Classification of solid wastes

There are several different ways of classifying solid waste. As you have seen, one way is to classify it by where it is generated. Another way is based on whether the waste is biodegradable or not.

Biodegradable solid wastes are those that can be broken down (decomposed) into their constituent elements by bacteria and other micro-organisms. Food waste, manures and waste from producing crops are the main biodegradable wastes. If the decomposition process takes place in the absence of air (anaerobically), methane gas can form. Methane is a powerful greenhouse gas and can explode if enough of it accumulates and an ignition source (such as an electrical spark) is present. The decomposition may also produce offensive and irritating smells.

However, controlled anaerobic decomposition can produce biogas – a useful fuel for heating, cooking and even power generation that you learned about in Study Session 5– as well as fertilizers and soil conditioners. Waste that decomposes in the presence of an adequate air supply (aerobically) under controlled conditions can produce compost, which can be used to improve the quality of soils.

Non-biodegradable (also sometimes called inorganic) solid wastes are those that do not decompose by microbial action. These wastes include plastic containers, scrap metal, food and drink cans and plastic bags.

Materials in solid wastes can also be classified as combustible or non-combustible, depending on whether they will burn or not.

Depending on the inherent dangers associated with its physical and chemical properties, solid waste can be classified as either hazardous or non-hazardous. Hazardous wastes pose substantial or potential threats to public health or the environment. For example, toxic, infectious and corrosive (acidic or alkaline) substances are all likely to be classed as hazardous. Nonhazardous wastes are those that do not possess hazardous characteristics, although they can still be harmful to people or the environment.

Various Sources of Solid Waste

Every day, tones of solid waste are disposed off at various landfill sites. This waste comes from homes, offices, industries and various other agricultural related activities. These landfill sites produce foul smell if waste is not stored and treated properly. It can pollute the surrounding air and can seriously affect the health of humans, wildlife and our environment. The following are major sources of solid waste:

Residential

Residences and homes where people live are some of the major sources of solid waste. Garbage from these places include food wastes, plastics, paper, glass, leather, cardboard, metals, yard wastes, ashes and special wastes like bulky household items like electronics, tires, batteries, old mattresses and used oil. Most homes have garbage bins where they can throw away their solid wastes in and later the bin is emptied by a garbage collecting firm or person for treatment.

Industrial

Industries are known to be one of the biggest contributors of solid waste. They include light and heavy manufacturing industries, construction sites, fabrication plants, canning plants, power and chemical plants. These industries produce solid waste in form of housekeeping wastes, food wastes, packaging wastes, ashes, construction and demolition materials, special wastes, medical wastes as well as other hazardous wastes.

Commercial

Commercial facilities and buildings are yet another source of solid waste today. Commercial buildings and facilities in this case refer to hotels, markets, restaurants, go downs, stores and office buildings. Some of the solid wastes generated from these places include plastics, food wastes, metals, paper, glass, wood, cardboard materials, special wastes and other hazardous wastes.

Institutional

The institutional centers like schools, colleges, prisons, military barracks and other government centers also produce solid waste. Some of the common solid wastes obtained from these places include glass, rubber waste, plastics, food wastes, wood, paper, metals, cardboard materials, electronics as well as various hazardous wastes.

Construction and Demolition Areas

Construction sites and demolition sites also contribute to the solid waste problem. Construction sites include new construction sites for buildings and roads, road repair sites, building renovation sites and

Building demolition sites. Some of the solid wastes produced in these places include steel materials, concrete, wood, plastics, rubber, copper wires, dirt and glass.

Municipal services

The urban centers also contribute immensely to the solid waste crisis in most countries today. Some of the solid waste brought about by the municipal services include, street cleaning,

wastes from parks and beaches, wastewater treatment plants, landscaping wastes and wastes from recreational areas including sludge.

Treatment Plants and Sites

Heavy and light manufacturing plants also produce solid waste. They include refineries, power plants, processing plants, mineral extraction plants and chemicals plants. Among the wastes produced by these plants include, industrial process wastes, unwanted specification products, plastics, metal parts just to mention but a few.

Agriculture

Crop farms, orchards, dairies, vineyards and feedlots are also sources of solid wastes. Among the wastes they produce include agricultural wastes, spoiled food, pesticide containers and other hazardous materials.

Biomedical

This refers to hospitals and biomedical equipment and chemical manufacturing firms. In hospitals there are different types of solid wastes produced. Some of these solid wastes include syringes, bandages, used gloves, drugs, paper, plastics, food wastes and chemicals. All these require proper disposal or else they will cause a huge problem to the environment and the people in these facilities.

Environmental Legislations and their relevance in Urban Planning

Constitutional Provisions & Environment

- **Art 21** “Right to pollution free environment.”

- **Art 48-A** “ The state shall endeavor to protect & improve the environment and to safeguard the forests and wildlife of the country.

- **Art 51-A(g)** “duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures.”

Environmental Legislations

1. General
2. Forest and wildlife
3. Water
4. Air

General

- **1986 - The Environment (Protection) Act** authorizes the central government to protect and improve environmental quality, control and reduce pollution from all sources, and prohibit or restrict the setting and /or operation of any industrial facility on environmental grounds.
- **1989 - The objective of Hazardous Waste (Management and Handling) Rules** is to control the generation, collection, treatment, import, storage, and handling of hazardous waste.
- **1998 - The Biomedical waste (Management and Handling) Rules** is a legal binding on the health care institutions to streamline the process of proper handling of hospital waste such as segregation, disposal, collection, and treatment.
- **2000 - The Municipal Solid Wastes (Management and Handling) Rules, 2000** apply to every municipal authority responsible for the collection, segregation, storage, transportation, processing, and disposal of municipal solid wastes.
- **2002 - The Noise Pollution (Regulation and Control) (Amendment)** Rules lay down
  such terms and conditions as are necessary to reduce noise pollution, permit use of loud speakers or public address systems during night hours on or during any cultural or religious festive occasion.

Forest and wildlife

- **1927 - The Indian Forest Act and Amendment, 1984,** is one of the many surviving colonial statutes. It was enacted to 'consolidate the law related to forest, the transit of forest produce, and the duty leviable on timber and other forest produce'.
- **1972 - The Wildlife Protection Act, Rules 1973 and Amendment 1991** provides for the protection of birds and animals and for all matters that are connected to it whether it be their habitat or the waterhole or the forests that sustain them.
- **1980 - The Forest (Conservation) Act and Rules, 1981,** provides for the protection of and the conservation of the forests.
- **2002 - The Biological Diversity Act** is an act to provide for the conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of the benefits arising out of the use of biological resources and knowledge associated with it.

Water

- **1974 - The Water (Prevention and Control of Pollution) Act** establishes an institutional structure for preventing and abating water pollution. It establishes standards for water quality and effluent. Polluting industries must seek permission to discharge waste into effluent bodies.
  The CPCB (Central Pollution Control Board) was constituted under this act.
- **1977 - The Water (Prevention and Control of Pollution) Cess Act** provides for the levy and collection of cess or fees on water consuming industries and local authorities.
- **1978 - The Water (Prevention and Control of Pollution) Cess Rules** contains the standard definitions and indicate the kind of and location of meters that every consumer of water is required to affix.
- **1991 - The Coastal Regulation Zone Notification** puts regulations on various activities, including construction. It gives some protection to the backwaters and estuaries.
- **2010 – Wetland Rules**

Air

- **1982 - The Air (Prevention and Control of Pollution) Rules** defines the procedures of the meetings of the Boards and the powers entrusted to them.
- **1987 - The Air (Prevention and Control of Pollution) Amendment Act** empowers the central and state pollution control boards to meet with grave emergencies of air pollution.

Environment Protection Act, 1986

- "environment" includes water, air and land and the inter- relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organism and property
- "environmental pollutant" means any solid, liquid or gaseous substance present in such concentration as may be, or tend to be, injurious to environment;
- "environmental pollution" means the presence in the environment of any environmental pollutant;

Environment Protection Act, 1986

- "handling", in relation to any substance, means the manufacture, processing, treatment, package, storage, transportation, use, collection, destruction, conversion, offering for sale, transfer or the like of such substance;
- “hazardous substance" means any substance or preparation which, by reason of its chemical or physio-chemical properties or handling, is liable to cause harm to human beings, other living creatures, plant, micro-organism, property or the environment;
- "occupier", in relation to any factory or premises, means a person who has control over the affairs of the factory or the premises and includes in relation to any substance, the person in possession of the substance;

Requirements under EPA

- Sec 7- no person carrying on any industry, operation or process shall discharge or emit or permit to be discharged or emitted any environmental pollutant in excess of such standards as may be prescribed
- Sec 8 – no person shall handle or cause to be handled any hazardous substance except in accordance with such procedure and after complying with such safeguards as may be prescribed

Interface with Planning - Issues and Challenges

- Siting criterion
  - National park/ Sanctuary
  - Floodplain
  - CRZ
- Sewage
  - Alteration to topography
  - Siting STP
- MSW
  - Siting
- Common facilities such as slaughter house, TSDF, green areas, pavements, C and D waste, biomedical waste, dairy, markets
- Roads, flyover, bridges – air and noise pollution
- Water requirement and its sourcing
- Construction material and its sourcing
- DG sets, Dewatering

Chapter VI

Segregation, Collection and Transportation of waste

6.1 Segregation

Segregation refers to the process of separation of municipal solid waste into four groups *i.e.,* organic, inorganic, recyclables and hazardous wastes. It is a critical requirement since it enables recycling, reuse, treatment and scientific disposal of different components of waste. Chapter 8 of Manual on MSWM, 2000 deals with the importance of sorting[19] waste.

