

Agricultural waste management and recycling: An overview

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Abstract

Annually, agricultural waste (AW) is produced and disposed of worldwide, including plant residues, animal manure, and byproducts from agricultural processing. The disposal and processing of AW have become a global issue due to incineration, improper management, and inappropriate burial, leading to serious environmental pollution and the release of various air and water pollutants. The purpose of this review is to emphasize the importance of investigating efficient methods for environmentally friendly agricultural waste management. These methods can reduce waste volume, increase water retention capacity, improve soil fertility and health, promote sustainable agriculture, and add nutrients and organic matter to enrich the soil. Ultimately, this creates direct and indirect job opportunities and economic value. In addition to effectively managing agricultural waste, these technologies help generate electricity and sequester carbon, thereby advancing the goals of reducing climate change and promoting a circular economy.

Keywords: “agricultural waste, waste management, Recycling, Reduction”.

1. Introduction

In recent years, a significant amount of agricultural waste has been generated worldwide annually and disposal of agricultural waste. Agricultural waste (AW) encompasses plant waste, livestock and poultry manure, as well as waste from processing agricultural and sideline products. This waste varies in composition depending on the products obtained during manufacturing processes in agro-industries, livestock, and aquaculture [1, 2]. The disposal of AWs and their processing is a global issue because the vast majority of them are currently being burned or buried in soil, leading to pollution of the air, water, and contributing to global warming [3]. Agricultural waste that is not properly managed can be a source of pollutants such as nitrate, phosphorus, significant amount of N₂O, SO₂, CH₄, greenhouse gas emissions, and smoke are produced during the process of agricultural waste incineration [4]. Also Improper disposition of agricultural wastes leading to serious environmental pollution [1, 3]. The effective utilization of agricultural waste is a great option to convert these wastes into recycling, including the use of agricultural waste as an adsorbent for the removal of contaminants, pyrolysis, biomass, and the production of new products [5]. In the face of agricultural waste and ecological environmental damage caused by agricultural waste, researching on the utilization of agricultural waste has caused widespread concern [6]. In recent years, the excessive production of enormous agriculture-waste and the great desire for a green and carbon-less society significantly inspire research efforts in the production of bioenergy from agriculture-waste [2]. Recycling agricultural producers' waste is considered important for generating energy sources and promoting agricultural development [6]. This review is strives to promote environmental awareness among the scientific community regarding the possibility of reducing, reusing and recycling of AWs. It promotes recycling and utilization pathway of agricultural wastes and elaborates all possible strategies (traditional, biological and biotechnological) for utilization and valorization of AWs into value-added products that could bring in economic growth, job opportunities soil-enrichment, bountiful harvests without yield penalty and ensure sustainable agriculture for food and health security. It discusses the factors influencing the recycling and utilization of AWs and shows comparative assessment. Agricultural waste management and recycling is very important for several reasons. Agricultural waste management and recycling can help improve soil health. Recycled agricultural waste can add nutrients and organic matter to the soil, which in turn can

lead to improved soil structure, increased water holding capacity, and increased soil fertility [7].

2. Materials and methods

The search strategies of the study were determined by reviewing previous similar studies and in line with the goal of the research (Agricultural waste management and recycling). In order to identify related studies, the main keywords agricultural waste, waste management, Recycling, and Reduction words were used in Mesh. Search without taking into account the time limit until 2024, in international electronic databases; PubMed, Science Direct, Web of Science, Scopus were performed. Then the articles that met the inclusion criteria were carefully reviewed.

3. Results Discussion

3.1. Types of agricultural waste

- Plant residues: stems, leaves, fruit and unwanted vegetables including corn, wheat, rice and sugarcane. These materials are bulky and difficult to transport [8].
- Animal manure: animal excrement, litter and milking wastewater. These materials can be a source of water pollutants such as nitrate and phosphorus [9].
- By-products of food processing: shells, kernels, meat scraps and used vegetable oils. These materials can be a source of valuable nutrients, but may be perishable and challenging to manage [10].

3.2. Agricultural waste management methods

Agricultural waste management is an important part of sustainable agriculture and includes a set of measures to reduce, reuse, recycle and properly dispose of agricultural waste in order to minimize their environmental impact. These methods are [11].

- **Reduction**

The first and most important strategy in agricultural waste management is to reduce waste production in the first place. This can be achieved by applying methods such as improving agricultural practices, using suitable seeds resistant to pests and diseases, planning planting and harvesting, proper storage of products and raising the awareness of farmers. By reducing waste from the very beginning, the need for other waste management methods is naturally reduced [12].

- **Reuse**

Agricultural waste that can be reused can be used for other purposes. For example, plant residues can be used as mulch in fields, animal manure can be used as livestock bedding, and food processing wastewater can be used to irrigate plants. Reusing waste not only helps to reduce the volume of waste, but can also have economic value [13].

Researchers emphasized the importance of reusing agricultural waste and explored its potential use as bio fertilizers, crop materials, soil amendments, absorbents, energy recovery, carbon sequestration, biodegradation, compost hydrolysis, pyrolysis, enzymes, and catalysts. Agricultural waste can also be utilized as a color adsorbent, with the optimal time for color adsorption ranging from 4 to 5 hours and pH conditions Between 8 to 10. Agricultural residues are particularly effective at absorbing acidic colors. Additionally, porous carbon is a valuable tool for removing color from water [14].

