden or galvanized walls or fences, etc. This can reduce some of the potential impacts of landfill operations such as noise, dust, and odor. Even simple regular covering of soil over rubbish can significantly reduce the eyesore potential.
- **<u>Public Health and Environmental Monitoring</u>** - Public health and environmental monitoring can provide an indication of the severity of impacts at the waste disposal site and how effective control measures are in reducing the impacts. Monitoring the aquifer(s) below a landfill site will provide an indication of how effective

the leachate collection system is operating. Groundwater wells should be installed upstream and downstream of the landfill so that regional concentrations (background values) can be monitored and compared to downstream values. Groundwater monitoring is quite expensive so the wells should be chosen with care and for optimum benefit.

Groundwater and surface water quality should be monitored on a quarterly (every 3 months) or bi-annual (every 6 months) frequency. It is important to account for seasonal variations in the groundwater monitoring program. Gas monitoring will need to be conducted where there is the potential of gas to accumulate in high concentrations, such as the outlets of gas venting pipes. There also needs to be a mechanism for reporting and responding to complaints and problem monitoring results. Results should be reported on a regular basis to the responsible body so that decisions can be made to minimize and manage any outstanding issues.

- **Surface Water Quality:** Landfill sites typically have a lot of exposed surfaces in which stormwater can become a significant source of sedimentation. A sedimentation basin or other soil erosion and sediment control measures may be useful so that water can be collected, and sediments be allowed to settle from the water prior to discharge from the site. Any measures constructed will need regular maintenance, particular after heavy rainfalls. Stormwater that has travelled across the site may become contaminated. If surface waters are contaminated, they may need to be directed for treatment along with the leachate (if a leachate treatment process is in place).
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- **<u>Status of Solid Waste Sector in India:</u>**

Urban areas in India generate more than 1,00,000 MT of waste per day (CPHERO, 2000). A large metropolis such as Mumbai generates about 7000 MT of waste per day (MOGM,

2014), Bangalore generates about 5000 MT (BBMP, 2014)and other large cities such as

Pune and Ahmedabad generate waste in the range of 1600-3500 MT per day (PMC,

2014). Collecting processing transporting and disposing this municipal solid waste (MSW) is the responsibility of urban local bodies (ULBS) in India Most local bodies are struggling to provide efficient waste management services to citizens. The coverage and efficiency of waste collection is still low, waste is collected in open trucks in an unsafe and insanitary manner, there is limited waste recovery and pro cussing and the waste is often dumped indiscriminately at open dump sites without leachate treatment (HPEC, 2011). Improper waste management has led to worsening sanitation conditions in urban areas. Recent events such as closing of landfills in Pune and Bangalore and processing plant in Thiruvananthapuram following protests by villagers highlight the severe impact of poor waste management on public health and environment

- **Legal and Regulatory Framework for SWM in India:**

In India, various acts, rules, and regulations have been framed to ensure qualitative municipal solid waste management services in the cities. The applicable acts and rules are listed in the Table 1

The most significant piece of legislation is the Municipal Solid Waste Management & Handling) Rules, 2000. The Rules are applicable to every urban local body in India responsible for collection, segregation, storage, transportation, processing, and disposal of municipal waste

As per the MSWM rules, waste should be collected in a segregated manner with categories including organic food waste, domestic hazardous waste, recyclable waste and silt and construction and demolition waste Further, transportation, pro cussing and disposal should be planned in accordance with the national plan as explained in the diagram.

Compliance with the MSW Rules, 2000 requires that ap propriate systems and infrastructure facilities be put in place to undertake scientific collection management, processing and disposal of municipal waste However, most ULBs in India are finding it difficult to comply with these rules, implement and sustain door-to-door collection

management processing and disposal of MSW Some ULBs are able to provide efficient services because of tecuucal, managerial and financial defi- ciencies and others because of a lack of vision or willingness to engage with the private sector, NGOs, and citizen to address SWM challenges and find solutions

Table 1:

