UNIT 17 AGRICULTURAL WASTE MANAGEMENT

Structure

17.1 INTRODUCTION

Agricultural wastes are the excesses and the residues generated from diverse agricultural activities such as farm operation, planting and harvesting of field crops, food processing, dairy and animal husbandry. The wastes are available in the form of wheat straw, paddy straw, maize straw, sugarcane trash, maize cobs, animal wastes, left over ration from the feed lots, and agro-industrial wastes. Intensive cropping, use of high analysis fertilizers and improved management practices have not only resulted in increased crop production but also increased generation of crop residues and the allied wastes. Animal dung is one of the major solid wastes available in country side.

The large amount of organic wastes produced in agriculture is a serious and increasing problem. It has been estimated that 70 % of total expenditure involved in waste management goes to meet the collection and transport charges and the remaining 30 % is spent towards treatment and disposal. Methods of handling, treating or disposing off agricultural wastes may also affect air, water and soil quality. There has been an increasing attention on agricultural waste management with the objective of continued food production while minimizing the environmental pollution. The residual wastes are national resources of large economic value and hold considerable promise for innovations in nutrient cycling in addition to their own utilization. During recent years a good deal of information has been generated for the maximum and efficient utilization and recycling of agricultural wastes and harnessing energy in relation to environment. Composting, vermi-composting, traditional indigenous nutrient management practices, bio-methanation, processing, etc., are some of the technologies for utilization and recycling of the agricultural wastes for improving soil health, producing fuel and manure, processing into value added products and retard the possible deterioration of environmental quality.

This unit deals with the availability and usage of crop residues and their effects on soil properties and crop yields along with different plant products. The practice of composting and vermi-composting as a route for recycling a variety of wastes in agriculture has been dealt. A special emphasis has been made on biogas technology for the economic recycling of animal wastes. The less intensive traditional agricultural practices to restore soil fertility and sustain productivity are also enumerated.

Objectives

After studying this unit, you should be able to:

- enumerate the quantities and the nutritive values of the agricultural wastes for processing and utilization;
- compare the different abilities of agricultural wastes in improving soil health;
- explain the process of composting and vermi-composting for conversion of agricultural wastes into eco-friendly valuable agricultural inputs; and
- describe indigenous and traditional methods of application and conservation of plant nutrients contained in agricultural wastes.

17.2 USE OF CROP RESIDUES

Crop residues are the part of the plants left in the field after crops have been harvested, threshed, pruned or processed. Though they have been regarded as waste materials that require disposal but it is now increasingly being realized that these are a tremendous natural resource and not a waste. Following traditional practices, farmers of South Asian Countries remove the major portion of crop residues from the fields for use as cattle feed, livestock bedding, thatching material for houses and fuel. Recently because of advent of mechanized harvesting, farmers prefer to burn large quantities of crop residues left in the field in sites as these interfere with tillage and seeding operations for the next crop. Burning of residues causes a serious waste of precious nutrient resource and contributes to intense air pollution.

Annual production of wheat and rice in India during 1999-2000 was 71.78 and 88.55 million tonnes respectively, amounting to generation of 258 million tonnes of straw. This accounts for about 70% of total crop residues available in India. About 45 million tonnes of fruit and vegetables wastes accumulate each year and an estimated 25 million rupees are lost annually.

India, having a large bovine population of 282 million heads, houses 50% of world's buffaloes and 15% of all goats and cattle in the world. Availability of dung from a total livestock population of 459 million is about 354 million tonnes per year. Cattle and buffalo alone make up 60% of total livestock population and are the source of 91% of total dung produced.

Proper use of crop residues provides a highly effective means for

- controlling soil erosion and sediment transport,
- reducing nutrient losses through runoff to streams, and
- supplying organic matter to maintain good soil tilth.

When incorporated into the soil or placed on its surface, crop residues and the resulting soil humus

- improve infiltration rates,
- reduce soil crusting,
- enhance soil aggregation, and
- increase the soil's water holding capacity.

Renewable organic matter from farm wastes can be novel closed systems efficiency utilized as a raw material for:

- the recovery of renewable energy as methane in biogas;
- the production of soil amendments/bio-fertilizers that contain energy plant nutrients and beneficial micro-organisms;
- the production of the environment as each yearly addition will increase the carbon sequestering abilities of soils.

So it may be said that we need a residue management system which will be ecologically favourable, economically profitable, environment friendly, holistic and resource efficient.

Availability and Usage

With the increase in food grains production, the production of crop residues has also proportionately increased. The use of mechanical harvesting in big farms leaves more residues for *in situ* utilization. Of the various considerations it is assumed that about one third of total crop residues can be made available for land application thus providing a gross annual nutrient potential of the order of million of tonnes in these countries.

Table 17.1: Estimates of the availability of some crop residues in India and their plant nutrient potential

Crop	Residue to economic yield ratio	Residue yield* ('000t)	Nutrient (%)			Nutrient potential, '000 tonnes		
			N	P_2O_5	K_2O	Total	Utilizable**	Fertilizer Equivalent***
Rice	1.5	110,495	0.61	0.18	1.38	2,398	799	399
Wheat	1.5	82,631	0.48	0.16	1.18	1,504	501	250
Sorghum	1.5	12,535	0.52	0.23	1.34	262	87	43
Maize	1.5	11,974	0.52	0.18	1.35	252	84	42
Pear millet	1.5	6,967	0.45	0.16	1.14	121	40	20
Barley	1.5	2,475	0.52	0.18	1.30	51	17	8
Finger millet	2.0	5,351	1.00	0.20	1.00	118	39	19
Sugarcane (stripped cane)	0.1	22,736	0.40	0.18	1.28	423	423	211
Potato tuber	0.5	7,867	0.52	0.21	1.06	141	141	70
Groundnut (pods)	1.5	10,598	1.60	0.23	1.37	339	339	169
Total		273,629				5,609	2,470	1,231

* Arrived at by multiplying the economic yield by the given residue: economic yield ratio.
** One- third of the total NPK potential assuming that two third of the total residue is used as animal feed on national basis.
*** 50 % of the utilizable NPK assuming 50 % mineralisation of NPK per season.
Source: Bhardwaj (1995)

Approximately 450 million tonnes of crop residues are produced annually in India. Estimates for the year 1991-92 give a total annual residues potential of 273 million tonnes with an associated nutrient potential of 5.6 million tonnes (Table.17.1).

Thus, the crop residues returned to the soil can potentially supply a substantial portion of the nutrient requirements for the succeeding crops. Besides, crop residues offer many benefits to soil fertility productivity.

17.2.1 Improvement in Soil Properties and Crop Yields

Freshly added crop residues play a significant role in improving the physical condition of soil, making it more favourable for optimum plant growth. The observed beneficial effects of residues incorporated may, therefore, be attributed mainly to improvements in the overall physical, chemical and biological properties of soils. We discuss some of these here.

