

2. The estimated generation of end of life ITEW 15 – feature phone in the FY 2016- 17
 3. = Sales in the (FY year 2016-7 – 2017-7) either in terms of weight or number
 4. = Sales in the financial year 2009-10 in terms of weight or number
- Therefore, generation of end of life of smart phone in the FY 2016-17 = Sales in the financial year 2011 – 12 either in terms of weight or number
 - Similarly, generation of end of life of feature phone = Sales in the financial year 2009-2010 either in terms of weight or number

5.10 Forecasting of solid waste generation

Municipal Waste

The mathematical calculation is an ultra-process beginning with the estimation of future population based on the present trend and then calculates the future amount of municipal solid waste generation (Weber, 2004) of studied countries

$$\text{Future Population} = \text{Initial Population} \left(1 + \frac{\% \text{ growthrate}}{100}\right)^{\text{years}}$$

Future amount of municipal solid waste generation = (Predicted population) x (Waste generation rate) x (Number of day) ÷ (1000 kg per metric ton)

Medical Waste

Total medical waste generation using the equation:

$$M = B.R/1000 \text{ (ton/day)}$$

Where-

M-Total medical waste generated (ton/day)

B-Number of sickbed (bed)

R-Generation rate of medical waste (kg/ bed/ day). It depends on a number of factors such as the increasing rate of population, socioeconomic condition, types and scales of hospitals, etc.

SAQ 3

1. What is E-waste?
2. Using following data evaluate the quantity of solid waste generated rate per week for a city residential area consists of 5000 homes. Given data are collected from local

transfer station and observation period was one week. Assume approximately 2 adults and 1 child per home (2.5 people per home).

No.of. vehicle	No. ofStrip	Volume(m ³)	Specificweight (kg/m ³)
I	15	10	280
II	20	8	210
III	25	12	320

5.11 Summary

The most important aspect of solid waste management is the quantity of waste to be managed. The quantity determines the size and number of functional units and equipment required for managing the waste. The quantities are measured in terms of weight and volume. The weight is fairly constant for a given set of discarded objects whereas volume is highly variable. Waste quantities are usually estimated based on past records of waste generation. The methods commonly used to assess the quantities are (i) load count analysis; (ii) weight volume analysis; and (iii) material balance analysis.

The prediction of municipal solid waste (MSW) generation plays an important role in a solid waste management system. Population growth and migration, underlying economic development, household size, employment changes, and the impact of waste recycling would influence the solid waste generation.

5.12 Keywords

MFA	Material flow analysis is an analytical method to quantify flow materials or substances in a well-defined system.
Transfer station	A transfer station, or resource recovery centre, is a building or processing site for the temporary deposition, consolidation and aggregation of waste
Landfill	A landfill site, also known as a tip, dump, rubbish dump, garbage dump, or dumping ground, is a site for the disposal of waste materials.
E-waste	Electronic waste or e-waste describes discarded electrical or electronic devices.
GDP	It stands for "gross domestic product" and represents the total monetary

	value of all final goods and services produced (and sold on the market) within a country during a period of time (typically 1 year).
Medical waste	Medical waste is any waste that is generated as a by-product of healthcare work at doctor's surgeries, dentists, hospitals and laboratories

5.13 Answers to SAQs

SAQ 1

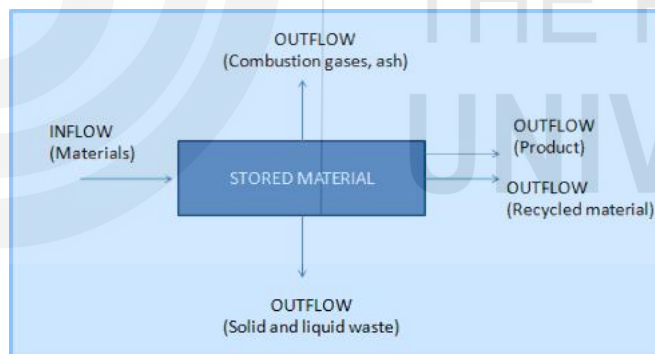
1. Refer Section 5.2

2. Refer Section 5.3

Steps involved in mass balance analysis are given below.

- 1) Identify boundary of the system or source for which mass balance is to be performed
- 2) Identify all activities within the system or across it that affects waste generation
- 3) Identify rate of waste generation associated with each of these activities
- 4) Use following mathematical relationship between quantity of waste generated, collected, stored and moved from the system for performing mass balance

