

**Recall a little**

- Already you know the food and also the waste that we generate
- The prime object is to understand the waste and the volume generated

13.1 Scenario

Waste management is the study of knowing waste generation, collection, transport, processing, recycling or disposal and monitoring waste material. Food supply and waste management are the emerging challenges for the policy makers and industries in the processing food supply. The global population is expected to grow 9 billion and demand for food is about 77% by 2050. Over the same period, food production will be under threat from climate change, competing land uses, and erosion and diminishing supplies of clean water. The food which we consume has to undergo a series of food processing operations soon after harvesting at the farm industry level.

The agro-food industry generate huge amount of waste material annually around the globe from a variety of sources. Food is a basic need of human beings, while food waste has been identified a major crucial challenge faced by human community today.

Over 4.2 million tons of food waste is dispersed to landfill in Australia each year. 2.7 million tons of this is from households and around 1.5 million tons of this is from commercial and industrial sector, costing around \$ 10.5 billion in waste disposal charges and waste product. The largest single contributor in the commercial and industrial sector is food service activities.(e.g. - cafes, restaurants, fast food outlets), which generate 661,000 tons of food waste per year, followed by manufacturing (312,000 tons) and food retail (179,000 tons).

Most waste in food manufacturing is unavoidable, and almost 90% is already recovered as animal feed, compost or bio-energy. Presently, around 21,000 people die every day due to hunger related causes and globally one in nine people go to bed each night hungry. Nevertheless, approximately one third of all the food produced goes to landfill as waste. The vast amount of food ending up as waste is not only a humanitarian problem but also serious economic, nutritional and environmental pollution problem.

13.1.1 World situation

At global statistics, according to the British Institute of Mechanical Engineers (IME) half of the food produced is wasted worldwide at different stages. The global volume of the food wastage has been reported to around 1.3 billion tons. The total volume of water used each year to produce food that is lost or wasted i.e. equivalent to the annual flow of Russian's Volga river or three times the Lake Geneva. Similarly, 1.4 billion hectares of land 28% of the world's agriculture area is used annually to produce food that is lost or wasted . About \$ 165 billion worth of food waste enters landfills each year.

World environmental problems

Population growth contributes to GHG (Green House Gas) emission through its effect on deforestation as land is grabbed for enhancing food production (Lambin and Moyfroidt, 2011). As the world's population grows and becomes more affluent, waste production rises and might double by 2025. According to the US Environmental Protection Agency (EPA), food wastage currently represents the single largest type of waste entering landfills. Wasted food leads to over utilization of water and fossil fuels and to increase greenhouse gas emission

i.e. methane and carbon di oxide arising from degradation of food in landfills.

Therefore, the environmental impact of food waste is two fold

1. It is associated with the depletion of natural resources used for its production (e.g. soil water).
2. It relates to the costs associated with waste disposal.

There is a growing awareness needed to minimize the amount of food waste at the end of the food supply chain- an issue particularly relevant in high-income countries where more than 40% of the food losses occur at retail and consumer level.

3. Globally per capita food waste by consumers amounts to 95-115 kg/ year in Europe and North America compared to 6-11 kg/year in South or South East Asia and Sub-Saharan Africa.
4. Food waste reduction at the consumption level represents indeed a large target for medium and high income countries, where evidence shows that the main source of the problem is the domestic setting.

13.1.2 Indian condition

In India, according to UN Development Program, 40% of the food produced is wasted at pre and post-harvest stages. According to Government of India's resources, about Rs. 58,000 crore worth of food is wasted every year. About 25% of fresh water used to produce the food is ultimately wasted. On the other hand millions of people still don't have access to drinking water. About 300 million of barrels of oil are used to produce the food that is ultimately wasted. As a result, a large quantity of food is wasted and being thrown away around the world, on the other hand, a child dies every five seconds because of hunger. In terms of food waste, agricultural produce, meat poultry and milk, India ranks seventh, with the Russian Federation at the top in the list. India's major land is under agriculture hence, there is highest wastage of cereals, pulses, fruits and vegetables.

Meat accounts for just four percent of the food wastage but contributes 20% of the economic loss of the wastage. Wastage of fruits and vegetables is 70% of the total produce, but translated into only 40% of the economic losses. Also, rice crop emits methane, a potent global warming gas, because of the decomposition of organic matter in submerged paddy fields. Food loss and waste costs the world about \$ 940 billion a year.



Can you recall?

- The volume, effect and consequences of waste.
- Which industry has the potential huge generation of waste.

