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Waste to Wealth Techniques in Agriculture: A Strategy for Environmental Sustainability

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Abstract

Global population increase over the decades has put a great demand on food productivity which has consequently made agriculture sector a major waste generator. Agriculture waste generation comes from crop residues, animal manure and droppings, food processing by-products as well as food packaging materials. Improper handling of farming by-products can lead to water pollution, air pollution, soil fertility distortion and loss of valuable organic matter. Therefore, an appropriate waste management strategy is essential to check the ugly trend due to agriculture waste. Agriculture wastes are thus transformed into valuable products such as enzymes, biochar, biogas, animal feeds and other useful products to support environmental sustainability and for economic empowerment of the farmer. The paper reviewed different techniques for converting agriculture wastes into valuable outputs and products for a sustainable environment.

Introduction

World population is growing, demanding food security and increased agricultural production. Farming activities will continue to generate large quantities of waste that must not end up in landfills.

Agricultural waste is the product of agriculture operations on-farm and off-the-farm. It starts from on-farm to post-harvest to marketing to processing to household.

There are varieties of wastes being generated either in liquid or solid form through human activities (domestic), agricultural or industrial activities.

All over the world approximately 147.2 million metric tons of fiber source are found, whereas 709.2 and 673.3 million metric tons of wheat straw residues and rice straws were estimated respectively, in the 1990's (Belewu and Babalola, 2009).

Most reports say that untreated and underutilized agro-industrial waste is disposed of by burning, dumping or placing it in landfill (Chilakamarry et.al, 2022; Awogbemi & Von, 2022)

Improper handling of farming by products can lead to water pollution, reduced soil fertility, climate impact, and the loss of valuable organic matter.

A large strain on the environment has resulted from increased global output of wastes, with detrimental effects on soils, air, and water resources (FAO, 2016) which in turn threaten the health of populations and the long term viability of ecosystem. About 21-37% of greenhouse gases are produced by the agricultural sector (Lynch et.al, 2021)

Agriculture is a big source of waste generator at different paths of food supply chain that occurs as follows: crop cultivation, post-harvest processing and handling, marketing, processing and consumption

Food is a basic human need and producing enough to feed the population of developing nations is one of the biggest challenges. Hence an environmental friendly technology intervention in food production is desirable. One of such intervention is adequate management of agro-waste particularly as it concerns agricultural and food processing.

Farmers need to recognize the potential of agricultural waste and adopt eco-friendly strategies for a more resource-efficient world.

This paper reviews the different techniques available in agricultural waste management, their benefits, limitations, challenges as well as overall contribution to economic and environmental sustainability of the nation.

Classification/Sources of Agriculture Waste

There are varieties of waste being generated either in liquid or solid form through human activities, agricultural or industrial activities.

Agricultural wastes are classified based on their origin, composition, and potential uses as:

i) Crop residues:- These are residues left after harvesting crops, including stalks, stems, leaves, husks and shells.(e.g. Rice straw, wheat straw, corn stalks and sugarcane bagasse).

ii) Animal waste:-Generated from livestock farming activities such as manure, urine, and bedding materials like straw or sawdust.

iii) Processing by-products:- Residues from processing of agricultural commodities such as bran, husks, pomace and press cakes e.g. rice bran, wheat bran, fruit pomace, and oilseed cakes.

iv) Aquaculture waste:- Generated from aquaculture operations such as fish feces, uneaten feed, and dead organisms.

v) Forestry residues:- Generated from forestry operations, including branches, barks, sawdust and wood chips.

vi) Agro-industrial wastes:- Generated from agro-industrial processes such as distillation residues, bagasse from sugar mills, and press mud from sugarcane processing.

vii) Green wastes from urban areas: - Generated from households, markets, restaurants, and other urban sources including fruit scraps, and garden wastes.

Influence of Agricultural Waste on Human Health/Economy

The effects of agriculture waste on human health vary depending on factors such as handling practices, exposure levels, and level of contamination.

Pitchel (2005), grouped environmental resultant effects from wastes under five categories as:-global warming, photochemical oxidation creation, abiotic resource depletion, acidification and eutrophication

Potential health risks associated with agriculture waste includes:

Air pollution:- Burning crop residues or animal manure releases particulate matter (PM) and harmful gases like ammonia and methane causing respiratory issues.

Water contamination:- Improper disposal of agriculture waste can lead to run-off containing pathogens, pesticides, and excess nutrient contaminating water sources and posing danger to humans.

Disease transmission:- Direct contact with animal manure or contaminated water can lead to spread of pathogens such as E-coli, Salmonella and Cryptosporidium causing Gastro-intestinal illness and other infections in humans.

Occupational hazards:- Workers involved in handling or processing agricultural waste may be exposed to dust, microbes, and harmful chemicals, increasing the risk of respiratory problems, skin irritations and other occupational health issues.

Sustainable Techniques in Management of Agricultural Wastes (Wastes as Wealth)

Agriculture waste management is the coordination, handling and controlling of waste generated from agricultural activities with the objective of preventing soil, water and air pollution.

The scientific innovation in the turn of the century has moved the world from use-waste-pollute to use- waste-reuse.

