Environmental Science and Engineering

Solid Waste Management

Principles and Practice

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Chapter 2
Waste Quantities and Characteristics

Waste management is one of the important services provided by most urban authorities. Solid wastes need to be characterized by sources, generation rates, types of wastes produced, and composition in order to monitor and control prevailing waste management systems while improving the existing system. These data will help to make financial, regulatory and institutional decisions. But population explosion and invention of new materials have kept the quantitities and characteristics changing every day. As per the conservative estimation done by the World Bank in 1999, the municipal solid waste (MSW) from urban areas of Asia would raise from 760,000 tonnes/day in 1999 to 1.8 million tonnes/day in 2025. With the increasing income in the countries of Asia, the solid waste management would be more challenging in the coming days in the continent.

New products wrapped with new packaging materials, new living standards and expectancy, change in income and life style practiced by the affluent people have increased global waste quantity. But as would be discussed in subsequent sections the per capita waste quantity would start declining after it reaches a maximum which is specific to a country or region. This could be due to change in technology which would decrease the waste generation or change in the attitude of people or change in the purchase power or drop in the demand of the product. The USA which has the maximum cars per thousand people in the world would obviously generate less cars and wastes from car manufacturing compared to India and China, where there is more aspiration among the people to own private transport.

MSW includes wastes produced from commercial, domestic, industrial, institutional, demolition, construction and municipal services. But the data pertaining to MSW vary greatly among the waste studies. Usually waste management decisions are based on house-hold waste, which constitutes a small portion of the total waste stream. Further, industries and commercial activity hide the information to avoid statutory obligations.

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2.1 Sources of Solid Waste

Solid waste sources could be urban or rural area. While rural area generates waste which is often organic rich and easily biodegradable the urban waste is characterized by culture and practices of society.

Different countries adopt different categorisation for statutory requirement. For example, solid waste in Singapore is categorised into three major categories (Low 1990): (1) domestic refuse (solid waste generated by markets, food centres, households and commercial premises etc.), (2) industrial refuse (does not include hazardous and toxic waste which requires special treatment, handling and disposal), (3) institutional solid waste (solid waste from government offices, schools, hospitals, recreational facilities etc.).

Figure 2.1 shows some major sources of solid waste. Industries often struggle to increase profit and reduce waste. Manufacturing sector generates MSW from offices and canteens as well as industrial wastes from manufacturing activities some of which are hazardous. Small workshops spread across the urban/rural area as well as along the highways generate both municipal and hazardous waste which requires treatment and disposal differentially. Healthcare establishments like hospitals, clinic, veterinary institutions, blood banks, pathological laboratories, diagnostic centres, artificial insemination centres, clinical research centres have multiplied in all countries over the years to generate MSW as well infectious/chemical/radioactive and sharps. Construction and demolition sites also produce some MSW like food and office wastes, along with construction and demolition wastes. Households produce construction and demolition wastes during repairs and refurbishment. Residences and commercials activities also generate ‘household hazardous wastes’ like pesticides, batteries, and discarded medicines. Some cities in the developed nations have waste management systems for each of these categories like hazardous, MSW, infectious separately. Activities like agricultural, mining, and quarrying will generate MSW and non-municipal waste streams.

Treatment of wastewater produces a semisolid, nutrient-rich sludge which is often referred as biosolids. It can be recycled and used to improve soil nutrition of crop land. Biosolids contain about 93–98 % water.

2.2 Quantities and Composition

Managing solid waste is one of the most essential services which often fails due to rapid urbanization along with changes in the waste quantity and composition. Quantity and composition vary from country to country making them difficult to adopt for waste management system which may be successful at other places.