Biological properties: Nitrogen immobilization

After the crop residues are incorporated into soil, a host of micro-organisms bring about mineralisation of carbon and other elements contained in the residues. This is accompanied by a large increase in soil microbial populations and evolution of carbon dioxide from the residues-treated soils. The microbiological activity is maximum during the first one to two weeks. During the active decomposition period, tremendous amount of mineral N (native or added) is immobilized by the micro-organisms into their body cells. This results in a temporary depletion of N during the initial stages of plant growth. Besides being a handicap from immediate plant nutrition point of view, immobilization is a means of conserving N. The mobile forms of N subject to leaching and denitrification are covered and subsequently re-mineralized.

The process of nitrogen immobilization has great practical significance in the management of crop residues in cropping systems. Therefore, sufficient time should be allowed for the decomposition of residues before the crop is sown. Alternatively, immobilization effect can be overcome by adding some fertilizer N to the residues.

The adverse effect can also be overcome by allowing adequate time for the decompos ition of organic residues before the sowing of crops.

Physical Properties: Erosion Control

As you have learnt in Units 6 and 10, sediments from erosion is our nation's greatest water pollutant. Returning crop residues to the land as surface mulch is a very effective and economical practice for reducing runoff, wind and water erosion, and water transport of sediments to streams. Prudent use of crop residues can reduce erosion over a wide range of soil and cropping conditions, from losses of 25 to 62 tonnes / hectare per year, or more, to 12.5 tonnes/ hectare per year, or less.

Soil moisture conservation

Crop residues cover plays a key role in moisture conservation for better crop yields in dry land areas. Surface residues trap snow and reduce evaporation. The residues increase infiltration by slowing the flow of water over the soil surface and increase soil moisture holding capacity. **Farmers in drought prone areas should always retain crop residues.**

Soil organic matter maintenance

Soil organic matter is a critical component of the soil and serves many purposes. Soil organic matter contributes to the soil structure stability and resistance to erosion. It is a storehouse of food for soil microbes. It stores carbon thereby opposing any build up of atmospheric carbon dioxide (a green house gas) and global warming. The addition of plant materials or other organic substances build or maintain soil organic matter. An often-asked important question is how much crop residues should be retained to have a sufficient level of soil organic matter? There is however no definite rule for the level of organic matter to be recommended for each soil type or zone. It may vary according to soil texture, initial organic matter content, management system and climate especially moisture and temperature.

For low organic matter soils, retaining crop residues is very important to maintain sufficient soil organic matter. For soils with high level of organic matter, the annual addition of straw may not always be critical; adequate fertilizer or use of zero tillage is often as important as straw retention for building soil organic matter levels.

Detrimental effects

It is generally agreed that crop residues returned to the land produces beneficial effects. However, problems crop up where crop residues are excessive and they are applied at loading rates that exceed the soil's capacity to decompose them within a reasonable time. In such cases, residues tend to accumulate because of slow rates of decomposition. This situation could lead to the microbiological production of chemicals and toxins that may adversely affect plant growth. Moreover, since many mature crop residues have a high carbon: nitrogen (C:N) ratio, excessive residues loading rates on soils can lead to immobilization of plant available nitrogen, resulting in nitrogen deficiencies in crops, a problem which can be offset only by application of additional fertilizer nitrogen.

The presence of excessive amount of residues, particularly of surface residues, can also cause physical obstructions that interfere with normal tilling and planting operations. This can often result in poor seed germination, stand reduction, phytotoxic effects, non-uniform moisture distribution, immobilization of nitrogen in a form unavailable to plants, and increased insect, disease and weed problems. Currently, excess residues are often burned, causing air pollution and other environmental problems.

Crop yields

In general, the residue incorporation may bring about an overall improvement in physical, chemical and biological properties of the soils. Many short and long-term experiments in India and elsewhere have shown mixed effects of crop residues incorporation on crop yields. The incorporation of wheat residues in general, increased the yield of rice and also had a positive residual effect on the yield of subsequent wheat in rotation. However, the incorporation of rice straw in wheat and wheat straw in rice caused yield reduction. High crop yields were obtained from the combined long-term use of fertilizers and crop residues. It has been realized that if sufficient time (25-30 days) is allowed for residue decomposition in the soil, the immobilization effect is greatly reduced. Control of weeds, diseases and pests is important for the success of residue management practices.

17.2.2 Application of Farm Refuse and Crop Residues

The higher level of crop production through the increased use of fertilizers and pesticides has created ecological imbalance and affected sustainability of crop production. It is now being realized that the yields are declining year after year with the same level of inputs use. Since exploitative agriculture with an immediate profit motive will lead to shrinking of natural resource base (land) for crop production, there will be no option but to produce more food and other agricultural commodities from its limited available land. The need for more food has to be met through higher yields per until of land, water, nutrient, energy and time.

It has thus become imperative to adopt appropriate blend of the traditional agricultural practices of the pre-green revolution era and the modern technology to restore soil fertility and sustain productivity. Traditional indigenous nutrient management practices popularly followed in most regions are:

- Application of farm yard manure (FYM) to the field.
- Use of rice straw/husk, wheat bhusa as bedding materials in the cattle shed.
- Storage of cow/buffalo dung in the ground surface for 6-8 month and its subsequent broadcast in the field during summer.
- Browsing of residues of harvested crops during summer by herds of goats and sheep
- Burying weeds and wild rice in rice field, which eventually decompose and augment plant available nutrient supply.
- Mulching: crop residues such as sorghum straw, soybean trash, dried weeds are used for this purpose. Mulching reduces runoff, reduced losses of soil and plant nutrients from cultivated lands.
- Polas (*Butea monosperma*) leaves are commonly used as mulch in vegetables for controlling weeds and conserving soil moisture. Subsequently, dried leaves are incorporated into the soil with a view to enrich soil which results in higher yield and nutrient use efficiency.
- Coating of urea with neem, mahua, karanj, sal cakes by physically mixing before application.

We cite below some practices specific to particular states in India:

- Khadin cultivation in Western Rajasthan.
- Permanent set furrow system for groundnut cultivation in Gujarat.
- Vermiculture through rishi-krishi method of Maharastra.
- Haveli and bundh cultivation in Madhya Pradesh.
- Collection and dropping of sheeps and goats followed by organic farming in Himachal Pradesh.
- Use of jute leaves as potential source of manure in West Bengal and Orissa.

- Recycling of nutrient through pond excavation, animal hey bed compost technology in Punjab.
- Application of sudumannh (burnt soil) in coastal Karnataka.
- Use of fresh dung for vegetable cultivation in Kerala.

These are the appropriate technologies innovated, tested/improved and implemented by the local peasants. These indigenous practices aim at adding organic matter to the soil, utilization of locally available waste materials and rational use of natural resources.

17.2.3 Competitive Uses of Crop Residues

There are two major competitive uses for crop residues as:

1) animal feed
2) energy source.

In addition, there is also some potential for industrial use.

1. Animal feed

Crop residues have considerable potential as feed for livestock and provide a portion of the roughage requirements of ruminants and horses. The nutritional value of the different types of crop residues varies widely. Low digestibility, however, is associated with the high lignin content in some crop residues. Transportation and processing cost are the chief limitations to wide scale utilization.

2. Energy source

Crop residues are used as an energy source for agriculture and industries. Technologies to convert crop residues into energy falls into two categories: **biological** and **thermo-chemical**.

