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# Review on Agricultural waste utilization

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**ABSTRACT**: *Agricultural wastes are non-product 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 use. Estimates of agricultural waste arising are rare, but they are generally thought of as contributing a significant proportion of the total waste matter in the developed world. 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 global environment in general. Generally, agricultural wastes are generated from a number of sources notably from cultivation, livestock and aquaculture. These wastes are currently used for a number of applications through the '3R' strategy of waste management. Agricultural waste management system (AWMS) was discussed and a typical waste management options for a poultry farm was also described using the six agricultural waste management functions. Agricultural waste has a toxicity potential to plant, animals and human through many direct and indirect channels. The effects of these toxic agricultural wastes on the environment were discussed as well as their management.*

**KEYWORD**: waste–management, waste-utilization, recycle, reduce

## INTRODUCTION

Agricultural wastes are defined as the residues from the growing and processing of raw agricultural products such as fruits, vegetables, meat, poultry, dairy products, and crops. They are the non-product 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 use. Their composition will depend on the system and type of agricultural activities and they can be in the form of liquids, slurries, or solids. Agricultural waste otherwise called agro-waste is comprised 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 (pesticides, insecticides and herbicides, etc). Estimates of agricultural waste arising are rare, but they are generally thought of as contributing a significant proportion of the total waste matter in the developed world. 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



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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 percent 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).

**Agricultural Waste Generation**

As earlier noted, 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 global environmental in general. The waste generated is dependent on the type of agricultural activities carried out. While tropical climate is favorable for growing crops, it also supports the generation and development of insects and weeds. This situation creates a high demand for pesticides in order to kill insects and protect against the spread of epidemic diseases; this need often lead to the abuse of pesticides by farmers. After using pesticides, most of the bottles and packages holding these pesticides are thrown into fields or ponds. According to an estimate made by the Plant Protection Department (PPD), about 1.8% of the chemicals remain in their packaging Dien and Vong (2006).These wastes have the potential to cause unpredictable environmental consequences such as food poisoning, unsafe food hygiene and contaminated farmland due to their potentially lasting and toxic chemicals. In addition to this, existing stagnant or unused pesticides and pesticide packages with residue from the original contents poses serious environmental consequence in that they could be stored or buried in the wrong way which may leak or enter the environment through osmosis and thereby affecting the environment. In agricultural production for example, fertilizers play an important role in maintaining the productivity and quality of plants. Inorganic fertilizer is inexpensive and characterized by high productivity. However, many farmers apply more fertilizer to their crops than the amount needed by the plants Hai and Tuyet (2010). The serious consequence of such an excessive application of fertilizer is that it is used to the point of abuse in order to increase the annual agricultural output. The rate of absorption of such fertilizer compounds (nitrogen, phosphorus, and potassium) varies depending on the land characteristics, plant types, and method of fertilization Thao (2003).Among the fertilizer excess, a portion is retained in the soil, a portion enters ponds, lakes and/or rivers as a result of either surface runoff or the irrigation system adopted, which results in the pollution of surface water; a portion enters the ground water, and a portion evaporates or becomes de nitrated causing air pollution.

**Wastes from Livestock Production**

Waste from livestock activities include solid waste such as manure and organic materials in the Slaughter house; wastewater such as urine, cage wash water, wastewater from the bathing of animals and from maintaining sanitation in slaughterhouses; air pollutants such as H2S and CH4; and odors. The pollution caused by livestock production is therefore a serious problem since most of them are usually built around residential areas. Air pollution includes odors emanating from cages resulting from the digestion process of livestock wastes; the putrefaction process of organic matter in manure; animal urine, and/or from redundant foods. The intensity of the smell depends on animal density, ventilation, temperature, and humidity. The proportion of NH3, H2S, and CH4 varies along with the stages of the digestion process and also depends on organic materials, the components of foods, microorganisms, and the status of the animals'



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health. This untreated and no reusable waste source can generate greenhouse gases while also having negative effects on the fertility of the soil and causing water pollution. In livestock waste, water volume accounts for 75–95% of total volume, while the rest includes organic matter, inorganic matter, and many species of microorganisms and parasite eggs Hai and Tuyet (2010). Those germs and substances can spread diseases to humans and cause many negative effects on the environment.