- **Enzymes and Catalysts**

Researchers have discovered that citrus peel waste can be utilized to produce pectinase induced by *Aspergillus niger*. Additionally, they have found that waste catalysts could serve as a viable alternative to metakaolin [14]. Furthermore, researchers have determined that cellulase stabilization on MnO₂ nanoparticles is highly effective for cellulolytic activity. They have also made strides in converting various fruit wastes, including citrus peels (orange, mandarin, grapefruit, lemon), banana peels, apple pomace, etc., into a single source of citrus peel waste (CPW) for a more sustainable approach to bioethanol production [14].

- **Purification**

Agricultural wastes that contain pollutants such as nitrates, phosphorus or organic matter must be treated before disposal in the environment. There are different methods for agricultural waste treatment, including biological treatment, chemical treatment and physical treatment. Waste treatment helps reduce water and soil pollution [15].

- **Disposal**

Agricultural waste that cannot be reduced, reused, recycled or treated must be disposed of in an appropriate manner. There are several methods of disposal of agricultural waste, including landfilling, incineration, and dumping in deep water. Waste disposal should be done in such a way that it has the least negative impact on the environment [11, 16].

Choosing the best agricultural waste management method depends on the type of waste, availability of resources and local regulations.

- **Recycling**

Agricultural waste that can be recycled can be turned into new products. For example, plant residues can be turned into compost, animal manure can be turned into organic manure, and food processing by-products can be turned into biogas or bioethanol. Waste recycling not only helps reduce the volume of waste, but can also provide a new source of nutrients and energy for agriculture and other sectors [17].

- **Utilizations of agricultural waste as adsorbent for the removal of contaminants**

M. Ghasemi et al. investigated the adsorption of Pb (II) from aqueous solutions using both ash and ash loaded with Fe nanoparticles (nFe-A) derived from Rosa Canina-L leaves, an agricultural byproduct. These materials showed promising potential for removing Pb (II) from water. The study highlighted the effectiveness of ash and nFe-A as affordable and efficient adsorbents for reducing Pb (II) contamination in water. This research implies that these adsorbents could be practical alternatives for treating liquid wastes with toxic Pb(II) ions [18]. Ashraf A. El-Bindary et al. investigated the effectiveness of activated carbon derived from rice straw (ACRS) as an adsorbent for removing azopyrazole dye from water solutions. The study found that ACRS had a significant adsorption capacity for the azopyrazole dye, especially in highly acidic conditions (pH=3), due to strong electrostatic interactions between the adsorption sites and the dye anions[19].

- **Pyrolysis of agricultural biomass**

Agricultural bio-waste is emerging as a promising renewable energy source with significant growth potential. Both biological and physicochemical processes are employed to convert agricultural bio-waste into bioenergy [2].

Bijoy Biswas et al. conducted a study on the pyrolysis of four different agricultural biomass residues, revealing that the product distributions were significantly influenced by the type of biomass used. The highest bio-oil yield, at 47.30 wt%, was obtained from corn cob, while rice

husk exhibited the maximum organic carbon conversion rate of 56.62%, as determined through TOC measurement. Examination of the bio-char produced by pyrolysis, conducted via XRD and FT-IR, indicated the breakdown of biomass components during pyrolysis, leading to the formation of various products [20].

- **Agricultural waste biomass**

The overreliance on conventional fossil fuel resources is due to a combination of increasing energy demands and excessive consumption of petroleum fuels, presenting a significant challenge in the 21st century. As a sustainable alternative, biomass derived from agricultural waste is being increasingly used for energy generation. [5].

- **Manure production by agricultural waste by microorganism (composting)**

Composting is a natural process in which microorganisms convert organic matter such as plant debris, animal waste, and food waste into a rich soil material known as manure. This process occurs naturally in the soil, but it can be accelerated by creating favorable conditions for microorganisms.

- **New product production From Agricultural Waste**

The production and use of plastic, vegetable, aluminum and even paper containers are harmful and dangerous for the environment due to the decomposition time of several hundred years. Chemicals and plastics are not used in its construction. A very small amount of water has been used in the production of a kiduri dish, less than the amount of water used to wash a dish. The most important feature and distinguishing point of Kidori products is its degradability, which is 100% degradable and biodegradable in just 30 days and turns into soil.

4. Conclusions

This evaluation aims to provide essential insights for efficiently recycling and utilizing agricultural waste. Investment and planning in waste management industries are necessary and inevitable. Cultivating awareness among citizens and strengthening communication methods such as virtual spaces, media advertising, and targeted education in public awareness classes increases knowledge of recycling principles. It is also debatable whether the use of innovative methods, in addition to creating positive economic benefits, can lead to the creation of new electronic products, reduction of healthcare costs, increased

environmental health, and reduced waste disposal costs for governments. Waste-based attractants in agriculture, due to their high efficiency in removing pollutants such as heavy metals and dyes from contaminated water and producing new products, have garnered significant attention. For example, iron nanoparticles (nFe-A) derived from *Rosa Canina*-L leaves can significantly act as a lead (II) pollution absorbent in water, and activated carbon derived from rice straw (ACRS) can be used as an adsorbent for removing azo dye from aqueous solutions. Key recommendations include fostering new industries, establishing economic incentives, enhancing laws and regulations, and formulating medium to long-term strategies to bolster the rural market for agricultural waste recycling [6].

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