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Energy Production from Solid Waste Generated from Wastewater

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Abstract

Solid waste has been among the greatest sources of surface water contamination all over the world. The rising human population, the rise in urbanization and industrialization of the world are the main factors of producing solid waste. This has brought about a significant issue which has both local and international implications. Among the 2 (billion tons) of the municipal solid waste produced yearly in the world, over 33 percent are not subjected to ecological control. The causes of greenhouse gas emissions and other air pollutants include an increasing amount of municipal solid garbage, a lot of organic waste, and their irresponsible disposal. The lack of management with the municipal solid waste (MSW) amplifies all manners of problems in society that threatened the people's health and negatively affected the ecological society. It needs the proper solid waste management and in order to achieve sustainability, it needs to recycle the waste products. To deal with these issues Solid waste is converted into energy through thermochemical and biological conversion of energy. The mitigation plan to handle and treat the trash involves a waste analysis that is in the environment. Waste transformation into energy leads to preference of the generation of a green environment and an effective economy at the same time through managing the environmental problems associated with the waste disposal and greenhouse gas emission. It gives the latest information and an overview of the suitability of different technologies in energy production. It discusses the challenges and ideas in this area of study as well.

Keywords: Energy recovery, Solid waste management, Environmental sustainability, Wastewater treatment sludge

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1. Introduction

The overall volume of municipal solid trash or waste is expanding which is result of financial development and metropolitan expansion. The rapid growth of population is the main cause in the production of trash, which generates major issues about ecological sustainability. Approximately one-third of the waste is originates in Asia, while China also produce some 1-4 kg of trash per person every day [1]. Low-income nations can only recycle sixteen percent of their waste, as compared to fifty one percent in developed countries. In comparison to highly developed countries which eliminates only 1-2% of their garbage in landfill while the developing countries like India, Bangladesh etc. eliminates almost 94% of their waste in dump sites. This indicates inappropriate solid trash management system procedures in under developing countries which puts the health of human, the ecological environment and the life of people at risk [2]. The effects of decades of poor solid waste management have been evident during floods, storms, earthquakes and pandemics, which have led to major health crises [3]. A growing number of complex waste management issues weigh heavily on society and have bad effect on the environment as well as society [4]. Problems stemming from landfills and the improper disposal of waste have led to concerns over economic development, well-being and security [5].

Synthesizing new elements from most elementary substances is very demanding in terms of the energy and materials required. Processing and extraction of materials may reduce through reprocessing and reuse of materials. This can also reduce ecological impact of extracting new materials. Human and animal health may be threatened by improper waste discard methods [6]. Proper disposal of waste reduces the likelihood that pests and vermin (small insects that are harmful to crops) will be attracted to it, protecting water sources from contamination and thus reducing risk of disease. Good waste disposal habits not only contribute to preservation of our environment but also help prevent diseases and promote public health. Environmental degradation can also be prevented through efficient waste disposal. Research indicates the energy which is produced from waste, trash is a highly viable technique of waste disposal as it has multiple environmental benefits, most notably reduced emissions and land use [7]. By way of recycling, the use of virgin feedstocks can be reduced, along with the emission of gasses which increase the temperature like greenhouse gases and the volume of waste sent to landfills [8].

This organic matter is broken down by beneficial soil microbes. These microbes create a plant nutrient rich fertilizer. The controllable system of the wastes in underdeveloped countries is here reviewed with a view to finding an appropriate method for energy recovery from such waste.

Discussed are the characteristics of municipal solid waste, the benefits to be derived from the recovery of energy from municipal waste and the possibility of producing recoverable resources from refuse. These recent technologies for energy generation from municipal solid waste are examined in this report, focusing on their limitations and unplanned outcomes. The review aims to explore the technology used in the energy generation and materials from waste and will aid the development of long-term policies on the transmutation of municipal waste into usable goods. The method tackles numerous issues connected with the proper way of solid trash. The paper deals with the properties of municipal solid waste, the possibility of waste to recovery of energy and creation of other products from the metropolitan areas trash. Technological innovations in the energy production sector, involving the recovery of solid urban waste, are presented and evaluated, along with the associated by-products. This report presents the current knowledge in the field of energy production from waste. In this report a summary of the work which has been done in this area is given.

