Chapter 15
Agricultural Waste: Its Impact on Environment and Management Approaches

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Abstract Waste materials are either usable or unusable products left behind after production or formulation of the main products produced by the human activities. According to the Press Information Bureau, India generates 62 million tonnes of waste (mixed waste containing both recyclable and nonrecyclable waste) every year, with an average annual growth rate of 4%. The agriculture sector is also contributing a large part through on field or off field activities. These waste materials consist of both usable and non-usable. Waste materials are of different kinds and come from various sources. The waste materials also have good nutritional values and thus, potential for its economics. The various forms, sources, and how the waste materials can be converted to many usable forms are studied and discussed here in this chapter. This chapter presented that there are solid and liquid types of waste which includes organics, dry, and biomedical wastes. The biodegradable wastes are being focused for utilizing its nutritional and desirable qualities and made into various usable products. Waste as in general is causing environmental pollution on earth surface, water, and air. Before their contamination it should be converted to usable form to minimize the pollution level as well as helps to generate employment and to make eco-friendly environment. Among the various sources agricultural crop residues, used pesticides, insecticides, fertilizers, and other indiscriminate use of chemicals causing environmental threats and already translocated through food chain causing several human diseases. The chapter also discussed the conversation of these wastes into valuable products with some tables and relevant information.

Keywords Agricultural waste · Environmental impact · Human activities · Management approaches

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15.1 Introduction

Waste materials are either usable or unusable products left behind after production or formulation of the main products produced by the human activities. A part of waste materials which is totally unsuitable for use is known as spoiled product. Economic development and rising living standards especially in the developing states have led to increase in the quantity and complexity of generated waste. Generally, waste is of two types: both hazardous and nonhazardous. The wastes are of major concern to keep the environment protected and thus, this part is generally not targeted for reuse. The nonhazardous waste has the potential to be used in many forms with little or no threat to environment and human health. Industrial diversification produces substantial quantities of industrial waste including biomedical waste which have severe environmental and human health consequences. There are several sources of waste generation including the home we reside in, besides public places, agricultural fields, hospitals, industry, etc.

India is the second largest population in the world after China with more than 1.27 billion people (17.6% of world's total population), however, it occupies only 5% of world's area (3,185,263 km^2). Sixty-eight percent of total Indian population lives in rural areas, while 32% lives in urban areas (World Bank 2014). Developing countries like India is in industrialization phase, which is an essential part to build modern society and contribute to urbanization. India is one of the fastest growing economies in the world with 7.30% GDP and expected to 10% GDP in 2030. Higher GDP is directly correlated to improved living standards. At the same time overpopulation, rapid industrialization, uncontrolled urbanization, and improved living standards produce more waste also (Nandan et al. 2017).

According to the Press Information Bureau, India generates 62 million tonnes of waste (both recyclable and nonrecyclable) every year, with an average annual growth rate of 4% (PIB 2016). The waste can be divided into three major categories: (1) organic (all kinds of biodegradable waste), (2) dry (or recyclable waste), and (3) biomedical (or sanitary and hazardous waste). Currently, 1,27,486 tonnes of municipal solid waste is being generated daily due to various household activities, other commercial and institutional activities (CPCB 2012). Among the various source municipal wastes, certain industrial waste and agriculture waste have comparatively significant impact on environment and few are extremely dangerous to the living organisms including human beings (Misra and Pandey 2005). These may pollute groundwater quality and cause air pollution by emission of greenhouse gases. With the fastest advancement of telecommunication and electronics industry e-waste and nuclear waste also need attention to solve the problem with solid waste management. A study on the wastes, their sources, nature, and effect is important to manage the waste to protect environment as well as human health.

15.1.1 Scenario of Waste Collection in India

Waste collection is much greater in metropolitan cities or other urban areas as compared to that of rural areas. Many local government bodies along with specific NGOs are involved in collecting these wastes as shown in Table 15.1.

15.1.2 Types of Waste

The principal sources of solid waste are residential households while, agricultural, commercial, construction, industrial, and institutional sectors also play an important role. A breakdown of solid waste types and sources is provided in Table 15.2. There are four major categories of waste: municipal solid waste, industrial waste, agricultural waste, and hazardous waste which are discussed in Table 15.2.

15.1.3 Classification of Waste

15.1.3.1 According to Physical Condition (Properties)

According to the physical properties, the waste is of mainly two types.

Solid Waste

Solid waste is the unwanted or useless solid materials generated from human activities in residential, industrial, or commercial areas. It may be categorized in three ways. According to its:

- Origin (domestic, industrial, commercial, construction, or institutional).
- Contents (organic material, glass, metal, plastic paper, etc.).
- Hazard potential (toxic, nontoxic, flammable, radioactive, infectious, etc.).