Applicable Acts and Rules for Solid Waste Management in India

National Acts and Rules for Solid Waste Management

Municipal Solid Waste (Management and Handling) Rules, 2000
The Bio-Medical Waste (Management and Handling) Rules, 1998
The Plastic Waste (Management and Handling) Rules, 2011
E-Waste (Management and Handling) Rules, 2011
Batteries (Management and Handling) Rules, 2001
The Environment (Protection) Act, 1986
EPA - Rule and Implementation Information for Standards of Performance for Municipal Waste Landfills
EPA - Non-Hazardous Waste Regulations
EPA Municipal Solid Waste Landfill Regulations
The Water (Prevention and Control of Pollution) Act, 1974
The Water (Prevention and Control of Pollution) Rules,1975
The Water (Prevention and Control of Pollution) Cess Act, 1977
Water (Prevention and Control of Pollution) Cess Rules, 1978
The Air (Prevention and Control of Pollution) Act, 1981
The Public Liability Insurance Act, 1991
The National Environment Tribunal Act, 1995
The National Environment Appellate Authority Act, 1997

- **Recent policy and program initiatives:**

The SWM sector has seen positive changes in the past decade. The Jawaharlal Nehru National Urban Renewal Mission (JnNURM) by the Government of India GoI funded 49 SWM projects in various cities between 2006 and 2009 (MoUD, 2014).

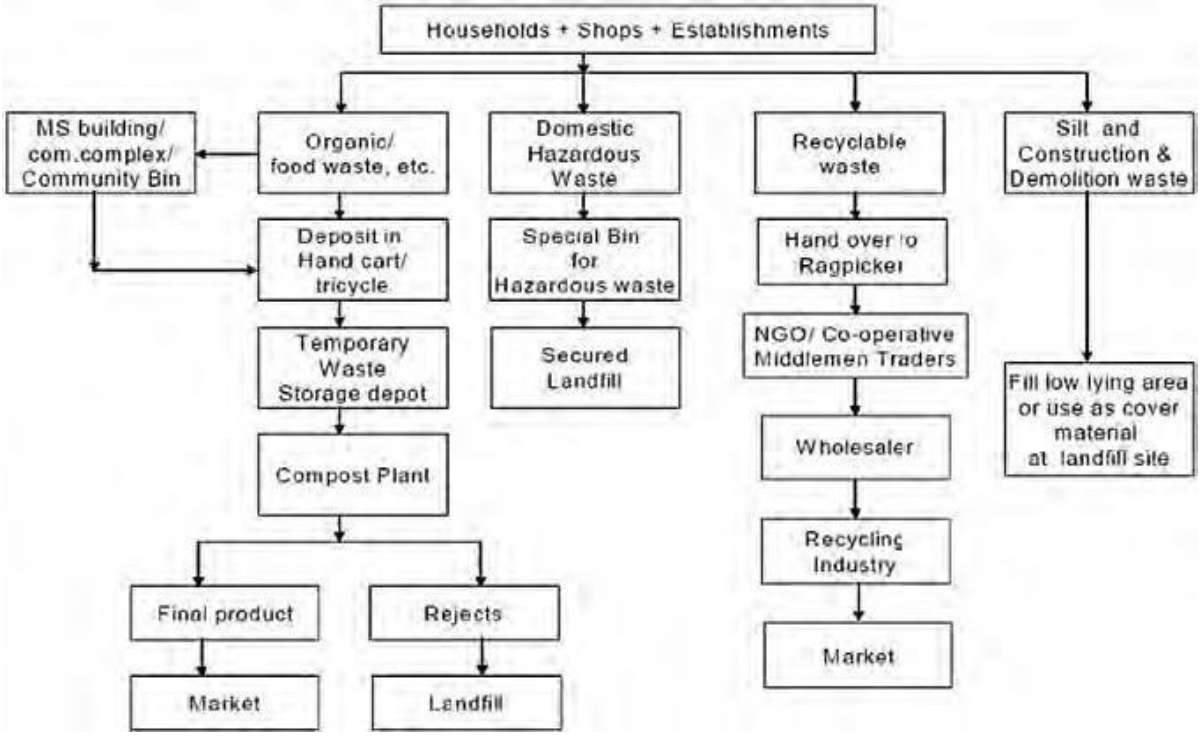
SWM is also one of the key areas under the National Mission on Sustainable Habitat (2010) announced by the Central Government in 2010. The Mission is one of the eight missions under the National Action Plan for Climate Change and addresses sustainability concerns related to habitats, primarily urban areas.

Similarly, State Governments also provide financial support to ULBs to improve their waste management systems under various schemes and programs. For example, the Gujarat Urban Development Corporation (GUDC) will provide financial assistance to 50 cities in the State to augment their solid and liquid waste management systems under the Mahatma Gandhi Swacchata Mission.

