3.1 DEFINATION OF WASTE

Defining waste is a contentious issue. In essence definition of waste is subjective. For legislation to be enforced there must be a clear definition of waste in order to identify what needs to be controlled and monitored. Waste can be defined as

“Any substance or object which the holder discards or intends to discard (Council Directive 75/442/EEC 1975)”

The ‘holder’ can either be the producer of waste or be in possession of waste [37]. Waste, however, is very subjective; one person may deem an item to be waste whilst another might see it as a resource [37][38]. The natural environment now acts as the source for resources and the sink for wastes [39]. Waste is something that doesn’t have any value [40] [41]. State that the current definition of waste used by the European Union (EU) lacks precision, and therefore each member state interprets it differently. This creates problems within the recycling industry due to trade barriers. [42] Proposes the definition:

“Either an output with (a negative market) no economic value from an industrial system or any substance or object that has been used for its intended purpose (or served its intended function) by the consumer and will not be reused”.

The environment act 1995 sets out a number of categories in which a number of different wastes are defined. This study is concerned with household waste. In the act, it is defined as:

“Household waste means waste from private domestic accommodation, caravans, residential homes, universities or schools or other educational establishment, hospital premises and nursing homes (Environmental Act 1995)”

There is no one definition of food waste. Using these definitions, for the purpose of this report municipal food waste is defined as:
“Waste material resulting from pre and post preparation of food, which is of a quality suitable for recycling via composting”

The Environmental Protection Act (EPA) 1990 defines waste as “any substance which constitutes scrap metal or an affluent or any unwanted substance arising from the application of a process or any substance which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled” [43] [44]. It is by-product which is having no value [45]. Solid waste is broadly comprised of many types like from houses, from industry, from residences etc. [46].

3.2 CLASSIFICATION OF WASTE

Following are schematic representation of waste types which includes all three forms i.e.e solid, liquid and gaseous.

![Figure 3.1: Structure for classifying waste](source: Classification of waste [47])
A report prepared by World Bank [48] lists eight major sectors that generate solid waste:

1. **Residential**: Includes waste generated in household units, such as food and fruit peels, rubbish, ashes etc.
2. **Industrial**: Has two components hazardous, which is toxic; corrosive; flammable; a strong sensitizer or irritant and may pose a substantial present or potential danger to human health or the environment when improperly processed, stored, transported, or disposed of or otherwise managed. Non-hazardous which includes inert and essentially insoluble industrial solid waste, usually including, but not limited to, materials such as rock, brick, glass, dirt, and certain plastics and rubber, etc., that are not readily decomposable.
3. **Commercial**: Waste produced from various commercial establishments like by wholesale, retail or service establishments, such as restaurants, stores, markets, superstores, malls etc.
4. **Institutional**: Waste that originates in schools, hospitals, institutions and public buildings.
5. **Construction and demolition**: Waste building material and rubble resulting from construction, remodelling, repair, and demolition operations on houses, commercial buildings, pavements and other structures.
6. **Municipal services**: Sludge from a sewage treatment plant which has been digested and dewatered and does not require liquid handling equipment etc.
7. **Process**: Treatment plant wastes principally composed of residual sludge.
8. **Agricultural**: Spoiled food wastes, agricultural wastes, rubbish, hazardous wastes.

As per the manual of Municipal solid waste, waste can be classified on the basis of source, origin and type of waste. A comprehensive classification is described below [49]:

(i) **Domestic/Residential Waste**
(ii) **Municipal Waste**
(iii) **Commercial Waste**
(iv) **Institutional Waste**
(v) **Garbage**
(vi) **Rubbish**
(vii) **Ashes**
(viii) Bulky Wastes
(ix) Street Sweeping
(x) Dead Animals

Figure 3.2: Classification of waste adopted from MSW Manual

Source: Pictorial representation of classification of waste [65]
(xi) Construction and Demolition Wastes
(xii) Industrial Wastes
(xiii) Hazardous Wastes
(xiv) Sewage Wastes

3.3 WASTE HIERARCHY

This model was given by European Union (EU) strategy on waste [37][50]. The waste hierarchy provides order for the best environmental options which have least impact on environment, and supports sustainable waste management [51]. According to Waste not Want not [51] in their hierarchy (see Figure 3.3) they contended various methods like reuse, recycle to reduce waste. The shape of the waste hierarchy taking into account current treatment rate, such as recycling, composting, and landfill rate, seems to be the triangle shown in Figure 3.3.