Liquid Waste

Liquid waste can be defined as wastewater, fats, oils or grease (FOG), used oil, liquids, solids, gases, or sludges and hazardous household liquids. These liquids are hazardous or potentially harmful to human health or the environment. They can also be discarded commercial products classified as "Liquid Industrial Waste" such as cleaning fluids or pesticides, or the by-products of manufacturing processes. There are general regulatory requirements relating to waste and additional regulations

Table 15.1 State-wise solid waste generation in urban areas, as on November 2017

S. No.	State/Union territories	Total waste generation (MT/D)	Total waste generation in (Lakh Mt./Annum)
1.	Andhra Pradesh	6525	23.82
2.	Andaman & Nicobar Islands	115	0.42
3.	Arunachal Pradesh	181	0.66
4.	Assam	1134	4.14
5.	Bihar	1192	4.35
6.	Chandigarh UT	340	1.24
7.	Chhattisgarh	1959	7.15
8.	Daman & Diu	23	0.08
9.	Dadar & Nagar Haveli	58	0.21
10.	NCT or Delhi	10,500	38.33
11.	Goa	240	0.88
12.	Gujarat	10,145	37.03
13.	Haryana	4514	37.03
14.	Himachal Pradesh	324	1.25
15.	Jammu & Kashmir	1792	6.54
16.	Jharkhand	2451	8.95
17.	Karnataka	10,000	36.50
18.	Kerala	1576	5.75
19.	Madhya Pradesh	6424	23.45
20.	Maharashtra	22,570	82.38
21.	Manipur	176	0.64
22.	Meghalaya	268	0.98
23.	Mizoram	201	0.73
24.	Nagaland	342	1.25
25.	Odisha	2460	8.98
26.	Puducherry UT	495	1.81
27.	Punjab	4100	14.97
28.	Rajasthan	6500	23.73
29.	Sikkim	89	0.32
30.	Tamil Nadu	15,547	56.75
31.	Telangana	7371	26.90
32.	Tripura	421	1.54
33.	Uttar Pradesh	15,500	56.58
34.	Uttarakhand	1400	5.11
35.	West Bengal	8675	31.66
Total		**1,45,626**	**531.53**

MT Million tonnes, *D* Day
Source: Government of India Ministry of New and Renewable Energy, 2017

Table 15.2 Sources and types of solid wastes

S. No.	Source	Typical waste generation	Types of solid wastes
1.	Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes
2.	Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes
3.	Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
4.	Institutional	Schools, hospitals, prisons, government centers	Same as commercial
5.	Construction and demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
6.	Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water, and wastewater treatment plants	Street sweepings, landscape and tree trimmings, general wastes from parks, beaches, and other recreational areas, sludge
7.	Process	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing	Industrial process wastes, scrap materials, off specification products, slag, tailings
8.	Medical waste	Hospitals, nursing homes, clinics	Infectious waste (bandages, gloves, cultures, swabs, blood and body fluids), hazardous waste (sharps, instruments, chemicals), radioactive waste from cancer therapies, pharmaceutical waste
9.	Agriculture and food processing industry wastes	Crops, orchards, vineyards, dairies, feedlots, farms	Spoiled food wastes, agricultural wastes, hazardous wastes (e.g., pesticides), pulp, fruit peel, seed
10.	Mining	Open-cast mining, underground mining	Mainly inert materials such as ash

Source: Adapted from What a Waste (2012) and https://www.unescap.org/sites/default/files/CH08.PDF apply to generating, storing, transporting, treating, and disposing of hazardous and liquid wastes.

15.1.3.2 According to Their Properties

Biodegradable Wastes

Biodegradable wastes are natural organic compounds which are degraded or decomposed by biological or microbial action. Biodegradable wastes are mainly generated in food processing units, cotton mills, paper mills, sugar mills, textile factories, and sewage. Waste of slaughterhouses is biodegradable and some part of it is usable (for example, skin is used to make leather). Most of the wastes from these industries are reused. When these wastes are in excess, they are not easily decomposed and may act as pollutants (Shrama and Dwivedi 2018).

Non-biodegradable Wastes

These are not decomposed by microbes but are oxidized and dissociated automatically. Coal stone, metal scraps, sludge are generated from colliery operations. Refineries produce inert dry solids and varieties of sludge containing oil. Fly ash is the major solid waste from thermal power plants. Recently fly ash has been used to make different products for use in construction, road, etc. Generally, these wastes are not reused and accumulate in the ecosystem.

15.1.3.3 According to Their Effect on Human Health and Environment

Hazardous Waste

Mostly chemical, biological, explosive, or radioactive wastes, which are highly toxic and reactive, having a negative effect on human, animals, and plants, are called hazardous. Hazardous wastes, when improperly handled, can cause substantial harm to human health as well as the environment. Hazardous wastes may be solids, liquids, sludges, or gases.

Nonhazardous

Nonhazardous wastes are generally used safely and have no corrosive, reactive, toxic properties. The huge amount of nonhazardous waste creates a disposal problem, but may be converted to other product.

15.1.3.4 According to Their Origin

Nuclear Waste

Wastes from nuclear reactor are highly dangerous and requires proper management and disposal. Carbon-14, uranium-238, uranium-239 and radium-226, thorium, and plutonium are the main nuclear wastes. Two sources of nuclear waste:

Natural source: Cosmic rays from outer space with increasing altitude and latitude and emission from earth crust.