Material Stored = Inflow – Outflow - Waste Generation

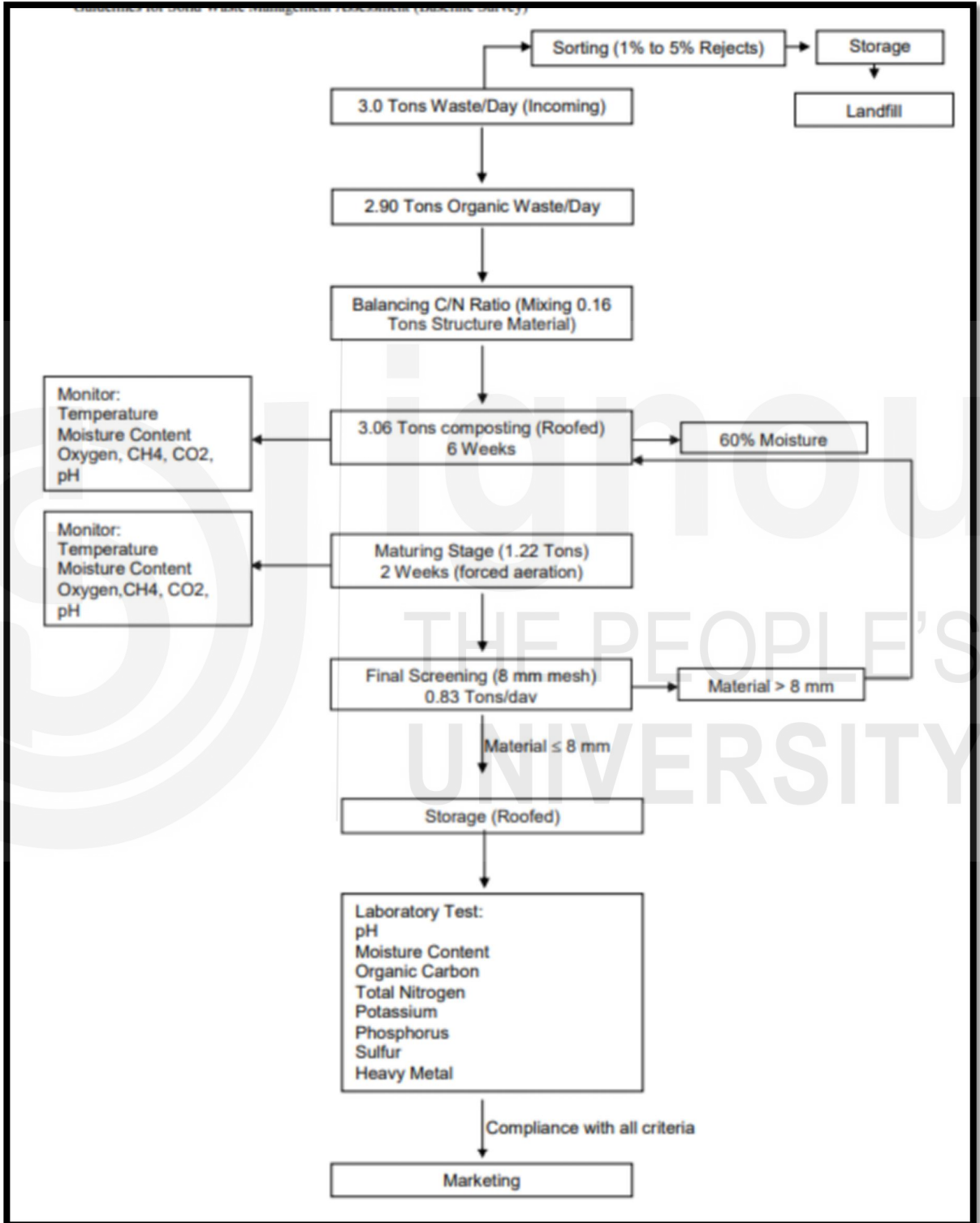


SAQ 2

1. Refer Section 5.7, 5.8

2. the total present population of a city is estimated at 50,000 and the waste generation rate is estimated at 0.322 kg/cap/day, the total waste generated per day would be $50,000 * 0.322 = 16,100$ kg/day, or 16.1 metric tons/day. Therefore, waste generated in a year = $16.1 * 365 = 5876.5$ Tons.

3. (a) Volume of MSW generated by town per year = $(0.05 \times 1000) \times 500000 / 500 = 50000$ m³, Land fill lift per year = $[50000 / (0.85)] / (0.8 \times 150 \times 100) = 4.902$ m
 (b) No. of years for which the land fill can be used = $25 / 4.902 = 5.1$ year
4. An example of a mass balance is shown below.



5. Refer Section 5.8

SAQ 3

1. Refer Section 5.9

2. Step 1: Determine the total quantity of waste

3. Total quantity of waste (kg) = No. of Strip * Volume (m³) * Specific weight (kg/m³)

No.of. vehicle	No. ofStrip	Volume(m ³)	Specificweight (kg/m ³)	Total Quantity(kg)
I	15	10	280	42000
II	20	8	210	33600
III	25	12	320	96000
				171600

Step2:Determinethequantityofsolidwastegeneratedrateperweekforacityresidentia larea consists of5000 homes.

$$\text{Quantity of solid waste generated} = \frac{\text{Total Quantity in kg}}{\text{no. of . homes} * \text{no. of. person per home} * \text{no. of day}}$$

Given: 2 adults and 1 child per home (2.5 people per home)

$$\text{Quantity of solid waste generated} = \frac{171600}{5000 * 2.5 * 7}$$

$$\text{Quantityofsolidwastegenerated} = \mathbf{1.9611\text{kg/capita/day}}$$

5.14 Further Reading

References:

- 1.Tchobanoglous George, Hilary Theisen, and Samuel Vigil. Integrated Solid Waste Management.Engineering Principles and Management Issues. New York: McGraw-Hill, 1993.
- 2.Kreith, Frank, ed. Handbook of Solid Waste Management. New York: McGraw-Hill, 1994
3. Action Plan on Management of Municipal Solid Waste by CPCB on 5th Feb 2015

UNIT6 SOLID WASTES POLLUTION AND EFFECTS

Structure

6.1 Introduction

Objectives

6.2 Definitions

6.3 Causes of solid waste pollution

6.4 Health effects of solid waste pollution

6.4.1 Effects of solid waste pollution on Human

6.4.2 Effects of solid waste pollution on Animals

6.4.3 Effects of solid waste pollution on Plants

6.4.4 Effects of solid waste pollution on Environment

6.5 Summary

6.6 Answers to SAQs

Key words: Solid waste pollution, Health effects.