Sorting/segregation shall take place at different levels such as source/household level; transfer station or centralised sorting facility; waste processing site and landfill site to segregate waste into different streams such as dry recyclables, biodegradable waste, C&D waste, hazardous waste, *etc.*, to minimise waste and ensure reduction in landfill space for final disposal besides ensuring appropriate processing.

6.1.1 Segregation of waste at source/household level

MSWM Manuals, 2000 (Section 8.10.1(a)) and 2016 (Section 2.2.1) stipulate that ULBs must accord highest priority for segregation of waste at source. DMA stated (June 2017) that only 105 out of 270 ULBs in the State started segregation at source (partially in few selected wards).

The test-checked ULBs also declared having achieved service level benchmarks between zero and 55 *per cent* for segregation. As per SLB declarations by the ULBs themselves, segregation was totally absent in seven ULBs and averaged 31 *per cent* in 28 ULBs during 2016-17, indicating poor segregation of waste. Based on JPVs, we found that segregation at source was not followed in 32 out of 35 test-checked ULBs and it was partially carried out in three test-checked ULBs (CC, Tumakuru, CMC, Dandeli and TMC, Kumta).

6.1.1.1 Issue of bins

Scrutiny of records revealed that 11[20] test-checked ULBs procured bins at a total cost of ₹3.45 crore during the review period and issued them to 35 *per cent* of households to encourage segregation of waste at source. We observed during JPV conducted along with the officials of ULBs that segregation of waste was not adopted despite the issue of bins (**Exhibit 6.1**).

The JPV also showed that mixed waste was handed over to waste collectors by households despite audio announcements regarding the importance of

[19] The word 'sorting' is used synonymously with 'separation' and 'segregation' in this Chapter.

[20] CCs - HDMC, Mangaluru and Tumakuru; CMCs - Bagalkote, Hosapete, Sira and Udupi; TMCs - Hiriyur and Manvi; TPs - Koppa and Kudligi.

segregation into wet and dry waste in 26 test-checked ULBs. In six[21] other ULBs, there was no segregation as the mechanism of door-to-door collection was totally absent resulting in dumping of waste on roadsides, streets, *etc*.

In CC, Tumakuru, though segregated waste was handed over to the waste collector (observed during JPV in one ward), the segregated waste was getting mixed in the secondary collection vehicle (Compactor). In CMC, Dandeli, segregation of waste at source was followed in 4 out of 31 wards that were managed voluntarily by West Coast Paper Mills (a company located at Dandeli). In TMC, Kumta, wet waste was being processed through pipe/pit composting at source level and therefore, only dry waste was being collected.

The good practices in segregated collection of MSW in CMCs, Dandeli and Kolar are detailed in **Appendix 11.4**.

6.1.1.2 Non-segregation of domestic hazardous waste

Domestic hazardous waste requires special handling and disposal because of its harmful physical and chemical characteristics, or biological properties. Hence, there is a greater need for proper segregation of such waste. Manual on MSWM, 2000 and SWM Rules, 2016 specify the roles and responsibilities of ULBs in this regard.

As stated in Paragraph 5.2 of IEC, the concerned authorities both at the State/district level and in all the 35 test-checked ULBs did not notify and publicise the list of items classified as domestic hazardous waste to be segregated at source. Consequently, people were not aware of the effect of non-segregation of domestic hazardous waste and contaminated mixed waste was reaching the landfills.

6.1.1.3 Non-segregation of sanitary waste

Sanitary waste generated by households was to be wrapped in old newspaper/pouches provided by the manufacturers and handed over to the waste collectors separately as per the guidelines of KSPCB and clause 4 under Section 2.2.1 of SWM Manual, 2016.

We observed that none of the test-checked ULBs emphasised segregation and disposal of sanitary waste as required (except ULBs in Uttara Kannada District and TP, Kudligi).

6.1.1.4 Absence of incentive mechanism and enforcement

MSWM Manuals, 2000 (Sections 18.3 and 18.4) and 2016 (Section 2.1.4) specify the various activities and methodologies required to be adopted by ULBs to ensure proper segregation of waste at source. One such methodology is providing incentives in the form of rewards/grants/subsidies.

Similarly, Section 18.5 of MSWM Manual, 2000 provides for enforcement. While all efforts should be made to educate people to effectively participate in

[21] CMC, Shidlaghatta; TMCs - Kakkera, Mugalkhod and T. Narasipura; TPs - Ainapura and Chinchali.

the management of waste through IEC, they also need to be made aware of penalties if they fail to discharge their civic duties. The provision for penalties should be made known to the people and details of those punished should be publicised widely to deter others.

Audit did not notice any instances of incentive/disincentive mechanism to promote segregation of waste in any of the test-checked ULBs. We also noticed that penalty provisions under Schedule XIII to Section 431A of KMC Act, 1976 were not enforced.

The above observations indicate that the test-checked ULBs made very little effort to emphasise the importance of segregation of waste at source. DMA attributed (July 2017) this to lack of (i) micro-level planning, (ii) citizen's co-operation and awareness, (iii) stringent laws, bye-laws, *etc.*, (iv) infrastructure such as bins, partitioned vehicles, storage facilities, *etc.* and (v) incentivisation for effective segregation at source and further stated (July 2017) that segregation of waste at source was prioritised and presently 105 ULBs started segregation at source (partially in few selected wards) and continuous efforts were being made to accomplish 100 *per cent* segregation at source.

The State Government stated (May 2018) that 100 *per cent* source segregation cannot be achieved in a single stretch. It further stated that efforts were being continuously taken to achieve source segregation in a progressive manner with the help of IEC tools and introducing penal clauses for non-compliance in the draft bye-laws. Top priority needs to be accorded to the operation of these two strategies for achieving higher levels of segregation.

6.1.2 Segregation of waste at transfer station/central sorting facility

Section 8.10.3(a) of the Manual on MSWM, 2000 states that sorting at the waste storage depot/transfer station is not desirable. However, if source level sorting is not developed, then such sorting may be allowed till a household-level sorting and collection system is established. Since source level segregation was absent/deficient in the ULBs as stated above, there was a need for ensuring segregation of waste at least before it reaches the processing/landfill site. Further, as per Clause 15 (h) of SWM Rules, 2016, the local authorities shall set up material recovery facilities or secondary storage facilities for sorting of recyclable materials.

We observed that:

- In all the test-checked ULBs, waste was transferred in mixed form from primary transportation vehicles to secondary transportation vehicles (mechanically-without manual intervention) near roadsides or vacant lands. In CC, Ballari, the primary transportation vehicles were transferring mixed waste to secondary transportation vehicles at a centralised point (transfer station); and
- Out of the 35 test-checked ULBs, dry waste collection centres were functioning only in three ULBs (CC, Tumakuru, CC, Mangaluru and TMC, Kumta). The dry waste collection centres constructed at CC, Ballari (July 2016 at a cost of ₹21.52 lakh); CMC, Chintamani (March 2017 at a cost of ₹15 lakh) and TMC, Humnabad (April 2015 at a cost of ₹1.75 lakh) were yet to be made functional (May 2017).

Failure to segregate resulted in failure to recover the recyclables, thereby leading to dumping these resources in landfills. It also led to sub-optimal use of precious landfill space.

The State Government accepted (May 2018) the audit observation.

6.1.3 Segregation of waste at processing site

Segregation of waste at processing site is desirable to ensure that the processed output (such as compost) meets the regulatory standards (Section 8.10.5 of Manual on MSWM, 2000).

We observed that five[22] out of 35 test-checked ULBs had compost processing facilities within the landfill site and TMC, Maddur had a decentralised processing facility. Hence, partial segregation was being practised in these ULBs.

Failure to segregate waste at different stages resulted in dumping of mixed waste on windrow platforms/landfill **(Exhibit 6.2)** leading to ineffective waste management. Dumping of mixed waste on windrow platforms also results in reduction in quality and quantity of compost.

The State Government accepted (May 2018) the audit observation and stated that efforts were being taken at all levels to increase the percentage of source segregation.

Recommendation 11: Segregation should be given greater emphasis by means of publicity and awareness campaigns and holding regular meetings with housing associations and NGOs. The State Government should encourage segregation of waste at source by devising a system for incentivising waste generators and collectors for segregation of waste, and should prevent mixing of segregated waste during various stages of SWM.

6.2 Collection

Collection of segregated waste is the second step of SWM process. Waste collection system is necessary to ensure that waste stored at source is collected regularly and it is not disposed of on the streets, drains, water bodies, *etc*. Inefficient waste collection has an impact on public health and aesthetics of urban areas. Waste collection service is divided into primary and secondary collection.

Sections 10.3 and 10.4 of Manual on MSWM, 2000, state that ULBs shall arrange for the collection of domestic, trade and institutional, food/biodegradable waste, recyclable waste material/non-biodegradable waste besides domestic hazardous/toxic waste from doorstep or community bins or waste deposition centres specially established for the purposes. The collection service provided by ULBs should be regular and reliable.

6.2.1 Inadequate collection of waste generated

The quantum of waste generated and collected during the period 2012-13 to 2016-17 in the State (other than BBMP) and in the test-checked ULBs is shown in **Table 6.1**.

[22] CCs - Mangaluru and Tumakuru; CMCs - Bagalkote and Sira; TP, Koppa.

Table 6.1: Statement showing the status of quantum of waste generated and collected in the State and the test-checked ULBs

(in tons)

Period	State			Test-checked ULBs		
	Generated	Collected	Uncollected	Generated	Collected	Uncollected
2012-13	Not Available			4,90,305	4,45,782	44,523
2013-14	19,28,660	16,79,730	2,48,930	4,99,868	4,55,600	44,268
2014-15	18,96,905	15,10,370	3,86,535	5,21,074	4,77,829	43,245
2015-16	19,55,172	16,71,156	2,84,016	5,59,523	5,14,914	44,609
2016-17	20,09,690	15,71,690	4,38,000	5,67,652	5,24,881	42,771
Total	**77,90,427**	**64,32,946**	**13,57,481**	**26,38,422**	**24,19,006**	**2,19,416**

Source: Information furnished by KSPCB and test-checked ULBs

On an average, 13-22 *per cent* of waste generated was not collected in the State and 8-9 *per cent* in the test-checked ULBs.