Manmade: Mining and processing of radioactive ores used in nuclear power plant, radioactive isotopes used in medicinal and industrial applications and nuclear weapons.

Thermal Waste

Thermal waste refers to the release of heat into any of the segment of environment and this type of pollution is called as thermal or heat pollution. Nuclear power plants, coal-fired power plants, nutrient effluents, domestic sewage, and hydroelectric power are the main sources of thermal waste. It degrades the water quality by changing the ambient water temperature which decreases oxygen supply and affects ecosystem composition.

Plastic Waste

Plastics are typically polymers of higher molecular mass containing other substances to improve performance and reduce cost. Monomers of plastic are either natural or synthetic organic compounds mainly generated through petroleum and natural gas industry.

There are two types of plastic waste:

Thermoplastic: which are softened by heat and can be molded (injection molded, blow molded, or vacuum formed). Good examples are acrylic, polypropylene, polystyrene, polyethylene, and PVC.

Thermosets: which are formed by heat process but are then set (like concrete) and cannot change shape by reheating. Good examples are melamine (kitchen worktops) Bakelite (black saucepan handles), polyesters, and epoxy resins.

Biomedical Waste

Solid or liquid wastes including containers, intermediate, or end products generated during diagnosis, treatment, pathological tests, and research activities of medical sciences, i.e., medicine bottles, expired medicines, syringes, medical instrument such as scissors, blades, etc.

E-Waste

E-waste or electronic waste is created when an electronic product is discarded after the end of its useful life. The rapid expansion of technology means that a very large amount of e-waste is created every minute. Electronic waste or e-waste may be defined as discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets, and refrigerators.

15.1.3.5 According to Reuse of Wastes

Reusable/Recyclable Waste

Recycling is processing used waste into new, useful products. This is done to reduce the use of raw materials that would have been used. Waste that can be potentially recycled is termed recyclable waste. Animal product (milk, urine, and animal-dung), agriculture product (crop residue, vegetable residue, fruit residue, and fertilizers bags), plastics (grocery shopping bags, plastics bottles), glass product (wine and beer bottles, broken glass), paper products (used envelopes, newspaper, cardboard boxes, and magazines) can be reused.

Nonreusable Waste

Nonreusable/recycled waste is solid waste which are not processed nor reclaimed by a waste management system or already sorted out. The disposal of these materials is a rising concern in many parts of the developed world where environment alertness has been a rising trend.

15.2 Agriculture Waste

15.2.1 Definition

Agricultural waste is defined as the residue from the growing and processing of raw agricultural and allied products such as fruits, vegetables, meat, poultry, dairy, fishery, and crops. They are the nonproduct outputs of production and processing of agricultural products that may contain material that can benefit man but whose economic values are less than the cost of collection, transportation, and processing for beneficial/safe use. It is also called as agro-waste comprising of animal waste (manure, animal carcasses), food processing waste (only 20% of maize is canned and 80% is waste), crop waste (corn stalks, sugarcane bagasse, drops, and culls from fruits and vegetables, prunings) and hazardous and toxic agricultural waste

Table 15.3 Composition of agriculture crop residue waste

Component	Percent by weight (dry basis)					
	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur	Ash
Wheat straw	48.5	5.5	39.9	0.3	0.1	5.7
Rice straw	29.2	5.1	35.8	0.6	0.1	19.2
Rice husk	38.5	5.7	39.8	0.5	<0.01	15.5
Had wood	50.8	6.4	41.5	0.4	<0.01	0.9
Soft wood	52.9	6.3	39.7	0.1	<0.01	1.0
Corn cob	46.2	7.6	42.3	1.2	0.3	2.4
Cotton stalk	45.3	5.6	45.3	0.5	<0.01	3.3
Anthracite coal	78.8	2.3	2.5	0.9	0.5	13

Source: International Environmental Technology Center

(pesticides, insecticides, herbicides, etc.). Expanding agricultural production has naturally resulted in increased quantities of livestock waste, agricultural crop residues, and agro-industrial by-products. There is likely to be a significant increase in agricultural wastes globally if developing countries continue to intensify farming systems. It is estimated that about 998 million tonnes of agricultural waste is produced yearly (Agamuthu 2009). Organic wastes can amount up to 80% of the total solid wastes generated in any farm (Brown and Root Environmental Consultancy Group 1997) of which manure production can amount up to 5.27 kg/day/1000 kg live weight, on a wet weight basis (Overcash 1973).

15.2.2 Types of Agriculture Waste

Agricultural waste may be on (A) field as crop residues or (B) from agro-based industries. Agricultural crop residues on field like stem, stalks, seeds, weeds, etc. and residue after processing like husk, roots, seeds, bagasse, molasses, etc. The wastes from agro-based industries include fruit peels, pulp, cakes (oil), coir, nuts, etc.

15.2.2.1 Agriculture Crop Residues

The agricultural crop residues are materials left in an agricultural field or orchard after harvesting. The residue can be ploughed directly into the ground or converted into compost. Good management of field residues can increase efficiency of irrigation, control of erosion, improve soil aeration, and soil health (Table 15.3).

