Comparative study of biosynthesis technology and traditional methods for organic solid waste

Yuzhou Wang*

Environment Science and Engineering, CHANGZHOU UNIVERSITY, Changzhou, 213164, China

Abstract. With the development of industrialization and trade, the amount of organic solid waste is increasing rapidly, which has a serious impact on the environment. Traditional methods of organic solid waste treatment method will have negative impacts during the process of the treating organic solid waste. The theme of the study is to find an efficient, environmentally friendly and economical organic solid waste treatment method. The best organic sold waste treatment method is determined by comparing landfill, incineration and biosynthesis technology in aspects of resource utilization, cost and environmental impact. Through research, in aspects of resource utilization and cost, biosynthesis technology has its own advantages and disadvantages compared with traditional landfill and incineration technologies. In aspects of environmental impact, biosynthesis technology has obvious advantages. This is not only because of the mild reaction conditions and no secondary pollutants of biosynthesis technology, but also because biosynthesis technology can improve the soil condition and reduce the emission of the greenhouse gas.

1 Introduction

As industrial production and trade growing continuously in many countries, the amount of solid organic waste is increasing rapidly, which has a serious impact on the environment. More than 2 billion tons of solid waste are generated worldwide every year, and organic solid waste account for a large proportion in the solid waste [1]. Traditional methods of organic solid waste treatment, such as landfill and incineration, have solved the problem to a certain extent. But at the same time, they have brought about a series of other problems, such as soil pollution and air pollution. The greenhouse gases from landfill and incineration, such as CO_2, CH_4 and N_2O, mix over the whole earth when they stay in the atmosphere long enough [2]. This will lead to global warming and do harm to the human health. The efforts to reduce greenhouse gas emissions becomes the key part to solve the problem. Therefore, carbon emissions should be increased when disposing the organic solid waste. Additionally, huge economic benefits are associated with it, exceeding $3 trillion per year [3]. Biosynthesis technology, an efficient, environmentally friendly and economical organic solid waste treatment technology, fits the advantages above and should be widely used.

* 2300380126@smail.cczu.edu.cn

Biosynthesis technology uses biological systems, such as microorganisms, to degrade pollutions in the environment. Organic solid waste degradation requires the action of microorganisms to break down complex polymers into simpler molecules [4]. Furthermore, biosynthesis technology can not only treat the amount of organic solid waste, but also turn waste into treasure, transforming waste into energy products such as organic fertilizer and biomass natural gas [5]. Improving the management efficiency of organic solid waste holds significant value for safeguarding the environment, conserving resources, fostering economic growth, and safeguarding public health [6]. The maturation of biosynthetic technologies necessitates a contemplation of challenges pertaining to biosecurity and the scalability of production processes. As a result, the widespread acknowledgment of biosynthetic technology is evident.

The goal of the study is filling the gap in the existing academic articles, which about the organic solid waste treatment. The study will compare biosynthesis technology with traditional technology in aspects of resource utilization, cost and environmental impact.

2 Landfill

The method of landfilling is accepted and used widely because of its economic advantages [7]. Currently, landfills are easy, adjustable and low-budget than other disposal methods. Virtually all waste can be disposed of through landfill, not just the organic solid waste [7]. But the organic solid waste in the landfill is not completely disposed harmlessly, and many bacteria, germs, heavy metal ions remain in it. Therefore, in the process of waste stacking and landfilling, leachate formed by mixing water and waste is highly toxic for the following reasons. Firstly, it will directly affect the quality of human drinking water. Secondly, these pollutants produced by organic solid waste will enter the biosphere and affect human health potentially by the pathway of bioaccumulation and biomagnification [8]. If a significant amount of financial resources and time is once again allocated to address the issue of landfill leachate, it will undoubtedly undermine its economic advantages. Additionally, a large amount of gas is emitted during the processes of landfilling. The typical composition of landfill gas is 60% methane and 40% carbon dioxide, respectively [9]. These gases act like a cover, absorbing Infra-Red radiation and preventing it from escaping to outer space [10]. Consequently, the temperature of the atmosphere and the surface increased significantly. The trend of the landfill gas over time is shown in the fig 1. As shown in this figure, in stage IV, landfill gas reaches its maximum volume and then decreases with time. The emission of the landfill gas will lead to global warming, which is not conform to the goal of environmentally friendliness.