**Waste from Aquaculture**

The growth in aquaculture has led to an increase in the use of feeds for improved production. The amount of feed used in a system is the most important factor used in determining the quantity of waste generated. The wastes that result from the use of aquaculture feeds are discussed in this section of the report and it is a summary of the information provided by Miller and Semmens (2002). One of the major wastes generated in aquaculture is metabolic waste which could be dissolved or suspended. In a properly managed farm, approximately 30% of the feed used will become solid waste. Feeding rates are dependent on the ambient temperature. Increase in temperature results in increased feeding which gives rise to increased generated waste. Water flow patterns in production units are important for waste management because a proper flow will minimize the fragmentation of fish faces and allow for rapid settling and concentration of the settle able solids. This can be critical because a high percentage of non-fragmented faeces can be quickly captured which will greatly reduce the dissolved organic waste Mathieu (1995).

**Waste Utilization Routes**

Agricultural waste utilization technology must either use the residues rapidly, or store the residues under conditions that do not cause spoilage or render the residues unsuitable for processing to the desired end product. There are a number of applications to which these wastes can be used. They include:

**Fertilizer Application**

The utilization of animal manures for fertilizer has a definite impact on input energy requirements at the farm level Timbers and Downing (1997). Manure could supply 19, 38 and 61% of nitrogen, phosphorus and potassium in chemical fertilizer Council for Agricultural Science and Technology Utilization of animal manures and sewage sludge in food and fiber production (1975). However, fertilizer use of manures from large confinement is associated with high energy costs for transport, distribution, storage facility requirements, odor problems and possibility of groundwater contamination. Mokwunye (2000). Reported that poultry manure contain high phosphorus which has positive effect on the growth and productivity of crops. It is also effective when combined with mineral phosphorus fertilizer for farm use. Adding manure to soil increases its fertility because it increases the nutrient retention capacity (or cation exchange capacity), improves the physical condition, the water holding capacity and the soil structure stability.



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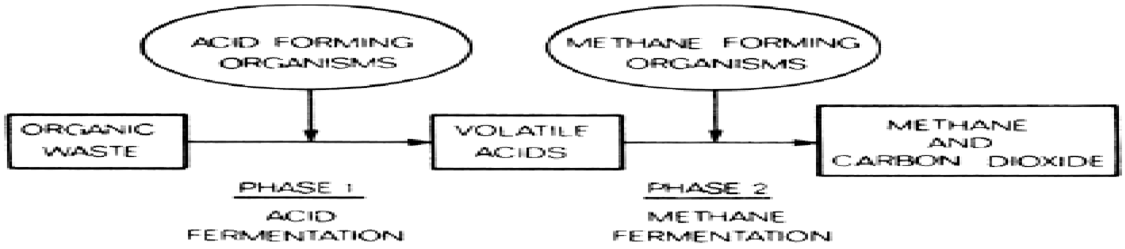


Figure1; Methane production by two-stage microbial fermentation, Timbers and Downing (1997).

**Anaerobic Digestion**

Methane gas can be produced from agricultural wastes particularly manures. The gas is best suited for heating purposes as in broiler operation, water heating, grain drying, etc. The anaerobic digestion of agricultural waste to form methane-rich gas is a twostep microbial fermentation. Initially, acid-forming bacteria break down the volatile solids to organic acids which are then utilized by methan-ogenic organisms to yield methane-rich gas (Figure1). The composition of the typical gas produced is: methane, 50-70%; CO2, 25-45%; N2, 0.5-3%; H2, 1-10% with traces of H2S; and the heating value of the gas is in the range of 18-25 MJ/m3 Timbers and Downing (1997). Some of the major disadvantages of the digestion system are the high capital costs and the explosive properties of the methane gas. However, the advantages far outweigh the aforementioned disadvantages. Anaerobic digestion makes the treatment and disposal of large poultry, swine and diary waste feasible, minimizing the odor problem. It stabilizes the waste and the digestion sludge is relatively odour-free and yet retains the fertilizer value of the original waste.

**Adsorbents in the *e*limination of heavy metals**

Excessive release of heavy metals into the environment due to industrialization and urbanization has posed a great problem worldwide. Unlike organic pollutants, the majority of which are susceptible to biological degradation, heavy metal ions such as copper, cadmium, mercury, zinc, chromium and lead ions do not degrade into harmless end products Gupta *et al.*, (2001). The presence of heavy metal ions is a major concern due to their toxicity to many life forms. Studies on the treatment of effluent bearing heavy metal have revealed adsorption to be a highly effective technique for the removal of heavy metal from waste stream and activated carbon has been widely used Chand *et al.*, (1994).

In recent years, agricultural wastes have proven to be a low cost alternative for the treatment of effluents containing heavy metals through the adsorption process. The low cost agricultural waste such as sugarcane bagasse Mohan and Singh (2002), rice husk Ayub *et al.*,(2002), sawdust Ajmal *et al*,(1996), coconut husk Tan *et al.*,(1993), oil palm shell Khan *et al.*,(2003), neem bark Ayub *et al.*,(2001). etc., for the elimination of heavy metals from wastewater have been investigated by various researchers.

