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Progress in the application of garden waste composting

Chaocheng Zheng[1,a]

[1]Nanjing Vocational Institute of Transport Technology, Nanjing, 211188, China
[a]zccnau@126.com

Abstract: *The current main resource utilization plan for garden waste is composting. The composting process can effectively decompose a large amount of macro-molecular organic matter into garden waste, and effectively kill pests and diseases in the waste to avoid further harm as well. In order to solve the problem of waste of urban green space resources, new technologies for composting garden greening waste and the application of composting products in agricultural and forestry production were mainly explored. The results indicate that mixed composting has been a major production measure in recent years; Compost products are currently not only used in agricultural and forestry production, but also have certain applications in the field of soil remediation.*

Keywords: *Garden waste; Compost utilization; Resource utilization plan; Soil remediation*

1. Introduction

The 2020 Global Electronic Waste Monitoring report released by the United Nations pointed out that in 2019, the total amount of electronic waste (waste with batteries or plugs) generated globally reached 53.6 million metric tons, including 24.9 million tons in Asia, 13.1 million tons in the United States, 12 million tons in Europe, 2.9 million tons in Africa, and 700000 tons in Oceania. Only 17.4% of electronic waste was collected and recycled throughout the year. By 2030, global electronic waste will reach 74 million tons. The World Bank's "How Much Garbage 2.0" report shows that in 2016, plastic waste generated globally was 242 million tons, accounting for 12% of the total solid waste. More than 50% of the plastic produced globally each year is disposable plastic products, and the majority cannot be effectively treated. The Global Environment Outlook 6 released by the United Nations shows that up to 8 million tons of plastic waste flow into the ocean each year. In 2017, the production of general industrial solid waste in China was 3315.92 million tons, and the comprehensive utilization was 1811.87 million tons. In 2019, 196 large and medium-sized cities in China generated 1.38 billion tons of general industrial solid waste, 850 million tons of comprehensive utilization, 44.989 million tons of industrial hazardous waste, 24.918 million tons of comprehensive utilization, and 843000 tons of medical waste, but they were promptly and properly disposed of. In 1979, the total amount of urban household waste cleared and transported in China was 25.08 million tons, increased to 148 million tons in 2006, and reached 179 million tons in 2014. The 2020 National Annual Report on the Prevention and Control of Solid Waste Pollution in Large and Medium sized Cities shows that in 2019, the amount of household waste generated in 196 large and medium sized cities reached 235.602 million tons[1]. In recent years, solid waste pollution has become an important aspect of environmental pollution. Solid waste pollution and garbage flooding have brought serious impacts, and harmful gases and dust in solid waste can pollute the atmosphere; The harmful components in solid waste will migrate to the soil, thereby polluting the soil and indirectly polluting plants; Solid waste can also pollute water bodies and further exacerbate eutrophication; Pollution of the atmosphere, soil, and water seriously affects human health. To reduce solid waste pollution, one is to reduce the amount of solid waste, which not only saves resources but also reduces carbon emissions; The second is to increase the utilization of solid waste and directly or indirectly reduce carbon emissions. Therefore, in our carbon peaking and carbon neutrality actions, we can also effectively promote the prevention and control of solid waste pollution. In China, with the acceleration of urbanization process and the continuous improvement of urban landscaping, the amount of landscaping waste generated has also increased year by year. The main types of landscaping waste are pruned branches and leaves, as well as dead branches and leaves during the landscaping process. In China, these wastes are often treated together with ordinary household waste in a centralized manner. In the past, the main treatment methods were incineration and landfill. In nature, dead branches and leaves will naturally decompose and mature on the ground before entering the soil interface, providing necessary organic

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matter and other nutrients for the soil[2]. However, in urban green spaces, this link is missing, which can easily lead to nutrient loss and soil compaction in urban green spaces; Composting garden greening waste and reusing the processed products into green soil is a key technology to solve the waste of urban green resources and soil problems.