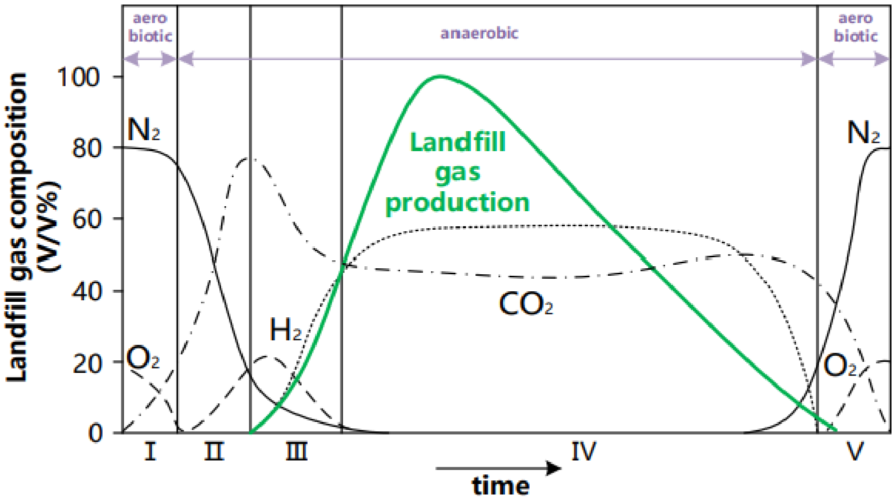

Fig. 1. Stages of landfill [8]

Landfill shows the certain feasibility in some aspects of the resource utilization. Humus formed after landfill is beneficial to the soil after removing the toxic substances in the organic solid waste. Application of humus-rich compost can increase soil dissolved organic carbon, microbial biomass carbon and fertility [11]. Furthermore, some useful materials can be formed by the screening of the organic solid waste in landfills. These organic solid materials have high calorific value, such as plastic [12]. Although these materials are not highly recycled or reused [13], they lay the foundation for waste derived fuels for heating and electric power generation. However, most of landfills are primarily built to solve the local pollution problems or to increase landfill capacities rather than to recycle the organic solid materials as secondary resources [14]. Therefore, landfill need to be further developed and widely used to solve the problem of the resource utilization of organic solid waste.

3 Incineration

Incineration is a traditional method of organic solid waste treatment. In the incinerator, the organic solid waste and air react to burn which releasing a large amount of energy. Meanwhile, the flue gas and ash produced by incineration are emitted into the atmosphere without any further treatment [15]. In aspects of economy, incineration has good prospects. Because the cost of the incineration is also relatively affordable and electricity generated from incineration can bring a lot of benefits. The net profit margin of the incineration power plant is attractive, reaching 25 percent [16]. In aspects of waste removal rate, the organic solid waste is directly turned into ash in the incinerator. After the process of incineration, the ash which falls to the bottom of the incinerator accounts for nearly 25 percent of the initial total mass of organic solid waste [17]. In addition, compared to the landfill, incineration power plant requires a smaller area, so that it is easier to select the site for the incineration plant [18]. But incineration has a huge impact on the human health and the environment. Organic solid waste is transformed into the secondary pollutants after the process of incineration. Major of them is dioxin, heavy metal element and greenhouse gas [19]. When people are exposed to a large amount of the dioxins, the incidence of cancer of the gastrointestinal sites and of the lymphatic and hematopoietic tissue increases [20]. Therefore, this may result in a big challenge for the global public health. Furthermore, the greenhouse gas, such as carbon dioxide, methane and nitrous oxide have a huge impact on the atmosphere

[21]. By statistically analyzing the concentrations of greenhouse gases generated by different types of incinerators, the concentration and emission factors of different gases are roughly with a certain range. The concentration of carbon dioxide is from 5.66% to 9.04%, the concentration of methane is from 2.35% to 5.88% and the concentration of nitrous oxide is from 1.49% to 42.64% [21]. Among these gas, nitrous oxide plays an important part in regulating stratospheric ozone levels, causing atmospheric greenhouse phenomena and participating in the generation of acid rain [22]. Therefore, while benefiting from the great energy advantages of incineration, the impact of secondary pollutants on the environment should be paid much attention.

4 Biosynthesis

At the microbial level, biosynthesis technology will synthesize some new substances to make microorganisms with better physical and chemical properties, which compared with the unsynthesized microorganisms. With the help of the synthetic micro-organisms, organic solid waste is transformed into the recyclable products. By comparison, the principles of traditional composting technology are similar with the biosynthesis technology in aspects of microbial treatment of organic solid waste [23]. But for the traditional composting technology, it has some disadvantages, such as long composting time, relatively low nutritional level and quality of compost product [24]. Biosynthesis technology can cleverly solve these problems. Firstly, supported by biosynthesis technology, effective microorganisms (EM) are generated by mixed culture of fermentation technology. It is composed of photosynthetic bacteria, lactic acid bacteria, yeast, ray fungi and other microorganisms [25]. During the process of the composting, the reactants with treatment of EM can reach a higher temperature than the reactants without treatment of EM [26]. As shown in the figure 2, the highest temperature of reactants with treatment reached more than 50 degrees Celsius, which was 5 degrees higher than the control group. The heat generated by the respiration of microorganisms, the breakdown of sugars, starches and proteins will lead to the increase in temperature [27]. The increase in temperature is beneficial to accelerate the degradation of organic solid waste.