2. Municipal Solid Waste Generation and Regulation

Increasing human populations and the resultant urbanization have led to an increased generation of MSW [9]. Many countries, like Africa, Bangladesh, Asia, the Caribbean, China, Latin America, the Czech Republic effort with implementing sound waste management strategies; urban areas are more densely populated and produce waste at a greater rate, yet proper waste disposal facilities are scarce there [10-11]. Because of escalating waste output, which has increased due to population growth and urbanization, the current situation demands further action to solve this problem. The disposal and storage of waste is a crucial part of waste management and also treatment and requires careful consideration [12]. It is essential that waste is sorted due to the need for various waste types to be treated in a manner which is appropriate to their make-up [13]. A considerable amount of the world's waste is dumped without any control [14]. Much more still has to be done before the disposal of solid waste is properly managed [15].

In Bangladesh the urban population and the resultant high consumption patterns which result increase the production of waste material. This represents a difficult task for the country's metropolitan authorities in waste management. Rapid urbanization has been observed in Bangladesh - the percentage of population residing in cities grew from 28.97% in 2008 to 36.63% in 2018. The country has a population of 164,802,127 which is growing at an annual rate of 1.01 percent. This results in a yearly increase in the amount of waste the country produces [16]. The municipal waste generated which include seventy four percent organic compounds, nine percent paper, approximately one percent rubber and leather, almost four percent plastic, one percent cloth and wood, iron, glass and many others [17]. Several factors supply the production of waste. These factors include seasonal changes in fruit production, a person's lifestyle, the weather, economic conditions and population increase [18].

3. Environmental Consequences of Solid Waste

One of the causes of climate change is production of methane gas using solid waste. CH_4 is produced which is the result of an anaerobic decomposition of organic waste scrap in waste sites. In the short run CH_4 is a significant greenhouse gas which captures a lot of heat compared to carbon dioxide. When solid waste decomposes the greenhouse emissions that are released are CH_4. CH_4 is estimated to be a big contributor to increasing the temperature on earth that causes global warming. Moreover, the water and the air may be contaminated with solid waste. Examples of dangerous air pollutants emitted during the burning of solid waste include oxides of nitrogen, sulfur dioxide and contaminant particles. These contaminants can cause heart disease, cancer as well as respiratory problems. Also solid waste may pollute drinking water through leakage of toxins in a water supply [19]. Due to porosity the open burning of MSW contaminates ground water as well as soil as well as releases harmful emissions to the atmosphere. The burning of organic waste may generate high levels of methane which can change climatic conditions and cause global warming. The natural organic matter that is found in solid waste is main contributor to produce methane. In addition, MSW can have microbial diseases that devastate soil and ground water and pollute atmosphere with harmful substances due to its porous nature. Organic waste burning can generate high volumes of methane gas that can alter climate and cause global warming [20-21]. Furthermore, OM in MSW may contain microbial diseases that harm neighbors populations and workers [22-23]. Based on studies, burning of MSW can effect several health issues which include respiratory allergies, nose, eye and skin irritation (Figure 1).

4. Advanced Waste Energy Recovery Technologies

4.1. Thermochemical Conversion

The fundamental idea behind thermochemical conversion techniques is that heat breaks down organic waste. This involves turning biomass into biofuels [24]. Thermochemical conversion can utilize a number of raw materials very quickly and often calls for a chemical addition. Among many other processes, this group includes gasification, pyrolysis, and incineration (Figure 2).

4.2. Pyrolysis

The main byproducts of pyrolysis (a method involving heat that handles solid waste in the absence of oxygen and requires higher operating temperatures) are char and compressed gases. After further upgrading, the pyrolytic fluid produced by cooling and recovery of volatile vapors which can be used as basic component or final output for the production of related compounds [25]. Char is widely used for carbon materials electricity generation. Pyrolysis-based char creation is not a novel concept, it also utilizes to produce coal, coke, charcoal and biomass. Because the pyrolysis process produces less oxides of nitrogen and oxides of sulfur due to the inert atmospheres, it can produce more energy than traditional MSW incinerators (Figure 3) [26-27].

4.3. Incineration

A reasonable model for the extraction of thermal energy is provided by the well-established technology of incineration[28]. Thermal energy, gases and ash are generated during the incineration process when a combustible component reacts with oxygen at temperatures above 800°C. In order to create steam, which in turn produces electricity, it mostly entails controlled energy recovery through waste burning [29]. This incineration method is favored due to its compact installation space, high productivity and larger decrease in waste volume [30]. The density, material makeup, level of moisture present and inactive waste fraction are all affect the final energy output [31]. Cement, construction materials, and other items can be made from ash, a generally inert by-product of burning solid waste [32]. One of the primary disadvantages of incineration plants is that they need to monitor and treat exhaust gases, which is expensive [33].