ignou
THE PEOPLE'S
UNIVERSITY

6.1 INTRODUCTION

The uncontrolled human population growth has put much pressure on the natural resources and at the same time, rapid urbanization and industrialization had also increase the worries due to the rising demand for food and other necessary essentials, which in turns there has been a rise in the amount of waste being generated daily by households, commercial and industrial entities leads to the release or generation of gigantic amount of solid waste. This solid waste is ultimately thrown into the environment through various landfills, waste treatment facilities and dumps. This solid waste must be handling with care and it requires an integrated solid waste management plan for the disposal of solid waste. However, either due to limited available resources or infrastructure, proper handling of waste is not done in many countries. There are potential hazards to environment and health of human, animal and plant from improper handling of solid wastes. A typical municipal solid waste management system involves various activities like collection, storage, transportation and disposal. An improper management leads to the solid waste pollution and even if properly controlled and with proper precautionary measures adopted, may have negative effect on land, water and air environment which has detrimental effects on environmental and organism health. The main risks from solid waste pollution to health are indirect and arise from the breeding of disease vectors, primarily flies and rats. Direct health risks concern mainly the garbage collectors and workers in this field, who need to be protected, as far as possible, from all forms of the contact with solid wastes. More serious scenario is the mixing of industrial hazardous waste with municipal solid waste increases the manifold damage to environment. The far-reaching problems are the pollution of air, water and soil done due to transfer of pollutants from solid waste which leads to the injurious effects on entire ecosystems. Figure 1 illustrates the consequences of solid waste pollution on our ecosystem. Figure depict that various sources of solid waste create pollution which has environment and health impact, further exposure of solid waste pollution to various stake holders has hazardous effects. It is required to reiterated that

complete control of solid waste pollution is challenging but we can minimize it by adopting sustainable integrated solid waste management system which has least precarious effects on all stake holders of the ecosystem.

Sources of Solid Waste

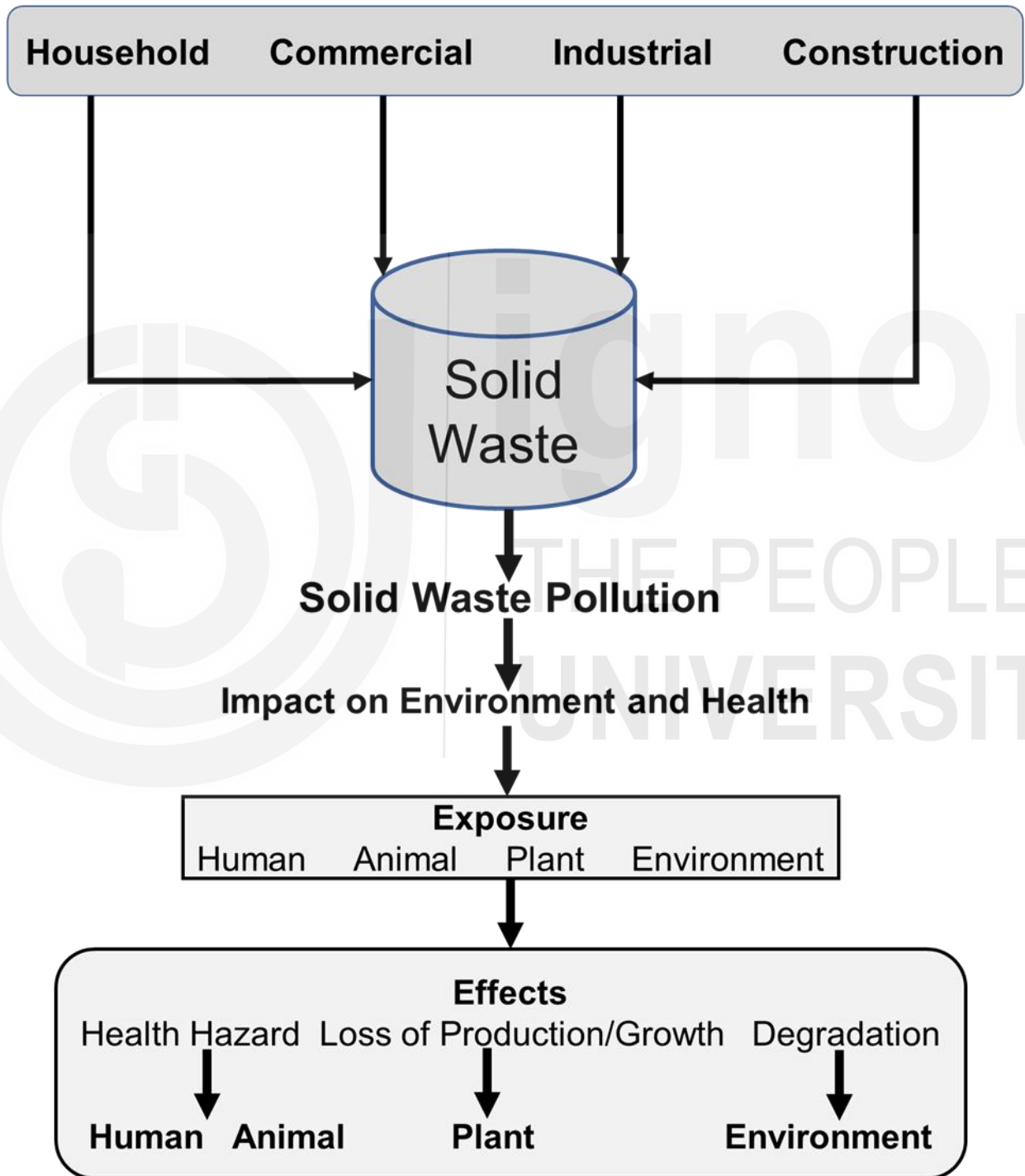


Figure 1. Consequences of Solid Waste Pollution.