2. Composition of garden waste

The main source of garden waste is plant waste generated from urban and rural landscaping sites, including branches, leaves, weeds, straw, and a small amount of soil. Its specific composition is related to local greening plants and can be predicted by the types of green plants. Currently, more than 20% of the total amount of household waste is generated in China, but there are very few enterprises that carry out corresponding resource treatment of garden and green waste. Generally speaking, the main components of waste generated in different seasons are also different, with pruning waste being the main source in spring and autumn, grass being the main source in summer, and dead branches and leaves being the main source in winter[3]. The biggest characteristic of garden waste compared to other organic waste is that it contains a large amount of lignin, resulting in a higher carbon to nitrogen ratio and lower moisture content of garden waste. Lignin is difficult to be decomposed by microorganisms in nature, and its decomposition process is relatively slow: in addition to lignin, garden waste also contains a large amount of cellulose and hemicellulose. Compared to lignin, cellulose and hemicellulose decompose faster under the action of microorganisms, but hemicellulose and lignin can be connected through chemical bonds and wrapped in cellulose, forming difficult to degrade lignocellulose; These reasons have led to a relatively long composting process for garden waste, with a general composting time of 90-160 days.

Due to the abundant presence of lignocellulose, landscaping waste has the characteristics of high carbon and low nitrogen compared to ordinary household waste. The total nitrogen, total phosphorus, and total potassium in landscaping waste have a rough range, which does not change with the composition of the waste. However, by distinguishing the waste by particle size, it can be found that the elemental composition of waste with different particle sizes is not the same.

3. Control factors during composting process

Composting involves a series of complicated chemical reactions and microbial conversions, including hydrolysis, proteolysis, ammonification, nitrification, carbon mineralization, and humification. It can be divided into three stages: warming, high-temperature fermentation, and cooling and maturation[4]. Thus, temperature can indicate the specific stage of the composting. It affects the growth and activity of microorganisms, which will in turn influence the decomposition and mineralization of carbonaceous organic materials in the compost, the sanitary index of the compost, and the compost maturing process.

3.1 Carbon nitrogen ratio

Carbon nitrogen ratio (C/N) refers to the ratio of carbon and nitrogen elements in the compost substrate. Carbon is the energy source for microorganisms during the composting process, and it is also a fundamental component of microbial cell structure. During the composting process, the carbon element in the organic matter is decomposed and converted into small molecule organic matter (humus) and carbon dioxide.

Nitrogen is an essential element for microbial growth and also a necessary element for microbial structural materials such as proteins. In addition to being absorbed and utilized by microorganisms themselves, excess nitrogen is converted into substances such as nitrate and nitrite, and some nitrogen elements form ammonia gas and are discharged. Generally speaking, the carbon to nitrogen ratio during the composting process is between 20:1 and 40:1, and the optimal carbon to nitrogen ratio is about 25:1[5]. A low carbon to nitrogen ratio can hinder the normal growth of microorganisms due to insufficient carbon sources, but excessive nitrogen elements can lead to a large amount of ammonia gas overflow, decreased compost quality, and unpleasant odor. Due to the large amount of organic matter such as lignocellulose in landscaping waste, the carbon to nitrogen ratio of pure landscaping waste composting substrates is often greater than 40:1. Generally, landscaping waste is mixed with other high nitrogen content waste, and the carbon to nitrogen ratio is reduced before subsequent composting treatment.

3.2 Moisture content

Moisture content is an important indicator in the composting process of landscaping waste. Moisture

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content affects the survival status and species of microorganisms during the composting process,while water evaporation can regulate the temperature during the composting process. The moisture content of ordinary compost is generally maintained at 60%~80%, while the presence of lignocellulose in landscaping waste compost is generally maintained at 50%~60%. During composting progresses, moisture content of the compost substrate will decrease accordingly, and the moisture content in the mature stage will generally decrease to 20% -30%[6]. When the moisture content of compost substrate is below 40%, it will inhibit the normal metabolism of microorganisms in the substrate, thereby reducing composting efficiency; When the moisture content is too high, it can lead to clogging of the pores in the compost substrate, thereby affecting the oxygen content in the compost substrate and reducing the efficiency of aerobic fermentation. The low moisture content during the maturity stage is conducive to the growth of fungi in the compost products, thereby stabilizing the nutritional structure of the compost products.

3.3 Porosity and oxygen supply

The porosity of the substrate in aerobic composting directly affects the oxygen content of the substrate during the composting process, which in turn affects the metabolic capacity of microorganisms during the composting process. Generally speaking, the suitable oxygen concentration in the compost substrate is generally between 8% and 18%. When the oxygen content is below 8%, anaerobic fermentation during the composting process will increase, resulting in a foul odor and affecting the quality of the compost products; If the oxygen content in the compost substrate is too high, it will cause the compost to heat up slowly and cannot effectively kill the insect eggs and pathogenic bacteria in the substrate. From this, it can be seen that ventilation is particularly important during the composting process