Organic Composting from Crop Residue

The crop residues focus on the equivalent fertilizer cost of the nutrients within. Although crop residues contain both macro- and micro nutrients, although values only for the macronutrients nitrogen, phosphorus, potassium, and sulfur are economically significant.

Importance of Crop Residue

Biofuel Production from Crop Residue

Because of the high carbohydrate content, crop residues can be considered as an appropriate feedstock to produce biofuels. Some algorithms have been developed to estimate the potential capacity of biofuel production from agricultural residues. Based on the experimental data obtained from a study that used ethanol organosolv pretreated rice straw to produce biohydrogen using *Enterobacter aerogenes*, the annual global amount of collectable rice straw (not total produced straw) for biofuel production was estimated about 249 million tonnes, that could approximately produce 355.78 kilotonnes of hydrogen and 11.32 million tonnes of lignin by the proposed organosolv technology and it was found that China contributes to about 32% of global potential capacity to produce biohydrogen from rice straw (Asadi and Zilouei 2017).

Mineralization Through Crop Residue

Nutrients in most crop residue are not immediately available for crop use. Their release (called mineralization) occurs over a period of years. The biological processes involved in soil nutrient cycles are complex. As a rough guide, cereal straw releases about 10–15% of its nutrients and pea residues release about 35% of their nutrients by the next year. The speed of mineralization depends on the nitrogen and lignin (fiber) content, soil moisture, temperature, and degree of mixing with the soil. N is released fairly quickly from residue when the content is higher than 1.5% (such as in pea residues). In contrast, below 1.2% (such as cereal residue), soil-available N is fixed (called immobilization) by the microbes as they decompose the residue (Table 15.4).

Thus, pea residue would have short- and long-term benefits to soil fertility, whereas cereal straw would reduce next year's soil supply of available nutrients. Over time, the nutrients fixed by soil microbes and humus are released and available to crops. Nutrients from residue are not fully recovered by crops. Just like fertilizer nutrients, nutrients released from crop residue into the soil are susceptible to losses such as leaching (N and S), denitrification (N), immobilization (N, P, K and S), and fixation (P and K).

Efficiency of Nutrient Uptake

The efficiency of nutrient uptake by crops from fertilizers or residue release is generally thought to be similar. For example, there is about 50% recovery of N in the above-ground plant in the first year. There is some residual benefit of fertilizers as the crops take up a small amount of the nutrients 2 and 3 years later. Fertilizer placement can significantly affect the efficiency of crop uptake. The impact of residue placement (buried by tillage or left on the surface in zero tillage) on nutrient cycling and efficiency is under study.

Composition of Crop Residue Waste

The composition of crop residue waste largely depends on the nature of crop plants as shown in Table 15.5.

15.2.2.2 Waste from Agricultural Livestock

Animal wastes are commonly considered the excreted materials from live animals. However, under certain production conditions, the waste may also include straw, hay, wood shavings, or other sources of organic debris. Application of excreta to soil brings benefits such as improved soil tilth, increased water-holding capacity, and some plant nutrients. Concentrated forms of excreta or high application rates to soils without proper management may lead to high salt concentrations in the soil and cause serious on- or off-site pollution. Animal waste contains many beneficial constituents that if recycled effectively, can be used as fertilizer for crops, fodder for animals, and to produce energy. Animal manure is rich in nitrogen, phosphorus, and potassium. In addition to providing supplemental nutrients for crop growth, manure has several beneficial effects on soil properties (Table 15.6). Application of organic waste decreases the bulk density of the soil by increasing both the organic fraction of the soil and the stability of aggregates (Mondal 2008).

The most common environment concern with animal wastes is that it affects the atmospheric air with offensive odors, release of large quantities of CO and ammonia which might contribute to acid rain and the greenhouse effect. It could also pollute water sources and be instrumental in spreading infectious diseases. If the disposal of water is not properly planned it might create social tension owing to the release of odors and contamination of water sources. Proper disposal and returning of nutrients back in the soil without pollution and spreading of diseases/pathogens, is required for efficient utilization of wastes on large farms (Mondal 2008).

Table 15.4 Composition of agriculture waste

Agriculture waste	Chemical composition (% w/w)						References
	Cellulose	Hemicellulose	Lignin	Ash (%)	Total solid (%)	Moisture (%)	
Sugarcane bagasse	30.2	56.7	13.4	1.9	91.66	4.8	El-Tayeb et al. (2012), Nigam et al. (2009)
Rice straw	29.2	23.5	36.1	12.4	98.62	6.58	El-Tayeb et al. (2012)
Corn stalks	61.2	19.3	6.9	10.8	97.78	6.40	El-Tayeb et al. (2012)
Sawdust	45.1	28.1	24.2	1.2	98.54	1.12	El-Tayeb et al. (2012), Martin et al. (2007)
Sugar beet waste	26.3	18.5	2.5	4.8	87.5	12.4	El-Tayeb et al. (2012)
Barley straw	33.8	21.9	13.8	11	–	–	Nigam et al. (2009)
Cotton stalks	58.5	14.4	21.5	9.8	–	7.45	Nigam et al. (2009)
Oat straw	29.4	27.1	17.5	8	–	–	Martin et al. (2007)
Soya stalks	34.5	24.8	19.8	10.3	–	11.84	Motte et al. (2013)
Sunflower stalks	42.1	29.7	13.4	11.7	–	–	Motte et al. (2013)
Wheat straw	32.9	24.8	8.9	6.7	95.6	7.0	Nigam (2001), Nigam et al. (2009), Martin et al. (2007)

Types of Livestock Waste

Solid Waste

Waste containing 20% or more solids or with moisture content of 50% MWB or less is considered to be solid waste. Solid wastes are treated by drying or composting. Dried wastes are used not only as fertilizer but also as fuel for combustion to obtain energy (Haga 1998).