Objectives of the Unit

After studying this unit, you should be able to

- recognize the definition of solid waste and pollution.
- outline the various causes of solid waste pollution.
- Judge about the devastating health effects of solid waste pollution.

6.2 DEFINITIONS

Solid waste means and includes solid or semi-solid domestic waste, sanitary waste, commercial waste, institutional waste, catering and market waste and other nonresidential wastes, street sweepings, silt removed or collected from the surface drains, horticulture waste, agriculture and dairy waste, treated bio-medical waste excluding industrial waste, bio-medical waste and e-waste, battery waste, radio-active waste generated.

Solid waste includes agricultural refuse, demolition waste, industrial waste, mining residues, municipal garbage, sewage sludge, etc.

The above definition is adopted from the Indian Solid Waste Management Rules, 2016.

Resource Conservation and Recovery Act (RCRA) of US EPA states that "**solid waste**" means any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, resulting from industrial, commercial, mining, and agricultural operations, and from community activities.

Nearly everything we do leaves behind some kind of waste.

It is important to note that the definition of solid waste is not limited to wastes that are physically solid. Many solid wastes are liquid, semi-solid, or contained gaseous material.

Pollution is an undesirable change in physical, chemical and biological characteristics of our land, air or water caused by excessive accumulation of pollutants (i.e. Substances which cause pollution) that causes detrimental effects to nature, natural resources and mankind.

Solid waste pollution is any unnatural and negative changes in all the dimensions like chemical, physical and biological characteristics of any component of the ecosystem i.e. air, water or soil due to the solid waste which can cause harmful effects on various forms of life and property.

In terms of origin it may be natural or anthropogenic (man-made) but mainly due to the human activities.

Several materials are excluded from the definition of solid waste. These materials are excluded for a variety of reasons, including public policy, economic impacts, regulation by other laws, lack of data, or impracticability of regulating the waste.

6.3 CAUSES OF SOLID WASTE POLLUTION

The problem of solid waste generation is increasing rapidly with urbanization and industrial development. Developed countries like USA, Canada, Japan, England, Germany and France are the main solid waste producers. Apart from these, countries like China, India and Brazil are also producing millions of tons of solid waste. Before focusing on the causes of solid waste pollution it is interesting recall the various sources of Solid wastes (defined as above) can be classified into

- Urban or municipal wastes
- Commercial wastes
- Industrial wastes
- Construction wastes
- Agricultural wastes
- Medical wastes
- Mining wastes
- Hazardous wastes

We will majorly focus on first five types of solid waste while rest types are handled according to their specific rules. Let examine the potential risk from solid waste pollution in Indian context, at present India produces about 60 million tons of municipal solid waste annually. Per capita generation of waste varies from 200 gm to 600 gm/day with average generation rate at 0.4 kg per capita per day in towns. Collection efficiency of the generated solid waste ranges between 50% to 90%. The estimated annual increase

in MSW generation is 1.33%, thus India produces huge amount of solid waste which may act as fuel for solid waste pollution if not disposed efficiently. The disposal of solid waste has always been a huge problem throughout India. The overwhelming majority of landfills in India are open dumps without leachate or gas recovery systems. Several are located in ecological or hydrologically sensitive areas. They are generally operated below the standards of sanitary practice. Municipal budgetary allocations for operation and maintenance are always inadequate. There are enormous origin/sources which causes solid waste pollution among them few are,

- Disposal of Industrial wastes is one of the major source of solid waste pollution includes the discharged from various origins such as pulp and paper mills, chemical fertilizers, oil refineries, sugar factories, tanneries, textiles, steel, distilleries, fertilizers, pesticides, coal and mineral mining industries, drugs, glass, cement, petroleum and engineering industries etc. These pollutants affect and alter the chemical and biological properties of various elements of ecosystem. As a result, hazardous chemicals can enter into human food chain from the soil or water, disturb the biochemical process and finally lead to serious effects on living organisms.
- Urban wastes comprise of both commercial and domestic wastes are another major source of solid waste pollution. All the urban solid wastes are commonly referred to as refuse. This refuse consists of garbage and materials like plastics, cans, fibres, paper, rubbers, street sweepings, fuel residues, leaves, containers and other discarded manufactured products. These materials possess major role in the solid waste pollution as they are not biodegradable, and their various soluble forms enter into the various cycles of ecosystem and create solid waste pollution.
- Modern agricultural practices are also responsible for solid waste pollution as huge quantities of fertilizers, pesticides, herbicides and weedicides are added to increase the crop yield. Apart from these farm wastes, manure, slurry, debris, soil erosion containing mostly inorganic chemicals are reported to cause pollution.
- Soil gets a large amount of human, animal and bird excreta which also constitute a major source of pollution by biological agents.

Apart from above mentioned sources of solid waste other issues responsible for solid waste pollution in urban area includes,

- absence of segregation of waste at source.
- lack of technical expertise and appropriate institutional arrangement.
- unwillingness to introduce proper collection, segregation, transportation and treatment/disposal systems.
- indifferent attitude of citizens towards solid waste management due to lack of awareness.
- lack of community participation towards waste management and hygienic conditions.
- Careless and indiscriminate open dumping of wastes creates unsightly and unsanitary conditions within municipalities e.g. along the roads and highways.
- Delay in delivery of solid wastes to landfills, resulting in nuisance dumps and unpleasant odours which attract flies and other vectors. Such dumps also lead to pollution of land/soils, ground and surface water through leachate and air through emission of noxious and offensive gases.
- During rainy seasons, produced leachate from the open dumped sites is causing serious pollution to water bodies.
- Some categories of solid wastes block permeability of soils and drainage systems, including water courses, open drains and sewers.