Several cities in India have taken positive steps towards implementing more sustainable waste management practices by involving the community in segregation and collection, by enforcing better PPP contracts and by investing in modern technology for waste transportation, processing, and disposal. The role of waste pickers/ informal sector in SWM is also increasingly being recognized. These interventions have great potential for wider replication in other cities and urban areas in the country. This compendium documents ten such leading practices from cities across India and highlights key aspects of the waste management programs including operational models, local government- NGO partnerships, financial sustainability and innovative outreach and awareness campaigns to engage communities and private sector.

Methodology for the documentation of Good Practices:

The following methodology was adopted to prepare this compendium of good practices in urban solid waste management:



✦ **Preparing an inventory of leading practices in SWM:**

Initiatives in solid waste management sector are relatively new (mostly post JnNURM). To identify and list these initiatives, the team prepared an exhaustive inventory of leading practices from across urban India by using the following methods:

- Review of past best practice documents, state of infrastructure reports, city development plans, etc.
  - Best practice publication by various organization's including National Institute of Urban Affairs (NIUA) amongst others ○ Special reports on SWM sector including report by High Powered Expert Committee (HPEC), 2011
  - Other publications and academic papers published on solid waste sector ○ Review of service level benchmarking (SLB) indicators and identifying cities with better performance
  - SWM and sanitation policies of various state governments
- Website scans of all major cities in India

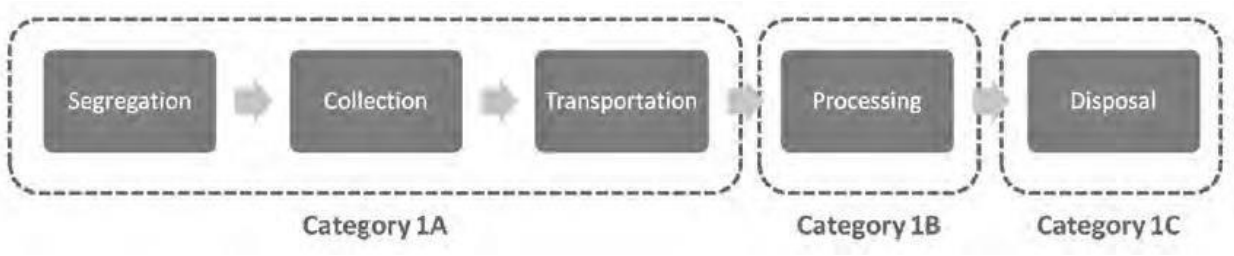
- Review of past awards in solid waste sector by various organization's such as Housing and Urban Development Corporation Limited (HUDCO), CRISIL
- Media scan in various solid waste and sanitation categories, and tracking of news and activities in urban SWM sector in all major geographical areas of the country
- Using the team's domain knowledge, discussions and interactions with subject matter experts including NIUA, NGOs working at grass-root level in the sector and government and private in-service officials in solid waste sector in India.

Based on the above methodology, a preliminary list of 73 potential best practices was identified. The inventory of the practices included a general outline of the initiative, implementing agency, key stakeholders involved, and scale of the project, funding and budgets (information available through reports, studies and websites of the respective ULBs or state government or central government). A brief profile of each case is provided in Annexure.

Figure 4. Achieving circular economy through waste management

Categorization of best practices:

These best practices were then categorized into the following groups based on key interventions in areas of operations, policy and planning, and involvement of citizens, NGOs, and private players in SWM sector.