Slurry

Slurry is a type of liquid manure that can be used on fields as fertilizer. If the soil or plants are unable to absorb the slurry or if the slurry is spread in too high a concentration, the run-off can get into water systems. Slurry is generally more polluting than raw sewage. When slurry tanks are accidentally or deliberately breached large amounts of slurry can spill into rivers, streams, or lakes, including wetlands causing severe environmental problems. Many incidents are not reported. Animal waste is found in soil, surface water and groundwater, and sea water. Slurry disturbs aquatic

Table 15.5 Cellulose content and composition [% (w/w) of dry matter] of agriculture waste

Agriculture waste	Cellulose (%)	Hemicelluloses (%)	Lignin (%)
Hard wood	40–50	24–40	18–25
Soft wood	40–50	25–35	25–35
Nut shells	25–30	25–30	30–40
Corn cob	45	35	15
Grasses	25–40	35–40	10–30
Wheat straw	33–40	20–25	15–20
Rice straw	40	18	5.5
Leaves	15–20	80–85	–
Switch grass	30–50	10–40	5–20
Solid cattle manure	1.6–4.7	1.4–3.3	2.7–5.7
Primary waste water solids	8–15	–	24–29
Paper	85–99	–	0–15
News paper	40–55	25–40	1830
Hardwood stem	40–50	24–40	18–25
Peanut shell	22.1	12.1	35.2
Rice hull	49.1	9.6	12.9
Sugarcane leaf and stalk	40	29	13
Sorghum leaf and stalk	31	30	11

Source: Sindhu (2015); Dueñas et al. (1995); Martin et al. (2007)

ecosystems by increasing nitrogen and phosphorus levels leading to the growth of toxic algae, which poison the fish and it decreases oxygen levels causing fish to suffocate (Table 15.7).

Importance of Agro-Livestock Waste

Livestock and poultry industries produce meat, milk, and egg, and also generate large volumes of waste water and solid wastes that could be beneficial or harmful to the environment. The waste products which include livestock or poultry excreta and associated feed losses, beddings, washwater, and other such waste materials represent a valuable resource that if used wisely, can replace significant amounts of inorganic fertilizers.

Animal waste contains many beneficial constituents that if recycled effectively, can be used as fertilizer for crops, fodder for animals, and to produce energy. Animal manure is rich in nitrogen, phosphorus, and potassium. In addition to providing supplemental nutrients for crop growth, manure has several beneficial effects on soil properties. Organic manure decreases the bulk density of the soil and also improves both organic fraction and stability of the soil. Organic manure also increases rate of water infiltration, water-holding capacity, and electrical conductivity of the soil.

15.2.2.3 Agro-Industry Waste

Waste from Fruit and Vegetable

Fruits and vegetables are the most utilized commodities among all horticultural crops. They are consumed raw, minimally processed, as well as processed, due to their nutrients and health-promoting compounds. With the growing population and changing diet habits, the production and processing of horticultural crops, especially fruits and vegetables, have increased very significantly to fulfill the increasing demands. The significant amount of fruits produced globally include 124.73 million metric tons (MMT) of citrus, 114.08 MMT of bananas, 84.63 MMT of apples, 74.49 MMT of grapes, 45.22 MMT of mangoes, mangosteen, and guavas, and 25.43 MMT of pineapples. Production of some vegetables include potato (3820.00 MMT), tomatoes (171.00 MMT), cabbages and other brassicas (71.77 MMT), carrots and turnips (38.83 MMT), cauliflower and broccoli (24.17 MMT), and peas (17.42 MMT) (FAO 2017).

Higher production and growth, and the lack of proper handling methods and infrastructure, have led to huge losses and waste of these important food commodities, as well as their components and by-products and residues. The United Nations has estimated that at least one-third of the food produced in the world (estimated as 1.3 billion metric tons) is lost and wasted every year (FAO 2014) and losses and waste of horticultural commodities are the highest among all types of foods, reaching up to 60% (Table 15.8).