Section 6.9.4.1 of MSWM Manual, 2000 stipulated that every landfill must have a weighbridge for assessing the quantum of waste. The availability and status of weighbridge in landfill sites is detailed in Paragraph 7.3.1. Only four test-checked ULBs had working weighbridge facility. Other ULBs did not maintain any documents to assess the actual extent of the collection. This led to poor oversight and monitoring as ULBs had no means to quantify SWM in order to address it suitably.

Audit attempted to verify[23] the correctness of data furnished by two ULBs (CC, Tumakuru and CMC, Sira) for the year 2016-17 with reference to the records made available. We found that the data was inconsistent in respect of both these ULBs as detailed in **Table 6.2**.

Table 6.2: Comparison of data furnished by ULBs with the records

(Quantity in TPD)

Sl. No.	Name of ULB	As per information furnished by ULB			As per records (weighbridge data)			As per DPR		
		G	C	CE	G	C	CE	G	C	CE
1	CMC, Sira	22	20	91	22	13	59	29	26	90
2	CC, Tumakuru	120	110	92	120	84	70	130	77	59

G – Generation; C – Collection and CE – Collection efficiency in percentage

The State Government cited (May 2018) inadequate number of vehicles and manpower with ULBs and non-existence of micro-level planning for inadequate collection of waste. The reply was silent on the inconsistency in data pointed out by audit.

6.2.2 Ward-wise collection of waste

The status of ward-wise collection of waste in the State and test-checked ULBs is indicated in **Table 6.3**.

[23] In CC, Mangaluru and CMC, Udupi, the landfills were provided with weighbridge facility and were also used by other ULBs. Hence, data of these ULBs was not compared.

Table 6.3: Status of ward-wise collection

Sl. No.	Position in	Number of ULBs		
		Complete coverage of wards	Partial coverage of wards	No coverage
1	State	128	76	66
2	Test-checked ULBs	20	9	6

Source: Information furnished by KSPCB and test-checked ULBs

Four[24] of the ULBs where there was no door-to-door collection were upgraded from Gram Panchayats in the year 2015. Two[25] ULBs where door-to-door collection was absent and nine[26] ULBs where the collection was partial, cited shortage of manpower and vehicles as the main reasons. Twenty test-checked ULBs with complete coverage of wards claimed household coverage between 70 to 100 *per cent*. We observed that the claims of 16 of these ULBs were inconsistent with their own SLB declaration on household coverage.

The State Government stated (May 2018) that replies would be obtained from concerned ULBs and furnished.

6.2.2.1 Use of community bins for collection

DMA issued directions (October 2014) prohibiting purchase of community bins. In contravention of these directions, TMC, Humnabad purchased (July 2017) containers (community bins) at a cost of ₹9.00 lakh. Chief Officer, TMC, Humnabad cited (August 2017) lack of awareness among citizens and non-implementation of 100 *per cent* door-to-door collection as the reasons for purchase of containers. The justification offered by Chief Officer, Humnabad, was not convincing. It was observed during JPV that the purchase of bins did not bring in improvement in waste collection (**Exhibit 6.3**).

6.2.2.2 Non-involvement of Self Help Groups and waste pickers in door-to-door waste collection

Manual on MSWM, 2000 and SWM Rules, 2016 stipulate that ULBs must establish a system for formation of SHGs and recognise organisation of waste pickers and integrate them into the waste management system including door-to-door collection. We observed that only five[27] test-checked ULBs involved SHGs in door-to-door collection of waste. In CMC, Shidlaghatta, SHGs were involved in street sweeping.

Thus, failure to enforce efficient and effective door-to-door collection resulted in littering/dumping of MSW/food waste on roadsides and encouraged the movement of stray animals towards the waste leading to serious consequences as illustrated in Paragraph 8.1.2.1.

The State Government stated (May 2018) that suitable action would be taken to involve SHGs and waste pickers.

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[24] TMCs - Kakkera and Mugalkhod; TPs - Ainapura and Chinchali.

[25] CMC, Shidlaghatta and TMC, T. Narasipura.

[26] CMC, Bidar (63 *per cent*), CMC, Hosapete (40 *per cent*), CMC, Nanjangud (33 *per cent*), TMC, Hiriyur (93 *per cent*), TMC, Humnabad (22 *per cent*), TMC, Maddur (87 *per cent*), TMC, Manvi (78 *per* cent), TMC, Ugar Khurd (22 *per cent*) and TP, Kudligi (40 *per cent*).

[27] CMCs -Dandeli (only during 2012-13 and 2013-14), Nanjangud and Udupi; TMC, Bhatkal and TP, Gudibande.

6.2.3 Street sweeping/street cleaning

Street cleaning is one of the primary services rendered by municipal authorities to ensure clean and hygienic urban conditions. Section 11.3.1 of Manual on MSWM, 2000 and Section 2.4.2 of Manual, 2016 stipulate that it is necessary to have a well-planned, time-bound daily system for street sweeping including adequate staffing and equipment. Further, the Supreme Court, keeping in view Articles 48A and 51A(g) of the Constitution, directed (1996) in one case that the streets, public premises, parks, *etc*., should be surface cleaned on daily basis, including on holidays (B.L. Wadhera vs. Union of India and others case).

We observed that the 35 test-checked ULBs did not carry out street sweeping of 6,935 (83 *per cent*) out of 8,324 km of roads on daily basis.

The State Government stated (May 2018) that ULBs based on the activities and population density decided the frequency of street sweeping and it varied from city to city. The reply is not consistent with the spirit of the Constitution enshrined in Articles 48A and 51A(g), which talk about protection and improvement of the environment. It is also in violation of the Supreme Court directives and does not address the fact of keeping the streets clean and hygienic at all times.

6.2.4 Mixing of occupational waste with Municipal Solid Waste

The provisions of Manual on MSWM, 2000 and SWM Rules, 2016 prohibit mixing of other wastes with MSW. We, however, observed mixing of occupational waste with MSW as detailed below:

6.2.4.1 Collection of cut *beedi* leaves

The activity of *beedi* rolling was prevalent in five[28] test-checked ULBs. The door-to-door collection of MSW in these ULBs involved sizeable quantity of 'cut *beedi* leaves', the residual product of the activity.

CC, Tumakuru and CMC, Sira, generated two TPD of cut *beedi* leaves each. Similarly, in CMC, Nanjangud (10 kg) and TMC, Maddur (300 kg), cut *beedi* leaves were generated each day on an average. A *Beedi Karmikara Nagara*, an exclusive colony of 200 houses established in Ward 66 in HDMC generated 150 kg of cut *beedi* leaf waste per day, which was found dumped openly in the colony as well as in the empty water sump (**Exhibit 6.4**). As cut *beedi* leaves waste is organic in nature and biodegradable, the collection of such waste along with MSW and transporting the mixed waste to the landfill contravenes the provisions of SWM Rules and may result in poor quality of compost.

The ULBs should have made separate arrangements for collection of this waste on collection of user charges or directed the concerned to arrange for collection and disposal of the waste either under 'Polluter pays principle' or 'Extended Producer Responsibility'.

6.2.4.2 Collection of ash waste generated from silk reeling units

CMC, Shidlaghatta houses approximately 1,450 to 1,650 silk reeling units, wherein, ash waste is generated by conventional method of burning wood to

[28] CCs - HDMC and Tumakuru; CMCs - Nanjangud and Sira; TMC, Maddur.

boil water for reeling silk (2 TPD which constitutes about 10 *per cent* of total waste generated). Similarly, TP, Sringeri generates ash waste (0.42 TPD – 12 *per cent* of total waste) from hotel industry (burning of rice husk). These two ULBs failed to make special arrangements to collect the ash waste from the generators and the ash waste was being mixed with MSW, ultimately, reaching the landfill site, without segregation **(Exhibit 6.5**).

Though DPR of CMC, Shidlaghatta suggested an economical way of disposal by channelising the ash waste to cement/brick industry, no steps were taken to implement the same. The DPR of TP, Sringeri did not suggest effective and economical way of ash disposal. Thus, failure to enforce segregation resulted in letting the ash waste mix with MSW. The ash waste generated, collected and dumped in landfill site in the two ULBs was 4,052 tonnes during the period 2012-17.

The State Government stated (May 2018) that steps were being taken in SWM DPRs to ensure that different types of waste including cut *beedi* leaves would not mix up with other wastes.

6.2.5 Personal protection equipment

MSWM Manuals, 2000 and 2016 prohibit manual handling of waste. If manual handling is unavoidable due to constraints, it should be carried out under proper precaution with due care for safety of workers. As per clause 15 (zd) of SWM Rules, 2016, local bodies shall ensure that the operator of a facility provides personal protection equipment including uniform, fluorescent jacket, hand gloves, raincoats, appropriate foot wear and masks to all workers handling solid waste and the same are used by workforce.

We observed during JPV in 30 test-checked ULBs (other than new upgraded ULBs) that majority of the work force involved in manual handling of waste were not using protective equipment particularly gloves and boots though they were provided with such equipment by the ULBs/contractors **(Exhibit 6.6)**. Non-utilisation of protective equipment is risky and may lead to serious health hazards especially in view of non-segregation of waste. ULBs need to analyse the reasons for non-utilisation of protective equipment by the work force and take steps to ensure utilisation.

