

SUSTAINABLE AGRICULTURAL WASTE MANAGEMENT PRACTICES AND APPROACHES: AN OVERVIEW

Abstract

The leftovers from the cultivation and processing of raw agricultural products, such as fruits, vegetables, meat, poultry, dairy products, and crops, are referred to as agricultural wastes. These are the byproducts of agricultural production and processing that are not products and may include materials useful to humanity, but whose economic worth is less than the expenses of gathering, transporting, and preparing them for use. They might be liquids, slurries or solids and their composition will vary depending on the system and kind of agricultural activity. Animal waste (manure, animal carcasses), food processing waste, crop waste (corn stalks, sugarcane bagasse, drops and culls from fruits and vegetables, prunings) and hazardous and toxic agricultural waste (pesticides, insecticides, and herbicides, etc.) are all considered to be part of agricultural waste, also known as agro-waste. Although estimates of the amount of agricultural waste generated are few, it is widely believed that they account for a sizable fraction of the trash produced in the developed world. Increases in livestock manure, crop wastes, and agro-industrial byproducts are inevitable outcomes of growing agricultural production. Global agricultural waste output is projected to rise significantly if developing nations keep up their intensification of farming practices. However, unplanned disposal of agro-industrial waste can cause extensive contamination of the land, water, and air. In order to reduce GHG emissions and the effects of climate change, it is important to use and manage these wastes in an environmentally friendly and sustainable way.

Keywords: Agricultural Waste Management, Sources, Agricultural Waste Generation, Pyrolysis.

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I. INTRODUCTION

As a result of many rural operations, agricultural waste is wasted and produced. It includes fertilizer and other waste from farms, slaughterhouses, and animal husbandry; wastes after harvesting the crop; fertilizer runoff from fields, etc.

The term "agricultural waste" is referring to the leftovers which come from the production and processing of agricultural products, including grains, crops, fruits, vegetables, meat, poultry, and dairy. Animal waste (manure, animal carcasses), food processing waste (Patil, 1998), crop waste, and toxic-xenobiotic compounds from pesticides and insecticides are all included in agricultural waste.

Although the estimate for generation of agricultural waste is uncommon, it can be estimated according to the amount of agricultural activities performed all around the world. Increased levels of livestock waste, crop leftovers, and agro-industrial byproducts are a natural consequence of expanding agricultural production. And since the developing countries are expanding their farming activities, there will probably be a noticeable rise in agricultural waste on a global scale. The annual production of agricultural waste is thought to be around 998 million tonnes (Aliku, 2019).

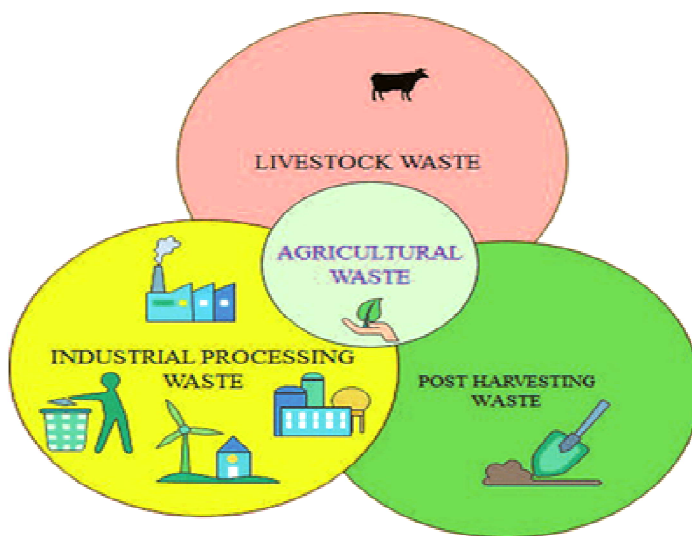


Figure 1: Types of Agricultural Waste (Iqbal *et al.*, 2020)

II. SOURCES

Increase in agricultural productivity has been an essential requirement, as the population is continuously growing. After the green revolution, it has been observed that productivity has improved and increased accordingly. The use of green revolution-related technology and the extension of productive soil are further factors that have improved agricultural output and quality. Around 24 million tons of food are reportedly produced by the agricultural sector each year, but there are also associated concerns about human health

and ecological threats (Krol *et al.*, 2013). A more effective and efficient method of processing agricultural solid wastes is required to boost agricultural production due to the detrimental effects of agriculture on the environment, aquatic life, and human health.