**Pyrolysis**

In pyrolysis systems, agricultural waste is heated up to a temperature of 400-600°C in the absence of oxygen to vaporize a portion of the material, leaving a char behind. This is considered to be a higher technology procedure for the utilization of agricultural wastes. Others



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are hydro-gasification, and hydrolysis. They are used for the preparation of chemicals from agricultural waste as well as for energy recovery. Of particular interest to agriculture are the preparation of alcohols for fuel, ammonia for fertilizers, glucose for food and feed. Pyrolysis of agricultural waste yields oil, char and low heating value gas.

**Animal feed**

In most developing countries, the problem with animal feed is in the limited availability of protein sources although great efforts are being made to find alternative supplements Leng *et al.*, (1992). Crop residues have high fiber content and are low in protein, starch and fat.

Therefore, the traditional method of increasing livestock production by supplementing forage and pasture with grains and protein concentrate may not meet future meat protein needs. Use of the grain and protein for human food will compete with such use for animal feed. These problems may be circumvented by utilizing residues to feed domesticated animals Hussein and Sawan (2010).

**Direct combustion**

The simple act of burning agricultural waste as fuel is one of the oldest biomass conversion processes known to mankind. Complete combustion of agrowaste "consists of the rapid chemical reaction (oxidation) of biomass and oxygen, the release of energy, and the simultaneous formation of the ultimate oxidation products of organic matter – $CO_2$ and water" Klass (2004).

The energy released is usually in the form of radiant and thermal energy provided oxidation occurs at sufficient rate; the amount of which is a function of the enthalpy of combustion of the biomass. If agricultural waste is to be utilized efficiently through thermal conversion process, there is need to fabricate these biomass wastes into solid form. It is usually burnt for heating, cooking, charcoal production, and the generation of steam, mechanical and electric power applications. Of all the processes that can be used to convert agricultural waste to energy or fuels, combustion is still the dominant technology accounting for more than 95% of all biomass energy utilized today Klass (2004).

**Agricultural Waste Management System (Arms)**

Recently, agricultural waste management (AWM) for ecological agriculture and sustainable development has become an issue of concern for policy makers Hai and Tuyet (2010). The usual approach to agricultural waste management has been discharge to the environment with or without treatment. There is need to consider wastes as potential resources rather than undesirable and unwanted, to avoid contamination of air, water, and land resources, and to avoid transmission of hazardous materials. This will require better use of technology and incentives, a change in philosophy and attitudes, and better approaches to agricultural waste management. The organic wastes, especially manure generated by animals, if improperly managed or left untreated can result in significant degradation of soil, water and air quality. Stagnant wastes provide a medium in which flies breed and diseases are transmitted. Uncontrolled decomposition of organic wastes produces odorous gases as well as ammonia volatilization, leading to acid rain Wright (1998). Because of the intensification of animal production on a small area of land, there are increasing concerns about: Water quality resulting from higher nitrogen and phosphorous loadings; Pathogens and antimicrobial compounds in the manure;