The State Government stated (May 2018) that steps to educate the workers regarding significance of protection equipment would be taken up continuously.

Recommendation 12: ULBs should ensure that the informal system co-exists and supplements the formal system of waste collection, treatment and disposal and larger percentage of MSW generated is collected. ULBs should also ensure that workers involved in handling waste follow occupational health and safety protocols by wearing safety gear and other protective equipment.

Recommendation 13: The State Government may issue suitable instructions to enable ULBs to manage occupational waste such as beedi leaves, wood ash, etc., effectively and efficiently.

Exhibit 6.1: Unsegregated waste being handed over (Paragraph 6.1.1.1)

HDMC (28.4.2017)

CMC, Bagalkote (29.8.2017)

TMC, Humnabad (4.8.2017)

Exhibit 6.2: Dumping of mixed waste on windrow platform (Paragraph 6.1.3)

CC, Tumakuru (21.3.2017)

Exhibit 6.3: Status of waste collection (Paragraph 6.2.2.1)

TMC, Humnabad (3.8.2017)

Exhibit 6.4: Cut *beedi* leaf waste (Paragraph 6.2.4.1)

HDMC (5.5.2017)

CMC, Sira (17.6.2017)

Exhibit 6.5: Ash waste (Paragraph 6.2.4.2)

CMC, Shidlaghatta (8.6.2017)

TP, Sringeri (5.7.2017)

Exhibit 6.6: Handling of waste without protective equipment (Paragraph 6.2.5)

TMC, Maddur (5.6.2017)

CC, Ballari (4.8.2017)

CMC, Shidlaghatta (7.6.2017)

6.3 Transportation

Transportation plays a vital role in SWM services. Depending on the local conditions and location of landfill site, ULBs use different types of vehicles such as pushcarts, auto tippers, tractors, tipper trucks and compactors for collection and transportation of waste.

6.3.1 Shortage of vehicles for door-to-door collection

The State policy, 2004 envisaged use of auto tippers for door-to-door collection of MSW. In accordance with the normative standards prescribed under the policy for use of auto tippers for door-to-door waste collection, one auto tipper is required for 1,000 households. The status of availability of auto tippers in the test-checked ULBs as of March 2017 is indicated in **Table 6.4**.

Table 6.4: Statement showing the status of auto tippers

Category of ULB[29]	No. of auto tippers required as per normative standards	No. of auto tippers available	Shortage	Percentage of shortage
CMC	249	94	155	62
TMC	86	51	35	41
TP	29	11	18	62
Total	**364**	**156**	**208**	**57**

Source: Information furnished by test-checked ULBs

It is seen from the table that there was acute shortage of auto tippers despite availability of funds. The impact of shortage of collection vehicles in few test-checked ULBs is detailed below:

- In CMC, Hosapete, only 14 out of 35 wards were covered due to non-availability of sufficient number of vehicles;
- TMC, Ugar Khurd had one mini truck that was used for collection of waste in five wards on alternate days; and
- TP, Kudligi had only one tipper that was used to cover 8 out of 20 wards.

Therefore, shortage of vehicles up to 62 *per cent* led to serious inefficiency and irregularity in collection and transportation of MSW.

The State Government stated (May 2018) that integrated SWM plan was being prepared to include/procure vehicles required to achieve 100 *per cent* door-to-door collection. The reply indicates lack of commitment towards this activity of SWM despite Rules being in force for last 17 years. Further, in the absence of 100 *per cent* door-to-door collection, unscientific dumping of waste is bound to continue.

6.3.2 Use of vehicles without partition/open vehicles for transportation of Municipal Solid Waste

Source segregation is successful only when the segregated streams are not mixed at any stage of transportation while being taken to the respective processing or disposal facility directly or through a transfer station. Hence, segregated transportation of solid waste from source to destination is essential. Further, Section 7.7.4 of Manual on MSWM, 2000 and Section 2.3.2 of

[29] In all the test-checked CCs, the door-to-door collection activity was outsourced.

Manual, 2016 stipulate that vehicles used for transportation of waste should be covered so that waste is not visible to public and that they should have the facility for preventing spillage of waste. For this purpose, MSW vehicles need to be covered and provided with two separate containers or a single container with an effective partition.

We observed during JPV that majority of the vehicles used for door-to-door collection did not have partition to collect the segregated waste, if any. In four[30] ULBs, though the new vehicles procured had partitions for collection of wet and dry waste, the waste collectors were depositing both wet and dry waste in both the sections thereby defeating the purpose of segregation of waste (**Exhibit 6.7)**. The JPV also revealed that the test-checked ULBs were using open vehicles for transportation (**Exhibit 6.8)**, leading to scattering of waste, which caused littering and could also be a health hazard. KSPCB confirmed (December 2017) that open vehicles were used by ULBs for transportation of MSW.

HDMC, CMC, Bidar and TP, Kudligi purchased new vehicles with a provision of slider opening for depositing waste (**Exhibit 6.9)**. These vehicles were more appropriate as they prevented visibility of waste during transportation.

Thus, even after 18 years of MSW Rules, 2000 coming into force, ULBs have failed to comply with minimal requirements of hygiene such as covered vehicles and vehicles with partition. This also indicates failure of IEC/enforcement of training given to waste collectors.

The State Government stated (May 2018) that ULBs would procure vehicles with partition to ensure non-mixing of wet and dry waste and that ULBs have been instructed to use covered vehicles for transportation of waste.

6.3.3 Use of transportation vehicles without authorisation

Government of Karnataka directed (January 2004) that transportation vehicles used for MSW should have to be registered with KSPCB within 30 days and the same has been reiterated by KSPCB. Further, as per Motor Vehicle Act, all public transport vehicles are required to obtain fitness certificate for use of the vehicle besides possession of a valid insurance for the vehicle.

Scrutiny of records in 35 ULBs showed that the vehicles used for transportation of MSW were deficient in:

(i) authorisation from KSPCB - all 463 vehicles (100 *per cent*). Thus, the vehicles were being used by ULBs unauthorisedly for SWM activities;

(ii) fitness certificate from Regional Transport Office - 255 out of 463 vehicles (55 *per cent*); and

(iii) valid insurance for the vehicles - 101 out of 463 vehicles (22 *per cent*). This indicates a general lapse of internal control on part of ULBs.

We further observed that 14 vehicles (13 vehicles in 2016 and one rapid action vehicle in 2013) purchased by CC, Ballari were not registered with RTO.

[30] HDMC; CMCs – Bagalkote and Hosapete; TP, Kudligi.

Similarly, in TMC, Humnabad, six vehicles purchased during the period 2009 to 2016 were not registered (August 2017) and in TP, Raibag, four auto tippers were not registered. Thus, ULBs were using the vehicles for SWM purposes without necessary registration for periods ranging up to nine years.

The above deficiencies highlight the absence of internal control mechanism within the department.

6.3.4 Monitoring of transportation vehicles

Transportation of MSW from source of generation to the authorised destination is important to ensure its proper disposal. MSWM Manual, 2016 stipulates that communication technologies such as global positioning system (GPS) are to be integrated as part of monitoring of SWM system. This also helps in improving the collection and transportation efficiency of the vehicles.

Out of 463 transportation vehicles, 139 vehicles were affixed with GPS devices in 10[31] test-checked ULBs. In 56 vehicles, in five ULBs (CC, Mangaluru, CMC, Bidar, CMC, Hosapete, CMC, Udupi and TMC, Maddur), the devices were functional and in the other five ULBs, GPS devices were not functional due to issues such as software problems, damages due to short circuit (CMC, Chintamani). In the absence of GPS, ULBs were deprived of an effective tracking mechanism.

Further, the test-checked ULBs, other than CC, Mangaluru, CC, Tumakuru and CMC, Sira did not have the facility of weighbridge and CC TV cameras resulting in absence of effective monitoring of transportation activity.

Illustration - Unauthorised dumping of waste in CMC, Nanjangud

The authorised landfill site was located at a distance of eight kilometres from Nanjangud city and the ULB stated that waste collected was being dumped in the authorised site. ULB neither fixed GPS in MSW transportation vehicles nor installed closed circuit television (CCTV) camera and weighbridge in the landfill site.

We observed that huge quantity of mixed waste including plastics, food waste, chicken waste, clothes, cut-hair was dumped in a vast area of 6 acres close to the bank of River Kabini (50 metres), which passes through Nanjangud city. This unauthorised dumpsite was located at a distance of one kilometre from the city. The above area, which was enroute to the landfill site, was found to be grazed by pigs and stray dogs and unbearable foul smell was emanating from the area (**Exhibit 6.10**).

The quantum of waste seen in the area only indicate dumping of waste in an unauthorised area. Regional Office, KSPCB, Mysuru (Rural) also communicated (2015) this observation to CMC, Nanjangud. The CMC, however, failed to take preventive measures by way of either installing GPS to each MSW transporting vehicle or installing CCTV camera in the landfill site, which could have prevented dumping of waste at unauthorised site besides ensuring proper monitoring of movement of MSW vehicles by ULB.

The State Government agreed (May 2018) to look into the matter.

[31] CCs - Mangaluru and Tumakuru; CMCs - Bagalkote, Bidar, Chintamani, Hosapete, Karwar, Sira and Udupi; TMC, Maddur.

6.3.5 Usage of compactor trucks for transportation of Municipal Solid Waste against State policy

The State policy, 2004 stipulates that compactors have a separate system for secondary collection and these vehicles are not recommended for towns with population of less than 20 lakh. The population of all ULBs in the State other than BBMP is less than 20 lakh and hence use of compactors for transportation was not permitted.