These wastes are hugely coming from the agricultural industries, which can either be exploited as raw materials for the bio-economy or allowed to pile indiscriminately and become a health hazard for everyone and a threat to food security. Recycling agricultural solid wastes has many advantages, including lowering greenhouse gas emissions and reducing the need for fossil fuels. It also has a positive impact on the growth of new green markets, generation of bioenergy, and the conversion of agricultural solid wastes into animal feed.

Solid agricultural wastes come from a variety of sources. Pesticides, which include insecticides and herbicides, are one such source. If the use of pesticides were to cease, it has been calculated that the amount of food produced on a global scale would decrease by approximately 42% (Blanchet *et al.*, 2016). Agricultural solid wastes are most of the time carelessly disposed of or burned in public areas, where safe disposal cannot be practiced due to lack of resources and space, which pollutes the air, soil, and aquatic environment as well as produces harmful gases, smoke, and dust. Remains may also be channelled into water sources to further contaminate the water supply.

Farming related practices and products are the main source of agricultural solid waste. However, it is not just production of crops due to intensive agriculture; it also includes other activities connected to farming. Every step and stage of the agricultural food chain has the potential to produce large amounts of agricultural solid waste. These are as follows:

- Solid wastes produced from the production of livestock for any purpose are referred to as "animal production solid wastes." These wastes include things like animal carcasses, broken feeders, water troughs, and bedding or litter.
- Solid wastes from food and meat processing come from facilities such as abattoirs or slaughterhouses that process crops or animal products for human use. Hoofs, bones, feathers, banana peels, and other agricultural solid wastes used in food and meat processing are a few examples.
- Wastes from production – wastes from crop production are often produced during agricultural activities that involve crop production. Such agricultural solid wastes include things like crop leftovers and husks.
- Toxic and xenobiotic waste – Solid wastes produced due to excessive usage of pesticides, or vaccines on animals are referred to as on-farm medical solid wastes. Such wastes include, for instance, syringes, disposable needles, vaccination wrappers or containers, etc.
- Wastes from horticulture production are under the category of agricultural solid wastes and are produced when horticultural plants are grown, maintained, and used for aesthetic purposes. Prunings and grass clippings are two examples of these wastes.
- Industrial agricultural solid wastes—livestock and produce are raised and generated for purposes other than human use. They are put to other purposes; thus, it is likely that these processes will produce agricultural solid wastes. Immediately coming to

mind as a source of agricultural solid waste is wood processing and cutting. Waste is also generated during the process of manufacturing and processing of wood pulp.

III. TYPE OF AGRICULTURAL WASTE MANAGEMENT

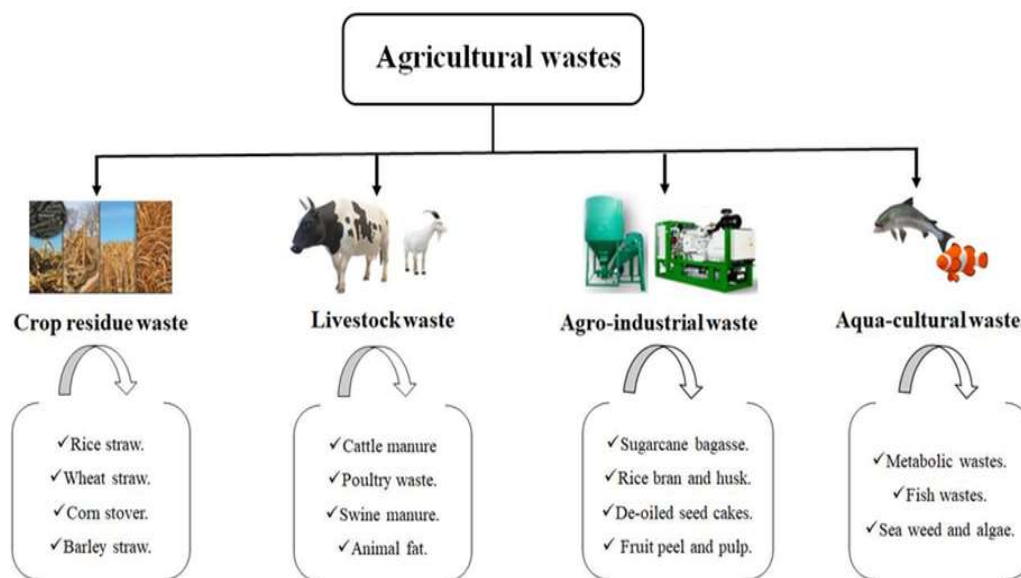


Figure 2: Illustration of different sources of Agricultural waste
 (Source: Muhammad et al., 2022)

“Agricultural waste” is associated with the leftovers, coming from the production and processing of agricultural products, including grains, crops, fruits, vegetables, meat, poultry, and dairy. Animal waste (manure, animal carcasses), food processing waste (Patil, 1998), crop waste, and toxic-xenobiotic compounds from pesticides and insecticides are all included in agricultural waste. They are the non-product byproducts of the production and processing of agricultural products, which may contain components that are useful to humans but whose economic values are lower than the expense of collecting, shipping, and processing for such purposes. They might be in the form of liquids, slurries, or solids, and their composition will depend on the system and kind of agriculture. Agro-industrial byproducts, agricultural crop wastes, and livestock manure have all naturally increased in volume as agricultural production has expanded. If the countries around the world continue to expand their agricultural systems, there will undoubtedly be a considerable rise in agricultural waste globally.