Category 1: Initiatives in value chain of municipal solid waste

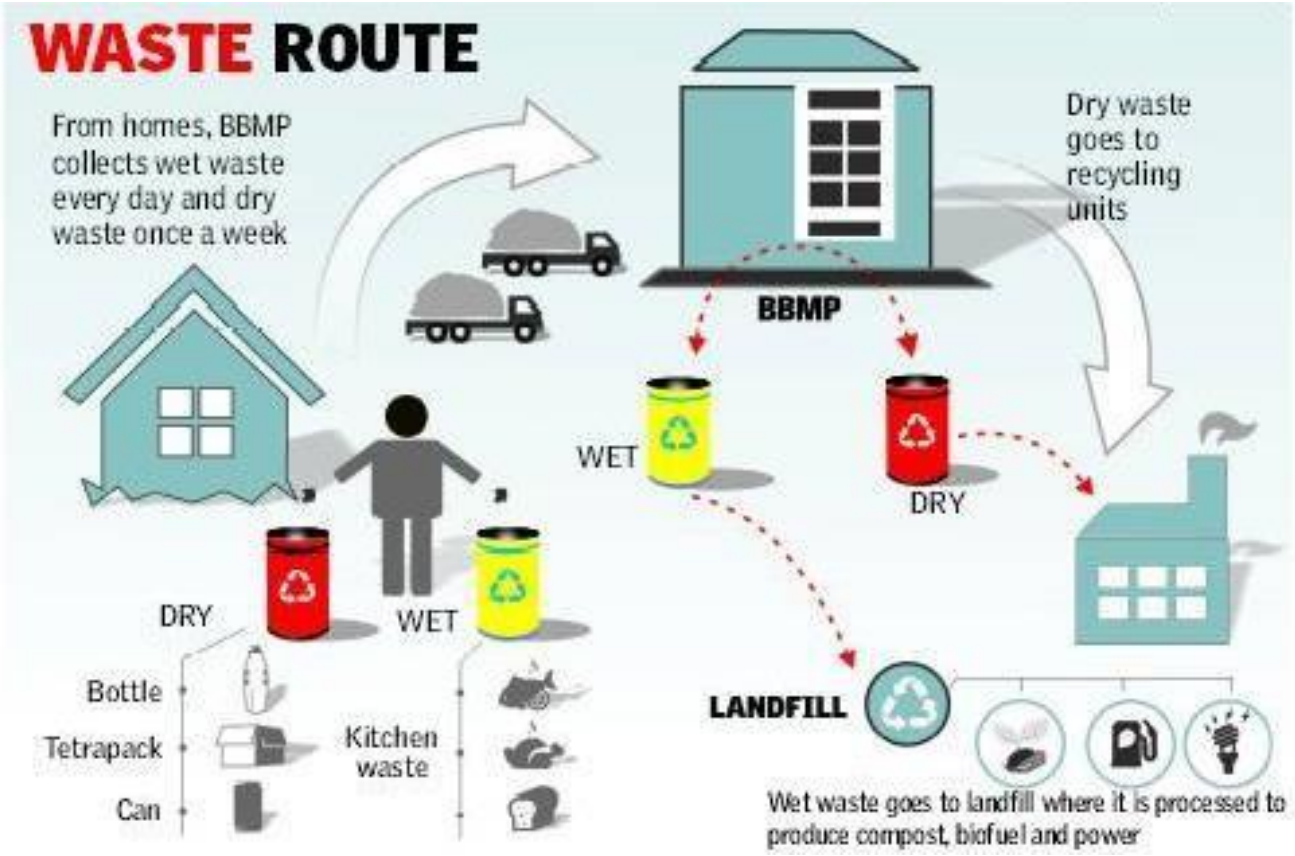
Category 2: Policy, planning and enforcement initiatives

Category 3: Initiatives involving community in solid waste management

While some initiatives qualify to fit in one of the above categories, most initiatives identified in the inventory relate to more than one category. In such cases, initiatives' primary emphasis was identified and used to categories them.

✞ Category 1: Initiatives in value chain of municipal solid waste

The complete solid waste management process includes waste collection, transportation, disposal, and treatment. Initiatives that have achieved operational improvements across this value chain of waste management were identified under this category.



⌘ **<u>Category 1A: Improvements in waste segregation, collection, and transportation</u>**

Segregated waste collection from households is the key to reducing landfilling. Segregation ensures maximum recycling and treatment at the local level. The emphasis in this category is on initiatives that have strengthened the door to door collection system and have involved informal sector/waste pickers and citizen groups to collect segregated waste. This category relates to three indicators from the SLB framework:

- **Household coverage of solid waste management services:** Percentage of households and establishments that are covered by a daily doorstep collection system.
- **Efficiency of collection of waste management service:** The total waste collected by the ULB and authorized service providers versus the total waste generated within the ULB, excluding recycling or processing at the generation point.
- **Extent of segregation of solid waste:** Percentage of waste from households and establishments that is segregated. Segregation should at least be at the level of separation of wet and dry waste at the source, that is, at the household or establishment level. Ideally, the separation should be in the following categories: biodegradable waste, waste that is non-biodegradable, and hazardous domestic waste such as batteries, etc.