We observed that nine[32] test-checked ULBs were using 47 compactors for secondary collection and transportation of MSW to landfill. In six ULBs, the DC/DMA, responsible for monitoring the functioning of ULBs, approved the action plans for purchase of compactors. In CC, Mangaluru, the agency entrusted with the work of secondary transportation was using compactors. Thus, the approval, purchase and usage of compactors was against the State policy.

As the unsegregated MSW which include domestic hazardous waste is compressed in the compactors, chances of contamination of MSW by toxic wastes such as batteries, glass pieces, *etc*., is significant. Therefore, handling of such waste would not only be risky but quality of by-products would be adversely affected. The usage of compactors also goes against the principle of facilitating aerobic composting in windrow platforms as it compresses waste, whereas windrows are meant to aerate waste to enhance the speed of aerobic decomposition.

The State Government stated (May 2018) that the State Policy would be suitably amended.

Recommendation 14: The ULBs, in addition to increasing the number of vehicles, should also ensure that the vehicles already procured comply with the statutory requirements of registration, obtaining authorisation, insurance, fitness certificate, etc. The vehicles procured should be suitably designed to collect and transport segregated waste efficiently.

[32] CCs – Ballari, HDMC, Mangaluru and Tumakuru; CMCs - Bidar, Hosapete and Udupi; TMCs – Hiriyur and Maddur.

Exhibit 6.7: Transportation of unsegregated waste (Paragraph 6.3.2)

CMC, Bagalkote (29.8.2017)

HDMC (28.4.2017)

CMC, Hosapete (11.5.2017)

Exhibit 6.8: Open vehicles used for transportation (Paragraph 6.3.2)

CMC, Shidlaghatta (8.6.2017)

CMC, Sira (17.6.2017)

TMC, Bhatkal (11.5.2017)

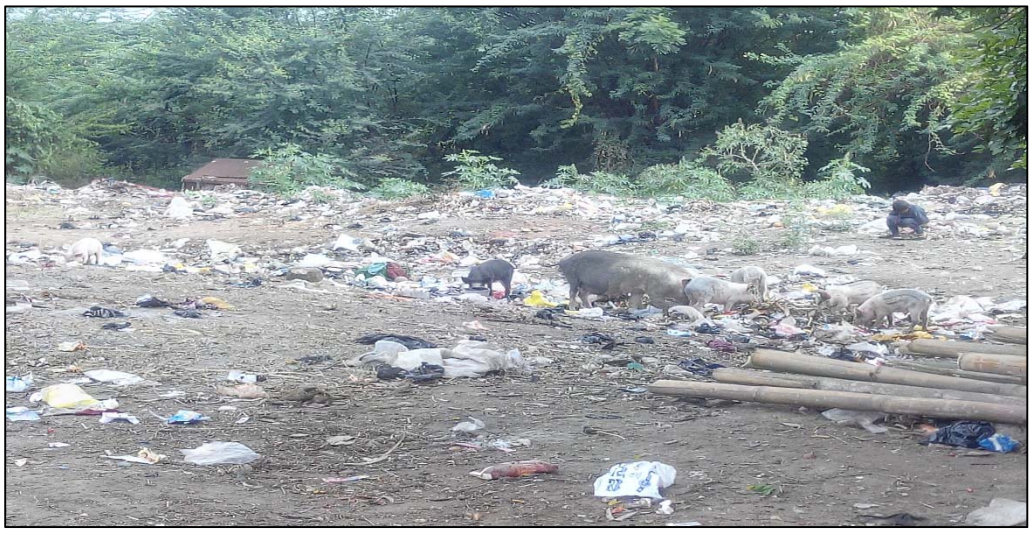
Exhibit 6.9: Vehicles with slider used for transportation (Paragraph 6.3.2)

HDMC (28.4.2017)

CMC, Bidar (8.8.2017)

Exhibit 6.10: Unauthorised dumping of waste (Paragraph 6.3.4)

CMC, Nanjangud (11.5.2017)



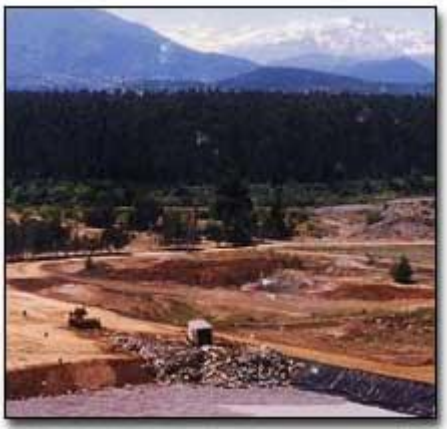
What is a Sanitary Landfill?

Sanitary landfills are sites where waste is isolated from the environment until it is safe.
It is considered when it has completely degraded biologically, chemically and physically. In high-income countries, the level of isolation achieved may be high. However, such an expensive high level of isolation may not be technically necessary to protect public health. Four basic conditions should be met before a site can be regarded as a sanitary landfill (see following.) The ways of doing this should be adapted to local conditions. The immediate goal is to meet, to the best extent possible, the four stated basic sanitary landfill conditions, with a longer term goal to meet them eventually in full.

Small incremental improvements in landfill design and operation over several years are more likely to succeed than attempts to make a single, large leap in engineering expectations.
Large landfills will require more investment to improve standards than smaller sites. However, the unit cost of these improvements (measured per tone of waste land filled or per head of population served) will decrease with increasing site size. There are financial and other benefits to sites with long operating lifetimes (ten years or more). Large regional sites serving two or more cities could be economically beneficial, providing waste transport costs are not too high.

Basicrequirements
As a minimum, four basic conditions should be met by any site design and operation before it can be regarded as a sanitary landfill:

- Full or partial hydrogeological isolation: if a site cannot be located on land which naturally contains leachate security, additional lining materials should be brought to the site to reduce leakage from the base of the site (leachate) and help reduce contamination of groundwater and surrounding soil. If a liner - soil or synthetic - is provided without a system of leachate collection, all leachate will eventually reach the surrounding environment. Leachate collection and treatment must be stressed as a basic requirement.
- Formal engineering preparations: designs should be developed from local geological and hydrogeological investigations. A waste disposal plan and a final restoration plan should also be developed.
- Permanent control: trained staff should be based at the landfill to supervise site preparation and construction, the depositing of waste and the regular operation and maintenance.
- Planned waste emplacement and covering: waste should be spread in layers and compacted. A small working area which is covered daily helps make the waste less accessible to pests and vermin.



Incineration

Incineration is a waste treatment process that involves the combustion of substances contained in waste materials. Industrial plants for waste incineration are commonly referred to as **waste-to-energy** facilities. Incineration and other high-temperature waste treatment systems are described as "thermal treatment". Incineration of waste materials converts the waste into ash, flue gas and heat. The ash is mostly formed by the inorganic constituents of the waste and may take the form of solid lumps or particulates carried by the flue gas. The flue gases must be cleaned of gaseous and particulate pollutants before they are dispersed into the atmosphere. In some cases, the heat that is generated by incineration can be used to generate electric power.

Incineration with energy recovery is one of several waste-to-energy technologies such as gasification, pyrolysis and anaerobic digestion. While incineration and gasification technologies are similar in principle, the energy produced from incineration is high-temperature heat whereas combustible gas is often the main energy product from gasification. Incineration and gasification may also be implemented without energy and materials recovery.

In several countries, there are still concerns from experts and local communities about the environmental effect of incinerators (see arguments against incineration).

In some countries, incinerators built just a few decades ago often did not include a materials separation to remove hazardous, bulky or recyclable materials before combustion. These facilities tended to risk the health of the plant workers and the local environment due to inadequate levels of gas cleaning and combustion process control. Most of these facilities did not generate electricity.

Incinerators reduce the solid mass of the original waste by 80%–85% and the volume (already compressed somewhat in garbage trucks) by 95%–96%, depending on composition and degree of recovery of materials such as metals from the ash for recycling. This means that while incineration does not completely replace landfilling, it significantly reduces the necessary volume for disposal. Garbage trucks often reduce the volume of waste in a built-in compressor before delivery to the incinerator. Alternatively, at landfills, the volume of the uncompressed garbage can be reduced by approximately 70% by using a stationary steel compressor, albeit

with a significant energy cost. In many countries, simpler waste compaction is a common practice for compaction at landfills.

Incineration has particularly strong benefits for the treatment of certain waste types in niche areas such as clinical wastes and certain hazardous wastes where pathogens and toxins can be destroyed by high temperatures. Examples include chemical multi-product plants with diverse toxic or very toxic wastewater streams, which cannot be routed to a conventional wastewater treatment plant.

Waste combustion is particularly popular in countries such as Japan, Singapore and the Netherlands, where land is a scarce resource. Denmark and Sweden have been leaders by using the energy generated from incineration for more than a century, in localised combined heat and power facilities supporting district heating schemes. In 2005, waste incineration produced 4.8% of the electricity consumption and 13.7% of the total domestic heat consumption in Denmark.[4] A number of other European countries rely heavily on incineration for handling municipal waste, in particular Luxembourg, the Netherlands, Germany, and France

CHAPTER 4: ORGANIC MANURES

MANURE

The manures are organic in nature, plant or animal origin and contain organic mater in large proportion and plant nutrients in small quantities and used to improve soil productivity by correcting soil physical, chemical and biological properties.

FERTILIZERS

"Fertilizer may be defined as materials having definite chemical composition with a higher analytical value and capable of supplying plant nutrients in available forms."