3.4 Temperature of composting

The temperature of composting can affect the activity of microorganisms during the composting process, and an appropriate temperature can promote the proliferation of microorganisms in the composting substrate, thereby improving the efficiency of composting. During the process of microbial decomposition of organic matter, cow heat is generated. As the composting process continues, the composting temperature will first increase and then decrease; In the initial state, the temperature of the compost substrate is consistent with the environmental temperature. As the composting progresses, the temperature of the pile will gradually increase to the suitable temperature for mesophilic bacteria, which is 40-50C. After 1-2 days of mesophilic bacteria action, the temperature of the pile will continue to rise to the suitable temperature for thermophilic bacteria, which is 50-65℃[7]. Generally speaking, the decomposition efficiency of thermophilic bacteria is superior to that of mesophilic bacteria. At a suitable temperature for thermophilic bacteria, it not only greatly helps the composting process, but also effectively kills the insect eggs and pathogenic microorganisms in the compost substrate.

3.5 Acidity and alkalinity

The pH value of the composting substrate during the composting process is an important indicator of microbial decomposition of organic matter. In previous studies, it was found that the suitable pH value for microorganisms during the composting process was between 5.5 and 8, while for landscaping waste due to its special substrate composition, the more suitable pH value for composting was between 7 and 8, which is basically a slightly alkaline environment. Research has reported that in a slightly alkaline environment, the decomposition efficiency of lignin during the composting process of landscaping waste is higher than that in a normal composting environment. Generally speaking, in the initial stage of the composting process, the acidity of the pile decreases due to the metabolism of organic acids by microorganisms. As the composting progresses, the temperature of the pile continues to rise, and some organic acids are volatilized. Some organic acids are decomposed and utilized by microorganisms, and the pH value of the pile also gradually increases accordingly.

4. Composting Technology and Utilization

Garden waste has the characteristics of high carbon content and low moisture content due to its high content of lignocellulose; Due to the physical and chemical properties of garden waste, it is not suitable for direct composting. Therefore, in actual production, garden waste is often mixed with other waste before subsequent composting work.

The remaining sludge from sewage treatment plants can be used as a soil improvement substrate in actual agricultural and forestry production. However, sludge contains certain pathogenic microorganisms and a large amount of nitrogen elements. Mixing sewage sludge as an additive with landscaping waste

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for composting can effectively compensate for the shortcomings of nitrogen element deficiency and low moisture content in landscaping waste compost. Liang Wentao found that the entire composting time was 120 days after mixing garden greening waste with sewage plant sludge. Among them, 20 days of composting were monitored at high temperatures above 55℃, and parasitic eggs and pathogenic bacteria in the sludge were killed[8]. The compost products of mixed composting of sludge and garden waste have been applied to agriculture and forestry to some extent, for instance, Zhao Xia et al found after applying the mixed compost product to the soil planted with Persian chrysanthemum, it was found that there was no significant change in the total nitrogen and organic matter content of the soil, but the plant height, fresh weight, and root length of Persian chrysanthemum increased with the increase of application amount. At the same time, the content of copper, zinc, and elements in the soil also increased to a certain extent, but the total content did not exceed the limit value. After applying the compost product, the enrichment ability of Persian chrysanthemum to copper element in the soil increased. Hence, mixed composting products of Ming garden waste and sludge have a positive effect on improving soil nutrient content and enhancing plant growth level. After applying mixed compost products of sludge and landscaping waste with different ratios to tall fescue, Si Liqing et al. found the germination rate of tall fescue reached the highest when the ratio of sludge to landscaping waste was 1:1. Regardless of the compost product ratio, the plant height and biomass of tall fescue significantly increased after use, And its maximum plant height and maximum biomass are achieved after using a 1:1 ratio of mixed compost products. Regardless of the ratio of compost products, the plant height and biomass of tall fescue significantly increased after use, and their maximum plant height and biomass were achieved after using the 1:1 ratio of mixed compost products. The above studies all indicate that the composting products of mixed composting of landscaping waste and sludge can effectively promote plant growth, but it is also necessary to pay attention to whether the content of various metal elements in the soil exceeds the standard after use.

In addition to sludge, landscaping waste is often mixed with other substances for composting to adjust the carbon nitrogen ratio and moisture content of the compost substrate to achieve the most suitable conditions for composting. Household waste has the characteristics of high moisture content and high nitrogen content, especially kitchen waste, which is often used as a composting additive and mixed with garden waste for composting. Fang Weicheng et al. [By mixing garden waste and kitchen waste in a 9:1 ratio, a mixture with a carbon to nitrogen ratio of 331 can be obtained. By composting this mixture at high temperature for more than 12 days, high-quality compost products can be obtained. After applying this compost product, the seed germination index is 115.6%, which can be applied to real garden production. In addition to household waste, animal husbandry preparation.