![Figure 3.3: The Waste Hierarchy](image)

Source: Waste not, wants not [51]

Waste not Want not [51] has also more detailed versions of the hierarchy. However, Department of Environment Food and Rural Affairs (DEFRA) [52] provides the waste hierarchy below as a target for waste management (See Figure 3.4).
The purpose of the waste hierarchy is to give priority to waste prevention. Failing that it aims to promote the re-use and recovery of waste. Food waste collection and composting fit into the recycling stage of the waste hierarchy. Only when all other options have been considered, should waste be disposed of, usually in the form of landfill. The higher up the waste hierarchy a waste management strategy is, the more sustainable it is. The purpose of the waste hierarchy is to give priority to waste prevention. Failing that it aims to promote the re-use and recovery of waste. Collection of food waste and composting fits into the process of recycling. Only when all other options have been considered, should waste be disposed of, usually in the form of landfill. The higher up the waste hierarchy a waste management strategy is, the more sustainable it is.
3.3.1 WASTE PREVENTION

Waste prevention or reduction at source is viewed as the best option for waste management and can be achieved through cleaner technologies and processes by manufacturing products that are more durable. Tonglet[54] argued that the commercial and industrial sector have received better attention than the municipal sector especially householders and they further stated that it could be as a result of the emphasis being placed on recycling by waste management strategies. At the household level, waste aware shopping is vital as the [55][56].

3.3.2 REUSE

Reuse is the process when an item can be used over and over again for the same purpose. Reuse is defined as “any operation by which end of life products and equipment (such as electrical and electronic goods) and its components are used for the same purpose for which they are conceived” [57]. The reuse or materials have been known to provide social, economic and environmental benefits especially in the voluntary and community waste sector which pioneered the reuse of furniture and white goods [58].

3.3.3 RECYCLING AND COMPOSTING

Waste recycling and composting is very beneficial in terms of energy savings and reduction of pressure on natural resources and emissions from landfill [59]. In a study carried out byWrap [60] on the benefits of recycling in the UK at that time found out that recycling saved 10-15 million tonnes of CO\textsubscript{2} equivalent per year and in the transport sector, it is the equivalent of taking 3.5 million cars off UK roads thereby highlighting it environmental benefits.

Recycled materials needs a market for the end product and by generating a long term and stable economic market locally, this will help to reduce pressure on virgin materials, energy consumption and CO\textsubscript{2} emissions [59]. Composting the biodegradable waste stream especially food and garden has been viewed as having a great potential in diverting biodegradable waste from landfill and has been encouraged so as to derive compost which is a form of fertilizer and soil conditioner. The EU has taken steps to promote this new form of recycling and have
worked on standards which have been put in the revised framework directive defining standards in quality to boast the market for compost products [61].

3.3.4 ENERGY RECOVERY

Recovery which is usually a process of energy from waste (EFW\(^2\)) or burning of landfill gas is also an option in the waste hierarchy and the energy recovered can be used for heating and electricity generation and producing energy with combined heat and power (CHP) as this enables maximum recovery of energy. Other energy from waste technologies include anaerobic digestion which produces methane that can be burnt to generate electricity, direct combustion\(^3\) or incineration, secondary derived fuel (SDF) which is output from mechanical and biological treatment, pyrolysis\(^4\), gasification\(^5\) and plasma arc heating [62].

3.3.5 DISPOSAL

Final disposal is the last hierarchy of model, which is the least preferred method because of the negatively environmental impacts such as release of methane and carbon dioxide from the breakdown of materials contributing to climate change, production of leachate which is a source of groundwater pollution and a loss of natural resources associated with landfill\(^6\)[63]. With the landfill directive, volume of waste landfill has reduced. Further because landfill cannot be totally avoided as a result of the production of some hazardous and clinical waste which cannot be reused, recycled or incinerated, stringent operation laws have been imposed to ensure then humans and the environment is not endangered.

3.4 WASTE POLICIES AND LAWS IN INDIA

In India there are some plocies on waste management along with historic judgements related to waste cases [64].

3.4.1 POLICIES AND RULES

Policy is the path along which the government is thinking, and reflects its priorities. Indian Policy clearly recognizes the informal recycling sector through as follows [64]:

25
The National Action Plan for Climate Change, 2009: The National Action Plan for Climate Change, 2009, which aims at finding ways to handle climate change within India. It states, “While the informal sector is the backbone of India’s highly successful recycling system, unfortunately a number of municipal regulations impede the operation of the recyclers, owing to which they remain at a tiny scale without access to finance or improved recycling technologies” This is part of the Mission on Urban Sustainability.

The National Environment Policy, 2006: The National Environment Policy, 2006, which states “Give legal recognition to, and strengthen the informal sector systems of collection and recycling of various materials. In particular enhance their access to institutional finance and relevant technologies” (Section 5.2.8, point (e), Pg. 36).

3.4.2 REPORTS

Indian history has got some great reports related to implementation of waste effective management [64]:

The CAG Audit on Municipal Solid Waste in India (December 2008): The CAG Audit on Municipal Solid Waste in India (December 2008) also recommends (Chapter 3, Section 3.5) that “MOEF/states should consider providing legal recognition to rag pickers so that recycling work becomes more organized and also ensure better working conditions for them.”

The Supreme Court recommendations report in 1999: this reports relate to upgrading rag pickers.

3.4.3 NATIONAL COMMITTEES

There have been several committees in the last 16 years that have recognized the importance of including the informal waste recycling sector into mainstream activities [64].

AsimBurman Committee, 1999, Bajaj Committee
3.4.4 REGIONAL LEGISLATION

There have been many instances of progressive legislation from different states [64] like Madhya Pradesh, Ahmedabad and Maharashtra.