⌘ Category 1B: Initiatives in waste recovery

The high degree of biodegradable content in municipal solid waste in India makes it ideal for techniques like composting wherein the chemical and biological transformation processes reduces the quantity of waste and products of economic value are recovered. Various initiatives being undertaken by cities to incorporate decentralized waste treatment options such as composting units, biogas plants, waste to energy plants etc. are documented under this category. This category relates to following indicators from the SLB indicator framework:

- **Extent of municipal solid waste recovered:** This is an indication of the quantum of waste collected, which is either recycled or processed. This is expressed in terms of percentage of waste collected.

⌘ Category 1C: Initiatives in scientific waste disposal

ULBs are challenged to dispose waste in engineered/ sanitary landfill sites. The various issues that have been cited include lack of land, lack of capacity to design and operate a landfill site. This category relates to following indicator from the SLB indicator framework:

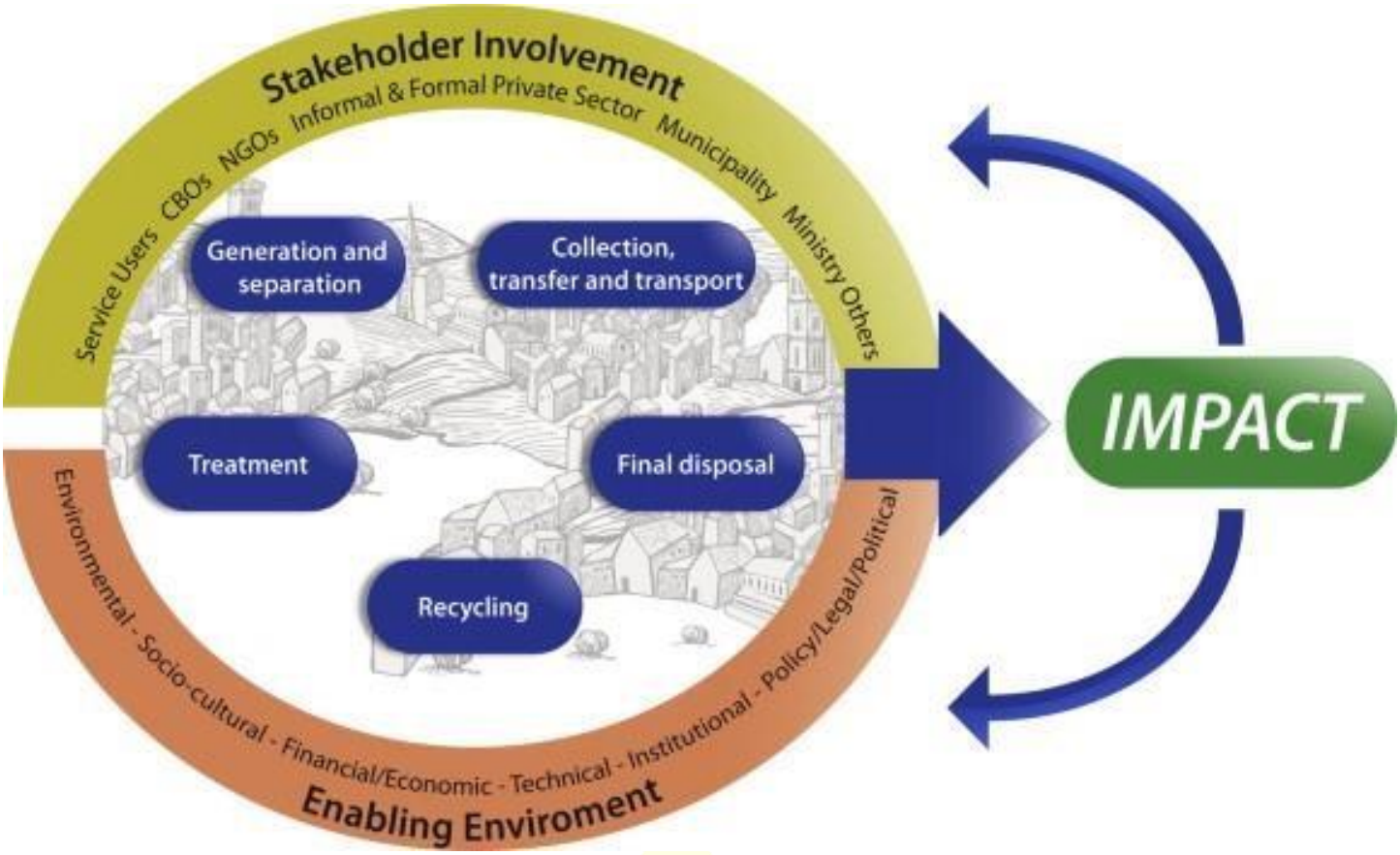
- Extent of scientific disposal of municipal solid waste (this is the amount of waste that is disposed in landfills that have been designed, built, operated, and maintained as per standards laid down by Central agencies. This is expressed as a percentage of the total quantum of waste disposed.