Quantity and composition of solid waste vary from place to place as pictorially explained in Figs. 2.2 and 2.3. The municipal solid waste characteristics and quantity is a function of the lifestyle and living standard of the region’s

Residential		Waste composes of decomposable food waste, packaging material comprising paper, plastic, old cloth, hazardous waste like old battery, nail polish bottles, insecticides, after shaving lotion, bottle, and biomedical waste like sanitary napkin. Waste quantity varies depending on income and development of the country.
Commercial		Waste composes of decomposable food waste, packaging material comprising paper, plastic, hazardous waste include used batteries, chemical containers. Waste quantity varies depending on the activities and turnover.
Gardens		Waste predominantly composes of garden trimming and leaves. Hazardous chemicals include packaging material of agro chemicals. The waste cold include packaging material like cover used for chips, ice cream cups etc.
Industrial		Waste depends of product of the industry. Industrial waste comprises highly hazardous chemicals to non hazardous packaging material. Quantity of waste depends on quantity and type of product manufactured.
Agriculture and Rural		Waste mainly comprises of rotten vegetable, fruits, leaves and other plant parts. Hazardous chemicals include packaging material of agrochemicals. Most of the waste will be used within the same farm/estate hence quantity is negligible.
Demolition and Construction		Waste mainly comprises of concrete, brick pieces, soil, wood, metals, and other debris. Recyclables material like steel and other metals are recovered by construction/demolition agencies. The quantity depends on size of construction/demolition and construction technology.

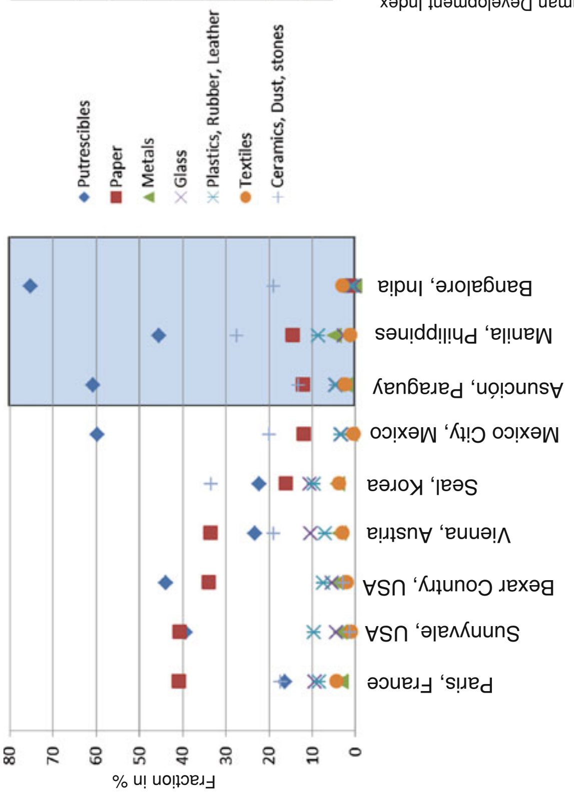
Fig. 2.1 Sources of solid waste

inhabitants. Figure 2.2 provides brief analyses of comparison of waste from differing culture and development. Other studies reveal that 60–70 % of waste from Ghana is organic (Carboo 2006; Fobil 2002; Hogaarh 2008). Within the available data, waste from high human development show higher fraction of non-degradable

Transportation		This category can be included as subcategory of commercial activity. While developed countries do not generate waste along roads and railway tracks. But people throw waste all along roads and railway tracks in developing world. The quantity of solid waste besides railway track depends on the traffic and number of passengers travelled.
Water and Wastewater Treatment Plants		These plants generate hazardous and nonhazardous sledges and packing material. Quantity of solid waste depends on the quality/quantity of water/wastewater treated.
Beaches and Recreation areas		This category mainly contains litters of food wrappers made up of paper, plastic, metal and glass. Quantity of waste depends on number of visitiors.
Slum		Slum people generate least quantity among all urban sectors. Since the dwellers are poor they make use of the materials available to maximum extent and sell recyclable fraction. Many of the dwellers depend on waste for livelihood. The waste mainly contains ash and decries which does not have recyclable value.
Fruits and Vegetable Market		Fruits and vegetable market prominently contains decomposable waste like rotten and damaged fruits and vegetables. A small percentage of packaging like cardboard, plastic and paper may be present in the waste. Citrus and other sour fruits like pine apple may add to acidity of the waste.
Slaughter House		Waste mainly comprises of hide, hair, undigested and digested food, bones, and meat. The waste is highly putricible in nature and likely to have pathogens that could cause zonoses.