3.4.5 THE MUNICIPAL SOLID WASTE (MANAGEMENT AND HANDLING) RULES, 2000 MANUAL

This manual directs storage, waste, segregation and transportation of all municipal wastes. [65]. The over-all responsibilities for the enforcement of the provisions of these rules in metropolitan cities have been given to the Secretary-in-charge of the Department of Urban Development of the State/Union Territory. Further, the District Magistrate/Deputy Commissioner of the concerned district shall have the overall responsibility for the enforcement of these rules within their area of jurisdiction.

1. Collection on municipal solid waste
2. Segregation of municipal solid wastes
3. Storage of municipal solid wastes
4. Transportation of municipal solid wastes
5. Processing of municipal solid waste (Biodegradable)
6. Disposal of municipal solid wastes (Non-biodegradable)

3.5 WASTE PROCESSING TECHNIQUES/ TREATMENT

Processing techniques are used in Solid Waste Management system to improve the efficiency of Solid waste disposal system, to recover resources (usable materials), to recover conversion products and energy [66].

3.5.1 RECYCLING

It is process of converting waste material into other useful matter that can be used further [66]. There are three main methods that can be used to recover recyclable materials from municipal solid waste management.
1. Collection of source-separated recyclable materials by either the generator or the collector, with and without subsequent processing.

2. Commingled recyclables collection with processing at centralized materials recovery facilities (MRFs).

3. Mixed Municipal Solid Waste (MSW) collection with processing for recovery of the recyclable materials from the waste stream at mixed-waste processing or front-end processing facilities.

Collection of source-separated materials

The separation of recyclable materials into individual components, either by the generator or at curb side by the collector, is known as source separation. The separated materials can be collected individually in single-compartment trucks, or more commonly, they are collected at the same time in a specially designed multi-compartment recycling vehicle. The segregated components are then transported to a consolidation site for further processing and subsequent shipment to markets.

Collection of commingled recyclable materials

Recyclable materials set out at curb side for commingled collection. The generator only needs to separate recyclable materials from non-recyclables. The recyclable materials are transported to an MRF\(^9\) (Material recovery facilities) where they are segregated into each recyclable component. Processing operations at MRFs can vary from facilities with relatively mechanization, depending primarily on the sorting of waste materials, to highly mechanized automated sorting processes.

Collection of mixed MSW\(^{10}\)

The third approach to recycling; there is no segregation of recyclables from other waste materials. Mixed wastes (including recyclables) are set out at curb side, as would be done for land filling or incineration. The mixed waste then transported to a central processing facility, which employs a high degree of mechanization, including separation equipment such
asshredders, trammels, magnets and air classifiers to recover the recyclables. Mixed waste processing of recyclables is also known as front-end processing or refuse-derived fuel (RDF) processing of MSW.

### 3.5.2 COMPOSTING

Composting is a controlled process by which, Biodegradable wastes (organic composition) gets decomposed through micro-organisms. Therefore only bio-degradable wastes can be composted, like vegetable wastes, green wastes, agricultural leaves etc. Decomposition of the organic solid waste may be done either aerobically or an aerobically. Aerobic includes even vermicomposting where earthworms are used to digest the wastes. Composting can be carried out at the local level, though compost pits and heaps and at the central level through composting plants. Compost is humus like materials that results from microbial action and degradable fraction of solid waste. The process of compositing can be either aerobic or anaerobic.

### 3.5.3 VERMICOMPOSTING

Vermicomposting is a process of degradation of organic matter by microbes and consumption of organic material by earthworms. Only selected species of earthworms like Eiseniafoetida, Eudriluseligeniae, Perionyx excavates, Lampitomaturi, etc., are suitable for vermicomposting process. These earthworm acts as crusher and aerator during the process. The microbe’s capacity associated and makes the final product odourless. Vermicompost can be used as good fertilizer. The concentration of macronutrients was increased after vermicomposting [67].

### 3.5.4 AEROBIC DIGESTION

Mainly aerobic processes are used to convert bio waste into compost. In these conditions, the bio waste is aerated during several weeks up to several months by forced suction or blowing, in order to remove moisture and heat and to create an optimal environment for the aerobic merophilic and thermophiles’ micro-organisms performing the biodegradation [68].
3.5.5 INCINERATION

Incineration is a technology where waste is burned in specially engineered machines. It is popularly linked primarily with hospital waste, because the use of incinerator is crucial need for the disposal of the pathological stream of Bio-medical wastes which includes body parts etc. Incineration is a process of controlled combustion for burning solid, liquid and gaseous combustible wastes to gases and residue containing non-combustible material. Heat can be recovered by incineration, which can be used for heating water and generating electricity [69]. Though incineration is not a complete method of disposal, its main advantage is that produces a residue that is substantially reduced in volume and may be relatively inert [70].

![Waste processing technique](image)

**Figure 3.5:** Waste processing techniques

*Source: Pictorial representation of waste processing techniques [65]*