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Outlook for Sustainable Utilization of Agricultural Waste and Biomass Fuel and Materials Production

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Abstract: The reasonable and effective treatment and utilization of agricultural production waste is an effective way to deal with energy depletion and climate change. Agricultural waste, including crop straw, livestock manure, agricultural film, pesticide packaging, the waste if improperly handled, can lead to soil, water and air pollution, like remains in agricultural land contains various chemical elements of crop straw and livestock manure, if improperly handled will cause irreversible of soil erosion and pollution. Through resource utilization, these wastes can be converted into organic fertilizers, bioenergy, feed or other valuable products, thus reducing environmental pollution, improving the efficiency of resource utilization, and promoting the sustainable development of agriculture. This study will discuss the technical progress of the treatment mode of agricultural waste in the current technical field, and find out the shortcomings and challenges of the existing technology. China, India, America, Japan, Thailand and many other countries are stepping up their research on biomass energy. The development and utilization of agricultural biomass have a strong competitiveness in the energy market.

Keywords: Agricultural wastes,Biomass fuel,Biomass insulation material,Renewable energy,Environmental protection.

1. Introduction

The development and use of fossil fuels is increasing the problem of energy depletion and environmental pollution. The burning of fossil fuels produces about 21.3 billion tons of carbon dioxide and other greenhouse gases every year. Natural processes are reported to eradicate only 50% of that amount. As a result, greenhouse gases generally increase by 10.65 billion tons in the atmosphere each year [1].The necessity of the transition to clean and renewable energy is increasing. Biomass energy will become the mainstream energy material in the future energy market, and its efficient, clean and pollution-free characteristics have attracted the research interest of many scholars. Agricultural production waste is one of the important sources of biomass; It mainly contains crop residues (such as leaves, stems, stalks, straw, rice husk and weeds), waste from livestock (including urine, feces, washing water and waste feed), poultry byproducts (overflow feed, feathers, feces and bedding), slaughterhouse waste (including blood, hair, skin, meat, and bone), agricultural industrial waste (e. g. bagasse, molasses, potato, cassava peel, And various pulp of fruits such as oranges, apples, mangoes, papaya and tomatoes, And palm fruit, peanuts, soybeans and coconuts) and waste from aquaculture activities [2]. As one of the world's leading beef exporters, the intensification of the cattle

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industry has led to an increase in fecal production. Similarly, large-scale industrialized agricultural operations in the United States produced large amounts of animal waste. According to the Ministry of Agriculture and Rural Affairs, China produces about 4.2 billion tons of livestock manure every year. Animal manure has become the third largest source of pollution after industrial wastewater and domestic sewage, and is considered to be one of the main sources of agricultural pollution [3].The toxic substances and chemical elements in the feces will not only pollute the soil environment, but also the harmful gases produced by the fermentation will cause great harm to the atmospheric environment.

Therefore, the correct and effective treatment of agricultural waste can alleviate the energy crisis and environmental pollution problems, which also puts forward high requirements for the relevant treatment technology and related policies. The Chinese government attaches great importance to the utilization of agricultural waste resources, and has formulated a series of policy measures, such as fiscal subsidies and tax incentives, legislation and policy support, to promote the development of this field. Composting of various agricultural wastes can completely and effectively remove harmful substances and produce nutrient-rich fertilizers, but due to the inability to accurately control the stability of various indicators, it is difficult for the technology to be widely used in agricultural production. This paper will summarize the current mature agricultural waste treatment methods, explore the limiting factors and challenges, summarize the mainstream technical products, and explore the new biomass materials with development prospects.

2. The treatment method of agricultural waste

2.1. Direct combustion and fuel pellet conversion

The prevailing method for addressing agricultural waste management is direct combustion, which converts the inherent chemical energy of biomass into useful heat and light energy, efficiently reducing the occupation of arable land. While this approach offers directness and expediency, it is not without its drawbacks. Inevitably, the process generates substantial quantities of greenhouse gases and other deleterious emissions, exacerbating both the greenhouse effect and atmospheric pollution. PAHs are common contaminants in urban environments, some of which have been shown to be precursors to carcinogens or carcinogenic subchemicals. According to a study at Washington State University, wheat and rice fields have an impact on the US [4].When testing soil samples containing PAHs in farmland soil in Changchun, China, we found that the concentration (15.661mg/kg) of straw incineration conditions was significantly higher than that of straw reduction conditions (9.517 mg / kg), and the continuous increase and accumulation of PAH was bound to bring great challenges to the environment and human environmental health [5].Therefore, the disposal method of environmentally friendly agricultural waste is required by the current technology.