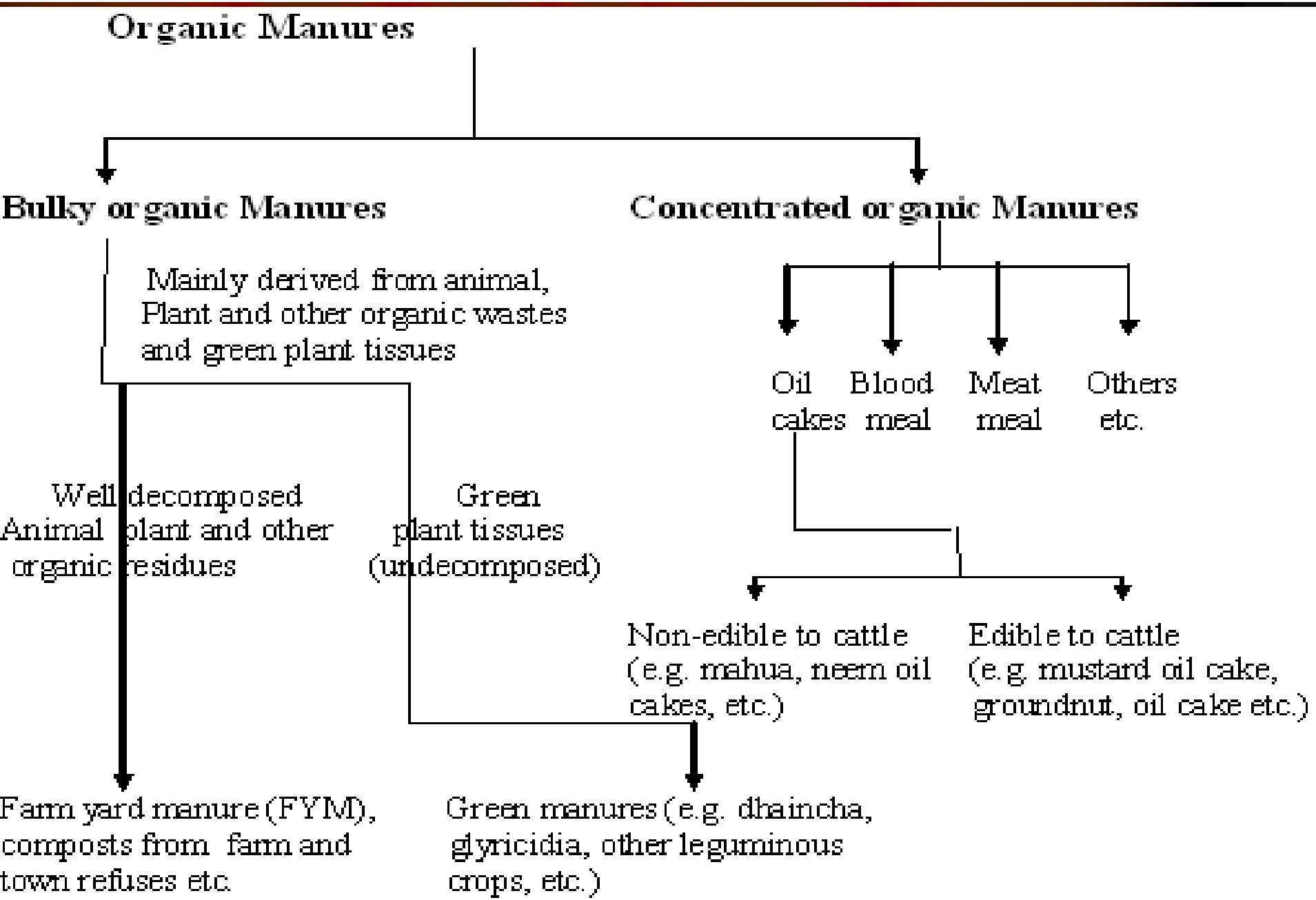
Difference between manures and fertilizers:

	Manure	Fertilizer
1.	Contains O.M. and hence improves soil physical properties	Do not contain O.M. and can not improve soil physical properties
2.	Improves soil fertility as well as productivity	Improves soil fertility
3.	Contains all plant nutrients but small in concentration	Contains one or more plant nutrients but in higher concentration
4.	Required in large quantity bulky and costly	Required in less quantity concentrated and cheaper
5.	Nutrients are slowly available upon decomposition	Nutrients are readily available.
6.	Long lasting effect on soil and crop	Very less residual effect
7.	No salt effect	Salt effect is high
8.	No adverse effect	Adverse effects are observed when not applied in time and in proper proportion.

Characteristics of manures:

- Manure required in large quantity.
- Bulky and costly.
- Nutrients are slowly available upon decomposition.
- It has long lasting effect on soil and crop.
- No salt and adverse effect.
- Manure is organic in nature so used it is used in organic farming.
- Manures contribute to the fertility of the soil by adding organic matter and nutrients, such as nitrogen, that are trapped by bacteria in the soil.
- Higher organisms then feed on the fungi and bacteria in a chain of life that comprises the soil food web.

Classification of organic manures



Importance of organic manures

1. Organic manure binds soil particles into structural units called aggregates. These aggregates help to maintain a loose, open, granular condition. Water infiltrates and percolates more readily. The granular condition of soil maintains favorable condition of aeration and permeability.
2. Water-holding capacity is increased by organic matter. Organic matter definitely increases the amount of available water in sandy and loamy soils. Further, the granular soil resulting from organic matter additions, supplies more water than sticky and impervious soil.
3. Surface run off and erosion are reduced by organic matter as there is good infiltration.
4. Organic matter or organic manure on the soil surface reduces losses of soil by wind erosion.

5. Surface mulching with coarse organic matter lowers soil temperatures in the summer and keeps soil warmer in winter.
6. The organic matter serves as a source of energy for the growth of soil microorganisms.
7. Organic matter serves as a reservoir of chemical elements that are essential for plant growth. Most of the soil nitrogen occurs in organic combination. Also a considerable quantity of phosphorus and sulphur exist in organic forms upon decomposition, organic matter supplies the nutrients needed by growing plants, as well as many hormones and antibiotics.
8. Fresh organic matter has a special function in making soil phosphorus more readily available in acid soils.
9. Organic acids released from decomposing organic matter help to reduce alkalinity in soils.

10. Fresh organic matter supplies food for such soil life as earthworms, ants and rodents. These macro-organisms improve drainage and aeration. Earthworms can flourish only in soils that are well provided with organic matter.
11. Organic matter on decomposition produces organic acids and carbon dioxide which help to dissolve minerals such as potassium and make them more available to growing plants.
12. Humus (highly decomposed organic matter) provides a storehouse for the exchangeable and available cations – potassium, calcium and magnesium. Ammonium fertilizers are also prevented from leaching because humus holds ammonium in an exchangeable and available form.
13. It acts as a buffering agent. Buffering checks rapid chemical changes in pH and in soil reaction.

Bulky Organic Manures:

Bulky organic manures include farm yard manure (FYM) or farm manure, farm compost, town compost, night soil, sludge, green manures and other bulky sources of organic matter.

All these manures are bulky in nature and supply

(i) plant nutrients in small quantities and

(ii) organic matter in large quantities.

Farm Yard Manure (FYM):

It refers to the decomposed mixture of dung and urine of farm animals along with litter (bedding material) and left over material from roughages or fodder fed to the cattle.

On an average well rotted FYM contains 0.5% N, 0.2% P_2O_5 and 0.5% K_2O.

Average percentage of N, $P_2 0_5$ and K_2O in the fresh excreta of farm animals :

Excreta of		N (%)	P_2O_5 (%)	K_2O (%)
Cows and bullocks	Dung	0.40	0.20	0.10
	Urine	1.00	Traces	1.35
Sheep and goat	Dung	0.75	0.50	0.45
	Urine	1.35	0.05	2.10
Buffalo	Dung	0.26	0.18	0.17
	Urine	0.62	Traces	1.61
Poultry	-	1.46	1.17	0.62

- Poultry manure is the richest of all
- Urine of all animals contains more percentage of N and K_2O compared to the dung portion.

Factors Affecting Nutritional Build up of FYM:

The following factors affect the composition of FYM:

1. **Age of animal**
2. **Feed**
3. **Nature of Litter Used**
4. **Ageing of Manure**
5. **Manner of Making and Storage**

Losses during handling and storage of FYM:

A. Losses during handling:

FYM consists of two original components the solid or dung and liquid or urine. Both the components contain N, P_2O_5 and K_2O the distribution of these nutrients in the dung and urine is shown in below:

Approximately half of N and K_2O is in the dung and the other half in urine. By contrast, nearly all of the P_2O_5 (96%) is in the solid portion.