SAQ 1

- a. What are the various consequences of solid waste pollution?
- b. Define solid waste, pollution and solid waste pollution.
- c. Enumerate the causes of solid waste pollution?

6.4 HEALTH EFFECTS OF SOLID WASTE POLLUTION

The health effects of solid waste pollution are of two types, one the direct effects and another indirect effects on health. These effects are based on the type and severity of health consequences occurred on individuals and it mainly depends on the type of exposure and contact concentration of various pollutants arising due to the solid waste

pollution. Direct effects involve the direct contact with solid waste can be dangerous and unsafe to the public, as infectious diseases such as cholera and dysentery can be spread through contact with these wastes. In most municipalities, scavenging on solid waste dumps is a common practice, and such people face danger of direct exposure to hazardous waste. Another type of the direct health effects including the exposure to the smoke or fumes generated at landfill sites. As previously mentioned, the main risks from solid waste pollution to health are indirect and arise from the breeding of disease vectors, primarily flies and rats, also escaping of various hazardous materials from the waste processing facility and their accumulation in various components of the ecosystem. Recycling too carries health hazards if proper precautions are not taken. Workers working with waste containing chemical and metals may experience toxic exposure. The solid waste pollution always has a source and a recipient. The various pathways of solid waste pollution are the routes the pollutants move from the source, enters into the environment, and finally how it reaches the human body or other recipient. The pathways between source and recipient can take several different routes and forms depending on the type of pollutants. Primary recipients for solid waste pollution are water, air, and soil. It is evident that once these pollutants released into the environment, the hazardous effects of many pollutants are reduced by following mechanisms:

Dispersion – smoke disperses into the air and is no longer harmful away from the source.

Dilution – soluble pollutants are diluted in the large quantity water of a river or lake.

Deposition – some suspended solids carried in a river or various stream and settle on their bed.

Degradation – some substances degrade by natural processes into simpler substances that are not polluting and non-harmful.

Health hazards related to solid waste pollution may be further ranked according to the magnitude and severity of their consequences. A major effect would include multiple loss of life and chronic disability. A moderate effect would include some loss of life and temporary disability. A semi-moderate effect would include illness and temporary

disability. Table 1 depict the various categories related to the environmental and health hazards of solid waste pollution.

Table 1: Types of Environmental & Health Hazards of Solid Waste Pollution

Types of Hazards	Causes with Examples
Pollution	Air, Water, Soil and noise
Disease (mainly communicable)	Skin diseases, respiratory disorder, gastrointestinal infection etc.
Non-communicable disease	Asthma, poisoning, hearing loss/defects etc.
Injury	Occupational injuries due to components of the solid waste like glass, sharp metals, blades etc.
Aesthetics	Dust exposure, Visibility, Odour.

6.4.1 Effects of Solid Waste Pollution on Human

Evidence showed that by end of twentieth century, the world's chemical production had increased 400 fold since 1930. Chemicals have made much of modern life easier, but they have also contaminated landscapes around the world. These solid waste pollutants can travel great distances by air or accumulate in the bodies of animals and humans who absorb pollutants through the skin or ingest them in food or water. While some pollutants may be harmless, others can cause damage. Increasingly, there is particular concern lately about three types of pollutants: pollutants that persist in the environment and accumulate in the bodies of wildlife and people, endocrine disruptors that can interfere with hormones, and pollutants that cause cancer or damage DNA.

The group at risk from the unscientific disposal of solid waste include, the population in areas where there is no proper waste disposal method, especially the school children, waste workers and workers in facilities producing toxic and infectious material. Other high-risk group include population living close to a waste dump and those, whose water supply has become contaminated either due to waste dumping or leakage from landfill

sites. Uncollected solid waste also increases risk of injury, and infection. Either by direct dumping of solid waste on water bodies or by leaching of pollutants into ground water causes water contamination or pollution by chemical toxic substances. In particular, organic domestic waste poses a serious threat, since they ferment, creating conditions favourable to the survival and growth of microbial pathogens. Inappropriate disposal of municipal solid waste on the roads and surroundings, results in the production of foul smell and spread of diseases, due to the decomposition of biological matter. Apart for above mentioned health hazards, solid waste pollution also impacts human health as.

- Inorganic chemicals of solid waste can cause skin cancer, make freshwater unusable for drinking and can damage nervous system, liver and kidneys.
- Organic chemicals of solid waste can threaten human health by causing nervous system damage and some cancers.
- Water contaminated due to improper disposal of solid waste causes diseases like diarrhoea, dysentery, typhoid, cholera, plague, etc.
- Photochemical smog causes respiratory problems and irritation to eyes
- Volatile organic compounds (VOCs) such as (benzene and formaldehyde) causes tiredness, drowsiness, dizziness, nausea, confusion, bone marrow disease, Skin cancers, leukemia, cardiovascular disease.
- Lead damages the brain and central nervous system, kidneys and brain.
- Mercury brings nervous disorders, insomnia, memory loss, excitability, irritation and stroke.
- Suspended particles for solid waste handling induce stuffy noses, sinusitis, sore throats, dry cough, burning eyes, aggravate bronchitis and asthma. Exposure to these particles over a long period of time damages lung tissue and contributes to the development of chronic respiratory disease and cancer.
- Drinking water with excessive levels of nitrates lower the oxygen carrying capacity of the blood and can be lethal to children and infants.
- Burning of industrial or domestic wastes (cans, pesticides, plastics, radioactive materials and batteries) produce carcinogenic chemicals like dioxins and polychlorinated biphenyls.