4.4. Gasification

Gasification is a procedure which utilizes heat and a condition with a decreased oxygen content to specifically oxidize carbon-derived fuel and produce energy [34]. This technique utilizes a controlled availability of oxygen and a very high temperature for converting the waste source into gaseous compounds. This can be caused by a variety of activities including ash, very little amount of char, and combustible gases. Hydrogen-based gas might be produced smoothly and cleanly using gasification process. Gasification systems tend to be classified according to the variety of oxidative environment and gasifier employed. A greater temperature must be used for this process as compared to pyrolysis. Petroleum tar, alkaline compound and halogens are released into final gas during gasification process, which may lead to technical as well as ecological issues [35].

4.5. Torrefaction

The basic concept of torrefaction, which occurs at temperatures between 200 and 350 °C, is water loss and devolatilization of substances. It is actually a slower and less harsh form of pyrolysis. The char produced by torrefaction usually has a higher energy content and is more stable (without going through additional microbial degradation) when compared to pyrolysis[34]. Char can be used as high-quality fuel for soil remediation, pollutant adsorption in water treatment, and co-firing in combustion [35]. Investigation of char characteristics following torrefaction of homogeneous biomass was the focus of recent research.

4.6. Biochemical Conversion

In biochemical conversion, the narrow selection of biomass feedstock is used through the use of microbes, their related enzymes, or a number of chemicals [36-37]. The productivity of this process is restricted, and improvement of production output would require a larger expenditure such as the development of larger processing units. This technique typically yields one of a few useful end product in addition selected biological culture and biological catalyst would be required for multi products generation [38]. The process is temperature-sensitive, and exposure to direct sunlight can occasionally lower process performance. In this process the residual biomass is frequently generated as a byproduct waste material.

4.7. Anaerobic Digestion

Anaerobic digestion (AD) needs microorganisms to break down substances that are organic in the lack of oxygen. Methane-containing biogas and nutrient rich bio-residue which is suitable for agriculture are the main products of AD. But since it takes longer to digest and uses more energy, normal muck AD is not sustainable. This problem is currently being addressed by mechanical, chemical, biological, and physio-chemical pre-treatment technologies .As a result, more methane has been produced, which has raised the AD process's energy output [39]. Numerous technological benefits of anaerobic digestion include possible electricity recovery, fertilizer generation, and low operating energy consumption [40]. Additionally, it is a highly adaptable system that manages a broad range of organic waste and foul-smelling pollutants. Most obvious product of contemporary bioeconomy to replace petroleum refineries is biofuels. While the breakdown of microbial material methods used in AD are comparable to those occurring in garbage dumps, the AD system generates more bioenergy in less time. The AD can generate up to fourfold as much methane per ton of MSW in three days as a garbage dump in seven years, according to studies[41]. For example, contrary to other kinds of natural wastes like solid AD may experience an unusual pH decline due to quick carbohydrate acid treatment in food waste (Figure 4) [42].

4.8. Composting

An aerobic biological breakdown of organic matter is the primary objective of the composting process which produces stabilized trash and dung. Reducing climate warming gas like greenhouse gas and the creation of naturally decomposed organic matter that may be utilized as natural soil enriching material are only two of the many environmental advantages of composting MSW organic waste [43]. Additionally, energy recovery can be achieved by using the heat generated during breakdown [44]. Composting efficacy is influenced by temperature, aeration, moisture concentrations, compaction level, and other parameters [45]. Composting techniques also have a significant impact on agricultural productivity, nitrogen usage, nitrogen mineralization, restoration, and other areas, according to several studies. Additionally, the composting process may result in several environmental problems, including the production of dust, toxic or foul-smelling gases and more.

4.9. Bio-based economy and Waste-to-resource-facility

Although the word bio-based economy is relatively new, its foundation is already established. Bioeconomy takes organic waste into account while managing waste as raw materials, turning them into products that are valuable, much like oil from crude is used as a primary resource input to make chemicals. Discarded residual materials biorefineries use a variety of transformation of biological resources methods and material processing and system design to turn biogenic waste into valuable biofuels and chemicals.