Foul odors and air quality from ammonia, methane and nitrous oxide emissions and Soil quality because of potassium and phosphorous loading Fabian (1993). An Agricultural Waste Management System (AWMS), according to USDA (2012) is a "planned system in which all necessary components are installed and managed to control and use byproducts of agricultural production in a manner that sustains or enhances the quality of air, water, soil, plant, and animal resources". Such a system is developed using total systems approach, i.e. it is designed to cater for all the waste associated with agricultural production to utilization throughout the year round. The Total Solids (TS) concentration of agricultural wastes is the main characteristic that determines the handling of the material. For excreted manure for example, the following factors affect the TS concentration and they include the climate, type of animal, amount of water consumed by the animal, and the feed type. In most systems the consistency of the waste can be anticipated or determined. The TS concentration of the waste can be increased by adding beddings or other solid waste to the waste, decreased by adding water, and stabilized by protecting it from additional water. The TS concentration is important in that it affects the total volume of the waste to be handled. Liquid waste management systems are often easier to automate and manage than those for solid wastes; however the initial cost of the liquid handling equipment may be greater than that for solid waste systems USDA (2012). AWMS consist of six basic functions (Figure 2) as noted by USDA (2012). These are production, collection, storage, treatment, transfer, and utilization. Production is a function of the amount and nature of agricultural waste generated. The waste requires management if quantities produced is sufficient enough to become a resource concern. A complete analysis of production includes the kind, consistency, volume, location, and timing of the waste produced. Collection refers to the initial capture and gathering of the generated waste from the point of origin or deposition. The AWMS plan should identify the method of collection, location of the collection points, scheduling of the collection, labor requirements, necessary equipment or structural facilities, management and installation costs of the components, and the impact that collection has on the consistency of the waste. The storage function has to do with the temporary containment or holding of the waste. The storage facility of a waste management system provides control over the scheduling and timing of the system functions such as the treatment and application or use of the waste which could be affected by weather or interfered with by other operations. The waste management system should identify the storage period; the required storage volume; the type, estimated size, location, and installation cost of the storage facility; the management cost of the storage process; and the impact of the storage on the consistency of the waste. Treatment is any function designed to reduce the pollution or toxic potential of the waste, including physical, biological, and chemical treatment and increases its potential beneficial use. It includes pretreatment activities such as analysis of the characteristics of the waste before treatment; a determination of the desired characteristics of the waste following treatment; the selection of the type, estimated size, location, and the installation cost of the treatment facility; and the management cost of the treatment process. Transfer refers to the movement and transportation of the waste throughout the system from the collection to the utilization stage either as a solid, liquid, or slurry, depending on the total solids concentration. Utilization is the application of the waste for beneficial use and it includes recycling reusable waste products and reintroducing non reusable waste products into the environment USDA (2012).



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**The '3R'Approach to AWM**

The concept of minimizing waste reduces the quantity and ill-effects of waste generation by reducing quantity of wastes, reusing the waste products with simple treatments and recycling the wastes by using it as resources to produce same or modified products. This is usually referred to as '3R'. Some waste products can be consumed as resources for production of different goods or the same product, meaning recycling the same resource. When wastes are reused time and again, it offsets harvesting of new similar or same products. This saves fresh resources exploitation and reduces waste generation. All in all, the 3Rs individually or collectively saves fresh resources exploitation, add value to the already exploited resources and very importantly minimizes the waste quantity and its ill effects. The principle of reducing waste, reusing and recycling resources and products (3Rs) aims at achieving efficient minimization of waste generation by: Choosing to use items with care to reduce the amount of waste generated, Repeated use of items or parts of items which still have usable aspects and The use of waste itself as resources.

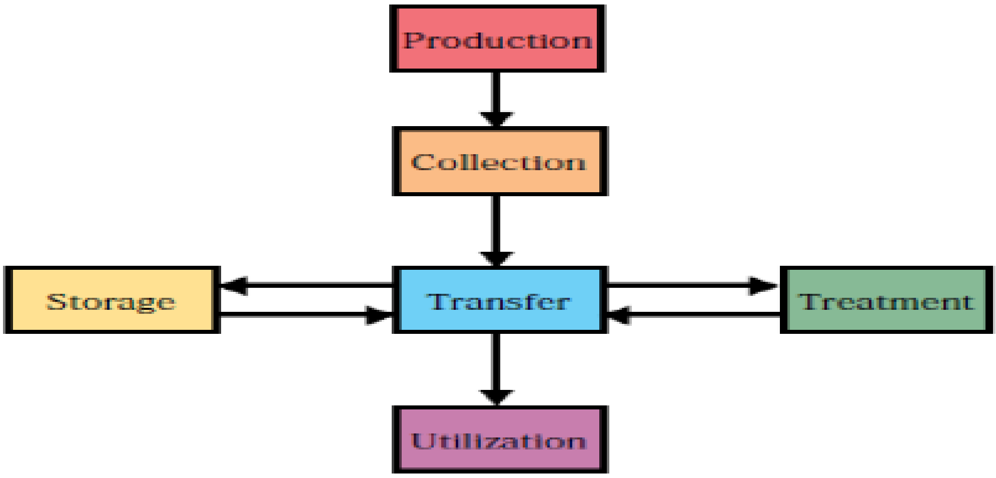


Figure 2: Agricultural Waste Management Functions USDA (2012).