Biological processes like **anaerobic digestion** and **alcoholic fermentation,** involve enzymatic break down of biomass by micro-organisms at low pressure and low temperature. The anaerobic digestion for the conversion of agricultural residues into fuel (biogas) and manure is considered as one of the most feasible technologies to meet the challenges of depleting reserves of fossil fuels and escalating deforestation.

The utilization of agro-residues for the production of ethanol, the biofuel has been considered as a source to meet the partial energy demand. Rice straw in North west India is neither currently utilized as livestock feed nor for any other purpose. Farmers in order to vacate the fields for timely wheat planting generally burn much of it. This straw could be an ideal and cheap substrate for ethanol production. To give you some idea, a rough estimate indicates that such rice straw is more than 5 million tonnes in Punjab and Haryana alone. Based on this, it is estimated that assuming the ethanol potential of crop residues is about 250 litres/tonne of the straw, the ethanol potential of the straw alone would be 1250 million litres. This is sufficient to meet 10 % blending requirement for gasohol of India at present (Sushil Kumar, *et. al.*, 2002).

Thermo-chemical processes use high temperatures to convert residues into energy by direct combustion, pyrolysis, gasification and liquefaction. Briquetting of agricultural residues helps in direct burning of biomass effectively. Briquetting is the conversion of solid fuel in the form of small pellets. It can be produced by compacting crop residues either directly or after pyrolysis.

Gasification implies the extraction of combustible gas (producer gas) from residues by burning them under conditions of limited air supply. In the presence of oxygen, carbon and moisture, agricultural residue is converted into a mixture of CO and H_2 gas, which is combustible in nature. Collection, transportation, and conversion costs are currently limiting the use of crop residues for energy. Nevertheless, the use of residues for energy seems feasible in areas where large volumes of residues are available in excess of the demands for other uses.

Industrial uses

Crop residues are now being used as raw materials in various chemical industries. For example, the plastics and pharmaceuticals industries use substantial amounts of certain crop residues. Corncobs are used to prepare mild abrasive and polishes, to absorb oil spills, and to make some cosmetic powders. Limited amounts of crop residues are used in the production of particle board, insulation, and paper. An additional potential use is in the production of single cell protein (SCP) by micro-organisms. Crude protein produced by this process may eventually become a major source of food for animals and people as well.

Cost of collection, processing, transportation and application

The cost of collection, transportation, and application of crop residues are minimal or zero when crop residues are returned to the land on which they are produced. Even where crop residues are available for land application, problems of their collection and transportations to the fields exist. Their manual handling is also laborious due to the bulk involved. In addition, most residues need some type of pre-incorporation, physical processing or shredding to facilitate their rapid decomposition in the soil. This needs suitable machinery, which is not available in most areas. Turning under by tractor discing is the common mode of incorporation by the farmers who own or rent tractors.

Large cultivated areas in South Asian countries are rainfed where the fallow periods generally fall under the dry months of the year. Hence, provision of adequate moisture for optimum decomposition of the incorporated residues is another limitation that restricts gainful recycling of these materials. Faced by these constraints, many cultivators generally prefer to burn the residues to clear the fields for tilling and planting. If the volume is small, the residues are converted into compost by natural decomposition.

Since crop residues are such a rich source of nutrients, fodder and fuel, we should ensure that these are judiciously recycled and reused. You will learn about these aspects in the next section. But you may like to first consolidate the ideas presented so far.

SAQ 1

a) How can crop residues control soil erosion due to wind and water?
b) Why and when should we incorporate crop residues in the soil?

17.3 ECONOMY THROUGH RECYCLING

Recycling of wastes for meeting the shortages of raw materials for industry and inputs for agriculture is an important aspect of national economy. Serious efforts in this direction could reduce the cost of production and ensure rich dividends as well as solve the disposal problem and minimize pollution effects.

The greatest benefit from cycling and recycling organic material in soils is the overall improvement in soil productivity/fertility, which is the key component. Our soils being in tropical zone are poor in organic matter due to high rate of decomposition and intensive cultivation. The organic carbon content is less than 1% in most of the soils in the plains. They are very low to low in N, low to medium in P and medium to high in K.

Since most of the recycles are organic, they directly add organic matter and plant nutrients, which improve the soil bio-physico properties and fertility, thus improving soil productivity. The old practice of fallow cultivation if combined with paddy straw incorporation will have many economic benefits such as

- increase in the return per unit land area,
- increase in the carbon content of the soil,
- enhancement in soil fertility,
- conservation of water resources,
- saving in the use of chemicals for weed control, and
- reduction in environmental pollution by not burning the straw.

Studies show that the recycling of different crop residues in soil by way of mulching (6t/ha) resulted in saving of irrigation water, induced reduction in maximum soil temperature and increase in the crop yield (Table 17.2).

Table 17.2: Effect of straw mulching on different crops

Crop	Mulch induced reduction in max. soil temp. (°C)	Saving irrigation water (cm)	Increased in crop yield (%)	Saving in fertilizer N (kg/ha)
Maize (forage)	1.1-7.9	15	26	50
Maize (grain)	1.4-6.8	-	20	-
Sugarcane	1.0-9.5	40	13	-
Sorghum (forage)	0.5-7.0	23	20	50
Japanese mint	0.6-9.4	32	9	25
Mung bean	0.8-9.1	7	17	-
Winter maize (grain)	2.0-5.5	23	20	-
Autumn potato	1.0-5.7	12	15	-

In a recent survey it has been estimated that the quantities of rice straw burnt in Punjab annually is about 12 million tonnes and through this, significant amounts of nutrients are being lost. Calculated in economic terms, the Punjab farmers are losing Rs. 684 million annually through N alone in the form of fertilizer. Moreover burning of rice straw is posing serious threat of air pollution and increasing respiratory problem to local population. However, application of 8 tonnes of rice straw compost per hectare to both rice and wheat increased the yield by 51% and 40%, respectively.

The process of composting and vermi-composting converts a wide variety of wastes into valuable agricultural inputs, which are an excellent source of humus and plant nutrients. Composting of organic residues and using them on farms can reduce the fertilizer dependence by about 25 %, besides improving the soil physical properties and health. It has been reported that the continuous application of 15 t FYM/ha could save 30 kg N and 20 kg P_2O_5 in rice-wheat cropping system. Vermi-composting is an efficient and inexpensive method of composting. On an average, the vermi-compost makes up 63% of total benefits, the worms and the waste disposal brings out the saving of 29% and 8%, respectively. Recycling of animal dung through the biogas plant can save enormous amount of firewood and produce the enriched manure. We now discuss the process of composting and vermi-composting as a route of recycling agricultural wastes.

17.3.1 Composting

Composting is an age-old process that simulates nature's method of recycling. It is the microbial decomposition of piled organic materials into partially decomposed residues, called as **compost** or **humus**. It occurs in the presence of air (aerobic) or in a closed container or underground (anaerobic).

Why composting?

Application of organic materials or crop residues to the soil if not treated properly may pose certain consequences. Materials low in nitrogen (sawdust, straws) may cause a lack of available nitrogen to growing plants in the first few weeks of rapid decomposition because nitrogen in the soil and that released by decomposition are preferentially used by soil bacteria. The decomposition of some materials may release substances that are toxic to plants or contain seeds of noxious weeds, diseased organisms, viruses, or certain parasitic worm eggs and have unpleasant odors.

