Solid Waste: An Environmental Issue

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Introduction

Unwanted solid materials generated from human activities in residential industrial or commercial area which being no longer of value for the respective economic, physiological or technological process, are removed from it is called Solid Waste. Solid waste in a broader sense is understood as any household, industrial and agricultural materials that have been used up. It predominantly includes food wastes, yard wastes, containers and product packaging, and other miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources. It may be categorized in three ways. According to its: origin (domestic, industrial, commercial, construction or institutional), contents (organic material, glass, metal, plastic paper etc.), hazard potential (toxic, non-toxin, flammable, radioactive, infectious etc.).

India is rapidly shifting from agricultural-based nation to industrial and services-oriented country. About 31.2% population is now living in urban areas. Over 377 million urban people are living in 7,935 towns/cities. India is a vast country divided into 29 States and 7 Union Territories (UTs). There are three mega cities—Greater Mumbai, Delhi, and Kolkata—having population of more than 10 million, 53 cities have more than 1 million population, and 415 cities having population 100,000 or more (Census, 2011a). The cities having population more than 10 million are basically State capitals, Union Territories, and other business/industrial-oriented centers. India has different geographic and climatic regions (tropical wet, tropical dry, subtropical humid climate, and mountain climate) and four seasons (winter, summer, rainy, and autumn) and accordingly residents living in these zones have different consumption and waste generation pattern.(Joshi, 2016).

Per capita waste generation rate:

Population size	Waste generation* (kg/capita/day)	Waste generation** (kg/capita/day)
>2000000	0.43	0.55
1000000–2000000	0.39	0.46
500000–1000000	0.38	0.48
100000–500000	0.39	0.46
<100000	0.36	-

Source: CPCB report (2000) and Calculated from R.K. Annepu (2012)

Sources and Generation of Solid Waste

Every day, tonnes of solid waste are disposed at various landfill sites. This waste comes from homes, shops, industries, hospitals and various agricultural related activities. The combined effects of population explosion and changing modern living standard have had a cumulative effect in the generation of a large amount of various types of wastes. Solid waste can be classified into different types depending on their sources:

1. Municipal Solid waste;
2. Hazardous Waste;
3. Industrial Waste;
4. Agricultural Waste;
5. Biomedical Waste;

Municipal Solid waste:

Municipal solid waste is the wastes which are coming from household works to industrial works of a municipal area. Municipal solid waste (MSW) or urban solid waste is normally comprised of food wastes, rubbish, demolition and construction wastes, street sweepings, garden wastes, abandoned vehicles and appliances, and treatment plant residues. Quantity and composition of MSW vary greatly for different municipalities and time of the year. Factors influencing the characteristics of MSW are climate, social customs, per capita income, and degree of urbanization and industrialization (Singh et.al, 2014). As per estimates more than 55 million

tons of MSW is generated in India per year; the yearly increase is estimated to be about 5%. It is estimated that solid waste generated in small, medium and large cities and towns in India is about 0.1 kg, 0.3 – 0.4 kg and 0.5 kg per capita per day respectively. The estimated annual increase in per capita waste generation is about 1.33 % per year. In India, the biodegradable portion dominates the bulk of MSW. This is mainly due to food and yard waste. With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition has been changing.

S. No.	States	Municipal Solid Waste (TPD) 2000	Municipal Solid Waste (TPD) (2009–2011)	Collected (TPD) (2009–2011)	Treated (TPD) (2009–2011)	Growth (%)
1	Andhra Pradesh	4376	11500	10655	3656	163
2	Assam	285	1146	807	73	302
3	Delhi	4000	7384	6796	1927	85
4	Gujarat	NA	7379	6744	873	–
5	Karnataka	3278	6500	2100	2100	98
6	Kerala	1298	8338	1739	4	542
7	Madhya Pradesh	2684	4500	2700	975	68
8	Maharashtra	9099	19204	19204	2080	111
9	Manipur	40	113	93	3	182
10	Meghalaya	35	285	238	100	713
11	Orissa	655	2239	1837	33	242
12	Punjab	1266	2794	NA	Nil	121
13	Puducherry	69	380	NA	Nil	451
14	Rajasthan	1966	5037	NA	Nil	156
15	Tamil Nadu	5403	12504	11626	603	131
16	Tripura	33	360	246	40	991
17	Uttar Pradesh	5960	11585	10563	Nil	94
18	West Bengal	4621	12557	5054	607	172

Statistics of MSW generated in different states in India (CPCB 2000,2013)

The sources of solid wastes have been consistent, dependent on sectors and activities and these include the following .