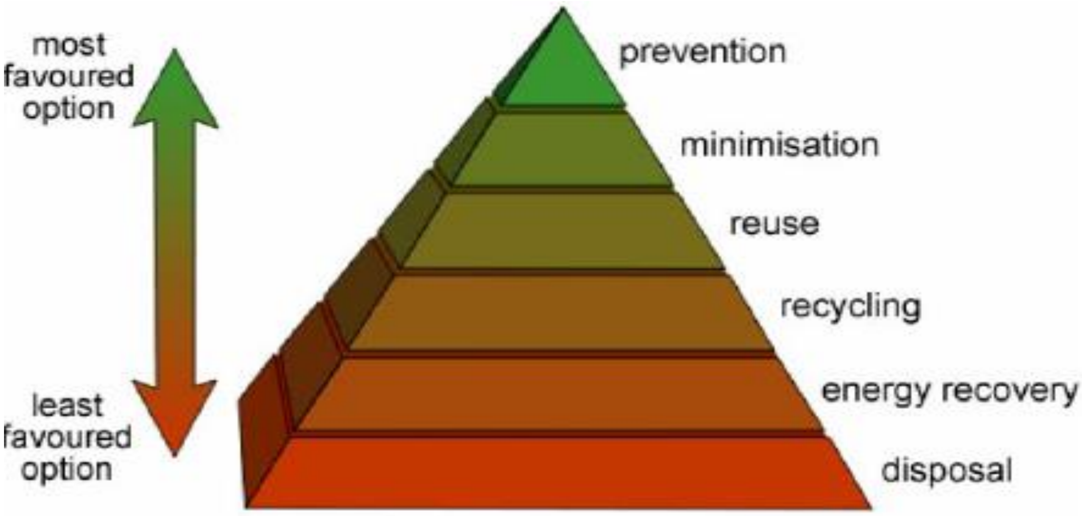


Figure 3: The 3Rs Hierarchy Bangladesh (2010).


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**The 3R Hierarchy in AWM**

Waste minimization efficiency is stated to be better achieved applying 3Rs in a hierarchical order- Reduce, Reuse and Recycle (Figure 3).The waste hierarchy refers to the "3Rs" i.e., reduce, reuse and recycle, which classify waste management strategies according to their desirability. The 3Rs are meant to be a hierarchy, in order of importance. The waste hierarchy has taken many forms over the past decade, but the basic concept has remained the foundation of most waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste. The 3R approach as noted by USDA (2012). Is conventionally expressed through a pyramid hierarchy in which increase in environmental benefits of each approach is placed from bottom to top.

**Typical poultry waste management options**

A poultry farm is used here to describe a typical waste management system showing the application of each component function of an AWMS. The poultry waste management system is as described in USDA (2012). A holistic view of the various waste management options for poultry production in shown in Figure 4.

4.3.1 Production

Wastes associated with poultry operations include manure and dead poultry.

Depending upon the system, waste can also include litter, wash-flush water, and waste feed.

**Collection**

The manure from poultry operations is allowed to accumulate on the floor where it is mixed with the litter. The manure litter pack forms a “cake” that generally is removed between flocks. The litter pack can be removed frequently to prevent disease transfer between flocks. In layer houses, the manure that drops below the cage is collected in deep stacks or is removed frequently using either a shallow pit located beneath the cages for flushing or scraping or belt scrapers positioned directly beneath the cages.

**Storage**

Litter from poultry operations is stored on the floor of the housing facility or outside the housing facility. When it is removed, it can be transported directly to the field for land application. In some areas the litter may be compacted in a pile and stored in the open for a limited time; however, it generally is better to cover the manure with a plastic or other waterproof cover until the litter can be used. But if it is needed to be stored for a long time, the litter should be stored in a roofed facility. If the manure from layer operations is kept reasonably dry, it can be stored in a roofed facility. If it is wet, it should be stored in a structural tank or an earthen storage pond.

**Treatment**

Poultry litter can be composted. This stabilizes the litter into a relatively odorless mass and helps to kill disease organisms so that the litter can be reused as bedding or supplemental feed to livestock. The litter can also be dried and burned directly as a fuel. Liquid manure may be placed into an aerobic digester to produce methane gas.



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### Transfer

The method used to transfer the waste depends on the total solid content of the waste. Liquid waste can be transferred in pipes, gutters, or tank wagons, and dried litter can be scraped, loaded, hauled as a solid and transported using trucks.

### Utilization

The waste from poultry facilities can be used for agricultural land application or sold because of the high nutrient value of the litter. Furthermore, poultry waste can also be used for the production of methane gas, buried directly as a fuel, reused as bedding, or used as a feed supplement to livestock.

## CONCLUSION

Agricultural wastes are residues from the growing and processing of raw agricultural products are nonproductive outputs of production and processing and may contain material that can benefit man. These residues are generated from a number of agricultural activities and they include cultivation, livestock production and aquaculture. It is important to not from the findings so far that proper waste collection, storage, treatment, transfer, and utilization is a panacea to a healthy environment. Proper waste utilization will assist in developing our agricultural sector and provide viable biofuel resource for many.

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