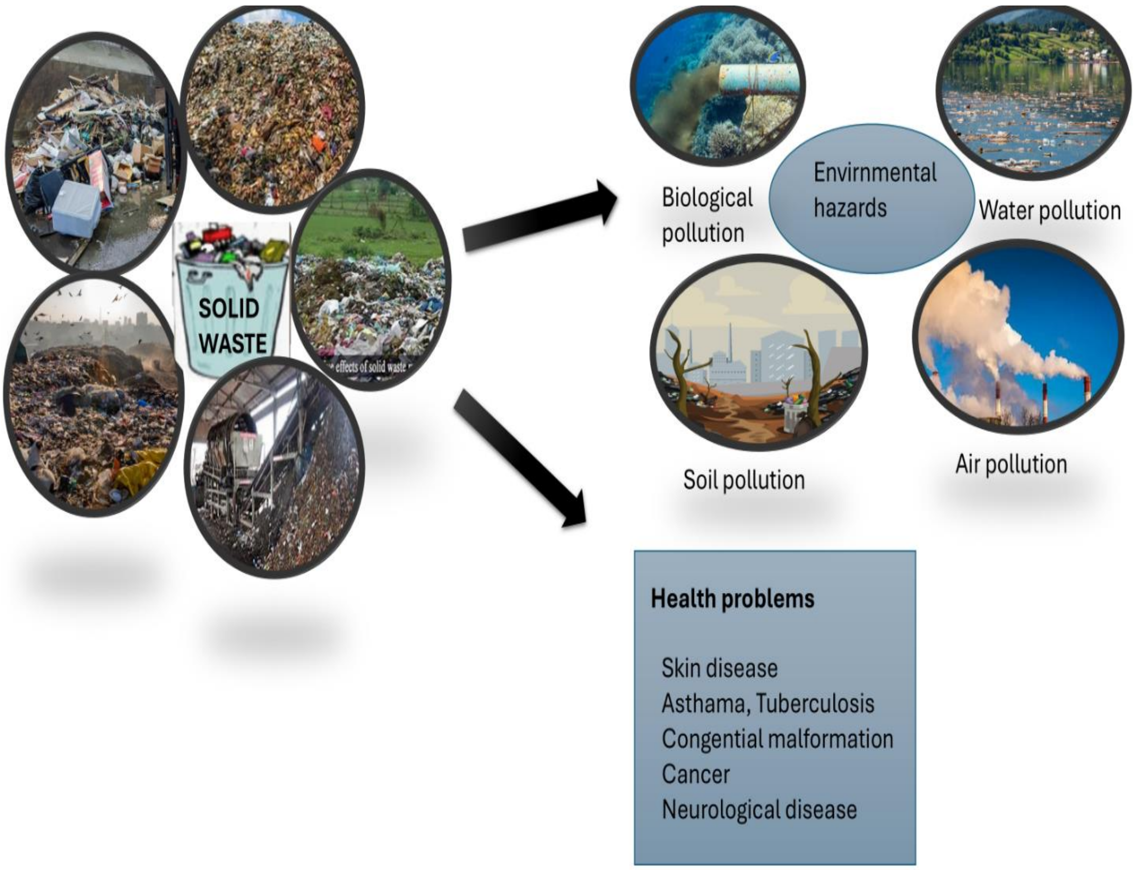

Figure 1: Environmental Effects

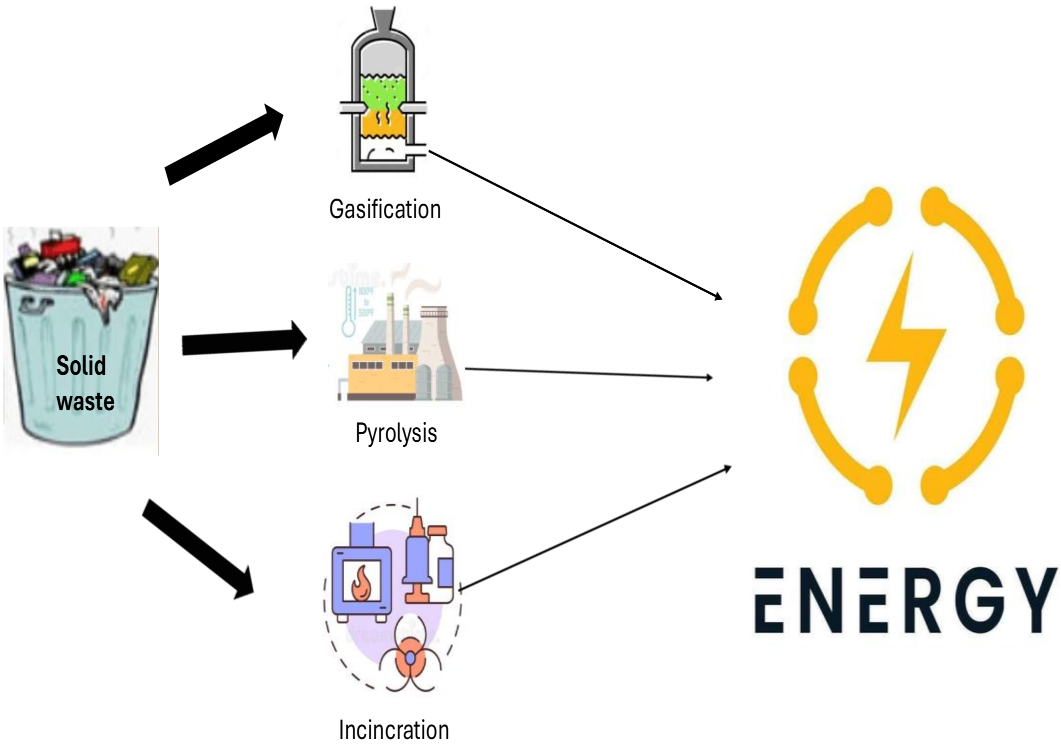

Figure 2: Thermochemical processes

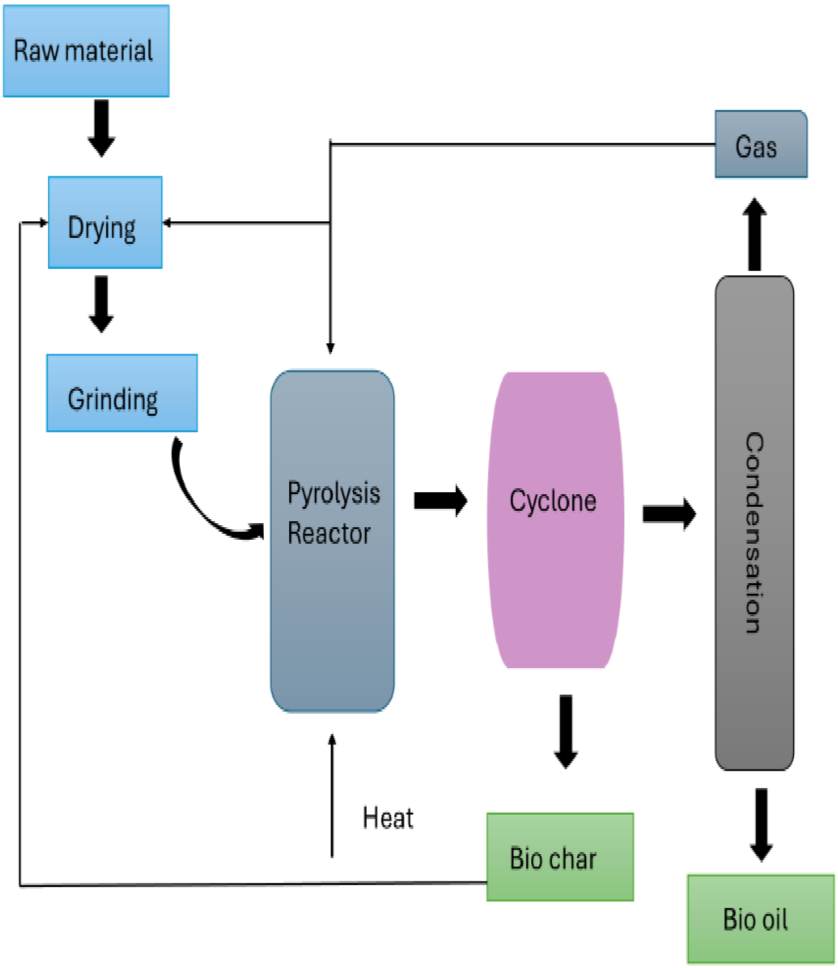

Figure 3: Flow sheet diagram

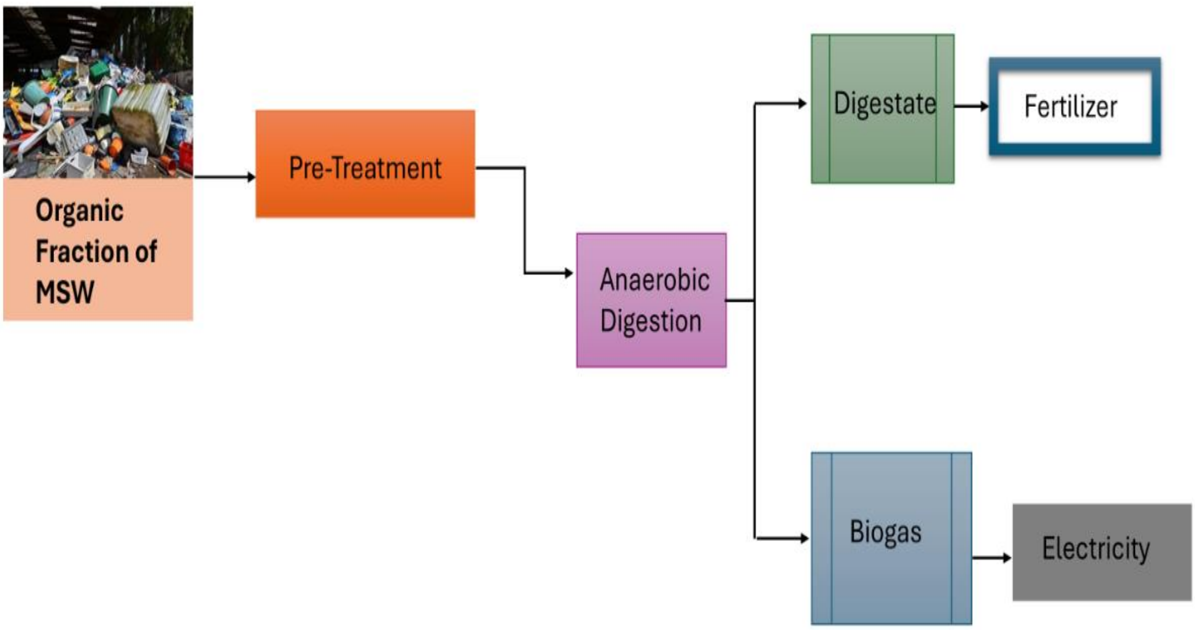

Figure 4: Flow sheet diagram

The economics of waste treatment gets improved by the enhanced value recovery bioproducts and the increased efficiency of fuel generation reduces need for energy from conventional energy conversion facilities. Consequently, waste biorefineries are a climate conscious and ecofriendly method of producing chemicals that are comparable to modern petroleum refineries.

4.10. Waste Valorization

Biological methods for organic waste can be applied in waste biomass refineries to generate sustainable base chemicals. Combining technologies of conversion is essential for effective waste valorization to minimize expenditures and enhance demand for high-value goods. The aim of current biorefinery concepts is to link several methods for continuous