Agricultural wastes such as straw and straw have large footprints, inconvenient transportation, difficult storage and low combustion efficiency [6]. The Indian Institute of Technology produced combustion particles by crushing garden waste, and determined that the combustion temperature is higher than only chopped biomass and produced no dust and dust residue, confirming that the combustion particles are clean and efficient [7]. A palm oil processing plant from the Republic of Indonesia dried large amounts of empty fruit strings from palm strings and chopped them into smaller fibers, thus making fuel particles with extremely high mechanical durability and particle density, and confirming their cleanliness and sustainability [8]. In Japan, the production of fuel pellets not only promoted the improvement of related industry production (increased by $981 million), but also created a lot of jobs (24,700 jobs), which shows that the development of fuel pellet industry has a positive impact on the future energy utilization and economic development [9].

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2.2. Composting and treatment of agricultural waste

Agricultural waste refers to the organic substances that are discarded in the whole agricultural production process, usually refers to crop straw and livestock manure. If the nitrogen, phosphorus, organic matter and trace elements contained in these wastes are improperly handled, they will lead to serious waste of resources, damage the environment and ecology, and bring great pressure and threat to the protection of agriculture and natural environment. Composting treatment is an effective means to reduce pollution and resource utilization.However, improper or incomplete composting will not only lead to the aggravation of diseases and insect pests, worsen the plant growth environment, and affect the growth of the next season, but also inhibit the growth of plants, leading to crop production. Therefore, an effective pretreatment of agricultural waste is a necessary step. Pretreatment can be done in various ways, such as physical, chemical, biological and combined pretreatment, but most compost treatments come at the cost of higher energy consumption and can even have some negative effects. Studies have shown that biological pretreatment is a more economical and environmentally friendly treatment method than other treatments. Inoculation of microbial agents that effectively degrade organic waste and inoculation of carrion animals such as earthworms or black gadflies during the compost cooling phase can improve the composting quality and reduce their negative effects [10]. Aerobic composting is also an effective means of using biological treatment. It refers to the process of microorganisms and organic matter in the reactor under aerobic conditions, causing the conversion of complex organic matter into simple and stable humus. Using microbial aerobic composting can not only improve the quality of composting, but also repair the soil environment and prevent plant diseases [11]. Organic matter content, pH value, cellulose content, total nitrogen content, carbon and nitrogen ratio are the evaluation indicators of composting quality, so how do we determine these data of fertilizer to determine its quality level? Near-infrared spectral analysis technology uses different visible light and near-infrared characteristic variable selection methods to quantify and analyze the values of various indicators in the composting to evaluate its quality, so as to ensure the stability of the final product quality. This study demonstrated its feasibility [12].

2.3. Microbial fermentation

Agricultural production waste is rich in protein, carbohydrates, minerals and lignin and other nutrients, which provides an excellent substrate and substrate for microbial fermentation. Solid fermentation is the fermentation method of microorganisms on a solid matrix with no or no free water. The literature shows that solid-state fermentation plays a crucial role in the production of drugs, enzymes, antibiotics, alkaloids, etc., with higher yields compared to other fermentation methods (e. g., submerged fermentation). Aspergillus giganeum can produce pectinases from agricultural waste through solid-state fermentation [13], which can be widely used in the food processing industry, and it is estimated that about 25% of the total enzymes used in the food industry [14]. Ferment is made from animals, plants, bacteria and other raw materials, by microbial fermentation of products containing specific biological active ingredients, which contain a variety of active substances, biological enzymes and probiotics, with rich nutrition and high economic value. Environmental protection ferment is under the condition of room temperature, by fresh fruit and vegetable waste, sugar, water, according to a certain proportion after mixed stored in a sealed container, after microbial anaerobic fermentation for more than 3 months contains specific biological active ingredients of available organic liquid, which contains a lot of beneficial bacteria can remove wastewater pathogenic bacteria, and containing protease, lipase and other hydrolysis ase class can effectively promote organic wastewater and soil decomposition, the realization of sewage purification and soil environment management [15]. Agricultural Ferment fermentation is a process of transforming organic matter into organic acids and other metabolites. The organic matter involved in fermentation

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is mainly Lactobacillus, acetobacter, Hydroobacter, halogenacter and Prevotella, which can be used in vitamin metabolism, carbohydrate metabolism and amino acid metabolism [16]. The enzymatic utilization of agricultural waste not only cleans its pollution, but also produces products with high economic added value.