Fig. 2.1 Sources of solid waste (Continued)

Country	Human Development Index	
France	0.952	High Human Development
USA	0.951	High Human Development
Austria	0.948	High Human Development
Korea	0.921	High Human Development
Mexico	0.829	High Human Development
Paraguay	0.775	Medium Human Development
Philippines	0.771	Medium Human Development
India	0.619	Medium Human Development



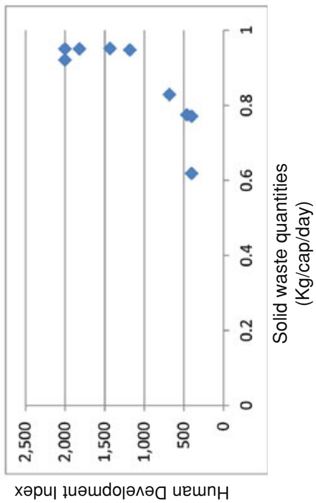
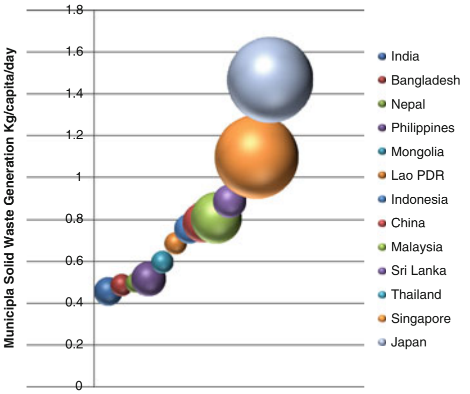


Fig. 2.2 Solid waste quantities, characteristics and human value indices. *Source* Based on previously reported data (Na th 1993; Diaz, 1985; JICA 1985; Scharff, 1994; CalRecovery, 1992, 1993; UNDP, 2007). Solid waste quantities (Kg/cap/day)



Country	Municipal Solid Waste Generation (kg/capita/day)	GDP Per capita (2005 US $)
India	0.46	3452
Bangladesh	0.49	2053
Nepal	0.5	1550
Philippines	0.52	5137
Mongolia	0.6	2107
Lao PDR	0.69	2039
Indonesia	0.76	3843
China	0.79	6757
Malaysia	0.81	10882
Sri Lanka	0.89	4595
Thailand	1.1	8677
Singapore	1.1	29663
Japan	1.47	31267

Source : World Bank 1999, UNDP, 2007

Fig. 2.3 Municipal solid waste generation vs. income

waste comparable to medium human development. The reason for such fraction is due to high spending of rich countries on packaging material, absence of rag picking, and low number of scrap dealers, etc.

The developing countries use newspaper and other unsoiled paper for packaging including food item. It is not uncommon to see restaurants and road side merchants packing food items, fruits and vegetables in newspapers and covers made-up of newspapers. The number of old scrap merchants in India is high and house and offices sell old paper to these dealers. These dealers in turn sell them to recyclers and other end users. The huge number of rag pickers is one of the reasons for very low amounts of paper, plastic, glass and metals in the wastes. Rag pickers can be seen at residential, commercial, industrial and waste dump areas trying to pick all recyclable fractions of waste.

The people in the developed countries are expected to have higher income jobs and hence there is a general absence of rag picking. The waste papers and old newspapers will be put into trash instead of storing at a point of generation for selling to scrap dealers. On the contrary the developing countries will generate high industrial waste due to the non adoption of waste minimisation technology and weak environmental legislations compared to the developed countries.

The quantity of municipal waste generated from urban settlement is a function of human development index which in turn depends on the life expectancy, gross domestic product and education indices. The quantity of municipal solid waste is invariably higher in the developed nations compared to the developing nations.

Typical waste characteristics of the developing nations are (1) high waste densities, (2) high moisture contents, (3) large organic fraction, (4) cities with sweeping as well as open ground storage characterized by large amount of dust and dirt.