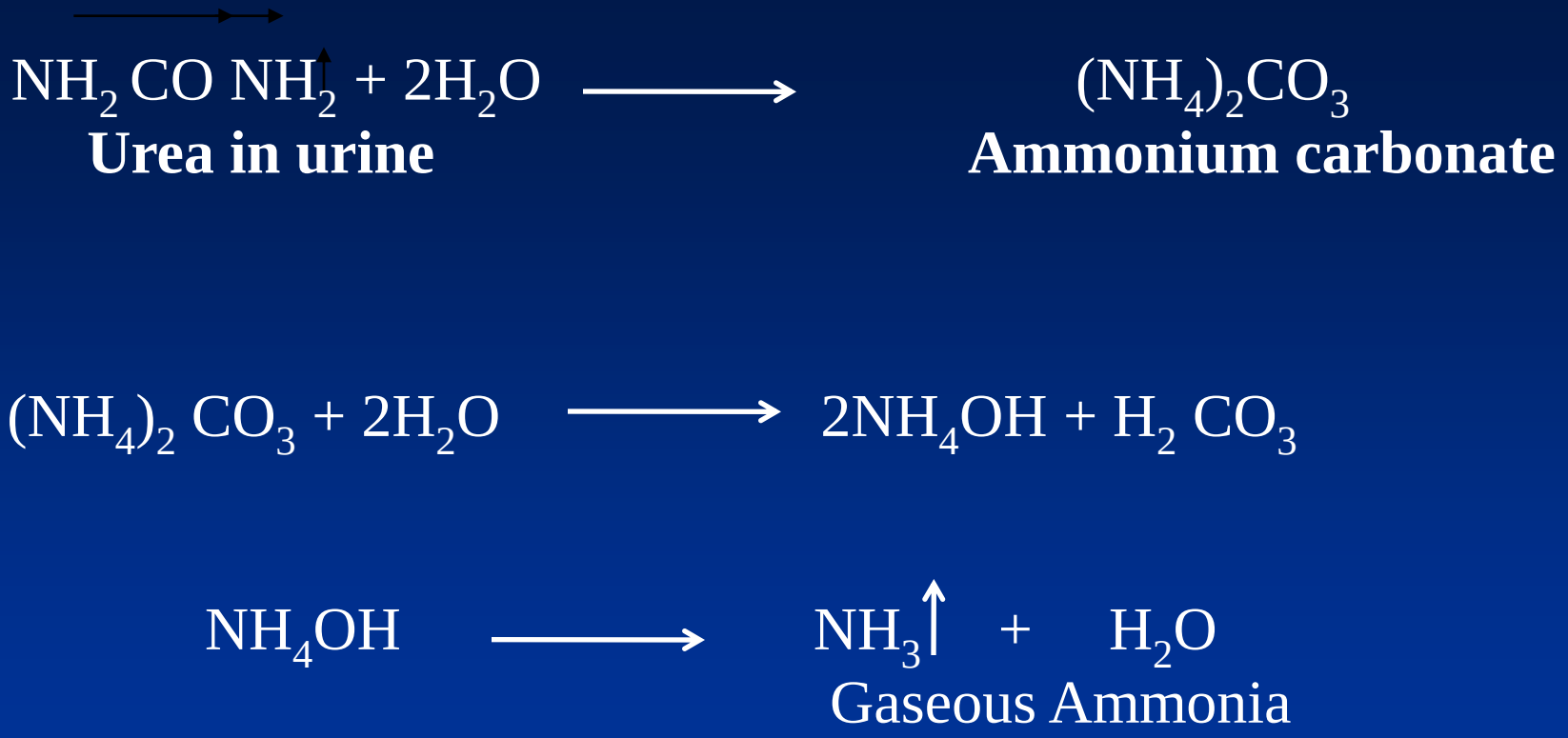
To conserve N, P_2O_5 and K_2O, it is most essential that both the parts of cattle manure are properly handled and stored.

i) Loss of liquid portion or urine

Under Indian conditions the floor of the cattle shed is usually un-cemented or Kachha. As such the urine passed by animals during night gets soaked into the Kachha floor.

When the animals, particularly bullocks, are kept in the fields during the summer season, urine gets soaked into soil. But during remaining period cattle are kept in a covered shed and therefore the Kachha floor soaks the urine every day.

Large quantities of nitrogen are thus lost through the formation of gaseous NH_3. The following reactions take place:



- The smell of NH_3 in the cattle shed clearly indicates the loss of N.
- No special efforts are made in India to collect the liquid portion of the manure.

ii) Loss of solid portion or dung

It is often said that 2/3 of the manure is either utilized for making cakes or is lost during grazing, the remaining manure is applied to the soil after collecting in heaps.

- Firstly, the most serious loss of dung is through cakes for burning or for use as fuel-
- Secondly, when milch animals go out for grazing, no efforts are made to collect the dung dropped by them, nor is this practicable, unless all milch animals are allowed to graze only in enclosed small size pastures.

B. Loss during storage:

Mostly, cattle dung and waste from fodder are collected daily in the morning by the cultivators and put in manure heaps in an open space outside the village. The manure remains exposed to the sun and rain. During such type of storage, nutrients are lost in the following ways:

i) By leaching:

Losses by leaching will vary with the intensity of rainfall and the slope of land on which manure is heaped. About half of portion of N and P_2O_5 of FYM and nearly 90% of K are water soluble. These water soluble nutrients are liable to get washed off by rain water.

ii) By Volatilization:

During storage considerable amount of NH_3 is produced in the manure heap from the decomposition of urea and other nitrogenous compounds of the urine and the much slower decomposition of the nitrogenous organic compounds of the dung. As the rotting proceeds, more and more quantity of ammonia is formed. This NH_3 combines with carbonic acid to form ammonium carbonate and bicarbonate. These ammonium compounds are unstable and gaseous NH_3 may be liberated as indicated below :

Improved Methods of Handling FYM:

It is practically impossible to check completely the losses of plant nutrients and organic matter during handing and storage of FYM.

However, improved methods could be adopted to reduce such losses considerably.

Among these methods are described here under:

- Trench method of preparing FYM
- Use of gobar gas-compost plant
- Proper field management of FYM
- Use of chemical preservatives

i) Trench method of preparing FYM :

This method has been recommended by Dr. C. N. Acharya. The manure preparation should be carried out in trenches, having size of

20 to 25 ft. long,

5 to 6 ft. broad and

3 to 3.5 ft. deep.

Cattle shed and portions of litter mixed with earth if available. When trench is completely filled up, say in about three months time.

ii) Use of gobar gas compost plant:

Methane gas is generated due to anaerobic fermentation of the most common organic materials such as cattle dung, grass, vegetable waste and human excreta. Gobar gas and manure both are useful on farms as well as in homes. A few advantages of this method are give below:

1) The methane gas generated can be used for heating, lighting and motive power.
2) The methane gas can be used for running oil engines and generators
3) The manure which comes out from the plant after decomposition is quite rich in nutrients. N -1.5%, P_2O_5- 0.5%, K_2O- 2.0%
4) Gobar gas manure is extremely cheap and is made by locally available materials.

iii) Proper field management of FYM:

Under field conditions, most of the cultivators unload FYM in small piles in the field before spreading. The manure is left in piles for a month or more before it is spread. Plant nutrients are lost through heating and drying.

To derive maximum benefit from FYM, it is most essential that it should not be kept in small piles in the field before spreading, but it should be spread evenly and mixed with the soil immediately.

iv) Use of Chemical Preservatives:

Chemical preservatives are added to the FYM to decrease N losses. To be most effective, the preservatives are applied in the cattle yard to permit direct contact with the liquid portion of excreta or urine. This has to be done because the **loss of N from urine starts immediately**.The commonly used chemical preservatives are **I) Gypsum and ii) Super phosphate.**

The value of gypsum in preserving the N of manure has been known and it has been used for many years in foreign countries. The reaction of gypsum with ammonium carbonate (intermediate product from decomposition of urea present in urine) is :

$$(NH_4)_2 CO_3 + CaSO_4 \longrightarrow CaCO_3 + (NH_4)_2 SO_4$$

As long as the manure is moist, no loss of NH_3 will occur, but if the manure becomes dry, the chemical reaction is reversed and the loss of NH_3 may occur. As such, under Indian conditions, use of gypsum to decrease N losses, does not offer a practical solution.

Superphosphate has been extensively used as a manure preservative:

$$2CaSO_4 + Ca(H_2PO_4)_2 + 2(NH_4)_2 CO_3 \longrightarrow Ca_3(PO_4)_2 + 2(NH_4)_2 SO_4 + 2H_2O + 2CO_2$$

In this reaction, tricalcium phosphate is formed which does not react with ammonium sulphate, when manure becomes dry. As such, there is no loss of NH_3.

Supply of plant nutrients through FYM:

On an average, FYM applied to various crops by the cultivators contains the following nutrients:

% N : 0.5 % P_2O_5 : 0.2 % K_2O : 0.5

Based on this analysis, an average dressing of 10 tones of FYM supplies about

50 Kg N, 20 Kg P_2O_5 and 50 Kg K_2O

All of these quantities are not available to crops in the year of application, particularly N which is very slow acting.

When FYM is applied every year, the crop yield goes on increasing due to direct plus residual effect on every succeeding crop. The beneficial effect is also known as **cumulative effect**.

Compost:

- **Compost** is composed of organic materials derived from plant and animal matter that has been decomposed largely through aerobic decomposition.
- The process of **composting** is simple and practiced by individuals in their homes, farmers on their land, and industrially by industries and cities.
- Composting is largely a bio-chemical process in which microorganisms both aerobic and anaerobic decompose organic residue and lower the C : N ratio.
- The final product of composting is well rotted manure known as **compost**.

Rural compost: Compost from farm litters, weeds, straw, leaves, husk, crop stubble, bhusa or straw, litter from cattle shed, waste fodder, etc. is called rural compost.

Urban compost: Compost from town refuse, night soil and street dustbin refuse, etc is called urban compost.

Composition of town compost:

Nitrogen (%N)	Phosphorus (%P_2O_5)	Potassium (%K_2O)
1.4	1.0	1.4

Decomposition:

- The dung and litter have to be fermented or decomposed before they become fit for use. Hence, the material is usually stored in heaps or pits, where it is allowed to decompose. Under suitable conditions of water supply, air, temperature, food supply and reaction, the microorganisms decompose the material.
- The decomposition is partly aerobic and partly anaerobic.
- During decomposition the usual yellow or green colour of the litter is changed to brown and ultimately to dark brown or black colour; its structural form is converted into a colloidal, slimy more or less homogenous material, commonly known as humus.
- A well decomposed manure has a typical black colour and a loose friable condition. It does not show the presence of the original litter or dung.

Factors controlling process of decomposition:

1) Food supply to micro-organisms and C : N ratio:

The suitable ratio of carbonaceous to nitrogenous materials is 40, if it is wider than this, the decomposition takes place very slowly and when narrow it is quick. C:N ratio of the dung of farm animals varies from 20 to 25, urine 1 to 2, poultry manure 5-10, litters-cereals straw 50, and legume refuse 20.

