REVIEW ARTICLE

Addressing agricultural waste management challenges: Innovative approaches and best practices

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Agricultural waste has become one of the increasing concerns in recent years, as they may cause significant environmental problems; however, they may also use for several beneficial purpose, as feed stock for energy production and for chemical recovery and chemical or dye adsorption. Agricultural wastes including manure, harvest waste, fertilizer run-off, pesticides and silt are produced from agricultural operations. Advancements in technology and sustainable practices have improved waste management with innovative methods like composting, anaerobic digestion and bioconversion offering valuable resources. The integration of Information and Communication Technologies (ICT) can enhance waste management processes. However, agricultural waste can be harmful to the environment and workers and storage can increase hazards by releasing harmful gases. This review is divided into the following four sections: agriculture waste characterization, waste reuse and recycling, waste treatment and waste management and minimization.

Key Words: *Agricultural waste; Waste generation; Waste management; Waste solution*

INTRODUCTION

Agricultural wastes are defined as the residues from the agricultural waste refers to waste that is produced from agricultural operations. Agricultural waste includes manure and other wastes from farms, poultry houses and slaughterhouses; harvest waste; fertilizer run-off from fields; pesticides that enter into water, air or soils; silt drained from fields. Recent advancements in technology and an increasing emphasis on sustainable practices have opened new methods for managing agricultural waste more efficiently. Innovative methods such as composting, anaerobic digestion and bioconversion offer potential solutions for converting waste into valuable resources like fertilizers, bioenergy and animal feed. Moreover, the integration of Information and Communication Technologies (ICT) can enhance waste management processes by providing real-time data, improving resource allocation and facilitating better decision-making.

This paper aims to explore the challenges associated with agricultural waste management and present innovative approaches and best practices for addressing these issues. By examining case studies and successful examples from various regions, we will highlight the potential of modern technologies and sustainable practices in transforming agricultural waste into valuable resources.

The agricultural waste potentially damaging to the environment and also these wastes may expose workers to harmful biological material that is biohazards.

Storing agricultural waste can multiply the hazards associated with it since stored waste can release harmful gases which are not good for health [1].

LITERATURE REVIEW

Agricultural waste generation

Earlier it is noted that agricultural development is usually accompanied by wastes from the irrational application of intensive farming methods and the improper use of chemicals in cultivation, remarkably affecting rural environments in particular and the global environmental in general. The waste generated is dependent on types of agricultural activities carried out.

Wastes from cultivation activities: While tropical climate is good 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 those insects and weeds and protect against the spread of epidemic diseases; this need often lead to the misuse of pesticides by farmers. After using pesticides, most of the pesticides 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. 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. 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. The rate of absorption of such fertilizer compounds such as nitrogen, phosphorus, potassium, etc. varies depending on the characteristics of land or yield, types of plants and method of fertilization. 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, these leads to air pollution [2].

Wastes from livestock production: Waste from farm animal activities include solid waste like manure and organic materials within the slaughterhouse; sewer water like urine, cage wash water, sewer water from the showering of animals and from maintaining sanitation in slaughterhouses; air pollutants like Hydrogen Sulfide (H_2S) and Methane (CH_4) and odours. The pollution caused by livestock production is so significant downsides since most of them are typically designed around residential areas. Air pollution includes odours emanating from cages ensuing from the digestion method of livestock wastes. The intensity of the smell depends on animal density, ventilation, temperature and humidness. The proportion of Ammonia (NH_3), H_2S and CH_4 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 animal's health. This untreated and non-reusable waste supply will generate greenhouse gases whereas also having negative effects on the fertility of the soil and inflicting 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. Those germs and substances will unfold diseases to humans and cause several negative effects on the environment.

Waste from aquaculture: The growth in cultivation has led to a rise within the use of feeds for improved production. The amount of feed employed in a system is the most significant issue employed in decisive the amount of waste generated. One of the key wastes generated in cultivation is metabolic

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waste which could be dissolved or suspended. Feeding rates are dependent on the ambient temperature. Increase in temperature leads to increased feeding which provides rise to increased generated waste. Water flow patterns in production units are vital for waste management as a result of a correct flow can minimize the fragmentation of fish body waste and permit for fast sinking and concentration of the settleable solids. This is vital as a result of a high proportion of non-fragmented body waste can be quickly captured which can greatly reduce the dissolved organic waste.