Compilation and comparison of solid waste generation in large cities of various countries show that waste is generated at the rate of 0.4–0.6 kg/person/day in low-income countries, as compared to 1.1–5.0 kg/person/day in high income countries

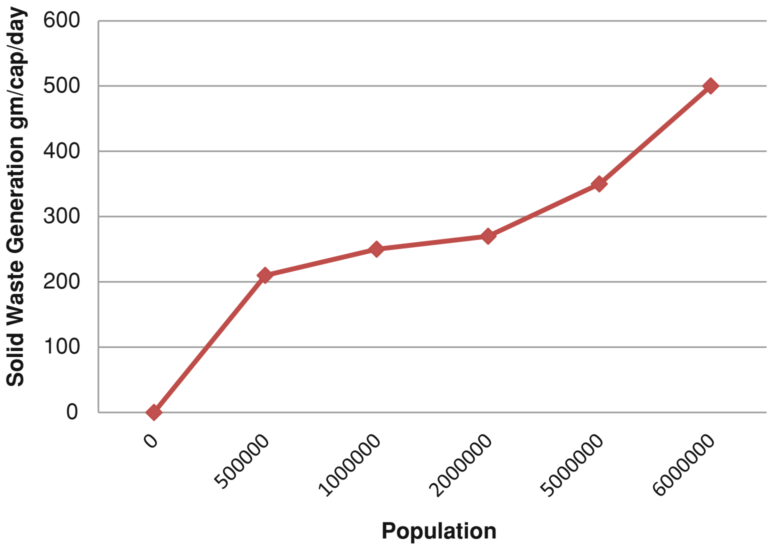


Fig. 2.4 Solid waste generation v/s population of urban settlement in India

and 0.52 and 1.0 kg/person/day in middle-income countries. These figures only indicate the scenarios in larger cities. As expected, the solid waste generation rates become smaller as cities become smaller.

The reason in the variation in waste quantises are mainly due to (1) differences in consumption pattern (people in lower income countries consume less, (2) differences in recycling/reuse at source of generation thus eliminating entry of substance into the waste stream, and (3) differences in culture (high income countries use large quantity of paper for personal hygiene after using toilets).

The following common differences can be observed in the composition of municipal solid waste in the developing countries: (1) waste density of developing nations are 2–3 times more than developed nations, (2) moisture content of developing nations is 2–3 times more than developed nations, (3) waste in developing nations will have large amount of organic waste, dust, (4) waste from developing country is characterized by a large fraction of smaller components (Cointreau 1982; Blight and Mbande 1996).

As per Central Public Health and Environmental Engineering Organisation (CPHEEO 2000) the total solid waste produced per year by 300 million people of urban India was 38 million tonnes. The findings of the National Environmental Engineering Research Institute (NEERI) (1996) with respect to the variations of the MSW generation in India in urban settlements are given in Fig. 2.4. Larger cities generate higher quantities due to the affluence of the city dwellers and higher economic activity.

The total solid waste in Singapore increased three folds in 1999 compared to that of 1980. Domestic solid waste augmented from 0.73 kg/day/person in 1980

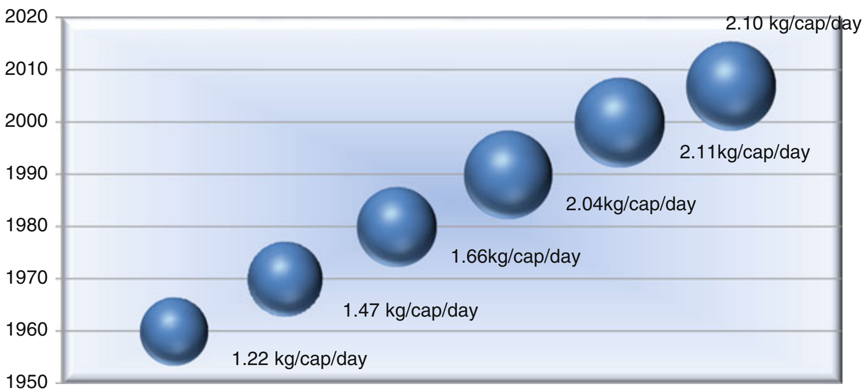
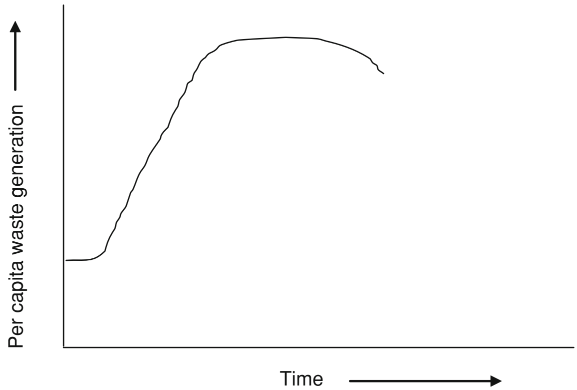


Fig. 2.5 Per capita municipal waste generation in the USA

Fig. 2.6 Variation of per capita municipal waste generation matured economy over time



and 0.96 kg/day/person in 1999 resulting in 640,000 tonnes in 1980 to 1360,000 tonnes in 1999 (Renbi 2002).