- Noise pollution created by the vehicles used in solid waste management have impact on nearby public like the adverse reactions are coupled with a change in hormone content of blood, which in-turn increases heartbeat, constriction of blood vessels, digestive spasms and dilation of the pupil of the eye.
- Excess of nitrate in drinking water is dangerous for infants and human health, excess fluoride causes neuromuscular disorder and teeth deformity, hardening of bones and painful joints.

6.4.2 Effects of Solid Waste Pollution on Animals

When toxic chemicals and metals from the solid waste enter into the environment, organisms may absorb them through their skin or ingest them in their food or water. Animals higher in the food chain accumulate these toxins in higher and higher concentrations, a process called biomagnification. Top predators including fish, birds, and mammals can have much higher levels of these toxins in their bodies, making them more likely to experience the diseases, birth defects, genetic mutations, and other deleterious effects of these harmful pollutants.

Over the past 50 years, use of pesticides and fertilizers on farms has increased by 26 fold which leads to the excessive residuals of these in the solid waste and may pollute nearby land and water, and pollutants may wash into nearby streams, waterways and groundwater when it rains. Pesticides residuals in solid waste can kill non-target organisms, including beneficial insects, soil bacteria and fish. Fertilizers residuals of solid waste are not directly toxic, but their presence can alter the nutrient system in freshwater and marine areas. This alteration can fuel the excessive growth of phytoplankton and algae, which can sometimes have devastating consequences. As a result, the water is depleted of dissolved oxygen, and fish and other aquatic life may be killed. Low dissolved oxygen levels thereby making aquatic organisms more vulnerable to disease, parasites and toxic chemicals. Harmful algal blooms of species that produce deadly toxins and sometimes known as red tides or brown tides for their appearance in the water can kill fish, marine mammals and seabirds and harm humans.

All kinds of animals are affected by solid waste soil pollution. Animals eat crops or plants in order to meet their energy demand from the dumpsites or landfills. However, if

the soil and therefore also the crops are contaminated with solid waste pollutants, the animals eating the crops and plants get contaminated as well. Similar to the adverse effect on humans, solid waste pollution can also have severe health effects on animals. Death of animals that graze near the area as a result of eating plastic materials.

Aquatic life is indirectly affected through solid waste pollution. Since through the excessive use of pesticides and harmful chemicals leached from the landfills will eventually reach our rivers, lakes and seas. Thus, sea animals will also be adversely affected by such kind of pollution. Sediment settles and destroys feeding and spawning grounds of fish. Besides these solid waste pollution affects the animals as with human for the particular types of illness or health hazard.

6.4.3 Effects of Solid Waste Pollution on Plants

It is self-explanatory that when entire ecosystem suffers from the solid waste pollution than plants are one of them. Consequences of solid waste pollution on Plants include.

Effects on the fertility of plants -The fertility of plants is likely to be reduced due to the issue of land pollution. Since plants are sensitive to changes in their natural environmental conditions, soil contamination from solid waste can lead to a decline in fertility of the affected plants.

Effects on growth behavior of plants - The growth behavior of plants can also be affected by land pollution. Solid waste pollution may alter the acidity of the soil, since plants require a stable level of acidity and also of nutrient supply, a change in these parameters through contamination will likely lead to adverse effects on the growth of plants.

Reduction in crop yields - Soil pollution is also likely to lead to a reduction in crop yields. When the natural environments of plants are contaminated with harmful chemicals which are accumulated as a result of solid waste pollution, they are usually not able to adapt to these new changed soil compositions in a short period of time. Thus, the crop yields will be lower compared to an environment without pollution.

When some solid waste pollutants enter leaf pores, they damage the leaves of crop plants. Further, chronic exposure of the leaves to pollutants can break down the waxy coating that helps prevent excessive water loss and leads to damage from diseases,

pests, drought and frost. Such exposure interferes with photosynthesis and plant growth, reduces nutrient uptake and causes leaves to turn yellow, brown or drop off altogether. At a higher concentration of such pollutants majority of the flower buds become stiff and hard. They eventually fall from the plants, as they are unable to flower.

Prolonged exposure to high levels of several air pollutants from smelters, coal burning power plants and industrial units as well as from cars and trucks can damage trees and other plants. High soluble solid concentration from waste decreases the water availability to the plants as increase in salt concentration reduces the osmotic potential resulting in stunted plant growth. Besides above the solid waste pollution also have following hazardous effects on plants.

- Solid waste modifies the physiochemical and biological properties of plants.
- Pollutants affect plants by entering through stomata and destroy chlorophyll.
- Damages the leaf structure and causes necrosis (dead areas of leaf), loss of chlorophyll content causing yellowing of leaves (Chlorosis) or downward curling of leaf (epinasty) and dropping of leaves (abscission).
- Some solid waste pollutants cause silvering of lower surface of leaf, damage to young and more sensitive leaves and suppressed growth.
- These pollutant seep into the soil and strip the land from any nutritional content with filling the soil with chemicals or metals that damage plant cells and keep plants from obtaining nutrients and growing.
- Sometimes there is an excess of nutrients in the water which causes an excessive plant growth. On the other hand, this excess nutrients causes a fluctuation in acidity and damages or kills the plant.