waste treatment and biological transformation into chemicals and biofuels. Additionally, the creation of marketplace products relies on the development of interconnected biorefinery process pathways. Food waste's nutritional benefits provide a remarkable feedstock for valorization however contamination issues create challenges for the overall biological economy. Furthermore, municipal solid trash usually unfits for wastewater treatment, which highlights the significance of creating collecting methods in accordance with the EU's circular economy principles. Inadequate sorting of trash might result in huge separation costs that exceed the value of bioproducts [46-47].

5. Conclusions

Waste is an economic issue as well as a problem of the environment. There is an urgent need for a sustainable waste handling strategy which will protect valuable materials or assist culture in switching to trash disposal of energy and resources recovery. The key to cleaner production will be waste segregation at the source and the deployment of specialized waste processing facilities to extract recyclable materials. It provides an overview of several economical ways to turn trash into energy, such as thermochemical (pyrolysis, gasification and incineration) and biochemical(bio-composting). Energy recovered from waste streams will receive more attention in the upcoming years than in the past. . The goal of sustainable MSW management in terms of environmental protection. We will develop a better understanding of how environmental biotechnologies should be connected and integrated to handle the organic fraction of MSW and biogenic wastes because of this new conversation in the bioeconomy. Thus, it is expected that the recent surge in interest in bioeconomy will result in the development of significant new resource recovery methods. Researchers are still trying to figure out what has to be completed, and AD technology in conjunction with numerous waste biorefinery techniques is undoubtedly a crucial part of this process.

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