Problems due to agricultural waste

Health problems: Pesticides, ammonia heavy metals, fertilizers and oils from farms and farm equipment have a serious impact on health when they get into drinking water. People who drink this tainted water take in these harmful substances, which can cause major health issues or even lead to early death. Reports show that nitrates from contaminated water result in blue baby syndrome causing infant deaths.

Other dangerous chemicals like heavy metals can damage vital organs, weaken the immune system and harm the nervous system. Farm waste can also introduce parasites and bacteria into water adding to the spread of diseases and deaths [3].

Reduction in long-term agricultural yields: Farmers keep using pesticides, herbicides and other farm chemicals to fight off pests, weeds and diseases. But many don't know how these harsh chemicals affect their land over time. These strong chemicals stick around in the soil for years. They can pollute water and plants and kill helpful bugs and tiny organisms in the soil.

This has an impact on how fertile the soil is how good the crops and how well nature balances itself. In the long run, it can lead to lower crop yields. Maybe that's why some farmers are going back to old-school manure and organic farming methods [1].

Effect on aquatic life: Agricultural pollution has a major impact on water systems and groundwater, which causes serious harm to aquatic life. Fish and other water-dwelling animals absorb farm chemicals, pesticides and fertilizers which affect their health and ability to reproduce. When surface waters have high levels of nitrogen and phosphorus from fertilizers, manure and animal waste it leads to eutrophication. This process uses up dissolved oxygen killing fish and other aquatic creatures. Other chemical compounds, like heavy metals and ammonia can also hurt aquatic life and cause fish deaths [4].

Eutrophication: Systems, nitrogen and phosphorus from manure and fertilizers cause eutrophication when rain or irrigation washes them into nearby surface waters. Eutrophication is the thick growth of plant life and algae on the water surface and results in lots of algal blooms.

Eutrophication reduces dissolved oxygen, which can kill fish and other water-dwelling creatures. It also has a link to more cases of paralytic shellfish poisoning in humans which can lead to death.

Soil pollution and depletion of soil fertility: Chemical pesticides, herbicides and agrochemicals used to control pests, diseases and weeds often pollute the soil and can stick around for years. This has an impact on soil microbial activities and soil chemistry over time reducing soil fertility by destroying soil microorganisms. Studies show that millions of fertile soils are lost each year due to synthetic fertilizers, pesticides and herbicides along with other farming methods [5].

Water pollution: Farming activities and methods like poor water control and watering cause water pollution from surface runoff affecting both surface and ground water. Using fertilizers, pesticides, manure, weed killers and other farm chemicals results in widespread contamination of waterways and ground waters and lowers water quality. Soil erosion and sediment buildup also pollute the water making it dirty and cloudier. As a result, plants, wildlife, humans, animals and water-dwelling creatures suffer negative effects.

Air pollution: Farm animals and fertilized fields can release a lot of gases into the air. These gases, like nitrogen oxides and ammonia, contain carbon and nitrogen and might contribute to the greenhouse effect. When farmers plow, harvest or use machines like tractors, they burn fossil fuels. This has an impact on greenhouse gas levels. Also, some natural processes in the soil give off many greenhouse gases.

Destruction in biodiversity: The ongoing use of chemical products in farming has a negative impact on and destroys soils, animals, plants, waters and wildlife. This changes the ecosystems that support biodiversity. Also, pesticides can kill helpful insects, soil microorganisms, birds and some uncommon small species like butterflies. This has far-reaching effects on biodiversity [6]. These chemicals stay in the soils for many years, which leads to huge consequences for biodiversity [1].

DISCUSSION

Multifaceted approach as a solution

Watershed efforts: The collaboration of a wide range of people and organizations across an entire watershed is important to cut down on nutrient pollution. State governments, farm groups, nature protection organizations, schools, non-profits and community clubs all play a role in successful efforts to boost water quality.

Nutrient management: Applying fertilizers in the proper amount at the right time of year and with the right method can significantly reduce the potential for pollution.

Cover crops: Planting certain grasses, grains or clovers can help keep nutrients out of the water by recycling excess nitrogen and reducing soil erosion.

Buffers: Planting trees, shrubs and grass around fields, especially those that border water bodies can help by absorbing or filtering out nutrients before they reach a water body.

Conservation tillage: Reducing how often fields are tilled reduces erosion and soil compaction, builds soil organic matter and reduces runoff.