6.4.4 Effects of Solid Waste Pollution on Environment

Solid waste pollution has impact on all facets of environment whether it be land, water or air. Lower resource allocation for solid waste management is the main reason behind the solid waste pollution with public awareness stood at second. Solid waste pollution has precarious effects on the environment among few can be mentioned as,

Groundwater contamination - If the soil is contaminated with pollutants and other harmful substances, with time lapse these chemicals will reach the groundwater through

heavy rainfalls, these chemicals will eventually be washed through the soil and thus contaminating our groundwater.

Changes in soil structure - The structure of the soil itself can change due to a contamination with certain pollutants which lead to an erosion and may harm the soil fertility. Acidic soils are inhospitable to several microorganisms that improve texture of soil and help in the decomposition of organic matter. Thus, the negative effects of soil pollution also impact soil quality and texture.

Effect on microorganisms – As microorganisms are sensitive to a change in their natural environmental conditions and harmed by solid waste pollution. Through the presence of pollutants, these microorganisms are often not able to adjust to the new environment appropriately and thus will die off. We know that all-natural processes are connected with each other, the decline in microorganisms may cause chain reactions which turn out to have great adverse effects on the whole environmental system.

Besides these solid waste pollution can cause damage to environment in following ways,

- Inorganic chemicals of solid waste can make freshwater unusable for irrigation.
- Hazardous solid wastes released by industries also cause soil pollution and affect the productivity of soils
- Heavy metals like mercury and lead are released into the environment due to inappropriate disposal of solid wastes and groundwater contamination takes place because of toxic substances release from solid wastes.
- Pollutants may change the soil pH level which affects the crop yields as plants are quite sensible to changes in pH-levels.
- Destruction of farms due to passing of heavy vehicles that transport waste through narrow roads.
- Large quantity of plastic, glass and papers which are non-biodegradable materials cover the area, this may through time compact the soil and change its texture or it may cause hazards such as accidental fires or can move to nearer ranges and animals.
- Decomposition of organic waste is a major source of escaping gases including methane (CH_4) which contributes to global warming as global warming potential of methane is significantly higher (about 56 times) than CO_2 .

- Leachate from decaying organic waste threatens future water supplies.
- Loss of vegetation cover in the area as a result of waste creeping.
- Loss of topsoil which eroded or was buried under waste.
- Blockage of irrigation channels: results from dust and waste or passing of vehicles.
- The economic loss of buildings and equipment of the farms.

Finally, long-term exposures of solid waste pollution can lead to significant climatic changes that can have far reaching negative impacts on food, water and ecosystems.

SAQ 2

- a. What are the health effects of solid waste pollution?
- b. How solid waste pollution affect human?
- c. Enumerate the effects of solid waste pollution on Animals?
- d. What are the effects of solid waste pollution on plants?
- e. What are the effects of solid waste pollution on Environment?

6.5 SUMMARY

Solid waste pollution arises from each step of the solid waste management like waste generation, collection, transportations, segregation and disposal. Every step contributes into the pollution which has hazardous effect on the health of human, animal, plants and environment. The major contributing factors for solid waste pollution are lesser allocation of resources for solid waste management, public awareness and absence of proper regulatory framework. One might ask, how we can limit the solid waste pollution and its precarious effects on human and others? By adopting the 3R rule, i.e.

Reduce, Reuse and Recycle with the aim of zero discharge after proper disposal of the solid waste. The integrated solid waste management plant is delineated in order to minimize adverse impact on the environment due to various activities involved in solid waste management with various mitigation measures. Create public awareness through information, education and communication campaign and educate the waste generators to minimize the solid waste which ultimately goes into the landfill and create solid waste pollution. Finally, we must shift from linear economy to circular economy which in turn at great help to reduce solid waste pollution and its hazardous effects on its stakeholders.

6.6 ANSWERS TO SAQS

SAQ 1

- (a) Refer section 6.1
- (b) Refer section 6.2
- (c) Refer section 6.3

SAQ 2

- (a) Refer section 6.4
- (b) Refer section 6.4.1
- (c) Refer section 6.4.2
- (d) Refer section 6.4.3
- (e) Refer section 6.4.4

References for Further reading

1. Al-Ghouti MA, Khan M, Nasser MS, Al-Saad K, Heng OE. Recent advances and applications of municipal solid wastes bottom and fly ashes: Insights into sustainable management and conservation of resources. *Environ Technol Innov.* 2021 Feb 1;21:101267.
2. Krystosik A, Njoroge G, Odhiambo L, Forsyth JE, Mutuku F, LaBeaud AD. Solid Wastes Provide Breeding Sites, Burrows, and Food for Biological Disease Vectors, and Urban Zoonotic Reservoirs: A Call to Action for Solutions-Based Research. *Front Public Heal.* 2020 Jan 17;0:405.
3. Mouhoun-Chouaki S, Derridj A, Tazdaït D, Salah-Tazdaït R. A Study of the Impact of Municipal Solid Waste on Some Soil Physicochemical Properties: The Case of the Landfill of Ain-El-Hammam Municipality, Algeria. *Appl Environ Soil Sci.* 2019;2019.
4. Tong L, Tang Y, Wang F, Hu B, Shi P, Hu Q. Investigation of controlling factors on toxic metal leaching behavior in municipal solid wastes incineration fly ash. *Environ Sci Pollut Res* 2019 2628 [Internet]. 2019 Aug 8 [cited 2021 Aug 5];26(28):29316–26. Available from: <https://link.springer.com/article/10.1007/s11356-019-06123-9>
5. Chen L, Liao Y, Ma X. Heavy metals volatilization characteristics and risk evaluation of co-combusted municipal solid wastes and sewage sludge without and with calcium-based sorbents. *Ecotoxicol Environ Saf.* 2019 Oct 30;182:109370.
6. Ramachandra T V., Bharath HA, Kulkarni G, Han SS. Municipal solid waste:

- Generation, composition and GHG emissions in Bangalore, India. *Renew Sustain Energy Rev.* 2018;82:1122–36.
7. Forbes R. McDougall, Peter R. White, Marina Franke, Peter Hindle , “Integrated Solid Waste Management: A Life Cycle Inventory” Blackwell science 2008
 8. Davis & Cornwell, “Introduction to Environmental Engineering” Second Edition, McGraw Hill
 9. Satpal Singh (2014). Decentralized solid waste management in India: a perspective on technological options. *Cities - the 21st century India.* 290-304
 10. Manual of central public health and environmental engineering organization (2016). Ministry of Urban Development.
 11. Desai, S. N., & Shah, M. A. (2018). Decentralized solid waste management in urban areas: a review. *Int J Curr Eng Technol*, 8, 21-23.
 12. Savage G. M., Diaz, L. F., Golueke, C. G., Martone, C. (1998) Guidance for Landfilling Waste in Economically Developing Countries. EPA-600/R-98-040. U.S. Environmental Protection Agency.
 13. Rushbrook P., Pugh, M. (1998) Decision-Maker’s Guide to Solid Waste Landfills. The World Bank.
 14. Waste and human health: Evidence and needs, WHO Meeting Report (2016)

Glossary

Agricultural waste

Waste material generated from agricultural activity or agro industry residues, e.g., straw, husk, tree pruning etc.

Biodegradable waste

Any organic material that can be degraded by micro-organisms into simpler stable compounds like paper, wood, fruits and others.

Bio-medical waste

Any waste, which is generated during the diagnosis, immunisation, treatment of human beings or animals, or in research activities pertaining thereto or in the production or testing of biologicals including the categories.

Bio-methanation

A process which entails enzymatic decomposition of the organic matter by microbial action to produce methane rich biogas.

Combustible waste

Non-biodegradable, non-recyclable, non-reusable, non-hazardous solid waste having minimum calorific value exceeding 1500 kcal/kg and excluding chlorinated materials like plastic, wood pulp, etc.

Disposal

The final and safe disposal of post processed residual solid waste and inert street sweepings and silt from surface drains on land as specified in Schedule I to prevent contamination of ground water, surface water, ambient air and attraction of animals or bird.

Domestic hazardous waste

Discarded paint drums, pesticide cans, CFL bulbs, tube lights, expired medicines, broken mercury thermometers, used batteries, used needles and syringes and contaminated gauge, etc., generated at the household level.

Dry waste

Waste other than bio-degradable waste and inert street sweepings and includes recyclable and non-recyclable waste, combustible waste and sanitary napkin and diapers, etc.

Garbage

It is the common term used for unwanted or discarded material, which is not used anymore, is called refuse or garbage.

Hazardous Waste

A waste that poses substantial or potential threats to public health or the environment generally exhibiting one or more of these characteristics: ignitable, oxidizing, corrosive, ecotoxic, radioactive, etc. Such wastes arising from industries are called as Industrial Hazardous Waste.

Heavy metals

Metals of high atomic weight and density that are toxic to living organisms, such as mercury, lead, and cadmium.

Inerts

Wastes which are not bio-degradable, recyclable or combustible street sweeping or dust and silt removed from the surface drains.

Incineration

An engineered process involving burning or combustion of solid waste to thermally degrade waste materials at high temperatures.

Integrated Solid Waste Management

It is referring to a strategic initiative for the sustained management of solid waste using a comprehensive integrated format generated through sustained preventive and consultative approach to the complementary use of a variety of practices to handle solid waste in a safe and effective manner.

Landfill gases

Gases arising from the decomposition of organic wastes; principally methane, carbon dioxide, and hydrogen sulphide. Such gases may cause explosions at landfills.

Landfilling

The disposal of residual municipal solid waste on land in a facility designed with protective measures against pollution of ground water, surface water and air fugitive dust, windblown litter, bad odour, fire hazard, bird menace, pests or rodents, greenhouse gas emissions, slope instability and erosion.

Leachate

The liquid that seeps through solid waste or other medium and has extracts of dissolved or suspended material from it.

Methane

An odourless, colourless, flammable, explosive gas, CH₄, produced by anaerobically decomposing solid waste at landfills.

Non-biodegradable waste

Any waste that cannot be degraded by microorganisms into simpler stable compounds like plastics bottles, old machines, glass, containers and others.

Pathogens

Disease-causing agents, especially microorganisms such as bacteria, viruses, and fungi.

Residual solid waste

Includes the waste and rejects from the solid waste processing facilities which are not suitable for recycling or further processing.

Sanitary waste

Wastes comprising of used diapers, sanitary towels or napkins, tampons, condoms, incontinence sheets and any other similar waste

Sludge

A semi-liquid residue remaining from the treatment of municipal and industrial water and wastewater.

Vector

An organism or insect which often carries diseases or parasites from one animal or plant to another, e.g., fly, mosquito etc.

Waste generator

Every person or group of persons, every residential premises and non-residential establishments which generate solid waste.

Waste picker

A person or groups of persons informally engaged in collection and recovery of reusable and recyclable solid waste from the source of waste generation the streets, bins, material recovery facilities, processing and waste disposal facilities for sale to recyclers directly or through intermediaries to earn their livelihood.