**WASTE MANAGEMENT IN AGRICULTURE- CREATING WEALTH FROM WASTE**

Susibna Subhadarshini, Alisha Mohapatra, Sahista Illias, Soumen Kar

C.V Raman Global University, Mahura, Janla, Odisha- 752054

**ABSTRACT:**

Farming has been in practice since human decided to settle down and start cultivating their own for food. Farming is the oldest occupation both in India and world which contributes towards all the sectors of a country’s economy. Agriculture encompasses activities like crop production and livestock management, aquaculture, forestry etc. Agricultural land is approximately 5 billion hectares or 38% of global land surface. This also generate wastes that may either be in range of organic or inorganic material. Agricultural wastes are the products produced after production/processing that are not desirable. These substances may have certain economic value but these values are much less than cost of collection, transportation, processing for beneficial uses. These may include various leftover material that were not used for primary agricultural purposes. Agricultural wastes were produced during different stages of production and contribute a significant amount to total wastes in the world. Agricultural wastes are currently being modified to other forms so that won’t possess serious threat to a wide range of human, animal and plant population.

**KEYWORDS:**

Agriculture, waste, generation, utilisation

**INTRODUCTION:**

Agricultural wastes comprise the materials that are produced by crop production and plant during its growth and also other enterprises (fishery, poultry, sericulture etc.). These materials are not directly useful in increasing the economic status but can be modified to some useful form. These wastes when converted can help soil to regain its fertility and transformed into other helpful substances such as biogas, manures etc. In the past, these wastes were either burnt or were converted into organic fertilisers under favourable conditions. But, now-a-days biomass produced from agricultural wastes are being utilized for energy generation. As the population is increasing, a wide range of gap is arising between energy required and energy available. As these biomasses, being biodegradable, have a wide range of potential to be converted into energy source; this provides a vast scope. Biomass is one of the most abundantly present form of resources that has capability of being converted to other energy forms. Utilisation of these agricultural wastes has become a concern for present day as it can be efficiently transformed into other forms of energy and useful products. In an estimate, it is stated that around 998 million tonnes of agricultural wastes are produced annually over the world, which is a serious concern. These wastes should be properly managed rather being just used for fuel purposes. Agricultural wastes should be managed in such a way that both human and planet get befitted. Rather than burning the wastes which cause pollution, it should be used in a manner that something very useful can be produced from it. Agricultural waste management (AWM) is crucial for sustainable agriculture and conservation of environment. There are various ways of AWM, but following are few examples:

1. Composting- This is the process of decomposition of organic wastes (crop residues, fruit and vegetable wastes, animal wastes etc.) into nutrient-rich compost. This compost can be used as an alternative of chemical fertilizers and help in enhancing fertility.

2. Biomass energy production- Agricultural wastes can be converted into biomass energy through various processes like anaerobic digestion, pyrolysis, or gasification. This helps in production of renewable energy and reduces burden on fossil fuels.

3. Crop residue management- Instead of burning crop residues after harvest, these can be incorporated in the soil or left in the field. This helps in soil conservation, acts as mulching material, improves soil fertility by returning organic matter to the soil.

4. Animal waste management- Manure from livestock production can be properly managed through techniques like composting, anaerobic digestion, or for biogas production. Effective waste management helps in reduction of greenhouse gas emissions, water pollution, etc.

5. Integrated Pest Management (IPM)- This is a strategy that focuses on combining multiple pest control methods to minimize the use of pesticides. It includes practices like crop rotation, biological pest control and using resistant crop varieties.

6. Cover Cropping- Planting of these crops during off-season can help in preventing soil erosion, improves soil health and suppresses weed growth. These also absorb excess nutrients, prevent nutrient run-off and water pollution.

7. Recycle and Reuse- Packaging materials and agricultural plastics can be recycled or reused to minimize wastes. This also reduces impact on environment.

8. Agroforestry- Integrating shrubs and trees with crop plants help in enhancing bio-diversity, reduce soil erosion along with providing additional income sources.

These practices help in reducing environmental pollution, conserving resources, improving soil health and promoting sustainable agricultural practices. Implementing agricultural waste management strategies is essential for the long-term health and productivity of agricultural systems.

There are various successful case studies of agricultural waste management.