(i) **Residential:** This refers to wastes from dwellings, apartments, etc., and consists of leftover food, vegetable peels, plastic, clothes, ashes, etc.

(ii) **Commercial**: This refers to wastes consisting of leftover food, glasses, metals, ashes, etc., generated from stores, restaurants, markets, hotels, motels, auto-repair shops, medical facilities, etc.

(iii) **Institutional**: This mainly consists of paper, plastic, glasses, etc., generated from educational, administrative and public buildings such as schools, colleges, offices, prisons, etc.

(iv) **Industrial**: This mainly consists of process wastes, ashes, demolition and construction wastes, hazardous wastes, etc., due to industrial activities.

(v) **Open areas:** this includes wastes from areas such as Streets, alleys, parks, vacant lots, playgrounds, beaches, highways, recreational areas, etc. (Tchobanoglous, et al., 1977)

Hazardous Waste:

The first few attempts to quantify hazardous waste generation in the country remain limited to indirect estimations. For instance, using the correlation between economic activity and hazardous waste generation established by the Organization for Economic Cooperation and Development (OECD), the reported generation of hazardous waste was about 0.3 million tonnes per annum in 1984. World Bank estimates place this at approximately 4 million tonnes annually for the year 1995. These scattered inventories were not very useful in designing hazardous waste strategies for the country since hazardous waste generation is very dynamic owing to the intense growth in industrial activities taking place. In order to generate an updated inventory for hazardous waste in the country, an exercise in different states of India was initiated by the CPCB (Central Pollution Control Board) in the year 1993. The present information on total hazardous waste generated from industries and facilities available for its disposal in Indian states has been collected by the MoEF through the respective SPCBs (state pollution control boards). The state-wise status of number of units generating hazardous waste as well as the quantity of waste generated till 24 March 2000, for recyclable, incinerable and disposable waste types. In total, at present, around 7.2 million tonnes of hazardous waste is generated in the country of which 1.4 million tonnes is recyclable, 0.1 million tonnes is incinerable and 5.2 million tonnes is destined for disposal on land (MoEF 2000). As per the information provided by the MoEF, there are 323 hazardous waste recycling units in India, and of these 303 recycling units use indigenous raw material while 20 depend on imported recyclable wastes. The

status of hazardous waste imported for recycling and recovery of mostly metallic constituents in country is presented. The major types of hazardous waste imported by the country include battery scrap, lead and zinc dross, ash, skimmings and residues and galvanised zinc.

The Environmental Protection Agency (EPA) has established two categories of hazardous wastes: characteristic and listed. A waste can be both a characteristic hazardous waste and a listed hazardous waste. Each characteristic and each listing has a waste code associated with it. These waste codes should be used by the generator on hazardous waste manifests, land disposal restriction (LDR) forms and on any waste determination documents, such as those provided with the PDEQ Hazardous Waste Determinations and Documentation technical guidance document (PDEQ).

Characteristic Hazardous Waste A waste can exhibit the characteristics of:

- Ignitability (waste code D001);
- Corrosively (waste code D002);
- Reactivity (waste code D003); and/or
- Toxicity (waste codes D004 to D043).