Composting can alleviate most of these problems and make organic matter suitable for later disposition onto soil. Phytotoxins and bad odors produced during early stages of decomposition of some organic materials are dissipated by evaporation of the substances at the elevated temperatures while in the composting bed. By the time the compost is added to the soil, most toxins and undesirable odors are gone or appreciably reduced.

Materials suitable for composting

A wide variety of by products and wastes can be used for composting. There exists an enormous potential of agricultural, rural and urban wastes in all these countries. The materials of compost from farm refuge include weeds, stubbles, straw, crop residues, remnants of fodder, hedge clippings, animal wastes, etc.

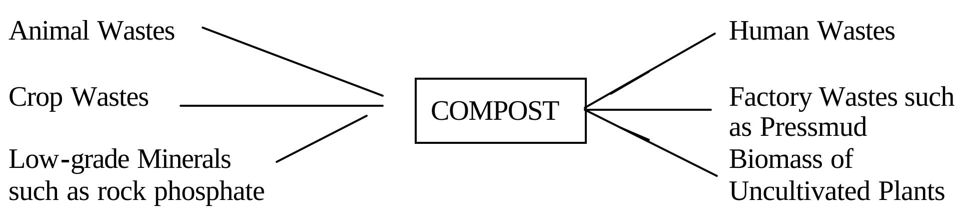

Fig.17.1: Materials suitable for composting

Process of composting

Composting is a fermentation process, which involves the break down of organic materials aided by an array of micro-organisms, earthworms and other insects in the presence of aerial moisture. This process yields compost (residual organic material often referred to as humus), ammonia, carbon dioxide, sulphur compounds, volatile organic acids, water vapour and heat. Typically the compost produced is 40-60 % of the volume of original wastes. The microbiological nature of composting requires several environmental parameters for the growth and proper functioning of numerous organisms which have an access to and synthesis compounds such as C, N, O_2, H_2, inorganic salts, sulphur, P and trace substances of micronutrients.

Optimum Parameters

1. **C:N ratio:** The key to initiate and maintain the composting process is to keep the C:N ratio between 25:1 and 30:1. When C:N ratio is in excess of 30:1, the decomposition process is suppressed due to inadequate N limiting the evolution of bacteria, that is essential for breaking strong C bonds. A C:N ratio of less than 25:1 will produce rapid localized decomposition with excess N given off as NH_3 which is source of offensive odours. Attaining such balance of ratio and range is possible because all organic materials have a fixed C:N ratio, e.g. food waste has

a C:N ratio of 15:1, grass clippings have a C:N ratio of 19:1, leaves have a C:N ratio of 60:1. When these and other materials are mixed in the right proportion, they provide optimum C:N ratio for composting. Typically N is the limiting component, that is encountered in waste materials and when insufficient N is present, the composting mixture can be augmented with fertilizers such as urea or ammonium nitrate.

2. **Particle size:** In addition to nutrients, the efficiency of composting process depends upon the size of the organic material and its surface characteristics. Small particles provide multifaceted surfaces for microbial action. Size also influences porosity (crevices and cracks which can hold H_2O) and permeability (circulation or movement of gases and moisture).

3. **Moisture content:** Moisture is an essential component in the biological degradation process. A moisture level of 55-60 % by weight is required for optimal microbial nutrient and air circulation. Below 50 % moisture, the nutrients to sustain microbial activity become limited, above 70 % moisture, air circulation is inhibited.

4. **Air flow (Aeration):** Air circulation controls the class of micro-organisms that will predominate in the composting process. Air breathing micro-organisms are collectively termed as **aerobic**, while those that can exist in the absence of air are called **anaerobic**. When anaerobic micro-organisms prevail, the composting process is slow and unpleasant, smelling NH_3, or H_2S which is frequently generated. Aerobic micro-organisms quickly decompose organic material into its principal components of CO_2, heat and water vapour.

5. **pH control:** The role of acidity and alkalinity in the composting process depends upon the source of organic material and predominant organisms. Anaerobic organisms generate acidic conditions, which can be neutralized with the addition of lime. Organic material with a balanced C:N ratio will initially produce acidic condition of 6.0 on pH scale. However, at the end of the process, mature compost is slightly alkaline with a pH >7.0 and <8.0.

6. **Temperature:** The regulation and measurement of temperature is fundamental to achieving satisfactory process of organic material decomposition. However, the effect of ambient temperature or surface temperature on the process is limited to periods of intense cold when biological growth is dormant. Expeditious processing and reduction of herbicides, pathogens and pesticides is achieved where internal temperature in the compost pits are maintained (55-60 °C). If the internal temperature is allowed to reach or exceed (65 °C), biological activity is inhibited due to heat stress.

7. **Activator:** The use of compost inoculants is known to speed up the process. These are cellulolytic and lignolytic microorganisms like *Trichurus spiralis*, *Paecilomyces funisporus*, *Trichoderma* and *Asperigillus* spp. Inoculation with mesophilic cellulolytic fungi are known to reduce the time needed for completion of the process and improve the quality of final product.

Methods of composting

There are several methods of composting:

Indore method (Heap method): The waste materials are chopped into small pieces of 5-10 cm size and are dried to 40-50% moisture before stacking. Then, they are spread in layers of 10-15 cm thickness either in pits or in heaps of 1m width, 4-6 m length and 1 m depth. The heap is properly moistened with dung, using earth or night soil. Sufficient quantity of water is sprinkled over the heap to wet the composting materials to the level of 50% moisture. Periodical turnings, usually three times at 15, 30 and 60 days after filling, are given to aerate and the material is covered with a thin layer of soil about 2-3 cm thickness. The compost obtained by the Indore method would have a composition of 0.8 % N, 0.3% P and 1.5% K_2O.

Bangalore method (pit method): The composting of the vegetative waste is done in the pits. The size of pit ($9 \times 2.1 \times 0.9$ m) varies with the quantity of material available for composting. A 22 cm thick layer of waste material is first laid in the pit. On each layer is spread slurry made of dung, urine and earth. A sufficient quantity of water is sprinkled over the material in the pit to make it moist but not too wet. The pot is filled in this way, layer by layer till it rises 2 ft above ground level. At the end dome shaped heap is plastered over with wet mud. It is left undisturbed. The compost is ready in about 4 to 5 months. This method overcomes many of disadvantages of the Indore-method like turning etc. After the initial aerobic decomposition during the first eight to ten days (i.e, filling of pit is going on) the material undergoes semi-anaerobic decomposition. Under these conditions, the decomposition is more gradual and slow. The process ensures less loss of organic matter and nitrogen. Therefore, this method is known as developed or superior method. The compost obtained by this method would contain 1.5% N, 1.0% P and 1.5% K_2O.

NADEP compost: In this method, plant wastes, dung slurry and clay soil are used as raw materials for composting. The process is similar to heap method of composting, but is done in brick lined enclosures provided with air holes in all sides.