However, the utilization or disposal of food waste is difficult due to its inadequate biological stability, potentially pathogenic nature, high water content, potential for rapid autoxidation, microbial decomposition through high level of enzymatic activity. The world population will reach to 9.6 billion by 2050 .



Can you tell?

- What are the consequences and health hazards of waste?
- What is the environmental impact of waste

13.2 Types of waste

13.2.1 Solid waste (Organic and inorganic)

Sources- domestic waste, factory waste, waste from oil industry, e-waste, agricultural waste, food processing waste, variety of plastic based waste, packaging material (industry and domestic waste), etc. Out of the total solid waste generated, 44% is wet organic.

13.2.2 Wet waste

- (a) Kitchen waste (food waste, cooked and uncooked food, egg shells, meat and bones, fish, fruit and vegetable inedible portion, etc.

- (b) Flower, fruit and vegetable waste
- (c) Garden, tree, leaves, branches, straw, trash waste
- (d) Sanitary waste (drainage waste)
- (e) Food industry waste (raw materials and finished goods)
- (f) Food waste (left over, stale, spoiled food)
- (g) Wet garbage and industry (sewage) waste

13.2.3 Dry waste

- (a) Paper, plastic (all kinds), laminates, foils
- (b) Card boards, cartoons, packaging, glass bottles, metal tins and containers, strappings, foils, rags, rubber, houses, pipes, sweepings, ashes, wrappings, discarded clothes, etc.

13.2.4 Domestic hazard waste

- (a) Compact florescent lamps, tubes, glasses, batteries, etc.
- (b) Chemicals, detergents, etc.

Non-hazard waste

Glass bottles, iron containers/ wares, plastic bottles/ wares and materials

13.2.5 E –waste

E- wastes are the electronic equipment / products that connect with power plug, batteries which have been become absolute due to

- advancement in technology.
- changes in fashion, style and status.
- nearing the end of their useful life.

Food waste from different food groups

- Cereals (grains), pulses, fruits and vegetables, meat, dairy products, marine, sugarcane, winery, plantation by-products, slaughter house, canning industry, etc.
- Wastes are untreated and underutilized; therefore its disposal is widely adopted through burning, dumping or land filling.
- Juice industry produces a large amount of waste as peels, pulp, seeds, fiber, etc.
- Fruit and vegetable processing industry waste.



Can you recall?

- Identify the reasons of food losses.
- What do you mean by lost / waste food.

13.3 Reasons for losses

These are the main reasons for losses in different areas, thereby generating different kinds of waste.

Table 3.1 : Major processed food and types of waste generated

Sr. no	Food crop	Food product	Waste
1	Rice, wheat, corn	Grain, flour, bread, biscuits, roti, cake, starch, flakes, bakery products, etc.	Straw, stem, leaves, husk, comb, hulls, fibers, brans, germ, gluten, fodder , etc.
2	Fruits and vegetables	Juice, pulp, preserved products, vegetable oil, potato products, fruits, roots, tubers, bulbs, sugar dehydrated, pickles, fermented products , etc.	Rotten fruits, vegetables and their parts, pomace, skin, seed, stones, fibers, etc.
3	Fish and sea food	Canned, salted fish, smoked fish, processed form, dehydrated, frozen , etc.	Scales, fins, shells, bones, guts, fish oil, skeleton, etc.
4	Meat and poultry	Processed meat (beef, pork, poultry, eggs and their products)	Blood, hairs, head, skin, horn, bones, carcass, fat, feet, guts, large intestinal parts, etc.

5	Dairy products	Milk, butter, cheese, milk powder, cream, ghee, paneer, ice cream, etc.	Whey, processed water, solids, waste material, effluents, etc.
6	Beverages	Cocoa, coffee, tea, fruits, alcohol (wine), molasses, grain based alcohol, etc.	Shells, seed coat, molasses, sewage water, etc.
7	Oils	Oil, hydrogenated fat, fatty acids, etc.	Oil cakes, solid impurities, water effluents, rancid spoiled seeds oil, etc.
8	Sugar	Sugar, jaggery, confectionary, etc.	Solid wastage, sugar industry effluents, waste, etc.