In addition to household waste, animal husbandry waste is also a good additive. The main component of animal husbandry waste is animal manure, which contains high nitrogen elements and a large amount of water. When mixed with garden waste, it can effectively compensate for the shortcomings of low nitrogen content and water content in garden waste. At the same time, after mixed composting, A higher composting temperature can effectively kill a large number of parasitic eggs and pathogenic microorganisms in feces, and can play a role in the harmless treatment of livestock waste. Hao Dan et al. used a certain proportion of garden waste and cow manure mixed compost products as the seedling substrate for calendula, hoping to obtain a sufficient growth substrate to replace peat; The results showed that using a 1:1 mixture as a growth agent to cultivate calendula officinalis, the emergence rate could reach 73.3%, significantly promoting the growth of calendula officinalis. Feng Hongmei et al After crushing garden waste and mixing it with different proportions of chicken manure for composting, the effect of this mixed composting on the composting process was studied. The results showed that the composting temperature of different proportions reached above 50C after a certain period of time and lasted for at least 2 weeks. Among them, the best composting effect was achieved by mixing green waste and chicken manure in a 1:1 ratio, and the time it entered high-temperature composting was 2-5 days earlier than other proportions of composting. After 40 days, the physicochemical properties of the compost products reached a relatively ideal effect; After the completion of composting, the compost products were applied to the plants, resulting in a seed germination potential of 86.69%, a carbon nitrogen ratio of 12.41, and a total nutrient content of 4.89%, significantly higher than other mixed ratios.

The composting products of garden waste have a wide range of applications in agricultural and forestry production. In addition to providing nutrients for agricultural and forestry soil, garden waste composting products can also play a role in regulating soil acidity and alkalinity, controlling soil heavy metal pollution, and so on. He Kun et al. mixed the compost products of landscaping waste and flue gas desulfurization gypsum in different proportions in coastal saline soil, and found that this mixed application agent can significantly reduce the pH value and total salt content of coastal saline soil, increase the content of soil nutrients and organic matter, and increase the biomass of plants growing on the soil; When the application amount of desulfurization gypsum reaches 25g/kg, the best effect is achieved, where the pH value decreases by 10% and the element content decreases by 30-40%. Applying compost products from landscaping waste in soil can regulate the microbial community in the soil and

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improve soil microbial activity. Lian Peng et al. applied different contents of garden waste compost products to forest soil, and the total enzyme activity in the soil increased with the increase of application amount. When 50kg was applied, the total enzyme activity increased by 119.05%~204.76%, and the total biochar in the soil also increased. This indicates that the application of garden waste compost products can increase the number of soil microorganisms and improve the soil biological environment.

The compost products of landscaping waste are mainly used as soil improvement substrates to provide necessary nutrients and organic matter for the soil. Research has shown that garden waste compost products have the advantages of low bulk density, high porosity, high organic matter, and high nitrogen, phosphorus, and potassium content, making them ideal substrates for flower and plant cultivation. After the application of compost products, the root growth and chlorophyll content of African impatiens and petunias increased, resulting in faster leaf growth. As a result, the flowering quality of African impatiens and petunias also improved, and the compost products of landscaping waste also had the same promoting effect on tree plants. Yu Yun et al. applied different concentrations of garden greening waste compost products to forest seedlings. Overall, the best effect was achieved at a concentration of 10%. The height growth, ground diameter, total biomass, and total chlorophyll content of olive seedlings increased by 8%, 5%, 19%, and 40%, respectively.

5. Summary

Current research and practice have shown that garden waste can be applied as a very suitable composting additive. The traditional aerobic composting substrate is generally kitchen waste, animal manure, municipal sludge and other waste, which often have characteristics such as high water content, high nitrogen and phosphorus content, low organic matter content, and low porosity. The physical and chemical characteristics of garden waste are complementary to them; Research has shown that mixed composting of garden waste and other composting substrates in a certain proportion can significantly shorten the composting time and improve the output quality of composting products; Especially in the current situation where municipal sludge needs to be reduced and harmless, mixed compost can simultaneously treat garden waste and urban sludge as resources, while generating certain economic benefits, making it a popular path for municipal sludge treatment and disposal.

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