3. Various fuels and energy materials after agricultural waste treatment

3.1. Bioalcohols

3.1.1. Biological methanol

Methanol is commonly referred to as methanol or xylitol. It is a transparent, volatile liquid with a unique odor and high flammability. Pectin is a potential route for the production of methanol through microbial conversion and fruits and byproducts such as fruit residue, peels and seeds are a good source of pectin. Methanol extracted from biomass is characterized by environmental protection, high efficiency and high economic benefit. The consumption of methanol is increasing, and the price of this fuel is expected to rise in the future. Therefore, biomass processing is the most cost-effective method for the methanol production [17]. One study produced bio-methanol by deesterifying the pectin in deteriorated fruits, including Lactobacter, Acestridium, and Lactococcus, and obtained the optimal process parameters [18].

3.1.2. Bioethanol

Bioethanol is produced from organic materials such as sugarcane, corn, wheat and other crops, as well as agricultural and forestry residues. As a clean energy source, bioethanol has the advantages of complete combustion and low emissions, and can be used as an effective substitute for fossil fuels. It can improve the power performance of the engine, extend the service life of components, effectively reduce and reduce harmful exhaust emissions. Moreover, the production and use of bioethanol helps reduce dependence on fossil fuels, reduce greenhouse gas emissions and combat climate change. With technological advances and reduced costs, bioethanol is expected to play an increasingly important role in the energy mix of the future. Researchers and industry are working to develop more efficient biorefinery technologies to achieve the large-scale conversion of lignofibrous biomass to fuel ethanol. Moreover, the application of emerging technologies such as synthetic biology and metabolic engineering also offers new possibilities to improve bioethanol production and reduce production costs.

3.1.3. Biobutanol

The its were similar to bioethanol but biobutanol has higher energy density and better fuel properties. The steam pressure of biobutanol is low, the tolerance of impurity water when mixed with gasoline, the corrosion is small, can reach a higher mixing ratio with gasoline, compared with ethanol, biobutanol can make the car walk 30% of the distance. Lignocellulosic biomass is an ideal ingredient for fermented butanol production because of its rich nature, low cost, and less competition with the food supply. Separation of hydrolysis fermentation (SHF) and simultaneous saccharification fermentation (SSF) are the most commonly used techniques for cellulosic alcohol production and transformation, but the process hydrolysis products may inhibit the cellulase activity in the hydrolysis process, and the decrease of sugar concentration will also affect the fermentation rate. It was found that a sequential SHF-SSF process (an improved version of SSF) was performed before the SSF procedure to increase the initial sugar concentration to increase the fermentation rate in terms of

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reaction kinetics, increasing overall productivity while ensuring similar maximal butanol concentrations [19].

3.2. Biodiesel

Biodiesel is mainly made from vegetable oil or animal oil through a chemical reaction, which has similar chemical properties to traditional petroleum diesel, and can be directly used in diesel engines. Current production technologies of biodiesel are mainly transesterification and fermentation. A recent study proved that Response Surface Methodology-Box Behnken Design can better convert papaya seed oil into biodiesel in the catalytic acidification environment of corn pods [20]. Biodiesel has higher flash point and hexadecane values than petrochemical diesel, which means it has better safety and combustion performance.

3.3. Biogas

Biobiogas is a renewable energy source produced by anaerobic digestion or fermented organic matter, including agricultural waste, food waste, sewage sludge, and other biodegradable materials. The process type of biogas production can be divided into wet or dry fermentation process, when the total solid concentration in fermenter is less than 10%, which allows the application of a fully stirred tank boiler; for dry fermentation, several osmosis and no mechanical mixing are mainly used for single fermentation of energy crops [21]. It is mainly composed of methane and carbon dioxide, methane is its main energy carrier, has a high calorific value, can be directly burned as fuel or used for power generation. The production process of biogas can not only reduce the pollution of organic waste to the environment, but also reduce the emission of greenhouse gas, helping to realize the sustainable use of energy. The application of biogas power generation and heating also has considerable potential. In Vietnam, the total amount of electricity generated by crop straw is expected to increase to 6.7193 billion KWH and 15.5867 billion KWH by 2030 and 2050, while the biogas generated by agricultural waste is expected to produce 211297.8 and 531014.0 million MJ heat respectively [22].