IV. AGRICULTURAL WASTE GENERATION

1. Cultivation Activities: Tropical climate is ideal for growing crops; however, it has been that it also fosters the growth of weeds and insects. Due to the enormous demand for pesticides caused by this condition to control the development of epidemic diseases and kill insects, farmers frequently abuse pesticides. The accumulation of these pesticides and fertilizers in huge amounts is also due to the dumping of their packaging bottles and bags

in the fields after their application. Generally, the xenobiotic compounds are toxic in nature, their prolonged usage can cause compound accumulation and later might exhibit negative impacts. In addition, pesticides that are already in use but are unused, and the packets in which the pesticides are packaged may contain remains of residue from their original contents, can have serious negative effects on the environment if they are used, kept or dumped improperly in an unprotected manner. Fertilizers, however, have been playing an important role in maintaining the crop quality and production. Cheap and very productive, inorganic fertilizer has both of these qualities. The quantity of fertilizer that many farmers use on their crops, however, is greater than what the plants actually require. The severe repercussion of using fertilizer so excessively is that it is abused to boost agricultural output every year. According to the characteristics of the soil, the types of plants grown in that soil, and the fertilization techniques used, the rate of uptake of fertilizers rich in nitrogen, phosphorus, and potassium is different in different species of plants and crops. A portion of excess fertilizer enters the groundwater, it is retained in the soil rhizosphere, goes to nearby water bodies via run off from the fields due to irrigation leading to the anthropogenic cause of eutrophication. Burning the crop residues results in air pollution as the absorbed fertilizers and pesticides are also burned alongside (Agricultural waste management field handbook).

2. **Waste Production via Livestock:** Livestock rearing and keeping comprises wastes like their dung and faeces and organic waste in slaughterhouses, grey waters from their urination, bathing and water used for cleaning purposes. Due to lack of space and change in land usage and demand pattern these slaughterhouses and livestock rearing farms are being built in and around the housing areas. Temperature, humidity, ventilation, animal density, and animal density all affect how strong the smell is. The ratio of ammonia, hydrogen sulphide, and methane fluctuates according to the various levels of digestion as well as organic materials, food ingredients, bacteria, and the conditions of the animal. This unprocessed waste source can produce gases contributing to greenhouse effect, harm the soil's fertility, and pollute the water in addition to other harmful effects if not treated well in time and properly. In animal waste, water volume makes up between 75 and 95 percent of the overall volume, with the remaining components being organic and inorganic debris, as well as numerous types of microbes and parasite eggs. These microorganisms and compounds have the potential to harm the environment and transmit diseases to people.
3. **Aquaculture:** Increased usage of feeds for better productivity is a result of the expansion of fish rearing in the crop fields alongside farming, also called integrated farming. Waste produced due to digestion and excretion processes are dissolved in the soil and if not managed might become a problem in the long run. Temperature-related factors affect feeding rates. A rise in temperature causes animals to feed more frequently, which leads to more excrement being produced. Since decomposition is a temperature sensitive phenomenon, the process may not go accordingly and might lead to settling down underneath, clogging the pores and seeps of soil leading to change in water and mineral percolation rate. This is important because it allows for the fast capture of a huge part of non decomposed faeces, which automatically lowers the amount of dissolved organic waste from water.

V. WASTE MANAGEMENT PRACTICES

Waste Utilization Routes: Waste utilization technology can be used to mitigate the problem of deterioration of stored leftovers. They consist of:

- 1. Fertilizer Application:** Utilizing organic waste as a useful resource is a key component of waste management, and fertilizer application is crucial in this regard. Organic waste that has been processed and converted into fertilizers includes food scraps, agricultural waste, and animal manure. We can efficiently recycle and repurpose the nutrients present in the waste by applying these organic fertilizers to agricultural fields or gardens. This promotes plant growth, enhances soil fertility, and lessens the need for synthetic fertilizers. Utilizing organic fertilizers made from waste materials lessens the need for chemical fertilizers, which, if not used properly, can have a negative impact on the environment (Handbook of Agricultural practices). We can reduce greenhouse gas emissions and help the environment by preventing organic waste from going to landfills and using it as fertilizer instead to a more sustainable, circular waste management system (Basu et al., 2015)
- 2. Anaerobic Digestion:** Through procedure known as anaerobic digestion, agricultural waste can be used to generate methane. In this procedure, the residues—such as crop leftovers, animal dung, and food waste—are put in an atmosphere devoid of oxygen, such as a digester or sealed tank. Aerobic bacteria in the digester convert the organic matter into residues while being exposed to oxygen through a series of biochemical processes. Methane gas, or biogas, as well as other byproducts including carbon dioxide and organic fertilizers are created during the decomposition process. This promotes a more sustainable energy system by reducing dependency on fossil fuel. It can be used for a variety of things, such creating power, providing heat, or even providing fuel for automobiles. Additionally, the remaining solids or liquid effluent from anaerobic digestion can be used as organic fertilizers in farming, giving the soil essential nutrients and completing the nutrient cycle. Overall, anaerobic digestion is a sustainable method for producing organic fertilizers and methane, as renewable energy source, from agricultural waste. This procedure aids in managing organic waste, lowering greenhouse gas emissions, and advancing the circular economy in agriculture.
- 3. Adsorbents in the Elimination of Heavy Metals:** The use of agricultural waste to remove heavy metals from wastewater has attracted much attention due to its economic advantages and high removal efficiency which is attributed to different functional groups. The sorption mechanism of biomass can consist of various steps consisting of chemisorption, complexation, adsorption on surface, diffusion through pores, and ion exchange. Heavy metals are removed at different rates depending on the adsorbent and metal. Heavy metals are capable of easy bioaccumulation through the food chain (Zhang et al., 2018; Bendjeffal et al., 2018). A wide range of technology is used in the physicochemical and biological treatment techniques used in industries for heavy metal extraction from wastewater and soil. These include Filtration, ion-exchange, reverse osmosis (Abdolali et al., 2015), chemical and electrochemical precipitation, membrane filtration (Semerjian, 2018), ultra-filtration, solvent extraction (Basu et al., 2017) electrolysis and coagulation (Kebede et al., 2018).

- 4. Pyrolysis:** In terms of trash management, pyrolysis is important. It provides a cutting-edge approach to handling various waste products in an eco-friendly manner. Pyrolysis can be used in the context of waste management to transform organic waste, such as agricultural byproducts or food waste, into marketable products (Kebede et al., 2018). Pyrolysis is the process of decomposing the organic stuff in these wastes at high temperatures without oxygen to create usable byproducts. Biochar is one of the main products of pyrolysis in waste management. Solid waste called biochar can be added to soil as a soil conditioner. By improving soil fertility, retaining moisture, and sequestering carbon when added to the soil, biochar aids in mitigating climate change. Bio oil, a liquid byproduct of pyrolysis, can also be produced that can be used as a replacement for fossil fuels or further processed into biofuels. This makes it possible to rely less on nonrenewable energy sources and promotes the development of a more sustainable energy future. By using pyrolysis in waste management, we can minimize the amount of waste that ends up in landfills, lower greenhouse gas emissions, and turn waste into useful resources. It's a win-win situation for our efforts to create a circular economy and the environment.
- 5. Animal Feed:** When discussing agricultural waste management, the term "animal feed" refers to the practices of turning specific wastes into animal feed. (Basu et al., 2017) This method aids in waste reduction and offers a long-term solution for handling organic materials. It is possible to process some agricultural leftovers and food byproducts that would otherwise go to waste and turn them into wholesome animal feed (Kebede et al., 2018). For instance, leftover grains from breweries, fruit and vegetable trimmings, and even some kinds of food waste can be processed and used as feed for animals. In conclusion, recycling waste into animal feed is a promising waste management strategy that helps reduce waste, nourish animals, and promote a more sustainable and effective use of resources.
- 6. Direct Combustion:** A method of managing agricultural waste called direct combustion involves burning waste products directly to generate heat or electricity. It is frequently used to dispose of waste that is not recyclable or hazardous. Direct combustion facilities, such as waste-to-energy plants, use specially constructed furnaces or incinerators to burn waste at high temperatures in the context of managing agricultural waste. The steam created by the combustion process is then used to power turbines, which produce electricity. It provides a number of benefits for waste management. As combustion significantly reduces the mass of the original waste materials, it reduces the volume of waste. As the ash residue produced can be safely disposed of in landfills, it also helps reduce the need for landfill space. Overall, direct combustion is a waste management technique that enables waste to be converted into energy, thereby reducing waste volume and aiding in the production of renewable energy.
- 7. Integrated Agricultural Waste Management:** Integrated agricultural waste management systems follow the resource management principle to lower production input costs. In this case, two or more companies are carefully combined so that the waste from one company can be used as input by another. For instance, animal manure is used to create biogas, biogas slurry is used to create vermicompost, which is then used for crop production (Management Handbook, 2011). Weeds and crop waste are also used as livestock feed. Only 25 to 30 percent of India's yearly production of more than 620