Case study 1- Rice straw management in Punjab, India

In Punjab, the problem aroused after rice crop harvest where it is the major crop. After harvest, large amounts of rice straw were traditionally burnt in the field which caused severe air pollution, contributed to greenhouse gas emissions and degraded soil health. To address this issue, the Punjab government and other organisations implemented the agricultural waste management initiative. They started practising “straw mulching”. Here, specialised machinery like ‘Happy Seeders” were used which cut and spread rice straw evenly on the field after harvest, instead of burning it. The outcome came out to be impressive. It reduced air pollution that was produced by burning of straw. It also enriched the soil fertility as the paddy wastes decomposed returning the nutrients back to the soil.

Case study 2- Fruit and vegetable waste management in South Africa.

In South Africa, large quantities of fruits and vegetable wastes were generated from agricultural markets, processing units, and retail stores. Improper disposal of this waste led to environmental pollution and resource wastage. For this, an innovative approach to agricultural waste management was adopted, wherein the wastes were collected and processed using anaerobic digestion, known as digestate and was used as nutrient rich organic fertiliser. There were several positive impacts of this like- production of renewable energy sources, diversion of wastes, organic fertiliser production and generation of employment.

Case study 3- Coffee waste utilisation in Costa Rica

Coffee production in Costa Rica generated substantial amounts of coffee pulp waste. The traditional disposal methods involved dumping the wastes in rivers or landfills, causing water pollution and environmental degradation. To address this problem, initiatives were launched. The coffee pulp wastes were used as soil amendments and organic fertiliser due to its high nutrient content. The utilisation of coffee waste yielded several benefits. This included waste reduction, reduced environmental impacts like water pollution, diversification of revenue streams.

These case studies demonstrate how innovative agricultural wastes management practices can lead to environmental protection, resource conservation and improved agricultural sustainability.

**GOAL OF AGRICULTURAL WASTE MANAGEMENT:**

The prime goal is to effectively and sustainably handle the waste generated during various agricultural practices. The primary objectives of waste management include environmental protection, resource conservation, improved soil health and fertility, economic efficiency, disease and pest control, compliance with regulations and mitigating for climate change. The main goal of waste management is to strike a balance between agricultural productivity and environmental sustainability, ensuring that agricultural practices remain viable and beneficial in the long term while minimizing negative impacts on the environment and human health. To stop the indiscriminate disposal of wastes, to reduce the environmental and health hazards, it becomes important to manage the agricultural wastes that are being produced during different stages of production.

**GENERATION OF AGRICULTURAL WASTES:**

Agricultural development activities are usually accompanied by wastes from the irrational application of intensive farming methods and the intense application of chemicals used in cultivation which is affecting the environmental conditions in a huge manner. The waste generated is dependent on the type of agricultural activities carried out.

**Wastes from organic sources:**

Wastes from Cultural activities- In crop field, where climate is favourable for growth of crops it also leads to the growth of weeds and development of insect population because of which farmers use high number of chemical pesticides to control this type of situations. After using immense number of pesticides farmers throw the bottles and packages holding pesticides to the fields and ponds. According to PPD (Plant Protection Department) about 1.8 percent of chemicals remain in that packaging which leads to environmental pollution, food poisoning, unsafe food hygiene and contaminated farm land. And the chemicals may leak or enter to the atmosphere by the process of osmosis thereby affecting the environment. In the process of cultivation, fertilizers play an important role in maintaining productivity and quality of plants. Inorganic fertilizers are cheap in cost and farmers apply more fertilizers in order to gain high productivity. Although the excessive application of fertilizers increases the annual agricultural output but the rate of absorption of such fertilizer compounds varies depending on the land characteristics, plant types, methods of irrigation. Among the excess portion, a portion is retained in soil, another portion enters to water channels as a result of surface runoff which results in pollution of surface water; a portion enters to the ground water and a portion enters to the atmosphere by the process of evaporation causing air pollution.

Wastes from Livestock Production- Wastes from livestock activities include solid wastes like manure and organic materials, liquid wastes such as urine, waste water from bathing of animals and maintaining sanitation in slaughterhouses, air pollutants such as H2S and CH4 and odours.

Solid waste:

\*Dung: also known as cow pats or cow manure is the waste Product of bovine animal species. Cow dung is the undigested Residue of plant matter which has passed through the animal Gut. The resultant fecal matter is rich in minerals.