- 1. Agricultural production:** Destruction from insects, pests, diseases, inappropriate crop cultivation practices, changing agro climatic conditions, not meeting the quality specifications, low yielding varieties, lack of inputs, poor crop yield due to drought and natural calamities, etc.
 - 2. Post-harvest handling and storage practices:** Not meeting the specifications for quality and/ or poor or lack of post-harvest handling, packaging, storage facilities may lead to damage due to insect, pest, spillage, germination and degradation (lack of pack houses, packaging materials, pre-cooling facilities, storage and transport facilities (cold chain, cold storages, poor supply chain management, etc.)
 - 3. Lack of primary processing and packaging facilities:** Inadequate infrastructure such as godowns, ware houses, cold storages for perishable commodities, referred vans for high value commodities like grapes, strawberry, broccoli, milk and milk products, poultry, meat, fish, etc. These operations create trimmings and other food preparation waste. Inedible portions, wet or dry material, their storage and transport or proper utilization at proper stage. Wet or dry garbage may create severe problems of their proper disposal, failure may create air pollution and health hazards.
 - 4. Distribution and logistics (wholesale and retail):** Damage or loss of food in transit/ storage due to packaging failures, shelf life of processed / fresh food commodities, poor road facilities, transit storage (warehouse/ cold storage) at the port or metro cities hub. Packaging failures, product spoilage, fresh produce (perishable), etc. may get damaged during handling, storage and distribution, short shelf life hence low sales.
 - 5. Food service sector:** Food wastage generated in the hotels, restaurants, institutional kitchens, poor management of such wet food wastages, their packaging, boxes, plastics, improper food handling, left over or stale food items.
 - 6. At home:** Trimmings, cuttings, peels, stones, seeds, and other food preparation waste, damaged or spoiled food items, preparing too much food, leftover food, improper stored food and food items. The overall food loss and wastage costs the world about \$ 940 billion a year. The food losses are reported to be higher in developing countries than the developed nations. However to overcome and handle the food wastage problem is a huge challenge and task all over the globe.
- The overall food loss (waste) in USA alone, annually people throw away 30% of the food produced which corresponds to 40 billion liters of water .

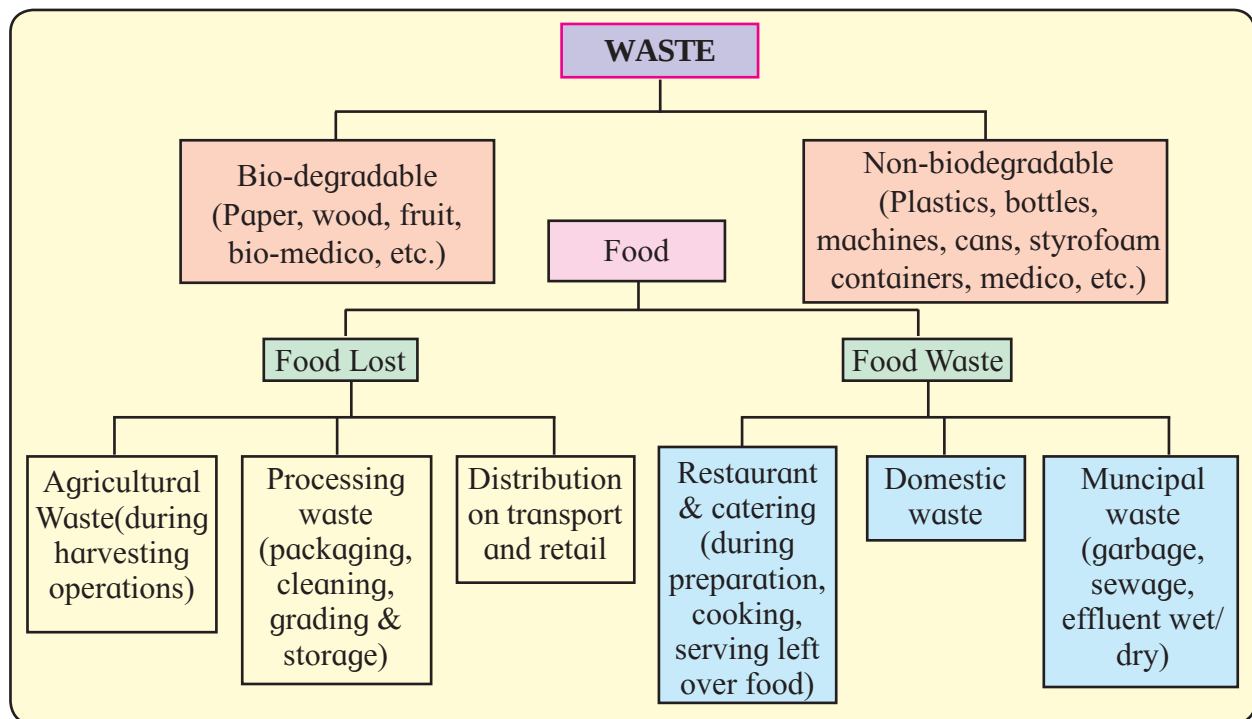
Whereas in UK, the household waste estimated to be 6.7 million MT from purchased goods. This means that approximately 32 % of all food purchased every year is not eaten. Most of this (5.9 million MT or 88%) is currently collected by local authorities. Most of the food waste (4.1 million MT or 61%) is avoidable and could have been eaten if had been better managed.