million tonnes of agricultural waste is used as animal feed or for energy production. Most Indian farmers use the rice-wheat cropping system, and they typically burn leftovers to get the land ready for the timely sowing of the next crop. The causes are a low nutritional value and higher labor costs to clear the field. Inflammable substances like CO₂, CH₄, N₂O, H₂S, O₃, and smog are released when crop residue is burned, adding to air pollution (Zhang et al., 2018). By removing beneficial soil microbes, it has a significant negative impact on daily life and changes the physical, biological, and chemical properties of soil. The issue of air pollution will be addressed by implementing effective agricultural waste management, but enhance crop inputs as well. 284.83 million tonnes of food grains are produced in India each year using 25.94 million tonnes of chemical fertilizers (NPK) Choudhary (2018) estimates that this can substitute for 6.5 million tonnes of chemical fertilizer, or 25% of the total amount required for NPK. India's economy is largely dependent on agriculture and the rural sector. India has 159.7 million hectares of arable land, which is the second-largest amount in the world after the United States of America (Plateau et al., 2018). Although farmers' primary focus is on crop production, a wide range of secondary products still fall under the category of agriculture because of various businesses, such as dairy, fishery, poultry, agroforestry) (Handbook on Agricultural Practices).

- **Objectives:** The intelligent application of science and technology in enhancing established procedures for maximum gain with the least possible harm to the nature and natural resources;
 - A plenty of opportunities in the area of employment and monetary increase throughout the year with a combination of two or more than two associated businesses.
 - Almost no waste production.
 - Utilization of waste coming from the farm
 - Reduce, reuse, and recycle as much garbage as possible
 - Waste to a novel product, such as methane
 - Long-term remedy
 - Sustainable solution

- **Factors to take into account when selecting businesses for integrated agricultural waste management include:**
 - Features of the soil and climate in a particular location or locale, such as the presence of livestock in certain ecosystems, such as fisheries and duck farming in wet ecosystems and sheep and goats in dry ones, etc.
 - The degree to which resources are currently being used
 - The planned system's financial viability
 - Local social practices for pre-calling

- **Integration of Enterprises for Agricultural Waste Management:** The establishment of a biogas plant with dairy would produce high-quality manure for crop cultivation as well as fuel for cooking and lighting uses.
 - Crop husbandry is the primary activity in agriculture that contributes to the most waste generation.
 - Vermicomposting works well with biogas slurry.

- Poultry use waste grains as feed more effectively.
 - Harvesting rainwater and collecting drainage water in a farm pond to irrigate crops
 - To cut down on water usage and weed growth, crop residue is used as mulch.
 - Agroforestry supplies wood for building purposes and shields crops from strong winds.
 - Year-round revenue is generated with sustainable productivity when businesses integrate science.
- **Advantages of Integrated Agricultural Waste Management:**
 - Enhance the health and fertility of the soil
 - The recycling of business waste as energy inputs for another system led to increased profitability.
 - Reduces trash accumulation (Patel *et al.*, 2020)
 - Greater production sustainability
 - Addressing the energy crisis
 - More effective use of family labour
 - Reduce the use of dangerous substances.
 - Resource Recycling
 - An environment devoid of pollution
 - **Limitations:**
 - Year-round shortages of labour
 - Farmers may be discouraged from transitioning to multi-enterprise systems and reaping the rewards of resource integration due to high start-up expenses.
 - The nutritional value of crop leftovers are often low.
 - Prolonged recycling can lead to nutritional losses.
 - Because it works quicker and is simpler to utilize, farmers prefer using chemical fertilizer instead of manure.
 - FYM and vermicompost are not enough to provide the nutritional needs of crops (Choudhary, 2018).

VI. CONCLUSION

Large volumes of organic waste are produced by agriculture, and if this garbage is not adequately managed, it may have detrimental effects on the environment and public health. These wastes are rich in nutrients and biodegradable, both of which are essential for enhancing crop development and soil fertility. Consequently, farmers may be able to benefit from the wastes' potential as bio-fertilizers for the growth of agricultural crops through management operations that include the collection, transfer, storage, processing, and use of agricultural wastes in organic farming.

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