Products can be reused again. Thus instead of becoming an environmental challenge, our wastes are turned into useful items (Ogawa, 2017)

An effective and sustainable agriculture waste management focuses on waste reduction, waste recycling and waste reuse.

Some of the basic techniques used in agriculture waste management are:

Composting:- Is the conversion of plant residues, trimmings, manure and other agricultural products into nutrient-rich compost. The compost is used for soil conditioning for increased crop productivity.

Bio-gas production:- Bio-gas digesters are used to convert waste to renewable energy for cooking, heating and electricity generation This technique help in managing waste as well as improve the living condition of farmers through use of cleaner energy.

Mulching:- Agricultural wastes are used as mulching materials to conserve soil moisture, suppress weed growth and enhancement of nutrient retention. Mulching also protects soil from erosion and temperature fluctuations.

Biomass conversion:- Biomass conversion is a process that converts agriculture waste through fermentation, pyrolysis, combustion or gasification into biofuels, biochemical and bio plastics.

Recycling packaging materials:- Use of various materials including plastic containers, bags and packaging, to facilitate crop planting, harvesting and transportation. It involves processing plastic material to turn them into new products.

Biochar production:- Converting the biomass waste into biochar, a soil amendment that enhances soil fertility and carbon sequestration.

Animal feeds:-Residues from agricultural wastes such as rice straw or corn stalks are converted into animal feeds.

Mushroom cultivation:- Crop residues are used as substrate for mushroom cultivation which can be sold for culinary or medicinal purposes.

Jonathan and Babalola (2013) studied 16 diverse agro-industrial wastes for cultivation of edible mushrooms i.e. Pleurotus tuber-regium.

Phytochemical extractions:- Extraction of valuable compounds from agriculture waste for use in pharmaceuticals, cosmetics or food additives.

Orange peel extracted with different solvents exhibit variable antioxidant activities (Hegazy and Ibrahium, 2012).

Enzyme production:- Agro-industrial waste consist of variable composition that supports the growth of microorganism as a result of fermentation produce different valuable enzymes.

Topakas et.al (2004) used corn cobs for the production of phenolic with solid state fermentation in addition to coupling enzyme treatment.

Antibiotic production:- Various agriculture waste are used for the production of different antibiotics.

Asagbara et.al (2005) successfully produced oxytetracycline with solid state fermentation by consuming groundnut shell as a raw material with strain of Streptomyces rimosus.

Benefits of Agriculture Waste Management

The benefits of waste management include:

Helping farmers mitigate the risk of contaminating natural resources and preserving ecosystem health.

Production of nutrient-rich fertilizer to replace inorganic fertilizers

Poverty reduction by sale of by-products.

Enhancement of food security by minimizing exposure to harmful chemicals and pathogens.

Reduced pressure on forest resources biodiversity.

Increased innovation on products manufacturing.

Challenges Associated with Agriculture Waste Management

Logistic challenges:- Transporting wastes from farms to processing facilities can be costly

Technological constraint:- Some of the technologies used in the waste conversion require specialized equipment and manpower.

Economic viability:- Profitability can only be achieved if the costs of processing waste products into value-added products are competitive with available alternatives.

Market demand: - Identifying and accessing markets for the products from waste is most a times challenging.

Regulatory hurdles:- Compliance with local environmental regulations and obtaining permits to cite waste processing facilities could be time consuming.

Seasonal variability:- Agriculture waste availability varies with season creating fluctuations in feedstock and production capacity utilization.

Resource intensity:- Some of the conversion techniques require a lot of water, energy or other resources leading to competition with other existing facilities.

Social acceptance:- Public perception and acceptance of products derived from wastes can influence market demand and hence investment in such ventures.

Collaboration and partnership:-Stakeholders collaboration is required to develop innovative solutions and supportive policies.

Addressing the Challenges of Agriculture Waste Management

Addressing the challenges associated with agriculture waste management requires multi-faceted approach as follows:

Research development:- Investment in research is necessary to develop cost effective and efficient conversion techniques to process different types of agriculture wastes.

Infrastructural development:- Infrastructures for waste collection, transportation and processing are required to help streamline the processing.

Financial incentives:- Incentives like grants, subsidies or tax exemption can encourage investment in agriculture waste conversion projects

Regulatory support:- Friendly policies and regulations are necessary to aid establishment of waste conversion facilities.

Market development:- Thorough market campaigns, certifications and partnership are required to promote the products derived from wastes.

Capacity building:- Training and education of stakeholders is necessary to enhance skills in the required areas.

Public engagement:- Engagement with local communities and stakeholders to address concerns, build trust and foster acceptance for the projects is pertinent.

Conclusion

Effective transformation of agricultural waste as a crucial aspect of sustainable farming protects the environment and human health.

The use of agriculture and agro-based industry waste as well as raw materials can help to reduce the production cost and contribute in recycling of waste as well as make the environment eco-friendly.

Among the most sustainable waste transformation techniques, small scale anaerobic digestion stands out as the most efficient and accessible to farmers of all categories.

It is simple but effective technology that keeps waste under control and helps farms to use green energy sources and depends less on fossil fuels.

Waste to wealth management techniques in agriculture leads to sustainable development. The government should actively promote it by providing essential incentives to rural sectors.

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