- The annual food losses and waste are estimated to be about 30% for cereals, 40-50% for root crops, 30% for fish and 20% for oilseeds and meat.

- On globe scale, just 43% of the fruits and vegetables produced are consumed and the remaining 57% are wasted.
- Food waste accounts for roughly US \$680 billion in industrialized countries and US \$ 310 billion in developing countries.
- Roughly one-third of the food is lost or wasted that translates into 1.30 billion MT each year worth nearly one trillion US dollars and equivalent of 6-10 % of human generated greenhouse gas emission.

13.4 Sources of waste

The following are main categories of waste generated.



13.5 Measures of Waste Management

- Effective supply chain management practices to fresh agro produce (fruits and vegetables, dairy products).
- Reduction in food wastage (at processing, storage, distribution)
- Improvement in post-harvest handling practices, transport, storage and distribution of food through appropriate technologies (cold chain, improved packaging, etc.)
- Value addition of the by-products generated in the food industry
- Quick and appropriate disposal of food industry wastage, garbage, effluents, sewage, etc.
- Food lost or wasted should be discarded to avoid environmental pollution (each year it accounts for 3.3 billion tons of carbon di oxide emission globally)
- Government and Community must work collaboratively to achieve policy of zero waste or policy “No to food waste”.

- The agro-industrial residue have high nutritional potential, therefore it can be utilized for production of a variety of by-products, chemicals or any suitable disposal.
- Conversion of waste into valuable product through biodegradation/ composting.
- Fermentation of the solids/ semi-solid waste.
- Formation of 'Food Banks' and its timely distribution to the needy/ hungry population
- Bio gas (fuel gas) production
- Composting through earthworms/ microbes into manure.

13.5.1 Methods of waste management

The waste material generated at different sources is disposed off by various methods; however some of the important methods are given below-

1. **Landfills :** Throwing daily waste/ garbage in the landfills is the most popularly used method of waste disposal used today. The waste is buried in the land; It is most easy and economical method. Landfills are commonly found in developing countries, Landfills give rise to air and water pollution which severely affect the environment and can prove fatal to the lives of humans and animals.
2. **Dumping :** The city garbage and waste in many countries is practiced to collect through garbage collecting vehicles and dumped in open barren space, lying there for many days. Some times it is covered or capped firmly by sheet, so as to avoid the air pollution. It will promote anaerobic fermentation by bacteria and thereby the decomposition and disposal is carried out. After a year or so the decomposed mass is used as manure in the field crops. It requires huge area and long time process, may lead to heavy environmental pollution during rainy season.

3. **Incineration / combustion :** It is a type of waste disposal method in which municipal solid wastes are burned at high temperatures of as to convert them into residue and gaseous products. The biggest advantage of this method is that it can reduce the volume of solid waste to 20 - 30 % of the original volume, decreases the space to take up reduce the stress on land fills. The process also known as the thermal treatment. Where solid waste materials are converted by incineration into heat, gas, steam and ash. It is adopted in Japan as the landfill space is no longer available.

4. **Recovery and recycling :** Recovery is the process of taking useful from the discarded items for a specific next use. The discarded items are then processed to extract or recover materials and resources or convert them to energy in the form of useful heat electricity or fuel (co-generating plant of sugar cane factory).

Recycling is the process of converting waste products into new products. Recycling is the third component of reduce, reuse and recycle waste hierarchy, The idea behind recycling is to reduce energy usage, reduce volume at land fills, reduce air and water pollution, reduce green house gas emission and preserve natural resources for future use.

5. **Composting :** Composting is the process of reducing vegetable and animal refuse or farm waste. Composting is a easy and natural bio-degradation process that takes organic wastes i.e. parts of plants, garden, kitchen waste and turns into nutrient rich manure for plants, composting, normally used for organic farming, occurs by allowing organic materials to sit in place for months until microbes decompose it. Composting is one of the best methods of waste disposal as it can turn organic products into sage compost. On the other side, it is slow process and takes lot of space.