Annual MSW generation in the USA has continued to increase from 88 million tons 254.1 million tons in 1960–2007. Findings of the US-EPA (2007) with respect to variation of waste quantities per person is pictorially depicted in Fig. 2.5. As depicted in Fig. 2.5 per capita waste generation varied from 1.22 kg/cap/day in 1960, it grew to 1.66 kg/cap/day in 1980, reached 4.50 kg/cap/day in 1990, and increased to 4.65 kg/cap/day in 2000. Since 2000, MSW generation has remained fairly steady and there is decrease in waste generation in 2007. The trend could follow growth curve discussed shown in Fig. 2.6.

Per capita waste generation ranges between 0.2 and 0.6 kg per day among the Indian city dwellers amounting to about 0.115 million MT of waste per day and 42 million MT annually as on 2006 but this would increase drastically with increase in urbanisation.

The industrial solid waste in Singapore augmented from 207,000 tonnes to 1,538,000 tonnes between 1980 and 1997, followed by a decline by 7.2 % since 1997–1999 (Renbi 2002). About 1.8 million tonnes of solid waste is being recycled since few years (Ministry of Environment 1999, 2000). The institutional solid waste augmented from 94,000 tonnes to 292,000 tonnes between 1980 and 1987 followed by decline to about 6,000 tonnes in 1999 due to waste recycling (Renbi 2002).

The Arab region generates nearly 250,000 tons per day of solid waste with per capita generation of municipal solid waste in some Arab cities, such as Kuwait, and Abu Dhabi, being over 1.5 kg per day (Mostafa and Najib 2008).

Kuala Lumpur, which is a city in a country of transition, generates 3,500 tons/d of domestic and industrial wastes with per capita domestic waste generation approximately 0.8–1.3 kg per day (Abdul 2010). 50 % of the waste generated in Kuala Lumpur is organic (Bavani and Phon 2009). Generation rates in Africa's major cities vary between 0.3 and 1.4 kg per capita per day (Eric 2003). More than 60 % of the urban area is inhabited by low-income citizens in African urban communities making collection difficult (Eric 2003).

As discussed in the earlier paragraphs and figures the waste quantity will increase with an increase in the national income, development, and size of urban settlement. But once the economy of a country reaches maturity in terms of creation of infrastructure, income and jobs there would be steadiness in per capita waste generation thereafter it would decline. The decline in waste generation could also be attributed to technology, regulation, civic responsibility in the society and lower corruption among enforcement agency.

The solid waste generation curve plotted over time would follow pattern of growth curve of a species in given ecosystem. The population of species show low growth during initial state to acclimatize itself to new environment and thereafter there would be speedy increase in population followed by steady phase due to decline in food and other factors. After steady phase there would be decline in population of species. Similarly solid waste quantity would grow up to certain extent and decline thereafter as shown in Fig. 2.6.

While the developed countries are showing growth of less than 3 % in the economy other countries in transition are showing a rapid growth of more than 7 %. Hence there would be more waste generation in countries in transition until people reach a stage wherein there is lesser demand for commodities.

Apart from households, the waste characteristics and quantities vary in airports, railway stations and bus stands, etc. In airports, in addition to the waste from airplanes, solid waste is also produced in airport offices, restaurants, shops, flight kitchens restrooms, maintenance areas, cargo operations, hangars, landscaping, construction and demolition. About 425,000 tons of waste were produced at the US airports in 2004 out of which 75 % of the waste generated is recyclable or compostable (Peter et al. 2006).