Managing livestock waste: Keeping animals and their waste out of streams, rivers and lakes keeps nitrogen and phosphorus out of the water and restores stream banks.

Drainage water management: Reducing nutrient loadings that drain from agricultural fields helps prevent degradation of the water in local streams and lakes [7].

Preventive measure

Aerobic fermentation (composting method): Turning organic waste into compost for farms is becoming a popular and workable way to handle organic trash. People think composting is the top method for dealing with organic waste. These days, you can compost in open areas using clean organic waste from parks and gardens without needing to add air. You can also do it in closed spaces to speed things up and avoid bad smells. In this case, the waste gets ground up, sifted and mixed first. Benefits and ways to prevent environmental risks are composting helps the environment by cutting down on waste in landfills. It's also good for health because it reduces the chance of germs in waste surviving and spreading [5]. Furthermore, the final product makes great fertilizer for soil. The main advantages and prevention measures of environmental risks of composting technology are as follows:

1. It ensures environmental protection near livestock rearing and also in the whole area in which it applies.
2. It replaces heavy to carry with a concentrated product, easily transportable, odorless, free of pathogens, easy to store, a bulky product with high humidity.
3. The compost is a product able to reduce the deficiency of organic matter and micronutrients in agricultural soils.
4. The use of compost as agricultural soil fertilizer or growing medium has significant environmental benefits. Besides reintegration nutrients in the soil and thus leads to reduction in the favoring of chemical fertilizers used, compost biodegradable waste is no longer reach to the ecological deposit. The greenhouse gases from composting have a low contribution to the global warming because this practice is not yet widespread. Bio-filter in the enclosed composting facilities removes odour emissions [8].

Anaerobic digestion process: Anaerobic digestion is a biochemical process. It breaks down complex organic materials like plant biomass, animal waste organic trash, wastewater and sewage sludge. This happens without oxygen

resulting in biogas and digested matter. Different types of anaerobic bacteria do this work. For years, people have used anaerobic digestion to stabilize sewage sludge. In recent times, this method has grown to treat and recover energy from other wastes. These include animal waste sorted household trash industrial organic waste and factory wastewater [6]. Making biogas through anaerobic fermentation and using it has many upsides. It benefits society as a whole and farmers involved. These benefits are social, economic and environmental they include: renewable energy source; reduced emissions of greenhouse gases and reduce the global warming; contribution of the alignment to the European Union requirements for energy and environmental protection for agriculture; reducing the odours from livestock but also from other organic waste; significant additional source of income for the agricultural sector.

The process of anaerobic digestion has a limited impact on the environment, which is related to the biogas production itself: risk of odours, solved by burning odorous components in the exhaustion air or other odour treatment techniques and risk of explosion, solved by utilization of explosion-proof equipment [9].

Integration of information and communication technologies: Information and Communication Technologies (ICT) can play a critical role in optimizing agricultural waste management processes by providing real-time data, improving resource allocation and facilitating better decision-making. Enhances efficiency and effectiveness of waste management operations through data-driven decision-making. Improves monitoring and tracking of waste generation, collection and processing. Facilitates communication and coordination among stakeholders, including farmers, waste processors and policymaker's real-time data, improving resource allocation and facilitating better decision-making [10].

Policy support and community engagement: Effective agricultural waste management requires supportive policies and active community engagement to ensure the adoption and sustainability of innovative solutions [10]. Creates an enabling environment for the adoption of sustainable waste management practices. Encourages community participation and collaboration in waste management initiatives. Enhances the scalability and impact of waste management solutions.

CONCLUSION

The challenge of managing agricultural waste requires a multifaceted approach to mitigate its adverse effects on the environment and human health. Despite the significant environmental hazards posed by agricultural waste such as soil and water pollution, air contamination and impacts on biodiversity innovative solutions offer potential methods for improvement. Advances in technology, including composting, anaerobic digestion and the integration of ICT, present viable methods for transforming waste into valuable resources. These practices not only help in reducing pollution but also contribute to sustainable agricultural development. Additionally, policy support and community engagement are important for the successful implementation of these solutions. By Encouraging a collaborative approach among stakeholders and leveraging modern technologies, we can address the pressing issues of agricultural waste and work towards a more sustainable and environmentally-friendly agricultural sector. The ongoing development and application of these practices will play a key role in shaping the future of agricultural waste management.

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