Coimbatore method: It is anaerobic degradation followed by the aerobic process. In a pit of 4 m length, 2 m width and 1 m depth, crop residues are filled to a thickness of about 15 cm. Over this layer, cow dung slurry is applied to a thickness of 5 cm to enhance the rate of biodegradation. Above this layer, 1 kg of bone meal or rock phosphate is applied to minimize the nitrogen loss and to add phosphorous. Alternate layers in this fashion are filled till the height reaches 0.5 m above the ground level. Then the above-ground portion is covered with red earth or mud to prevent the rainwater entry and it becomes an anaerobic process. After 30-35 days, the material is turned and it becomes an aerobic process. The compost will be ready within five months.

Windrow composting: Windrowing is a method in which long narrow piles of organic matter are periodically turned and moistened as necessary to allow sufficient oxygen to penetrate all the parts of the pile or, alternatively, air can be blown into the piles. Windrows are usually about 3 m wide at the base and 1.5 m high. Temperature within a windrow approach is 140 ^{0}F, entirely because of biological activity. The pH will approach neutrality after an initial drop. Windrowing composting requires large land surfaces and a month to several months time to produce satisfactory results.

Mechanized composting: On a community scale, composting may be a mechanized operation, using anaerobic digesters or a low-technology operation using long rows of shredded refuse known as windrows. The machinery used varies according to the kind and quality of the materials to be treated. Digesters are usually enclosed composting systems where moisture, temperature, nutrients and mixing are carefully controlled. Some refuse digesters take only a few days for processing, but equipments costs are high compared with other composting practices.

Characteristics of mature compost

The matured compost should have an earthy smell, similar to peat moss and a dark brown colour. Typical final compost will have composition in the following range:

Organic matter	25-50 %	Carbon	8.40 %
Nitrogen	0.5-3.5 %	Phosphorous (as P_2O_5)	0.5-3.5 %
Potassium (as K_2O)	0.5-2.0 %	Calcium (as CaO)	2-7 %
Incombustible matter	20-60 %		

The average nutrient contents of some common composts are given in Table 17.3.

Table 17.3: Average nutrient content of some common composts of animal and plant origin

Manures/Composts	Nutrient Content (%)		
	N	P_2O_5	K_2O
Farm Yard Manure	0.80	0.41	0.74
Poultry Manure	2.87	2.93	2.35
Rural compost	1.22	1.08	1.47
Urban compost	1.24	1.92	1.07
Mixed farm wastes	0.87	0.59	2.22
Mixed dry residues	0.90	0.45	1.95
Cotton stalks	1.61	0.48	3.38
Water hyacinth compost	2.00	1.00	2.30
Paddy straw	1.59	1.34	3.37
Dry grass/ weeds	1.90	0.55	1.09
Cotton wastes and groundnut husk	1.62	1.04	1.26
Lantana stalks and leaves	1.55	0.52	1.07
Wheat straw	2.90	2.05	0.90
Maize stalks	1.99	1.30	1.01
Sugarcane trash	2.73	1.81	1.31
Vermi-compost	1.60	2.20	0.67

Enrichment of compost

Compost is bulky and low in major plant nutrients such as N, P and K. Hence there is a need to improve its quality. The missing ingredients can be added to the compost, assuming that the nutrients are tested for and determined to be deficient. Nitrogen, phosphates, and lime are the most frequently added. Fertilizers, legumes, seed meals, manures, and animal slaughter wastes (dried blood, fish carps, tankage) are commonly recommended materials that can improve composts. Presently these materials are more often used for animals feed rather than having their energy wasted on microbial growth in composts. Some examples of the enriched compost are:

- Phosphocompost made from organic refuge (crop residues, leaves, grasses, weeds, etc.), cattle dung or biogas slurry, soil, well decomposed FYM and Mussoorie rock phosphate. It contains 68 % P_2O_5.
- Granulated compost (15-15-5) consisting of 44 % conventional compost, 25 % DAP, 22 % SSP, 1 % urea and 8 % MOP.

SAQ 2

What are the essential conditions for the production of a good quality compost? Enumerate various changes that take place during composting.

17.3.2 Vermi-composting

Vermi-compost refers to organic manure produced by earthworms. It is a mixture of worm castings (faecal excretions or excretions or excreta), organic material including humus, live earthworms, their cocoons and other organisms. Vermi-composting is the most appropriate technique for disposal of non toxic solid and liquid organic wastes. It helps in cost effective and efficient recycling of animal wastes, agricultural residues and industrial wastes. **Vermiculture** is the process of culturing earthworms in various kinds of wastes material and using the excretion of the earthworms as manure.

Vermi-composting process

Earthworms accelerate the process of breakdown of wastes greatly by fragmenting the organic matter, thereby increasing the surface area available for growth of micro organisms and thus promoting further breakdown. A number of steps are involved in the **preparation of good quality vermi-compost.** We describe them below .

- **Selection of earthworm:** Earthworm which is native to the local soil may be used for vermi-composting.
- **Size of pit:** Any convenient dimension such as 2 m × 1 m × 1 m may be prepared. This can hold 10-40 thousand worms giving one tonne manure per month.
- **Preparation of vermin bed:** A layer 15-20 cm thick of good loamy soil above a thin layer (5 cm) of broken bricks and sand should be made. This layer is inhabited by earthworms.
- **Inoculation of earthworms:** About one hundred earthworms are introduced as an optimum inoculating into a compost pit of about 2 m × 1 m × 1 m. provided with a vermibed.
- **Organic layering:** It is done on the vermibed with fresh cattle dung. The compost pit is then layered to about 5 cm with dry leaves or hay. Moisture content of the pit without flooding is maintained through the addition of water.
- **Wet organic layering:** It is done after four weeks with moist/green organic wastes which can be spread over it to a thickness of 5 cms. This practice can be repeated every 3-4 days. Mixing of wastes periodically without disturbing the vermibed ensures proper vermi-composting. Wet layering with organic wastes can be repeated till the compost pit is nearly full.
- **Harvesting of Vermi-compost:** At maturation, the moisture content is brought down by stopping the addition of water for 3-4 days. This ensures drying of compost and migration of worms into the Vermibed. The mature compost, a fine loose granular mass is removed out from the pit, sieved, dried and packed.
- **Rate of application:** Mature Vermi-compost is recommended @ 5t/ha.

The successive layers to be made for vermi-composting are shown in Fig. 17.2.

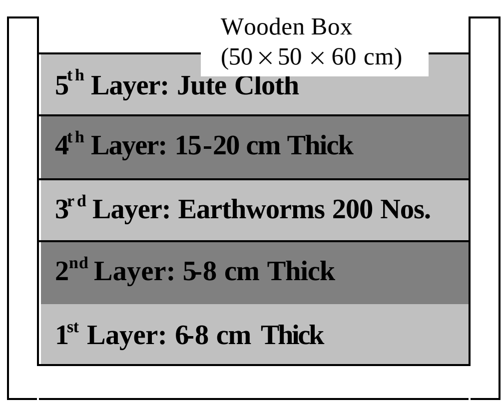

Fig.17.2: Layers in a wooden box for the preparation of Vermi-compost

Nutrient content of vermi-compost

Vermi-compost is an excellent soil additive made up of digested and undigested compost. The digested part is known as worm castings. Worm castings are much higher in nutrients and microbial life and are of higher value product. Worm castings contain up to 5 times the plant available nutrients found in average potting soil mixes. The nutrients are readily available to the plant. There is abundant evidence to show that concentration of exchangeable Ca, Na, Mg, K and available P and Mo are higher in earthworm casts than in the surrounding soil (Table 17.4).