Cow dung contains-

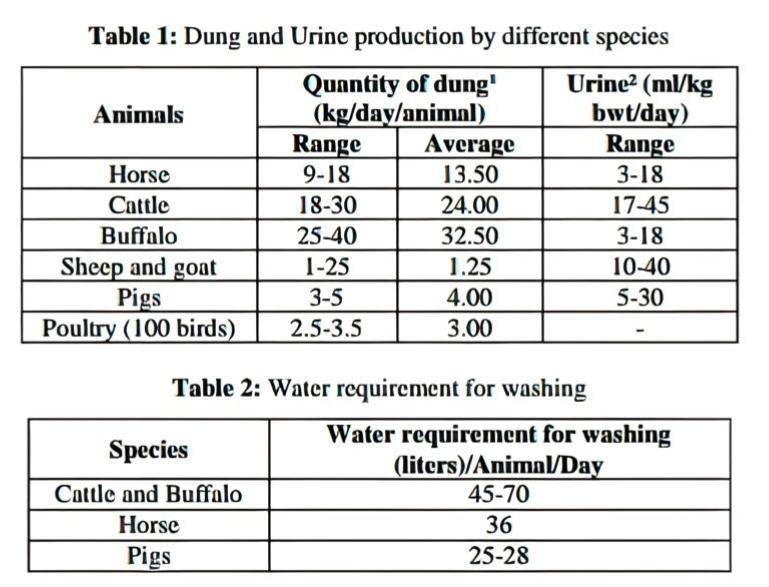
* Moisture-77 per cent
* Organic matter-20 per cent
* Nitrogen-0.32 per cent
* Phosphorus-0.14 per cent
* Potassium-0.30 per cent
* Calcium-0.40 per cent

\*Wasted feeding material: Food waste or food loss is food that is discarded or lost or uneaten.

\*Soiled bedding material: Straw, saw dust and wood shavings, Paper-based bedding materials etc.

Liquid Waste:

1. Urine
2. Washed water



Wastes from Aquaculture- Aquaculture is one of the fastest growing food sectors providing an ultimate livelihood option to a million of peoples across the world. In the last three decades, capture fisheries production increased from 69 million to 93 million tons; during an equivalent time, world aquaculture production inflated from 5 million to 63 million tons. Globally, fish currently represents about 16.6 percent of animal protein supply and 6.5 percent of all protein for human consumption (FAO, 2012). The continuous increase in global fish resources results in 25% of wastage among total fish catch annually (FAO, 2012). Fisheries generate large number of solid wastes such as whole fish waste, fish head, viscera, tails, skin, bones, blood, liver, gonads, guts and some muscle tissues and also liquid wastes consisting of wastewater used during fish processing. Every year, enormous amount of these processing wastes is discarded from seafood processing plants and fish markets. Because of the specificity of certain raw material and its processing in relation to a specific product, surplus and waste food processing co-products are not readily used by the parent processors. During 2006-07, an estimate of 3, 02,750 tonnes of waste was generated from fish processing (both processing and pre-processing taken together) industries of India alone. The maximum waste was generated from processing of shrimps followed by fin fishes and cephalopods. On the context of environmental pollution, waste generation from fish processing is of great concern today. This waste may be a superlative staple for the preparation of high value-added products including proteinaceous foods. These are also a valuable source of raw material for recovery of bioactive compounds. Additionally, inappropriate disposal is a major cause of environmental pollution.

Wastes from Poultry- The poultry industry produces large amounts of solid waste like bedding material, excreta, feed, feathers, hatchery waste, mortality waste and waste water like faeces, urine, saw dust, remnants of drugs pesticides, disinfection of chicken houses and abattoirs. Poultry manure contains 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. The poultry wastes also pose serious environmental pollution problems through offensive odours and promotion of fly and rodent breeding.

**HOW TO UTILIZE WASTES THROUGH OTHER ROUTES (WEALTH FROM WASTES):**

Agricultural waste utilization technology uses the wastes produced rapidly or store them in conditions that do not cause spoilage or any other changes unsuitable for being converted into a useful product. There are a number of applications to which these wastes can be used. These include:

1. Fertilizer application

The use of animal manures as fertilizer decreases the reliance on use of chemical fertilizers. Manures can supply 19,38 and 61% of nitrogen, phosphorus and potassium in chemical fertilizers. Poultry manure contain high amount of phosphorus which has a positive impact on growth and productivity of crop. Adding manures to soil increases nutrition retention capacity, improves physical condition, increases water holding capacity and soil structure stability. However high energy costs, transportation, storage facility requirements, odour problems and possibility of groundwater contamination possess substantial amount of risk.