The first three characteristics are fairly easy to determine: **Ignitable hazardous waste** has a flashpoint of less than 140 degrees Fahrenheit. **Corrosive hazardous waste** has a pH of 0 to 2 or 12.5 to 14. **Reactive hazardous waste** is waste that is normally unstable, reacts violently with water or corrosive materials, or is capable of detonation or explosion when exposed to heat or flame. There is no analytical test currently approved by the EPA to determine if a waste is reactive. The fourth characteristic **toxic hazardous waste** is more difficult to determine. EPA has set regulatory limits for 40 toxic compounds. To determine if a waste meets or exceeds these regulatory limits, a representative sample of the waste should be collected and submitted to an ADHS-certified laboratory. The laboratory should prepare the sample for analysis using the Toxicity Characteristic Leaching Procedure (TCLP) extraction method to analyze the sample, using EPA-approved test methods, for the contaminants.(Characteristic and Listed Hazardous Wastes: Technical Guidance)

Biomedical Waste

According to Biomedical Waste (Management and Handling) Rules, 1998 of India "Any waste which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals."

Medical centers including hospitals, clinics and places where diagnosis and treatment are conducted generate wastes that are highly hazardous and put people under risk of fatal diseases. Biomedical waste may be solid or liquid. Examples of infectious waste include discarded blood, sharps, unwanted microbiological cultures and stocks, identifiable body parts (including those as a result of amputation), other human or animal tissue, used bandages and dressings, discarded gloves, other medical supplies that may have been in contact with blood and body fluids, and laboratory waste that exhibits the characteristics described above. Waste sharps include potentially contaminated used (and unused discarded) needles, scalpels, lancets and other devices capable of penetrating skin.

While waste management has become a critical issue which has taken a central place in the national health policies of developed nations and is attracting considerable interest, in most developin6ig countries like Nigeria, the handling and treatment of municipal solid waste (MSW) or domestic waste have not received sufficient attention. (Yelebe et. al, 2012). Proper management of hospital waste is essential to maintain hygiene, aesthetics, cleanliness and control of environmental pollution. The hospital waste like body parts, organs, tissues, blood and body fluids along with soiled linen, cotton, bandage and plaster casts from infected and contaminated areas are very essential to be properly collected, segregated, stored, transported, treated and disposed of in safe manner to prevent hospital acquired infection.(Barr et. al ,2005 ; Batterman , 2004 ; Chauhan et. al ,2002.) The segregation of various types of waste into their different categories according to their treatment/disposal option was done at the point of generation in color coded plastic bags and containers, to Protect waste handlers and the public from possible injury and disease that could result from exposure to the waste and Avoid attraction to rodents and vermin. Hospital solid waste were observed to be collected in an open dumping site within the Hospital premises and burnt openly. Sorting of waste at source of generation with pretreatment in hospital only before disposal would be the best option.

Color coding	Type of container	Waste categories
Yellow	Plastic bags	Category 1: Human anatomical Waste, Category 2: Animal waste, Category 3: Microbiology waste from pathological lab. Category 6: Soiled waste i.e. items contaminated with blood and body fluids
Red	Disinfected container Plastic bags	Category 3: Microbiological Category 6: Soiled waste Category 7: Solid waste (waste IV tubes) (catheter, etc
Blue/white translucent	Plastic bag/puncture proof containers.	Category 4: Waste sharps Category 7: Plastic disposal tubings. etc
Black	Plastic bag/Puncture Proof Containers	Category 5: Discarded medicines Category 9: Incineration ash Category 10: Chemical waste

Fig : Colour coding-biomedical Waste (management and handling rules,1998)

In India, the Bio Medical Waste Management Rules, 1998 and further amendments were passed for the regulation of bio medical waste management. Each state's Pollution Control Board or Pollution control Committee will be liable for implementing the new legislation in India. There are a number of special disposal methods, yet most are harmful rather than helpful. If body fluids are nearby, the substance desires to be incinerated or put into an autoclave. Although this is the appropriate method, most medical facilities fail to follow the system. It is often found that biomedical waste is put into the ocean, where it ultimately washes up on shore, or in landfills due to inappropriate sorting when in the medical facility. Improper disposal can lead to many diseases in animals as well as humans (Ganesh C.P , Bio-Medical Waste Management System). Rules and guidelines in opposition to Biomedical Waste Management System,