6. **Vermi composting** : It is ideal for biodegradable waste from kitchens, hotels, municipal, waste, etc. A barrel or pit is provided in which the macerated moist waste mass is dumped and mixed with earthworm culture, moistened, covered, sprinkled with water intermittently, kept closed for about 30 days; The compost is taken out in dry form, sieved and then used as manure.

The same mixture is used as earthworm culture which can be used for next lot. Sometimes, microbes also added in the pit or drum to hasten the decomposition process.

7. **Farm Yard Manure (FYM)** : It is the method of composing farm waste. FYM is the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. A rectangular pit is dugged and filled with the above trash material plastered with cow dung earth slurry. The manure becomes ready for use in about 4-5 months after plastering. FYM is the most commonly used organic manure in India.
8. **Sewage and sludge** : The solid portion in the sewage is called sludge and liquid portion is sewage water.
9. **Mechanical composting** : The process of stabilization is expedited by mechanical devices of turning the compost which is stabilization in about 1 to 2 weeks. To enrich night soil, cow dung, etc. are added to the refuge. Usually done in compost pit, require excess moisture, process carried out by micro-organisms within 30 days.
10. **Biogas** : The farm waste, food industry waste municipal wet waste is disposed of by decompositing the wet waste along with cow dung in a close chamber known as bio-gas plant. During the process the cellulose material is decomposed by the bacteria from cow dung slurry and anaerobically into the methane gas, which is used as fuel



Can you tell?

How the waste is disposed off efficiently.

gas for lightening and cooking purposes. The slurry coming out of the plant is dried and used as farm manure. Big size plants are seen in many municipal areas and at rural areas at domestic level.

13.6 By - products of waste

By-products resulting from processing of papaya, pineapple and mango represent approx. 10 – 16% of fruit weight. In case of citrus fruits , amount residues accounts for about 50% of the original fruit weight. Seeds constitute considerable proportion of grape ranging from 38 -52 % on dry mater bases.

- **Pineapple pomace** has good nutritive value, rich in dietary fibers, contains calcium, phosphorus and iron. About 25% of fresh fruit is lost as pomace. Pomace contains about 1.8% ash, 21.5mg / 100gm ascorbic acid and 0.41 % crude fiber .
- **Pomegranate peels** contain 249.4mg/gm. of phenolic compounds as compare to only 24.4 mg/gm of phenolic compounds found in the pulp of pomegranate.
- **Banana peels** constituting about 40% of total weight of fresh banana as a major waste. It is rich source of starch (3%), crude protein (6-9 %) total dietary fiber (43.2-49.7%) and crude fat (3.8-11.0%). Banana peels is a good source of micronutrients (K, P Ca, Mg) PUFA (linolenic acid and alpha linolenic acid) and essential amino acids (leucin, valine, phenylalanine, threonine). Moreover significant amount of lignin (6-12%) pectin (10-11%), cellulose (7.6-9.6 %).
- During **tomato processing**, about 3-7% of the raw material is lost as waste. Tomato pomace generally consists of the crushed are dried skin and seeds of the fruit. Appropriately, the seeds account for 10% of fruit and 60% of the total waste.

The seeds are reported to be good source of protein (35%) and fat (25%). Tomato seed oil is found to be rich in unsaturated fatty acids such as linolenic acid that has largely attracted the interest of researchers. As compared to seeds and pulp, the tomato peel contains higher levels of total flavonoids, total phenolic compounds, lycopene and ascorbic acid exhibiting higher antioxidant activity.

- **Carrot pomace**, generated during processing, contains 14.75% soluble fiber, 30% insoluble fiber, 6.50 proteins, 5.12% ash, 5456 µg total carotenes and 607 µg β-carotene.
- **Chemically, the agricultural wastes** contain 31-60% cellulose, 11-38% pentosane and 12-28% lignin. This product has been reported to be used in the alcohol production. Fruits are very rich in sugar content which can be a very good source of alcohol production.
- **Grape and wine making** industry generate a number of waste and by products. These material include wine pruning, grape stalks, grape pomace, grape seed, yeasts, tartrate, carbon dioxide and waste matter, every by- product will become fertilizers, animal feed or fuel.. The grape seed extracts have gained ground as nutritional supplement in view of its antioxidant activity.