2. Anaerobic digestion

Manures can also be used in production of methane gas. This gas is very suitable for heating purposes in broiler operation, water heating, grain drying, etc. The production of methane rich gas from manure is a two-step reaction of microbial fermentation. Initially the acid forming bacteria break down the volatile solids to organic acids. These are then utilized by methane-ogenic organisms to yield methane rich gas. The gas produced by this process consists of methane (50-70%), carbon dioxide (25-45%), nitrogen (0.5-3%), hydrogen (1-10%) with traces of hydrogen sulphide. The disadvantages include high initial costs and its explosive property. However, the advantages overweigh the mentioned disadvantages.

3. Adsorbents in the elimination of heavy metals

Unlike organic pollutants, that are susceptible to biological degradation, the heavy metal ions such as copper, cadmium, mercury, zinc, chromium mad lead ions do not get degraded and causes a major concern due to their toxicity to many life forms. To reduce this toxicity, treatment of effluent bearing heavy metals have revealed adsorption to be a highly effective technique for the removal of heavy metal from waste streams. Activated charcoal is being widely used for this purpose. In recent years, agricultural wastes have proven to be a low-cost alternative for treating the effluents containing heavy metals through the adsorption process. Various researchers have found the positive usage of sugarcane bagasse, rice husk, saw dust, coconut husk, oil palm shell, neem bark etc., for elimination of heavy metals from wastewater.

4. Pyrolysis

This is a process in which agricultural waste is heated to a temperature of 400-600°C in the absence of oxygen to vaporize a portion of material, leaving the char behind. This is a high technology procedure for waste utilization. Other processes include hydro gasification and hydrolysis. They are used for energy recovery as well as for preparation of chemicals. Of particular interest in agriculture are the preparation of alcohols for fuel, ammonia for fertilizers, glucose for food and feed. The pyrolysis of agricultural waste yields oil, char and low heating value gas.

5. Animal feeds

In most of the developing countries, the main problem in animal feeds is that a low protein source is available. For this, great efforts are being made to find alternative supplements. As the crop residues are high in fibre content and low in protein, fat and starch content, the traditional method of increasing livestock production by supplementing forage and pasture with grain and protein concentrate may not meet future meat protein needs. Use of grain and protein for human food will compete with use for animal feed. This problem can be circumvented by utilizing residues to feed animals.

6. Direct combustion

Burning agricultural waste as fuel is one of the oldest biomass conversion processes known to mankind. Complete combustion of wastes leads to simultaneous formation of ultimate oxidation of organic matter – carbon dioxide and water. The agricultural waste should be fabricated to solid form if it needs to be utilized efficiently through the thermal conversion process. 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.

**WASTE MANAGEMENT IN DIFFERENT SECTORS OF AGRICULTURE:**

The first goal of any waste management system is to maximise the economic benefit from the waste resources keeping in mind the safety standards of environment. If wastes produced are not properly handled and managed can lead to various environmental hazards.

*“Management that puts into the practice the principles of the four Rs of Reduce, Reuse, Recycle and Recover is the best first option.”*

* The amount of waste generated should be reduced.
* The waste product should b reused on the farm itself or provided to others for their use.
* After complete process of reducing and reusing, the other left portion should be recycled on the farm like land application of wastes, or off-farm like plastic recycling.
* Methane gas should be recovered from manure waste.

Only after considering the four Rs, farm wastes should be disposed. Following are some important sectors with their waste management strategies:

1. Crop Residue Management:

After harvesting, proper crop residues management helps in preventing soil erosion, improving soil fertility, and reduces outbreak of diseases and pests. The practices include:

* They could be left on field as mulching material to protect the soil from erosion and retaining moisture.
* The crop residues can be incorporated in the field to enhance the soil organic matter content. It also improves soil structure.
* Crop residues can be converted into bio-energy by various processes.