Waste from gate areas, ticketing counters and passenger airplanes is called airline waste and usually includes food containers, drink containers, newspapers,

Table 2.1 Waste generation in different category of viewers in a sports event

Sl. No.	Section	Facilities	Waste quantities
1	Very important persons	Complimentary drinks, meals, advertisement material, cheering material.	Two to three kg/person
2	Elite club	Drinks and eatable on payment. Viewers have to bring own cheering material, banners. Free advertising hand out, caps.	One to two kg/person
3	General class	Drinks and eatables on payment. Viewers have to bring own cheering material, banners. Free advertising hand out paper caps.	Quarter to one kg/person

uneaten food, magazines, and computer printouts and other papers in ticketing counters.

The quantities and characteristics of waste produced in an airplane depend on length of the flight. The quantity of waste generated in the airports of the US was approximately 1.28 pound per passenger departed in 2004. As per the bstudies conducted by Peter et al. (2006) the airport waste had 20 % compostables, 26 % non-recyclables, 14 % newspaper, 11 % mixed paper, 3 % magazines, 12 % cardboard, 1 % aluminium, 2 % glass bottles, 2 % plastic bottles and 9 % other plastics (packaging, bags, etc.).

The airline industry in the US disposed 9,000 tons of plastic in 2004 (Peter et al. 2006). Similar studies carried out by the Central Pollution Control Board (2009) in India revealed the quantity of plastic waste production form Indian airports to be 4,130 kg per day out of which the amount of plastic bottles was 3,370 kg with per capita plastic waste production at domestic and international airports being 70 and 68 gm, respectively.

Airport can operate with either centralized or decentralized waste management system. Centralized waste management system will have one waste management point for all terminals and airplane waste with the exception of waste from the flight kitchens, which generally manage their own waste. The waste generators are charged based on the quantity of waste generated or included in the lease for tenants or landing fees for airlines.

The quantity of solid waste depends on special occasions like festival, sports events, conferences and elections. Table 2.1 shows waste generation in different category of viewers in a sports event. A typical international sports event is likely to generate about one kg of waste per person entering the stadium. But within the stadium Very Important Persona (VIP) and elite club would generate more waste than other general viewers.

Festivals throughout the world are accompanied by waste generation creating a shock load to existing system. The responsible collection agency would usually collect waste with its existing capacity leaving behind additional burden to be cleared in subsequent days. Apart from festivals other reasons for shock loads will be elections and disasters. Festivals and elections are responsible for increase in quantity by two to ten times the daily average waste. On the other hand disasters can increase waste by 300–500 times the daily average.

2.3 Physical, Chemical and Biological Characteristics

The major physical characteristics measured in waste are: (1) density, (2) size distribution of components, and (3) moisture content. Other characteristics which may be used in making decision about solid waste management are: (1) colour, (2) voids, (3) shape of components, (4) optical property, (5) magnetic properties, and (6) electric properties.

Optical property can be used to segregate opaque materials from transparent substances which would predominately contain glass and plastic. Magnetic separators are designed based on the magnetic characteristics of the waste. Moisture content is essential for leachate calculation and composting. Density is used to assess volume of transportation vehicle and size of the disposal facility. Shape can be used for segregation as flaky substance will behave differently compared to non-flaky substance.

Important chemical properties measured for solid waste are: (1) moisture (water content can change chemical and physical properties), (2) volatile matter, (3) ash, (4) fixed carbon, (5) fusing point of ash, (6) calorific value, (7) percent of carbon, hydrogen, oxygen, sulphur and ash.

Proximate analysis of waste aims to determine moisture, volatile matter, ash and fixed carbon. Ultimate analysis of waste aims to analyse percent of carbon, hydrogen, oxygen, sulphur and ash.

Solid waste production is a function of land use as well as its composition is inversely proportional to the possible soil damage and bacterial contamination of the environment (Achudume and Olawale 2009; Lober 1996; Omuta 1999; Shakibaie et al. 2009).

Wet waste will host more bacteria compared to dry waste. The nutrition in waste also acts as a key factor which decides population balance of species in the waste and immediate environment. Toxic elements discourage multi-cellular organism in the waste. But micro-organisms may still persist at places which may favour some species of micro organism. Saprophytes and fungi will flourish in decomposable matter.

As shown in Fig. 2.7 which is dominated by bottles reveals that physical, chemical and biological characteristics vary hugely from place to place. The collective waste density depends on the fraction of the waste and density of individual waste. Table 2.2 gives proximate analysis and ultimate analysis of various components of waste along with physical properties of the waste.