Enzyme production

Grape pomace, main polluting waste from the wine industry, is a good natural medium for solid state fermentation that is used for production of hydrolytic enzymes such as cellulases, xylanses, and pectinases using *Aspergillus awamori*. Proteolytic enzymes such as bromelain is recovered from pineapple pomace and papain from papaya latex. Moreover, orange peel and orange finished pulp, sugarbeet pulping and peas waste are good substrates for polygalacturonase production.

Apple pomace, a waste from the apple processing industry is also used as a substrate for pectinase production by *aspergillus* spp. in solid state fermentation.

Pectin production

Pectin a heteropolysaccharide having properties like capacity to make gels, emulsify and stabilize. The major waste during processing is peel (citrus) which is widely used for the producing pectin powder; other sources of pectin are mango peels, residue of sunflower and guava. Many researchers have given the detail information about utilizing waste of fruit and vegetables. Apple peel, pomace for pectin, guava peels for preparation of guava cheese, water melon rind for pickle making, jackfruit for pectin, pineapple for vinegar production, limes for citric acid, seeds for oil, orange, lime peel can be used for extraction of essential oil, Citrus oil/ orange oil. Banana pseudostem, leaves for preparation of paper pulp and banana fiber (for clothes), green papaya for latex and tutti frutti preparation, other waste and garbage can be used in feed or decomposition of compost manuring.

1. Salad dressing- orange peels and orange waste pulp.
2. Yoghurt- added with grape pomace extract for enrichment of bioactive compound.
3. Grape seed oil rich in polyphenols, antioxidants and vitamins used in cooking oil.
4. Mango stone kernel oil/ fat to be used as cocoa butter equivalent.
5. Pulpy waste in ethanol production by fermentation.
6. Tomato pomace can be used in extruded products.
7. Others for recovery of fiber, vitamins, β-carotene.
8. Natural colouring agents- beetroot (red), leaves (green), paprika (chilli powder),

turmeric (yellow), carrot (orange red), kesar (pink-yellow), radish (anthocyanin).

9. Brewery and wine industry waste- the brewery industry waste are the spent grain, the trub, and the residual yeast. Brewer spent grain (BSG) is the main by-product of brewing industry representing approximately 85% of the total.

13.7 Consequences of waste

1. Wastage of valuable bulk.
2. Loss of bulk nutrients.
3. Loss of functional nutraceuticals nutrients (natural ingredients/ nutrients).
4. Severe problem of their disposal, transport, movement.
5. Being wet/ perishable likely to undergo fermentation quickly; need to provide additional attention.
6. Emission of toxic as well as green house gases (CO₂, CO, methane), microbes, when wasted food is kept open as such or buried in landfills.
7. Air, water, atmosphere get severely polluted due to improper disposal.
8. Loss of energy, manpower, water, land, etc. for growing of the food being lost.
9. Heavy financial loss to the community/ government on disposal.
10. Loss of soil fertility (that soil remain as waste land).
11. Food industry causes health hazards and air pollution to human beings.



Garbage Collection Machine

Exercise

Q.1 A. Fill in the blanks.

1. Disposal of food waste is difficult due to its -----.
2. Wasted food is generated because of over utilization of -----.
3. Major reason for food losses is -----.
4. The example of solid waste is -----.
5. Cheapest method of waste management is -----.

B. Make the pairs.

'A' group

1. Dry waste
2. Wet waste
3. E- waste
4. Agri-waste
5. Muncipal waste

'B' group

- a. CD
- b. Food powders
- c. Plant Trash
- d. Fruit peels and pomace
- e. Machines
- f. Water
- g. Garbage

C. State true or false.

1. Wet garbage is useful for environmental pollution.
2. E- waste disposal is easy for landfill.
3. Fruit pomace are used for production of chemicals.
4. Burning of waste is the most beneficial method.
5. Domestic waste is disposed by land filling method.

Q. 2 Answer in brief.

1. Give various sources of food waste generated.
2. Give example of food waste generated.
3. Discuss any two methods of waste management
4. Give a brief account of pectins.
5. What do you mean by waste management?

Q. 3 Answer the following questions.

1. Explain composting method of waste management.
2. Write in brief about wet waste.
3. Complete the following chart.

Food	Food product
Rice	
Fruits	
Fish	

Q. 4 Answer in detail

1. Explain in detail production of various enzymes from food waste.
2. Give the various consequencec of waste generation.
3. Complete the following chart

Food	Waste
Meat and poultry	
Dairy products	
Beverages	
Oils	