Application of vermi-compost

Castings should be spread liberally around plants to a minimum depth of approximately 2-3mm. They should be lightly covered over with soil and watered in to encourage growth of bacteria and hatching of baby worms. Castings may be used safely on all plants, including indoor plants. In orchards the dose depends on the age of the tree. A deep ring of 15-30 cm should be formed around the tree. A thin layer of dry cow dung and bone meal with 2-5 kg of vermi-compost is then applied. This is covered with thin layer of soil and is mulched with organic matter and a light spray of water is given. For general use in agriculture, Vermi-compost should be applied @ 5 t/ha. Vermi-compost is mixed with equal quantity of dried cow dung and broadcast when seedlings are 12-15 cm high and water should be sprinkled.

Table 17.4: Comparison of the available mineral elements in the cast of earth worms and in the upper layer of ploughed soil

Particulars	Earthworm cast	Depth of soil layer	
		0-15 cm	20-40 cm
Loss of ignition (%)	13.1	9.8	4.9
C:N ratio	14.7	13.8	13.8
NO_3–Nitrogen (ppm)	130.0	20.8	8.3
Available P (ppm)	130.0	20.8	8.3
Available K (ppm)	335.0	32.0	27.0
Exchangeable Ca (ppm)	2.7	1.9	1.8
Total Ca (%)	1.1	0.8	0.8
Total Mg (%)	0.5	0.5	0.5
Exchangeable Mg (ppm)	49.2	162.0	69.0
pH	7.0	6.3	6.0

Advantages

Vermi-compost is a "live" product. It contains soil benevolent bacteria. Vermi-compost may contain up to 1000 times more soil benevolent bacteria than the original organic material consumed by the worms. Soils treated with vermi-compost produce stronger, healthier and more disease resistant plants. Vermi-compost is a rich source of phosphorous, nitrogen, potassium, calcium and magnesium. The unique action of worms' digestive systems on organic matter has made these minerals more readily available to the plants. Vermi-compost is formed of aggregates, which are mineral granules bonded together in such a way that they are resistant to wind and water erosion and compaction.

Economic Benefits

The potential economic benefits of vermiculture are the (i) worms, (ii) worm-worked wastes (vermi-compost) and (iii) reduction in waste disposal costs. It is estimated that the earthworms numbering 1000 fed on 300 kg FYM, 350 kg garbage in an area of 100 ft^2 give a recovery of at least 400 kg compost and about 25,000-30,000 earthworms, thus making substantial monetary profits. In comparison with other feedstuffs, earthworms are high in protein and essential amino acids. Assuming that the dried earthworms can substitute for existing protein sources in animal feed rations, their values per tonne would be high. Vermi-compost is odourless compost, similar to peat, which is potentially valuable in agriculture. Vermi-compost is 5 times richer in N, 7 times richer in P, 11 times richer in K, 2 times richer in Mg and Ca and 7 times richer in actinomycetes than the ordinary soil. Besides it contains valuable vitamins, enzymes and hormones like gibberline.

The third area of benefit which could result from vermic ulture is reduction of waste management costs. The cost of handling, storage and reduction of wastes are substantially greater than their manurial value. The reduction in volume that occurs when worms are grown on it brings about reduction in waste disposal costs. On the average, the compost makes 63 % of total benefits, the worms 29 % and waste disposal savings 8 %. While the figures vary accordingly to the assumed values of the worm and compost, they are more or less the same for all sizes of unit.

SAQ 3

Do you agree that vermi-composting should be promoted on a large scale in developing countries? Justify your answer.

17.4 RECYCLING OF ANIMAL WASTES

Wastes of animal origin are one of the major underutilized resources in many countries. These wastes are available either in dairies, slaughterhouses, near the cities or in the backyards in rural houses. Their presence is a source of nuisance and pollution since they contain pathogenic organisms and produce unbearable smell. The scattered and bulky nature of these wastes and their smell pose collection and transportation problems although many of these are valuable sources of organic matter and plant nutrients. In the past, these wastes were mainly used as manures and were important in sustaining sustenance agriculture. Recently, research efforts have identified several uses of these wastes for fuel and manure, as substrates for microbial protein synthesis and as ingredients for animals feed.

Availability

Availability of dung from animals varies with the type of the animal. It has been estimated that cattle on an average produce 10-15 kg of fresh dung/day whereas the buffaloes give 15-25 kg fresh dung/day. Cattle and buffaloes make up a large proportion of total livestock population in South Asian countries.

Composition

The composition and characteristics of excreta are a function of the composition of the feed ration, its digestibility, species of animals and their physiology. The wastes from ruminants such as cattle, buffalo, goat and sheep have a different composition than the wastes of pigs and poultry, which are highly digestible. The chemical composition and the nutrients in different classes of animal excreta are given in Table 17.5.

Disposal and Utilization pattern

There exists a good deal of variation in the disposal pattern of dung from one area to another. The pattern depends upon climate, local customs and the availability of firewood. In Himachal Pradesh in India where plenty of firewood is available from forests, 8 % of the total dung collection was thrown into manure pits and 2 % was used for preparing dung cakes. In Kerala, Andhra Pradesh, Karnataka, Maharastra and Tamil Nadu which have coastal areas and where the climate is warm and humid, the percentage of dung thrown into manure pits was high. In Madhya Pradesh, where firewood is available in abundance, about three-fourth of the total dung collected was thrown into manure pits and the use of dung for fuel was comparatively less. In Punjab, Haryana, Eastern U.P., and Bihar, a fairly high percentage of the total dung collected was converted into cakes for fuel purpose and the proportion of dung thrown into manure pits was comparatively less. This may be due to the non-availability of alternate cheap domestic fuel and cold weather for over five months of the year.

Table17. 5: Nutrient content in excreta of different animals

Material	Nutrients (% on dry basis)				
	N	**P_2O_5**	**K_2O**	**Ca**	**Mg**
Pig dung	2.27	3.1	1.8	0.21	0.54
Cow dung	1.74	1.7	0.6	0.37	0.53
Horse dung	1.07	2.1	3.6	0.26	0.49
Camel dung	1.51	0.35	1.8	0.7	0.69
Poultry excreta	2.17	2.0	4.2	2.28	1.39
Goat and sheep excreta	0.65	0.5	0.03	-	-
Material	**Micronutrients (ppm)**				
	Fe	**Zn**	**Mn**	**Cu**	**B**
Pig excreta	1200	50	70	8.9	-
Poultry excreta	1400	90	210	7.1	5.0
Goat and sheep excreta	-	2570	150	6.1	4600

Sources: Gaur et.al; (1984) Sushil Kumar and Biswas (1982)

Utilization as Soil Conditioner and Manure

There are various methods for handling and treating animal wastes. The aim is to process and recycle these in one or more ways so as to be utilized efficiently in an environment-friendly manner. The simplest and most effective method is to utilize them as a soil nutrient by recycling it back to the soil. Methods that are available for applying the animal excreta to the soil include

i) direct surface application followed by immediate ploughing
ii) application after processing as FYM
iii) conversion into compost, and
iv) as feed stock in biogas plants to produce gas and slurry manure.