1. The Air (Preclusion and Organize of Pollution) Act 1981

2. The Environment (Security) Act 1986

3. The Dangerous Waste (Managing & Handling) Rules 1989

4. The National Environmental Tribunal Act 1995

5. The Biomedical Waste (Managing & Behaviour) Rules 1998

6. The Municipal Solid Waste (Management & Handling) Rules 2000.

Industrial Waste

Environmental pollution is the major problem associated with rapid industrialisation, urbanisation and rise in living standards of people. For developing countries, industrialisation was must and still this activity very much demands to build self-reliant and in uplifting nation's economy. However, industrialisation on the other hand has also caused serious problems relating to environmental pollution. Current technology allows, with lower or higher costs and with some exceptions, most waste to be recycled. Moreover, it is a more complex issue when the combination of several techniques is required for optimising the process, thus affecting their viability and, ultimately, their profitability. In turn, each of these processes can be a new waste generator, often with very different characteristics from those at the starting point, entering a complex spiral, which can be approached in many different ways.

As a result, numerous studies have examined what strategies companies can follow and have proposed methods to assess the performance of technologies and treatments used (Coelho et al., 2012) or indexes also to allow the assessment of destination or end use of solid waste (Coelho et al., 2011). The same problem has been addressed in the case of municipal solid waste (MSW) (Consonni et al., 2011; Santiago and Dias, 2012), perhaps with greater intensity owing to the existence of policies that set specific targets for recycling and MSW recovery (Cucchiella et al., 2012; European Union UE, 2008; Stanic-Maruna and Fellner, 2012). A usual approach is the use of life cycle analysis (LCA) (Buttol et al., 2007; Kirkeby et al., 2007; Massarutto et al., 2011; Song et al., 2013), in order to assess or compare products or processes.

S. No	Name	Quantity (million tonnes per annum)	Source/Origin
1.	Steel and Blast furnace	35.0	Conversion of pig iron to steel and manufacture of Iron
2.	Brine mud	0.02	Caustic soda industry
3.	Copper slag	0.0164	By product from smelting of copper
4.	Fly ash	70.0	Coal based thermal power plants
5.	Kiln dust	1.6	Cement plants
6.	Lime sludge	3.0	Sugar, paper, fertilizer tanneries, soda ash, calcium carbide industries
7.	Mica scraper waste	0.005	Mica mining areas
8.	Phosphogypsum	4.5	Phosphoric acid plant, Ammonium phosphate
9.	Red mud/ Bauxite	3.0	Mining and extraction of alumina from Bauxite
10.	Coal washery dust	3.0	Coal mines
11.	Iron tailing	11.25	Iron Ore
12.	Lime stone wastes	50.0	Lime stone quarry

Source: National Waste Management Council-Ministry of Environment and Forests-1990/1999

Agricultural Waste

Agricultural wastes are defined as the residues from the growing and processing of raw agricultural products such as fruits, vegetables, meat, poultry, dairy products, and crops. They are the non-product outputs of production and processing of agricultural products that may contain material that can benefit man but whose economic values are less than the cost of collection, transportation, and processing for beneficial use. Their composition will depend on the system and type of agricultural activities and they can be in the form of liquids, slurries, or solids. Agricultural waste otherwise called agro-waste is comprised of animal waste (manure, animal carcasses), food processing waste (only 20% of maize is canned and 80% is waste), crop waste (corn stalks, sugarcane bagasse, drops and culls

from fruits and vegetables, prunings) and hazardous and toxic agricultural waste (pesticides, insecticides and herbicides, etc). Estimates of agricultural waste arising are rare, but they are generally thought of as contributing a significant proportion of the total waste matter in the developed world. Expanding agricultural production has naturally resulted in increased quantities of livestock waste, agricultural crop residues and agro-industrial by-products. There is likely to be a significant increase in agricultural wastes globally if developing countries continue to intensify farming systems (Obi et. al, 2016). As earlier noted, agricultural development is usually accompanied by wastes from the irrational application of intensive farming methods and the abuse of chemicals used in cultivation, remarkably affecting rural environments in particular and the global environmental in general. The waste generated is dependent on the type of agricultural activities carried out i.e. Wastes from Cultivation Activities, Wastes from Livestock Production, waste from Aquaculture.

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Online Resources

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6. Image Source : Google Image