Fig. 2.7 Physical, chemical and biological characteristics vary hugely from place to place

Proximate analysis is the analysis of waste to determine moisture, volatile matter, ash and fixed carbon. Ultimate analysis is the percent of carbon, hydrogen, oxygen, nitrogen, sulphur and ash. Analysis for solid waste for carbon, hydrogen, nitrogen and sulphur can be done using CHNS analyser (Fig. 2.8). In the absence of such equipment chemical formula for solid waste can be calculated as illustrated in Box 2.1.

Table 2.3 shows the majors living organisms in various solid wastes. Most protozoa feed on bacteria. The free living protozoa can be found in any aerobic environment in which bacteria are present to support their growth. Some of the protozoa are parasitic to humans/animals. Protozoa are primarily aquatic animals but they are also found in solid waste and soil. The ability to form cysts allows them to survive during desiccation and unfavourable conditions. Numerous human diseases are caused by protozoa including *amoebic dysentery*.

Solid waste also hosts substantial amount of fungi. Of about 100,000 species of fungi about 100 are pathogenic to animals and humans (Anthony and Elizabeth, 1981). Gungi causes infection to hair, nail, skin, and lung. Infection occurs by person sores in air which may be present in solid waste. Toxins generated by *Asperigillus flavus* can cause liver cancer and fatty degeneration of liver in people who eat contaminated food.

Some of the bacteria can form spores to allow them to survive when nutrients are not available during dry period. These spores can easily carry away by wind. Contamination of wounds and food by spores of *Clostridium* can lead to fatal consequences. Species such as *C.botulinum* produce toxins which lead to food poisoning. Species such as *C. Persringens,* grow speedily in wounds leading to gangrene (Anthony and Elizabeth 1981).

Waste from slaughter house, fish market and hospital will have abundant pathogens and diverse with respect of species (Fig. 2.9).

Table 2.2 Proximate and ultimate analysis of waste components

Waste material	Waste density (kg/m^3)	Moisture content (%)	Inert residue (%)	Calorific value (kj/Kg)	Carbon (%)	Hydrogen (%)	Oxygen (%)	Nitrogen (%)	Sulphur (%)
Asphalt	680	6–12		17100–18400	83–87	9.9–11	0.2–0.8	0.3–1.1	1.0–5.4
Cardboard, corrugated paper box	30–80	4–10	3–6	16375	44.0	5.9	44.6	0.3	0.2
Brick/Concrete/Tile/dirt	800–1500	6–12	99						
Electronic equipments	105		0–50.8	14116.27–45358.28	38.85–83.10	3.56–14.22	7.46–51.50	0.03–9.95	–
Food waste	120–480	50–80	2–8		48.0	6.4	37.6	2.6	0.4
Garden trimmings	60–225	30–80	2–6	4785–18563	47.8	6.0	38.0	3.4	0.3
Glass	90–260	1–4	99						
Leather	90–450	8–12	8–20		60.0	8.0	11.6	10.0	0.4
Metal–Ferrous	120–1200	2–6	99						
Metal–Non Ferrous	60–240	2–4	99						
Municipal solid waste/biomedical waste	8 7–348	15–40							
Paper	30–130	4–10	6–20	12216–18540	43.5	6.0	44.0	0.3	0.2
Plastic	30–156	1–4	6–20		60.0	7.2	22.8		
Rubber	90–200	1–4	8–20		78.0	10.0		2.0	
Sawdust	250–350			20510	49.0	6.0			0.10
Textile	30–100	6–15	2–4		55.0	6.6	31.2	4.6	0.15
Wood	156–900	15–40	1–2	14,400–17,400	49.5	6.0	42.7	0.2	0.1

Source Tchobanoglaus (1977); Integrated publishing, $NA_{a,\ b}$; Engineering tool box, NA; University of technology Vienna, NA; USEPA, NA; Wess et al. (2004); Othman (2008)

Box 2.1 Chemical formula of solid waste.
Solid waste is mixture of various components which have their own chemical composition and chemical formula. But deriving approximate formula will help calculating oxygen requirement and other probable emission during natural degradation or waste treatment. The procedure for deriving chemical formula is given in following example.