Direct Surface Application

The run off (both liquid and solid wastes) from the paid and unpaid areas is directly spread on the open fields and is subjected to sun drying under natural conditions. This practice is the oldest and easiest method of recycling the animal wastes and is commonly adopted in case of poultry excreta.

Farmyard Manure (FYM)

Farmyard manure (FYM) is the decomposed mixture of dung and urine of the farm animals along with litter (bedding material) and left over material from roughage or fodder fed to the cattle. The FYM occupies a prominent place among the bulky organic manures. A well-decomposed FYM contains 0.7-1.3 % N, 0.3-0.8 % P_2O_5 and 0.4-1.0 % K_2O on dry weight basis. However, the composition depends upon the kind of the animal, its ration intake, age, species and condition. Sheep, pig and poultry excreta are richer in nutrients than the dung from cow and horse.

Utilization for fuel and manure

Animal excreta can be recycled for fuel and manure by two different processes:

- one involves the physical and chemical processes at high temperature and/or pressure viz., direct combustion, gasification and liquefaction and

- the other involves the use of micro organisms at ambient temperature and atmospheric pressure in the absence of air, i.e., anaerobic fermentation.

For the purpose of recycling, only the second process is of interest, as it not only provides clean fuel but also manure.

Recycling through biogas technology

Anaerobic fermentation is the process of biological conversion of animal wastes into fuel without sacrificing their manurial potential value. This technology about which you have read in Unit 9 has generated a worldwide interest because it is amongst the most feasible ones as renewable sources of energy to meet the challenges for depleting reserves of fossil fuels and escalating deforestation.

Manurial value of the biogas slurry: One of the major advantages of biogas technology, besides cooking, lighting and electricity generation, is the utilization of residual slurry obtained after digestion as manure for crop production. It has been found that the biogas spent slurry is far better than FYM, since it is well digested and has higher nutrient contents for soil micro organisms and for plants. It increases carbon content in cultivated soils and improves physical, biological and chemical properties of the crop-land on long term basis. A Comparative analysis of biogas slurry and FYM is given in Table 17.5.

Table 17.5: Composting of biogas slurry and FYM (% on dry weight basis)

Constituent	Biogas slurry	FYM
Nitrogen (N)	1.41	0.78
Phosphorous (P_2O_5)	0.92	0.72
Potash (K_2O)	0.84	0.65
Organic Carbon	27.32	24.40
C/N ratio	19.37	31.28

Socio Economic Benefits: The viability and potential benefits of the biogas technology have been established beyond doubt. Biogas technology is cheap, simple and site specific. It can be easily adopted by the farmers in the rural areas.

Moreover, biogas is a clean and time saving cooking fuel. There is a reduction in the family fuel budget, saving in fuel wood, reduction in the drudgery of rural women's lives and improvement in rural sanitation. In addition, the residual slurry obtained after gasification is excellent manure. It not only improves the soil structure and water holding capacity but is ideal for mushroom cultivation, feed for the fish and can be used for vermi-composting. The combined use of biogas spent slurry with fertilizer has increased the yields of different crops by 35 % accompanied by a discount in fertilizer costs.

In this section you have studied how different kinds of plant and animal wastes can be recycled and reused. We now discuss how post harvest waste can be reduced. But you may like to attempt an exercise before you study the next section.

SAQ 4

Outline the various ways in which animal wastes can be recycled and reused.

17.5 REDUCING POST HARVEST WASTAGE

A grain saved is a grain produced. Ample evidence and statistics are available on losses, which occur from harvest until it reaches customers. It has been estimated that the post harvest losses may range from 8-25% in case of cereals such as rice, wheat, barley, millet, sorghum, etc. The estimate of perishable fruits and vegetables may be as high as 20-30%. Quantitatively this means a lot, since a minimum of 10% lost of over 196 million tonnes of food grains production in would amount to over 19.6 million tones. Post harvest technology and agro-processing are recognized as major instruments in minimizing losses of agricultural produce.

Harvest and post harvest loss

Losses to agricultural produce and by products both quantitative as well as qualitative, take place at various stages of harvest and post-harvest operations. Efforts to increase production should minimize losses that occur during the harvest and post harvest operations like threshing, transport, drying, and storage. It is estimated that 10 % of food grain produced in India are lost due to improper and inefficient methods of storage, transport and handling. If better methods of processing and storage are adopted, the losses could be reduced to 2 to 3% and more food grain could be available to the people. Table 17.6 presents the estimates of percentage losses of paddy in various stages of post harvest operation.

Table 17.6: Estimated post harvest losses of paddy in South and South eastern Asia

Operation	Range of losses (% of production)
Harvesting	1-3
Threshing	2-6
Drying	1-5
Handling	2-7
Milling	2-10
Storing	2-6
Total	10-37

Horticulture crops

As far as fruits and vegetables are concerned, nearly 20-30% are wasted during harvesting, packaging, transport and storage. Preservation of fruits and vegetables by sophisticated methods like canning, freezing or dehydration raise the raw material cost many folds. Alternate cheaper processing technologies based on solar dehydration, chemical preservation and use of recyclables need to be developed. Further development of 'Intermediate technology' in fruit growing areas to preserve fruits as pulp, juice or their concentrates would help for their subsequent use by processing industries. Converting large scale factory wastes into useful value added products like poultry and cattle feed, oil, pectin, vinegar etc., would reduce losses.

Flowers and ornamentals

The high perishability of flowers and foliage plants render them vulnerable to large post harvest losses. Owing to their delicacy and tenderness, flowers and ornamental plants are more susceptible to mechanical and physical damage and infection by diseases and pests during and after harvest. Even after detaching from the mother plant, the cut flowers are metabolically active and carry on all life processes at the expense of stored reserve food in the forms of carbohydrates, proteins and fats. Proper handling, packaging, storage conditions (light, temperature, environment), watering, preservatives and control of diseases and pest and cushioning influence the longevity of flowers and foliage plants. Lower temperature protects flower quality by reducing production of ethylene. High relative humidity of the storage environment maintains freshness by conserving water loss.

Utilization of the Post Harvest Wastes

In order to cope with the challenge of minimizing post harvest wastage, producing value added products, better utilization of wastes and by products and appropriate marketing need to be considered. A brief account of the wastes generated from some major crops and their possible utilization is given below:

Rice: The rice milling industry produces rice husk (20% of paddy) and rice bran (5%) as by products. It is possible to use rice husk, though high in silica content and relatively impervious to bio degradation after alkali treatment as cattle feed. Besides, it is used in chicken litter, fruit pressing and production of activated carbon, hard boards or acoustic boards, etc. The rice bran itself is a source of edible oil containing 15-20% of rice bran oil and has been traditionally used as a feed for poultry and livestock. Rice straw is traditionally used as feed, fuel, manure, packaging material. However, it is suitable for preparation of quality pulp and paper in combination with wood rag in hand made paper sector. Besides it is used for generation of electricity and a source of domestic/ industrial fuel.