3.4. Biomass insulation material

Biomass insulation materials are a kind of insulating materials prepared from renewable resources as raw materials. They usually include biomass-based materials such as plant cellulose, straw fiber and cotton fiber, as well as natural fiber-based materials such as wool and flax fiber. Straw biomass has the potential as an insulation material for cold storage facilities. With its high thermal resistance, it can effectively slow down the heat transfer and maintain a constant temperature. Studies have found that biomass insulation is similar to conventional insulation materials (such as foam polystyrene and PUF), even under wet conditions [23]. Biomass insulation materials are gradually becoming an important part of sustainable development and green building practice in the building industry [24], and their application scope and market share are expected to continue to expand.

3.5. Biological hydrogen

Hydrogen is the cleanest energy carrier, with high calorific value and high power generation, and its combustion product is only water, and it is the cleanest energy carrier. Production of biohydrogen energy from lignocellulosic agricultural residues is a sustainable, carbon-neutral, and most cost-effective method. The researchers used agricultural residues such as wheat, rice and corn stalks as deep fermentation feedstocks for biohydrogen production, but the presence of complex organic polymers in the substrate as well as inhibitory acid-rich by-products produced during acid production led to low hydrogen production [25]. One of the common difficulties in hydrogen fermentation is the

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presence of hydrogen-consuming microorganisms (methanogens) in the production of mixed cultures, and the use of Clostridium species and Clostridium strain and the addition of trace elements to the substrate can effectively increase the hydrogen production efficiency [26]. Microbial electrolytic cell, also known as electrofermentation or biocatalytic electrolytic cell, can produce biohydrogen through bioelectrochemical reaction, which can effectively promote the biodegradation of agricultural straw biomass. The substrate into biohydrogen, CO2 and volatile fatty acids, and then the electrohydrogen generation process in the microbial electrolytic cell can further improve the efficiency of biohydrogen conversion [27]. The use of hydrogen energy will greatly reduce greenhouse gas emissions and effectively alleviate air pollution.

4. Challenges and future prospects

Improper disposal of agricultural waste can lead to soil, water, and air pollution. Water pollution may lead to the deterioration of water quality, affect the safety of drinking water sources, and may cause damage to aquatic ecosystems, and toxic substances will enter the human body through the food chain. In addition, the open burning of agricultural waste will release a large number of greenhouse gases and harmful air pollutants, exacerbating the problem of air pollution. Although the biomass energy treatment of agricultural waste has a broad prospect, the imperfect technical equipment will lead to the disadvantages of high impurity content, low purity and insufficient combustion in the biomass energy products, thus increasing the cost of biomass resource production and reducing the social and economic benefits.

In order to optimize the agricultural waste treatment system, we should not only promote technological progress, improve the pretreatment means of biomass raw materials, improve the efficiency of energy conversion, but also need to introduce and improve relevant policies, increase government support, and build a technical and economic support system. At present, all countries in the world have realized the necessity of effective treatment of agricultural waste and the importance of biomass energy promotion, which fully reflects the urgency of the current international energy and environmental issues. Mastering the core technology of biomass energy is not only a proof of a country's technical level, but also a full embodiment of the comprehensive national strength. The production of agricultural biomass energy can also provide a large number of employment opportunities, effectively promote the economic income of local farmers, improve the construction of the rural industrial chain, and improve the rural economic system.

5. Conclusion

Biomass resource utilization of agricultural production wastes is a clean, pollution-free, recycling and sustainable treatment and utilization method of these wastes, which has a broad application prospect. This paper discusses the popular ways and utilization forms of agricultural waste treatment, and puts forward the advantages and disadvantages of various methods and the feasible means of improvement. For example, in the production of biohydrogen energy, the complex organic polymers contained in the fermentation substrate and the inhibitory acid-rich byproducts produced in the acid production stage are undoubtedly a big problem in the inhibition of product quality. However, it was experimentally shown that Clostridium genus and Bharati can convert pyruvate to acetate and butyrate but do not use lactate, thus effectively reducing the acid concentration in the matrix. Fermentation, an oft-overlooked aspect of biomass transformation, boasts a broad spectrum of applications, encompassing functionalities such as enhancing food flavors and facilitating stain removal. However, extant technological limitations impede large-scale production of ferment-derived products. The present article highlights the potential of enzyme catalysis in this context, as it elucidates research findings that may provide a wellspring of inspiration for future studies pertaining to fermentation processes and their optimization. By advancing our understanding of enzyme-catalyzed reactions, we can forge a path toward scaling up the production of valuable fermentation-derived compounds.

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