Agricultural Waste Generation

As noted earlier, agricultural development is usually accompanied by wastes from the irrational application of intensive farming methods and the abuse of chemicals used in cultivation, remarkably affecting rural environments in particular and the

Table 15.6 Composition of oil cake

Oil cakes	Dry matter	Crude protein	Crude fiber	Ash	Calcium	Phosphorus	References
CaOC	90.0	33.9	9.7	6.2	0.79	1.06	Ewing (1997)
COC	88.8	25.2	10.8	6.0	0.08	0.67	Gohl (1970)
CSC	94.3	40.3	15.7	6.8	0.31	0.11	Friesecke (1970)
GOC	92.6	49.5	5.3	4.5	0.11	0.75	Kuo (1967)
MOC	89.8	38.5	3.5	9.9	0.05	1.11	Kuo (1967)
OOC	85.2	6.3	40.0	4.2	–	–	Maymone et al. (1961)
PKC	90.8	18.6	37.0	4.5	0.31	0.85	Owusu et al. (1970)
SuOC	91.0	34.1	13.2	6.6	0.30	1.30	Owusu et al. (1970)

CaOC Canola oil cake, *COC* Coconut oil cake, *CSC* Cotton seed cake, *GOC* Groundnut oil cake, *MOC* mustard oil cake, *OOC* Olive oil cake, *PKC* Palm kernel cake, *SuOC* Sunflower oil cake global environmental in general. The waste generated is dependent on the type of agricultural activities carried out.

15.3 Impact of Agricultural Waste

Environment is everything that is around us. It can be living or non-living things. It includes physical, chemical and other natural forces. Living things live in their environment. They constantly interact with it and adapt themselves to conditions in their environment. In the environment there are different interactions between animals, plants, Insects, soil, water, and other living and nonliving things (Wikipedia 2018a). Agriculture is the cultivation of land and breeding of animals and plants to provide food, fiber, medicinal plants, and other products to sustain and enhance life (Anonymous 1999).

15.3.1 Soil

Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that together support life. Earth's body of soil is the pedosphere, which has four important functions:

It is a medium for plant growth.
It is a means of water storage.
It is a means for supply and purification.
It is a modifier of Earth's atmosphere.
It is a habitat for organisms; all of which, in turn, modify the soil (Wikipedia 2018b).

Soil erosion and sedimentation are caused by the agriculture waste. Increased erosion rates from tilled fields can cause excessive deposition of fine sediments in receiving streams that block interstitial spaces and river-bed gravels which are

Table 15.7 Composition of agro-livestock waste

Nutrient	Poultry manure	Cow dung	Swine waste	Goat droppings
Organic carbon (%)	16.0	8.0	13.1	5.2
Nitrogen (%)	2.1	1.6	2.0	1.8
Available phosphorus (mg kg^{-1})	2.2	0.75	0.70	2.10
Organic matter (%)	28.8	13.5	24.2	10.9
Calcium (%)	6.2	4.2	6.1	3.2
Magnesium (%)	2.0	2	2.1	1.3
Potassium (%)	3.3	0.65	0.60	0.40
Sodium (%)	0.70	0.32	0.40	0.24
Carbon:nitrogen ratio	8.0	4.3	6.8	2.6

important spawning habitats for many fish species. Sediment deposition also contributes to changes in channel morphology and flow regime. Additionally, suspended sediments reduce light penetration, scour surfaces and may interfere with feeding mechanisms, drift rates and respiration of macro invertebrates and fish (Doeg and Koehn 1994; Wood and Armitage 1997; Relyea et al. 2000).

15.3.2 Environment

Pesticides that are used for the elimination of harmful insects, microorganisms, and other pests when they mix with soil, water, air, and food, cause problems on the agricultural foods and affect both human health and natural balance and so finally become an environment problem. Pesticide runoff is an important contributor to surface-water contamination (Wohlfahrt et al. 2010). Additionally fields, streams, lakes, ground water, and sea are converted to a kind of poison storage in time (Şimşek et al. 1991). There are hundreds of pesticides that are used in the world. According to WHO's classification, 33 pesticides are very dangerous, 48 of them are quite dangerous, 118 of them are moderately dangerous, and 239 of them are less dangerous of the total 700 mostly used pesticides. A 75% rate of pesticide usage belongs to developed countries. Pesticides and insecticides contaminate water. Contaminated water contains the heavy metals viz.; mercury, arsenic, lead, cadmium, etc. which affect the environment.

Table 15.8 Commercially manufactured products from fruit and vegetable wastes

Apple	Extra pomace after juice extraction used to prepare pectin, cider, vinegar, chutney
Apricot	Kernels after removing seed coat of white apricot can be added to jam to improve color and appearance. Oil from kernel and seed are used in pharmaceutical and cosmetic industry. Oil cake is used for cattle feed
Citrus	Fruit peels are utilized for making candy and oil is used in confectionery. Rages from galgal and orange are used to make pectin. Rages are utilized in making marmalade, toffee. This is also a good feed for cattle. Citric acid is produced from sludge and others residues can be fermented to make vinegar. Peel and seed oil are also used in many cosmetic industry
Grapes	Seed oil is used as cattle feed. Pomace is used in jelly, chutney, and jam making. Stem portion is used to prepare cream of tartar
Guava	Fruit cores, seeds, peels left after juice extraction is used to prepare popular product guava cheese
Mango	Stone of fruits are powdered followed by drying and utilized in many edible products. Peels are used to make vinegar by fermentation
Jackfruit	Seeds from fully ripe fruit are eaten after roasting. Pectin is extracted from rind and perigons
Tomato	Seeds are used to prepare edible oil
Pineapple	Juice from shell, trimmings, and other wastes may be used for secondary canning. Fruit core is used to prepare candy as well as used as cattle feed