2. Livestock Waste Management:

* Livestock wastes can be composted to produce compost with rich organic matter content.
* Manure can be converted into biogas for energy production through anaerobic digestion.
* Manures can be applied to plants to avoid nutrient run-off.

3. Food Processing Waste Management:

Wastes after food processing includes peels, shells and several other by-products. Their management includes:

* Recycling wastes to form animal feed or compost.
* Using them in generating renewable energy sources.
* Can be used in waste segregation processes.

4. Agrochemical Waste Management:

The use of pesticides and fertilizers, lead to generation of wastes and environmental pollution.

* The empty containers and left chemicals should be disposed safely following local regulations.
* Excessive dependence on agrochemicals should be reduced by adopting practices like integrated pest management (IPM) and integrated disease management (IDM).

5. Aquaculture Waste Management:

The wastes from aquaculture includes uneaten feeds, faeces and dead organisms.

* The water quality in ponds or other structures should be properly managed to minimise waste.
* The waste water should be treated and recycled for other purposes.
* Biological processes and organisms should be used for waste treatment.

6. Post-Harvest Waste Management:

The post-harvest operation wastes can be reduced by:

* Use of efficient post-harvest techniques to minimise wastes and spoilage.
* Converting them to value-added products like jams, pickles, juices etc. through processing.
* Donating the edible surplus food to different food banks or charitable organisations.

Hence, the agricultural waste management should prioritise sustainable practices, this will help in reducing waste, promoting the concepts of recycling and reuse and protecting the environment so that there will be ecological balance and long-term agricultural produce. So, the government, farmers and other stake-holders should work together to implement the practices effectively.

**AGRICULTURAL WASTE MANAGEMENT SYSTEM (AWMS):**

Agricultural waste management system (AWMS) refers to a set of practices, strategies and technologies used to handle and dispose of agricultural wastes in an environmentally sustainable and responsible manner. There is a 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. The AWMS consist of six basic functions. These are production, collection, storage, treatment, transfer, and utilisation. Production is a function of nature and amount of waste generated. If the quantities produced is sufficient enough to become a resource, waste management is required. Production includes the kind, consistency, volume and timing of waste produced. AWMS considers all the methods of collection, location of the wastes to be collected, labour requirements, necessary equipment and facilities, cost of installation, impact of collection etc. The storage function deals with the temporary residence of the wastes generated. It helps in storing the wastes when there is an unavailability of suitable facilities for waste utilisation. The treatment function deals with the removal of toxic substances from the wastes, including physical, biological and chemical treatments. Transfer of waste refers to the movement and transportation of wastes from the point of collection to the utilisation. The wastes are transferred as solid, liquid or slurry depending on the requirements and total solid concentration. Utilisation refers to the application of the substances derived from the wastes for beneficial use. It includes recycling, reusing of wastes and also re-introducing non-reusable products to the environment.

**CONCLUSION:**

The wastes generated from the agricultural sector are outputs of processing of raw agricultural products and non-products. These residues are formed from agricultural activities like cultivation, livestock production, aquaculture and poultry. These wastes when managed properly through application of 3R systems (Reduce, Reuse, Recycle) those can be transformed into beneficial materials for human and agricultural usage. Proper collection of wastes, storage, treatment, transfer and utilisation of wastes can develop a healthy environment, agriculture sector and provide viable biofuel resources.

**FUTURE PROSPECTIVES:**

1. The agricultural waste management is expected to be closer to sustainability and circular economy. Rather than considering wastes as unwanted, it possesses the capability to be converted to a valuable resource.
2. With advancement of technologies, it is expected that efficient and timely waste collection and utilisation of wastes is possible.
3. Agricultural wastes such as crop residues and other organic matter have the capability of being converted to biofuels and bio-chemicals. This is expected to fulfil the increasing energy demands.
4. Rather than wasting or destroying the wastes, several value-added products like biochar, compost and animal feed supplements can be produced.
5. Implementation of more stringent actions and plans by the government and international agencies will help in removing the tax breaks, disposal restrictions of waste for wastes to be converted to value-added products.
6. Creating wealth from wastes will also increase the public awareness. There will be enhancement of practising sustainability.
7. Waste management would also help in combatting the climate change and reduce burden on the mother earth.

**DECLARATIONS:**

We hereby declare that the work entitled “Agricultural Waste Management” is a record of original work by our members and with reference to following eminent persons and the listed websites.

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