Component	Wet mass in kg	Dry mass in kg	Moisture in kg	Composition in kg					
				C	H	O	N	S	Ash
Food Waste	16	5	11	2.40	0.32	1.88	0.13	0.02	0.26
Paper	46	43	3	18.70	2.58	18.92	0.13	0.08	2.58
Cardboard	11	10	1	4.40	0.59	4.46	0.03	0.02	0.51
Plastic	11	10	1	6.00	0.72	2.38	0.00	0.00	1.00
Total	**84**	**68**	**16**	**31.5**	**4.21**	**27.64**	**0.29**	**0.12**	**4.35**

Step one: Derive ultimate analysis and moisture of individual solid waste components.
Step two: Convert moisture content into Hydrogen and Oxygen.
Hydrogen : (2/18) 16 kg = 1.78 kg.
Oxygen : (16/18) 16 kg = 14.22 kg.
Step three: Revise composition in kg.

C	H	O	N	S	Ash
31.5	5.99	41.86	0.29	0.12	4.35

Step four: Compute molar composition of the waste.
Step five: Compute normalised mole ratio.
Chemical formula of solid waste is $\mathbf{C_{98.26}\,H_{1.57}\,O_{173.96}\,N_{1.05}S}$.

	C	H	O	N	S
Mass, kg	31.50	5.99	41.86	0.29	0.12
Kg/mol	12.01	1.01	16.00	14.01	32.06
Moles	378.32	6.05	669.76	4.06	3.85

	C	H	O	N	S
Moles	378.32	6.05	669.76	4.06	3.85
Mole ratio	98.26	1.57	173.96	1.05	1.00

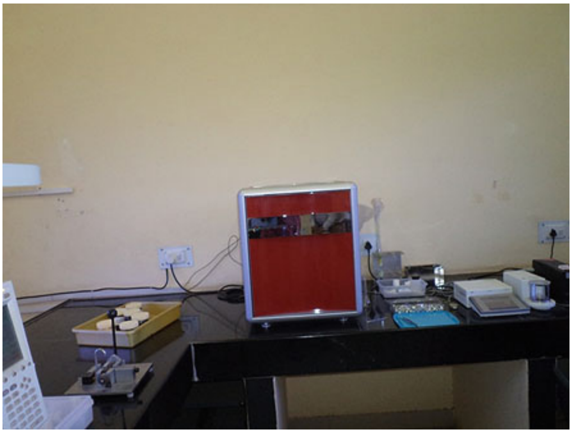


Fig. 2.8 CHNS analyser used for analysis of carbon, hydrogen, nitrogen and sulphur

Table 2.3 Major living organisms present in various solid wastes

Waste category	Fungus	Protozoa	Bacteria	Insect	Rodent
Biomedical waste	✔	✔	✔	✔	✔
Food waste	✔	✔	✔	✔	✔
Hazardous waste					
Municipal solid waste	✔	✔	✔	✔	✔
Radio active waste					
WEEE				✔	✔

Fig. 2.9 Waste from sources like slaughter house would be biologically diverse and dangerous

Solid waste can host an array of insects, arthropod and annelids. The examples of insects include cockroaches, dung beetles, ants, termites, mosquitos, honey bees and house flies. Some of the arthropods in solid waste are spiders and scorpions. Annelids in solid waste include centipede, millipede and earthworm. In some of the waste dumps adjacent to forest area attract wild life as well. While herbivores are attracted towards vegetables and food carnivores are attracted towards hospital waste and other animals which come to eat solid waste. Solid waste dumps attract and host rats, lizards, snakes and street dogs depending on the food available. Due to the absence of agricultural land honey bees in urban area are attracted to left over sweet drinks in trash for collecting nectar.

Micro-organisms play an important role in the decomposition of decomposable fraction of solid waste. Thermophilic bacteria would breakdown of proteins and other easily biodegradable material. Fungi and actinomycetes would degrade complex organic matter like cellulose and lignin. Streptomyces and micromonospora species are commonly observed actinomycetes in compost. Thermonomyces sp., asperigallus and penicillium dupontii fumigatus are common fungi observed in compost. Most of these organisms will be present in municipal solid waste even before composting (CPHEEO 2000).

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