15.3.3 Human Health

Water pollution creates a vicious cycle of contamination of the human food chain. Water and food are interlinked and difficult to separate. Many communicable and noncommunicable human diseases are related to water, soil geochemistry, and environmental pollution. There are numerous examples of environmental pollution leading to epidemics of serious human diseases (Kolpakova 2004; Deleanu et al. 1981). In agricultural areas, water can be contaminated with microbes, toxic heavy metals, such as lead, cadmium, or arsenic; fluoride; and various toxic agrochemicals (Wittmer et al. 2010, Belden et al. 2000 and Meyer et al. 2011). According to Gadde et al. (2009), open burning of crop stubble results in the emissions of harmful chemicals like polychlorinated dibenzo-p-dioxins, polycyclic aromatic hydrocarbons (PAH's), and polychlorinated dibenzofurans (PCDFs). Burning of crop stubble has severe adverse impacts especially for those people suffering from respiratory disease and cardiovascular disease. Pregnant women and small children are also likely to suffer from the smoke produced due to stubble burning. Inhaling of fine particulate matter of less than PM 2.5 μg triggers asthma and can even aggravate symptoms of bronchial attack (Kumar et al. 2015).

Industrial agriculture focuses on the growth of the same crop season after season. Mono crops cause nutrient loss and reduce the soil's ability to naturally eliminate pests and replenish nutrients. To compensate, industrial agriculture uses heavy doses of chemical pesticides. Likewise, factory farming is contaminating the world with industrial operations that raise massive quantities of animals (usually cows, pigs, chickens, or turkeys) in overcrowded, confined, and unsanitary conditions (Hatz 2009). The price of food is at a relatively cheap cost, but is actually a cost affecting our health in a significant way. The oldest and most well-studied agricultural respiratory diseases are from exposures to organic dusts such as grain processing and confined animal feeding operations (CAFOs), (e.g., swine confinement facilities) (Kirkhorn and Facoem 2001). Organic dust toxic syndrome (ODTS) is common and may be seen in up to 34% of CAFO workers (Von Essen and Donham 1999).

15.4 Conversion and Utilization of Agricultural Waste

Agricultural wastes are basically unusable substances which may be either liquid or solid produced as result of cultivation processes such as fertilizers, pesticides, crop residues, and animal waste. Agricultural waste management is part of the ecological cycle in which everything is cycled and recycled such that an interdependent relationship is maintained in the ecosystem. By waste management, all the plant wastes are placed at the right place and right time for the best utilization in order to convert into useful products and pollution control. Globally, 140 billion metric tons of biomass is generated every year from agriculture. Ministry of New and Renewable Energy, Govt. of India estimated that about 500 Mt. of crop residue is generated every year (Shehrawat and Sindhu 2012). Agricultural waste contains biodegradable hemicellulose and cellulose materials, which on decomposition gives good nutrients to plants. Cow dung is commonly available in rural areas, which is rich in nutrients and microorganisms. Cow dung can be used as good seeding material as it is available in the agricultural farm itself from livestock. One of the main aims of the study is to reduce the overall time required for composting. Therefore, cow dung is mixed with agricultural waste as seeding agent (Kale 2000).

15.4.1 Agricultural Waste Improves Soil Fertility

Edwards and Bohlen (1996) reported that the pH range between 6 and 7 promotes the availability of plant nutrients like NPK, so vermicompost should be applied in soil. Chemical parameters like pH and electrical conductivity (EC) were determined by ISI Bulletin (Butterworth and Mosi 1986) by using digital pH and conductivity meters. Vermicompost improves the pH of soil and make available the nutrient for the crop yield reported by Srikanth et al. (2000). The deficiency in organic carbon reduces the storage capacity of soil nutrients and reduction in soil fertility reported by Kale et al. (1992). Vasanthi and Kumarasamy (1999) and Srikanth et al. (2000) reported that the incorporation of vermicompost with farm yard manure have been shown to increase organic carbon content in the soil.

Atiyeh et al. (1998) reported that the conventional compost had higher ammonium, while the vermicompost tended to be higher in nitrates, which is the more available form of nitrogen. Kale and Bano (1994) reported that the vermicompost shows the high values of NPK as high as 7.37% nitrogen (N) and 19.58% phosphorus as P_2O_5 in worm's vermicast. Lee et al. (2004) suggested that the passage of organic matter through the gut of worm results in phosphorus (P) converted to forms which are more bioavailable to plants. Suhane et al. (2008) reported that exchangeable potassium (K) was over 95% higher in vermicompost. The nutrients N and P and the intestinal mucus excreted by worms are further used by the microbes for multiplication and vigorous soil remediation and fertility improvement action reported by Teotia et al. (1950).

15.4.2 Conservation of Paddy Straw Waste Material

Paddy straw can be used as a source of energy for small-scale processing units, for carrying out various processes like washing, boiling, canning, etc. A mushroom processing unit is being run by a farmer in village Aterna of district Sonipat; his processing unit works under biomass energy. Paddy straw, cotton sticks, mustard sticks, and husk is utilized as a source of energy in the processing unit (Shehrawat and Sindhu 2012).