2) Moisture:

About **60-70 per cent** moisture is considered to be the optimum requirement to start decomposition and with the advance in decomposition, it diminishes gradually being 30-40 per cent in the final product.

Excess of moisture prevents the temperature form rising high and retards decomposition, resulting in loss of a part of the soluble plant nutrients through leaching and drainage.

In the absence of sufficient moisture, microbial activity ceases and the decomposition practically comes to an end.

3) Areation:

Most of the microbial processes are oxidative and hence a free supply of oxygen is necessary.

Reasons for poor aeration in pit/heap

✓Excessive watering

✓Compaction

✓Use of large quantities of fine and green material as litters

✓High and big heaps or deep pits.

4) Temperature:

Under the optimum conditions of air, moisture and food supply, there is a rapid increase in the temperature in the manure heap or pit. The temperature usually rises to **50º – 60ºC and even to 70ºC**.

The high temperature destroys weed seeds, worms, pathogenic bacteria, etc; which prevents fly breeding and makes the manure safe from hygienic point of view.

Heap V/S Pit decomposition:

Heap	Pit
1. Aerobic	1. Anaerobic
2. Turning is required	2. No turning is required
3. Physical disintegration	3. Very little physical disintegration
4. Quick oxidation	4. Slow rate of decomposition
5. High temp. 60^{o} – $70^{o}C$. Kill weed seeds and pathogenic organisms	5. High temp. is not developed but weed seeds and MO destroyed due to toxic products of decomposition.
6. Loss of OM is about 50%	6. Loss is about 25%
7. If not properly protected, moisture loss is high. Watering is necessary	7. Moisture loss is minimized. No watering is necessary
8. If rainfall is high, leaching takes place	8. Protected form leaching but anaerobic condition occurs.

Vermicompostiong:

- Vermicompost is the product of composting utilizing various species of **worms**, usually red wigglers, white worms, and earthworms to create a heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and vermicast.
- Vermicast is also known as worm castings, worm humus or worm manure, is the end-product of the breakdown of organic matter by species of earthworm.
- The earthworm species (or **composting worms**) most often used are Red Wigglers (*Eisenia foetida* or *Eisenia andrei*), though European nightcrawlers (*Eisenia hortensis*) could also be used. Users refer to European night crawlers by a variety of other names, including *dendrobaenas*, *dendras*, and Belgian nightcrawlers. Containing water-soluble nutrients, vermicompost is a nutrient-rich organic fertilizer and soil conditioner.

Vermiculture means artificial rearing or cultivation of worms (Earthworms)

Vermicompost is the excreta of earthworm, which is rich in humus. Earthworms eat cow dung or farm yard manure along with other farm wastes and pass it through their body and in the process convert it into vermicompost.

Method of preparation of Vermicompost Large/community Scale

A thatched roof shed preferably open from all sides with unpaved (katcha) floor is erected in East-West direction length wise to protect the site from direct sunlight.

A shed area of 12'X12' is sufficient to accommodate three vermibeds of 10'X3' each having 1' space in between for treatment of 9-12 quintals of waste in a cycle of 40-45 days.

The length of shed can be increased/decreased depending upon the quantity of waste to be treated and availability of space.

The height of thatched roof is kept at 8 feet from the centre and 6 feet from the sides. The base of the site is raised at least 6 inches above ground to protect it from flooding during the rains. The vermibeds are laid over the raised ground as per the procedure given below.

The site marked for **vermibeds** on the raised ground is watered and a 4”-6” layer of any slowly biodegradable agricultural residue such as dried leaves/straw/sugarcane trash etc. is laid over it after soaking with water. This is followed by 1” layer of vermicompost or farm yard manure.

Earthworms are released on each vermibed at the following rates :

For treatment of cowdung/agriwaste : 1.0 kg. per vermibed
For treatment of household garbage : 1.5 kg. per vermibed

Multiplication of worms in large scale:

Prepare a mixture of cow dung and dried leaves in 1:1 proportion.

Release earthworm @ 50 numbers/10 kg. of mixture and mix dried grass/leaves or husk and keep it in shade.

Sprinkle water over it time to time to maintain moisture level.

By this process, earthworms multiply 300 times within one to two months.

These earthworms can be used to prepare vermicompost.

Advantages of Vermicomposting:

- Vermicompost is an ecofriendly natural fertilizer prepared from biodegradable organic wastes and is free from chemical inputs.
- It does not have any adverse effect on soil, plant and environment.
- It improves soil aeration, texture and tilth thereby reducing soil compaction.
- It improves water retention capacity of soil because of its high organic matter content.
- It promotes better root growth and nutrient absorption.
- It improves nutrient status of soil-both macro-nutrients and micro-nutrients.

Precautions during vermicomposting:

- Vermicompost pit should be protected from direct sun light.
- To maintain moisture level, spray water on the pit as an when required.
- Protect the worms from ant, rat and bird

Nutrient Profile of Vermicompost and Farm Yard Manure:

Nutrient	Vermicompost	Farm Yard Manure
N (%)	1.6	0.5
P (%)	0.7	0.2
K (%)	0.8	0.5
Ca (%)	0.5	0.9
Mg (%)	0.2	0.2
Fe (ppm)	175.0	146.5
Mn (ppm)	96.5	69.0
Zn (ppm)	24.5	14.5
Cu (ppm)	5.0	2.8
C:N ratio	15.5	31.3

Night Soil:

- Night soil is human excrement i.e. solid and liquid.
- Night soil is richer in N, P_2O_5 and K_2O as compared to FYM or compost. On oven dry basis, it has an average chemical composition of:

N%	P_2O_5%	K_2O%
5.5	4.0	2.0

- In India it is applied to a limited extent directly to the soil.

Sewage and Sludge:

In the modern system of sanitation adopted in cities, water is used for the removal of human excreta and other wastes. This is called the **sewage system of sanitation**. In this system, there is a considerable dilution of the material in solution and in dispersion in fact, water is the main constituent of sewage, amounting often to 99.0%.

In general sewage has two components, namely

- Solid portion, technically known as sludge and
- Liquid portion, commonly known as sewage water.

Both the components are used in increasing crop production as they contain plant nutrients.

Green Manuring:

Practice of incorporating undecomposed green plant tissues into the soil for the purpose of improving physical structure as well as fertility of the soil.

In agriculture, a **green manure** is a type of cover crop grown primarily to add nutrients and organic matter to the soil.

Typically, a green manure crop is grown for a specific period, and then plowed under and incorporated into the soil.

Green manures usually perform multiple functions that include soil improvement and soil protection:

Types of green manuring :

Broadly two types of green manuring can be differentiated.

i. Green manuring *in situ* and
ii. Green leaf manuring

i) Green manuring in situ:

In this system green manure crops are grown and buried in the same field, either as a pure crop or as intercrop with the main crop.

The most common green manure crops grown under this system are **Sannhemp, dhaincha and guar**.

ii)Green leaf manuring :

Green leaf manuring refers to turning into the soil green leaves and tender green twigs collected from shrubs and trees grown on bunds, waste lands and nearby forest areas.

The common shrubs and trees used are **Glyricidia, Sesbania (wild dhaincha), Karanj,** etc.

The former system is followed in northern India, while the latter is common in eastern and central India.

Advantages of Green Manuring:

1. It adds organic matter to the soil. This stimulates the activity of soil micro-organisms.
2. Green manure crops return to the upper top soil, plant nutrients taken up by the crop from deeper layers.
3. It improves the structure of the soil.
4. It facilitates the penetration of rain water thus decreasing run off and erosion.
5. The green manure crops hold plant nutrients that would otherwise be lost by leaching.
6. When leguminous plants, like sannhemp and dhaincha are used as green manure crops, they add nitrogen to the soil for the succeeding crop.
7. It increases the availability of certain plant nutrients like phosphorus, calcium, potassium, magnesium and iron.

Disadvantages of green manuring:

When the proper technique of green manuring is not followed or when weather conditions become unfavourable, the following disadvantages are likely to become evident.

1. Under rainfed conditions, it is feared that proper decomposition of the green manure crop and satisfactory germination of the succeeding crop may not take place, if sufficient rainfall is not received after burying the green manure crop.
2. Since green manuring for wheat means loss of kharif crop, the practice of green manuring may not be always economical.
3. In case the main advantage of green manuring is to be derived from addition of nitrogen, the **cost of growing green manure crops may be more than the cost of commercial nitrogenous fertilizers.**
4. An increase of diseases, insects and nematodes is possible.
5. A risk is involved in obtaining a satisfactory stand and growth of the green manure crops, if sufficient rainfall is not available.

Green manure crops:

Leguminous

1. Sannhemp
2. Dhaincha
3. Mung
4. Cowpea
5. Guar
6. Senji
7. Khesari
8. Berseem

Non-leguminous

1. Bhang
2. Jowar
3. Maize
4. Sunflower

Selection of Green manure crops *in situ*:

Certain green manure crops are suitable for certain parts of the country. Suitability and regional distribution of important green manure crops are given below:

Sannhemp: This is the most outstanding green manure crop. It is well suited to **almost all parts of the country**, provided that the area receives sufficient rainfall or has an assured irrigation. It is extensively used with sugarcane, potatoes, garden crops, second crop of paddy in South India and irrigated wheat in Northern India.

Dhaincha: It occupies the second place next to sannhemp for green manuring. It has the advantage of growing under **adverse conditions of drought, water-logging, salinity and acidity**. It is in wide use in Assam, West Bengal, Bihar and Chennai with sugarcane, Potatoes and paddy.

Guar: It is well suited in areas of low rainfall and poor fertility. It is the most common green manure crop in Rajasthan, North Gujarat and Punjab.


Thanks