✞ Category 2: Planning, policy, and enforcement initiatives

Policy and planning initiatives undertaken by state and local governments ensure that long term improvements in SWM infrastructure and systems are carried out in a logical, systematic way. Several cities have also taken the initiative to prepare health and sanitation byelaws that clearly spell out the role of the urban local body and citizens in the solid waste management process. The byelaws also allow ULBs to put in place an enforcement framework to deal with solid waste violations. This category documents innovative initiatives in SWM planning and enforcement.

✞ Category 3: Initiatives Involving Community in Solid Waste Management:

Sustainability of initiatives has been a key challenge for most efforts undertaken for SWM sector in the past. The challenges are due to various factors including human resource shortage, insufficient training and motivation of staff, delayed procurement of equipment and vehicles, poor enforcement of policies, poor financial recovery, casual engagement of stakeholders, shifting priorities of ULBs amongst many others. Some initiatives which have sustained over a long period of time have been listed in the following categories. It is important to analyses the strengths and weaknesses of these cases to replicate it in other cities and activities in SWM.



⌘ Category 3A: Initiatives towards Information Education and Communication

While ULBs are undertaking numerous initiatives for efficiently managing municipal waste, it is also important to create awareness amongst citizens on their roles and responsibilities. Cities

have also created public health byelaws and a regulatory framework and are taking steps to communicate these to citizens.

⌘ Category 3B: Community Led Initiatives in Solid Waste Management

This category documents the emergence of citizen/ community led initiatives in solid waste management to fill the gaps in municipal solid waste management services. For effective waste management, cities must enter partnerships with citizens, community-based organizations, other stakeholders in the city and private sector for either end-to-end contracts or service contracts. This is also since ULBs lack capacity in terms of adequate and skilled human resources. Many cities have shown innovative partnerships and contracting mechanisms towards such partnerships.

⌘ Category 3C: Initiatives towards training and capacity building

Training and capacity building (TCB) of officials and workers is key to sustenance of initiatives in SWM sector. SWM sector involved large scale human resource management challenges. Cities like Ahmedabad employ around 12,000 sanitation workers, mostly working in SWM sector. Regular training of technical issues, reporting regimes, work discipline, health and safety need to be regularly provided for an efficient system. The challenges increase with engagement of private companies and other informal workers in the sector. Cities undertake TCB as a component under projects or programs. Many case studies listed above involve TCB and hence, no case studies have been listed under this category exclusively.

CONCLUSION

Developing and least developed countries have no alternative but to plan for a sustainable development processes acknowledging the importance of encountering the problems in persistence and facing the development challenges with an active participation of stakeholders including the public. With the growth in urbanization MSW services is becoming one of the most challenges which if not properly and sustainably dealt with will adversely impact all other

development sectors. The best approach for dealing with solid waste sector is by implementing an integrated and sustainable management approach that ensures the good health of the society and the environment and the active participation of the society. An example of implementing the ISSWM approach has recently been initiated by the Palestinian Authority and if political atmosphere permits the adequate implementation of the ISSWM strategy feedback would be of most beneficial to many developing and least developed countries. Effective waste reduction and recycling is predicated upon credible data on refuse generation and disposal. Despite improvements in the quality of data for municipal solid wastes (MSW) disposal, dependable generation, and recycling statistics to support planning, regulation and administration are lacking. The available aggregates on national waste production from two sources do not conform to each other and fail to serve the requirements of local solid waste planning. As recycling estimates will be difficult to discern, the collection of generation data based on weighing waste samples at generator sites has been portrayed as the key for developing sustainable local databases. The coefficients developed from the databases for the various categories of residential, commercial, industrial, and institutional wastes can be used as variables for waste generation models.

REFERENCES

https://www.coursera.org/learn/solid-waste-management/home/welcome

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