15.4.3 Utilization of Biogas Plant Waste

Forty-one farmers possessed biogas plant. Slurry thrown out of the biogas plant is utilized by the farmers (100.00) as manure and for composting and vermicomposting by 78.04% of farmers. This result was analogous with the findings of Ponni et al. (2007) that vermicompost can be used as manure on farm, the application of FYM + vermicompost @ 2.5 t/ha along with the panchagavya 3% proved to be the best treatment as it was found to record the highest plant height (83.17 cm), number of branches (38.23) and leaves (1115.87) and also recorded the mass herbage (44.81 g/plant).

15.4.4 Utilization of Floricultural Waste Product

After picking flowers, the whole plant is a waste along with the damaged and unsold flowers. The left out flowers are generally unsold or sold at least price. Few farmers use it in composting, vermicomposting, and green manuring, but mostly it becomes a waste. The left out flowers can be dried and used for making dry flowers which is an upcoming industry. The dry flowers can be painted, colored, and dyed and various floral products such as cards, pictures, wall hangings, arrangements, potpourris, and pomanders can be made out of them. Dilta et al. (2011) also suggested that dry flowers can be painted, colored, dyed, and sold at very high prices.

15.4.5 Conservation of Horticultural Waste Product

Horticultural crops were cultivated by 64 farmers. Damaged or spoiled fruits and vegetables, dead plants, branches, leaves, and unsold fruits and vegetables are the horticultural wastes. Among these, damaged fruits and vegetables are turned into compost/vermicompost or fed to animals by 70.31% of farmers. The dead plants, branches, and leaves were fed to animals by 100.00% and composted by 70.31% of farmers. Unsold fruits and vegetables are fed to animals by 100.00%, composted by 70.31%, and 26.56% farmers sold it after processing.

Value added products can be made from surplus fruits and vegetables and then sold in market; this will not only help the farmers avoid wastage but to earn more. Another way of preserving the unsold fruits and vegetables is drying them and then selling. Various chemicals can also be extracted from waste fruits and vegetables like citric acid, lactic acid, acetic acid, etc. Production of lactic acid was studied that it can be produced through the batch and fed batch fermentation method using hydrolyzed potato starch, results from the findings of Zhang and Mu (2011) concluded that potato residues can also be used for extraction of pectin.

15.4.6 Uses of Sugarcane Waste Product

From sugarcane crop, residues are sugarcane trash and bagasse. From the farmers those who cultivated sugarcane (43 farmers), 48.83% used the bagasse as fuel in making jaggery, 46.51% turned it into compost/vermicompost, and only 11.62% sold it to paper/cardboard industry or power plant. Farmers used sugarcane trash to feed their animals (100.00), composting/vermicomposting (46.51), sell as animal feed (16.28), and use it for mulching (1.67). Apart from composting and feeding bagasse and trash to animal, bagasse can also be used as planting for growing green fodder. Besides this, sugarcane bagasse has one more important use which is production of biogas; this is similar to the findings of Dellepiane et al. (2003) who conducted the study due to the existing difficulty of finding energy sources and reducing pollution, the use of renewable sources and highly efficient technologies for electrical energy production, the combination of these two aspects, namely, a molten carbonate fuel cell system fed with biomass-derived syngas. In particular, the biogas comes from bagasse and barbojo, the sugarcane residues. So far in developing countries they have been wasted or partly used with poorly efficient technology.

15.4.7 Conservation of Cotton Waste Material

Seventy-five farmers cultivated cotton crop. Cotton sticks which are left after the picking of cotton are used as fuel and stored by all the farmers. Cotton sticks were not utilized for any other purpose. If the farmers sell the cotton sticks to power plants, plywood industries, particle board industries they can add to their income. Another way of changing the waste cotton sticks into useful material is by chipping and converting them into compost. Cotton waste can also be used in biogas production by treating it anaerobically. This was similar to the findings of Isci and Demirer (2006), who found out that cotton wastes are a good source of biogas. Approximately, 65, 86 and 78 mL CH4 were produced in 23 days from 1 g of cotton stalks, cotton seed hull and cotton oil cake in the presence of basal medium (BM), respectively. BM supplementation had an important positive effect on the production of biogas.

15.5 Summary

Waste materials are produced by human activities and it is being used as potential source for making various products. Generally, agricultural wastes are rich in nutrients, sugars, vitamins, pigments etc. also which make them source materials instead of wastes. They are utilized as both edible and nonedible products. Agri-wastes are of solid and liquid in nature causing environmental hazards making the ecosystem unsustainable when they are lying unattended. Industrial liquid waste is polluting river water and air. With intervention of some practices these wastes may be converted to many products like bio-compost, fermented products, candy, cosmetic products, pharmaceutical products, etc. Thus, reuse of agri-wastes is the future of alternative source of raw materials for various products which not only will reduce the production cost but also reduce the pollution level and will make the planet eco-friendly.

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