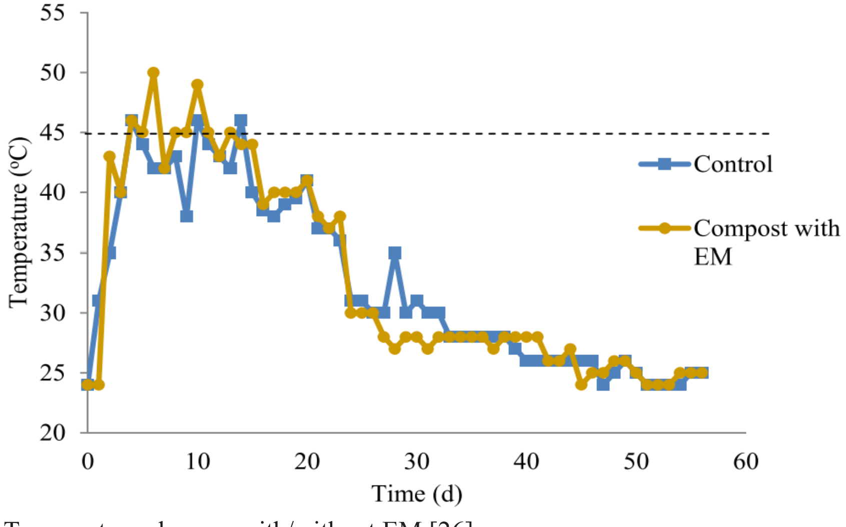

Fig. 2. Temperature changes with/without EM [26]

Secondly, combining biochar with nanomaterials through biosynthesis technology can synthesis a series of biochar nanocomposites. Due to the large surface area, porous structure and surface hydrophobicity, the biochar nanocomposites can treat organic solid waste [28].

During the composting process, adding with 10% biochar nanocomposites is beneficial to accelerate humification and generate the important nutrients [29]. Nitrogen, phosphorus and potassium elements in ionic form to enhance microorganisms' activity, to accelerate the conversion of organic solid waste. Compared with landfill, biosynthesis technology can improve the soil nutrient content instead of generating toxic substances. Additionally, biochar nanocomposites can reduce the emission of the greenhouse gas, such as carbon dioxide and nitrous oxide, which generate from the degradation of biomass [30]. Compared with incineration, biosynthesis technology decreases the amount of the greenhouse instead of increasing it.

Thirdly, the utilize of biosynthesis technology in the secondary fermentation of compost can improve the quality of compost products by adding bacteria, which can generate indole-3-acetic acid (IAA). After adding with these bacteria, the degree of humification and germination rate of seed increased [31]. The content of IAA in compost product increased between 2.9 and 5.2 times [31], showing that biosynthesis technology can improve the quality of compost product.

5 Comparation

In aspects of resource utilization, landfill, incineration and biosynthesis technology have all shown their respective advantages, which is transforming the organic solid waste into corresponding energy and materials. If the energy and materials can be effectively utilized, the value of them should not be judge whether is good or not. In aspects of cost, compared with landfill and incineration, although the initial research and technical support of biosynthesis technology is high, its resource recycling and emission reduction potential can bring benefits. In aspects of environment protection, biosynthesis technology has less impact on the environment due to its mild reaction conditions and no secondary pollution. In addition, biosynthesis technology can improve soil conditions and reduce greenhouse gas emissions, while landfill may cause soil and groundwater pollution, and incineration may produce harmful gas emissions. In summary, biosynthesis technology has the most obvious advantages in the environmental direction. In other directions, the three treatment all have their advantages and disadvantages.

6 Conclusion

The study compared biosynthesis technology with traditional landfilling and incineration for treating organic solid waste in aspects of resource utilization, cost and environment impact. It fills academic gap in the field of biosynthesis technology and provide suggestions for treating organic solid waste. But the study does not involve a large amount of data and algorithmic comparison of different treatment method. In the future experiments, each treatment method will be digitized and the specific organic solid waste will be track in different treatment method through life cycle assessment. Biosynthesis technology shows great potential in the treatment of organic solid waste, beginning a new era of environmental protection and resource recycling. By transforming organic solid waste into valuable chemicals, biomaterials and bioenergy, biosynthesis technology not only reduces the environmental pressure of waste treatment, but also promotes the environmental and economic integration. In the future, with the advancement of gene editing and microbial engineering, human expect to further improve the efficiency and economy of the conversion processes. In addition, the application of biosynthesis technology will also expand to the field of biorefining, improve the utilization efficiency of biomass, and develop new biomaterials, thereby reducing dependence on fossil fuels. With the development and innovation of technology, biosynthesis technology is expected to become a key tool for achieving the goals of economy and environmental protection.

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