Wheat: Wheat is seldom used whole. Primary processed products of wheat are flour, maida, suji/rawa and dalia. Wheat straw is the major residue, which is mainly used as cattle feed and partly in straw board production, as cheap fuel or manure. It could be utilized for production of various types of paper, such as, cine bleached paper, cigarette paper, news prints etc.

Maize: Maize is used as food. Maize stalk, husk, bran gern and gern oil cakes etc., are the by products. The maize stalks are fed to farm animals along with husk besides their use as compost. They could be economically utilized in production of pulp and paper insulating boards/hardboards and domestic fuel. Industrially maize is milled by dry and wet process. Corn sleep liquor obtained in wet milling process is used for production of penicillin and other antibiotics.

Cotton: Cotton waste includes stalks, stems, leaves, seed hull and dust; cotton waste can be used for making a wide range of products, paper, boards, cattle feed, fertilizers, food, acids, chemicals and fuel. Cotton stalks contain 71.2% hemi cellulose and fairly low lignin and are therefore suitable raw material for paper making. Cotton seed hulls contain 64.7% hemi cellulose and are used in the production of cheaper and improved fire resistant particle board. Cotton textile mills, mainly in the blowing rooms, produce a large quantity of waste, which is mainly used either as fuel in boiler or as cheap filling in blankets. Willow dust, which is the residual trash from cotton processing textiles mills, can be used for biogas production.

Post Harvest Wastage Conservation Measures

The conservation of post-harvest produce should be a well co-ordinated effort. It requires a multi disciplinary approach involving agronomists, cereal chemists, food technologists, nutritionists and rural development personnel to accelerate progress in checking food losses. In general, the following aspects may be given priority:

- Popularization of methods and techniques to reduce post harvest losses of all types of crops,
- Simple and effective storage system for grain crops and vegetables,
- Development of post harvest techniques for special crop like makhana, litchi, mango, banana and other fruits and vegetables that are grown in abundance. Such a strategy would help the farmers to get remunerative price as well as consumers through prolonged availability of quality products.
- Centrifuge and rubber roll sheller be used in place of hullers. Extra cost incurred by the entrepreneurs be subsidized to give momentum to this programme,

- More emphasis on the use of power and mechanical (screw type) Ghani or expeller in place of kolhu for higher recovery,
- Popularization of low cost engineering storage structures,
- Use of crop residues for animal feeds,
- Food grain processing for developing new acceptable products and technology for oil extraction and by-products utilization.

With this discussion, we come to an end of this unit. Let us summarise its contents.

17.6 SUMMARY

- The **agricultural and farm waste problem** must be addressed from the point of view of their utilization as a resource. Agricultural and farm wastes are available in large quantities in all agriculture based economies. They contain valuable nutrients. Many reuse and recycling methods have been developed and are being effectively utilized to solve the problem.
- **Traditional agricultural practices** are being adopted by farmers to restore soil fertility and sustain productivity. Application of FYM, incorporation of rice straw/wheat straw into the soil before the next crop is planted, use of rice straw/husk or wheat straw/bhusa in the cattle shed, penning of cattle in the field and use of weeds like *Lantana camera*, Ipomea, water hyacinth in the soil are some of the most common indigenous nutrient management methods adopted by the local farmers.
- **Use of organic residues** in the soil surface decreases the raindrop impact on soil resulting in reduced depression of soil aggregates and enhance infiltration rates. The run off and sediments losses are considerably reduced.
- **Direct mixing of farm refuge and crop residues** leads to temporary immobilization of plant nutrients and the possible release of phytotoxic compounds. Hence, the crop residues must be modified to use as either mulch or as composted manures prior to their application to the soil.
- **Composting** and **vermi-composting** of these wastes gives a good solution as a waste disposal method, besides increasing the availability of plant nutrients, destruction of pathogens, elimination of unfavourable odours and easy handling. Vermi-composting is an efficient and inexpensive method of composting. The castings excreted by earthworms are rich source of available minerals and humus. They have the potential to raise soil productivity by improving physical, chemical and biological properties of soil, thereby improving the plant growth. In the days of increasing fertilizer price and in view of necessity to improve the yield of rain fed agriculture, it is imperative to look for these agricultural wastes recycling by composting.
- Lack of **post harvest management** and cold chain infrastructure, account for heavy economic losses in developing countries. There is an urgency to strengthen the network of post harvest management and cold chain infrastructures, grading/packaging centres, pre-cooling units, refrigerated vans, cold storage etc., both in the areas of production and at the retail outlets.
- In rural development, there is an urgent need for **fuel with higher thermal efficiency** from the non-commercial local sources with lower thermal efficiency. Recycling of animal wastes through biomethanation is one such source, which deserves serious attention. This technology adoptable on a small scale is labour intensive, needs little skilled labour and uses locally available residues such as animal dung and crop residues. The technology provides an easy way of producing fuel gas known as biogas by anaerobic fermentation of wet dung and

rich manure from the residual matter. The gas is a source of energy for lighting cooking and operating engines; the residual slurry provides energy and nutrients for agricultural production.

17.7 TERMINAL QUESTIONS

1. Can crop residues be managed without burning?
2. What alternative measures could be taken to avoid burning of crop residues?
3. What are the possible options for managing crop residues in the present scenario?
4. How can various losses during harvest and post harvest operations of an agricultural produce be reduced?
5. **Activity: Vermi-composting**

   Take unused packing boxes (Khokha) or pots. Place them on roofs or the spare for kitchen garden wherever is available. Use the garbage of your house for vermicomposting.

   (i) Observe the smell of garbage after 48 hrs – You will notice that the foul smell has subsided.
   (ii) Use sieve to separate earthworms from the matured compost – You will observe that 40% garbage fed to the earthworm is converted into compost and the population of earthworms is doubled.

REFERENCES

1. Bhardwaj, K.K.R. (1995) Recycling of Crop Residues, Oilcakes and Other Plant Products in Agriculture. In: *Recycling of Crop, Animal, Human and Industrial Wastes in Agriculture*. (Ed. Tondon, H.L.S.), Fertiliser Development and Consultation Organisation. New Delhi. pp. 9-30.
2. Gaur, A.C., Neelakantan, S., and Dargan K.S. (1984) Organic Manures. ICAR, New Delhi. pp.159.
3. Mishra and Hesse (1982) Hand book of Manures and Fertilisers, ICAR, New Delhi.
4. Palaniappan, S.P. and Annadurai, K. (1999) Organic Farming Theory and Practices. Scientific Publishers (India) Jodhpur.
5. Pillai, K.G.K. and Krishnamurthy, K. (1983) Studies on new sources of N for its efficient use in rice. *Fert. News*, 28(6), 25-30.
6. Sushil, K., Aggarwal, P.K., Gupta, N. and Sujith, K. (2002) Agri-Resource for Ethanol Production in different Agroclimatic Regions of India- Current states and Future Prospects. Final Report submitted to MNES. Division of Environmental Sciences, IARI, New Delhi.
7. Sushil, K. and Biswas, T.D. (1982) Biogas production from different animal excreta. Indian J. Agric. Sci. 52, 513-520.
8. Svedelius, R. and Watkin, S.J. (2003) Your body renewable organic waste and the environment rsvedelius@hotmail.com (Sweden).