Study on eco-utilization and treatments of highway greening waste

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Abstract

With the rapid development of highway greening protection construction, the amount of greening waste is continuously increasing, including litter, pruning and turf cutting litter and so on. As the traditional treatment approach of greening waste, such as incineration, landfill could not meet the requirement of sustainable development, the harmless and resourceful treatment method of greening waste becomes the necessary trend. In order to reasonably dispose and make use of the increasing litter, from the ecological resources point of highway greening waste, on the basis of ecological functions of litter, the several ecological utilization ways of greening waste were overviewed, moreover composting treatment technology of greening waste and its advantages, product development, application effect and market prospect were highlighted, it is thought that the composting is the effective utilization approach for greening waste, it has fairly good social benefit and ecological benefit, which can provide one kind of practical and feasible pattern for developing circular economy of highway greening industry. At the same time, being lacked of corresponding policy support and management requirement of greening waste utilization in China, the countermeasures and suggestions suitable for China of green waste recycling utilization were put forward by learning from the foreign successful experience and policy in this paper.

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1. Introduction

Highway greening is an important kind of land greening, which can be utilized in the restoration projects of damaged roadside ecosystem along highway. But with the rapid development of highway construction, the amount of greening wastes including litter, pruning and turf cutting litter and so on are continuously increasing. In the past, the majority of greening wastes were treated as the solid wastes to landfill. However, this is very costly to collect, transport and fill the greening wasters, in addition to frequently-occurred incineration in autumn and winter. It is urgent to replace the traditional methods of greening waste treatment with innovative one to promote the recycling of greening wastes in highway construction projects.

2. Ecological functions of litter

1.1. Increasing soil nutrients

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During the decomposition process of litter, the nutrients from the litter are continuously released to the soil, and increased soil fertility. The results show that [1] when the litter increases 100 g/m² averagely, organic matter, the N, the P and the K in soil increased 17.9%, 7.6%, 26.4% and 3.8%, respectively.

1.2. Improving soil structure

Under the extensive management of highway greening, the surface soils are commonly dense and compacted, with poor physical and chemical properties. Poor soil condition and greater density are not conducive to the growth and development of the plants. Because the loose structure of litter has good hydraulic permeability and water holding capacity, therefore on the occasion of the decomposition of litter, a lot of organic matter are added to surface soil to improve soil moisture and fertility.

1.3. Increasing soil moisture and regulating soil temperature

Litter itself can increase soil moisture by preventing evaporation of soil surface and reduce soil moisture loss. The ground covered by litter would avoid direct sunlight, and it separate the soil from the air of temperature fluctuating sharply. Litter can redistribute heat quantity by absorbing, storing and releasing energy, so it makes the soil temperature tend to be cooler in summer and warmer in winter. Therefore, the litter can affect plant growth by changing the temperature of the soil surface.

1.4. Enriching soil animal community

Litter can provide good habitat for the soil animals such as the insects, at the same time it is the food sources for the microorganism and small arthropod. Moreover, some birds feed on these creatures, so it creates wildlife habitats.

1.5. Depressing the growth of weeds

Some seeds of the weed in soil surface can not germinate because the litter cover was too dense to defend the light penetrate for seed germination. The weed seeds under the litter have exhausted the storage of carbohydrates in the germination process in order to penetrate the coverings to obtain sunlight. Meanwhile, litter leachate can release toxic compounds and can effectively inhibit the growth of weed.

3. Adverse effects of litter on plant growth

3.1. Reducing the oxygen and moisture in soil

If litter layer is too thick, it may not let the oxygen get into the soil, especially in poor drained or hardened soil. In addition, the retardation of water vertical infiltration can benefit water accumulation in pits after irrigation or rainfall, leading to the death of plants due to rot. High-density litter cover may also cause water saturation or instauration from soil surface, resulting in soil hypoxia or drought stress.

3.2. Increasing pathogen infection

Soil microorganisms and animals are functioning in Litter decomposition process, which may bring some breeding pathogen and make some plants are infected by the pathogen.

4. Ecological utilization ways of greening waste

4.1. Degradation
Green belt in highway has a suitable hydrothermal condition in the natural state, the formation and decomposition of litter in the natural cycle is in a dynamic state. The use of the natural degradation can not only provide the fertility to green space system, but also provide the habitat to wildlife, create rustic charm of the green landscape.

4.2. Organic mulch

Litter, pruning and other greening waste are made into organic mulch after being crushed and processed, and are layed on the highway green belts, around the surface of plants and bare soil in urban green areas, so that there are some effects such as soil moisture conservation, increasing soil fertility, improving soil structure, inhibiting the growth of weeds, suppressing fugitive dust and promoting tree growth and so on. For good irrigation conditions and seasonal dry climate areas, the thickness of organic mulch is 7-10 cm can help reduce drought stress level; for heavy soil of the rain-rich areas, the thickness of organic mulch is 5-7 cm compare suitable for tree growth[2]. According to other researchers’ findings[3], wood grinding size is 0.5-1 cm thick, 3 cm wide and 8 cm long are more appropriate Shanghai Greenland habitat conditions, and 2 cm of covering thickness can decompose about 70% after covering 1 year, and it can obviously improve soil quality of green space.

Greening waste consumption base in Chaoyang District, Beijing was designed to produce organic mulch that is being used in their own green plant and Laiguangying green plant. Ocean Wide Horticulture Co., Ltd., Beijing has also carried out a model of organic mulch in The China Millennium Monument and Fuxingmen area[4].

4.3. Culture edible fungi

Using litter of highway green plants and cultivating edible fungi to make full use of waste resources and increase economic efficiency, with a vast developing foreground. Wang et al.[5]used forest shading and adjusted temperature and moisture retention of microclimate environment to carry out cultivation test of pleurotus under forest, the results show that the production of pleurotus with ferment material in forest can increase 3.5-4.5 kg/m² than non ferment material, improve bio-efficiency 40%-45%, net income per hectare will be 8196 Yuan, with significant economic benefits.

4.4. Composting treatment

4.4.1. Compost and its advantages

Composting of greening wastes is a process using the branches, leaves, turf cutting litter through a certain treatment and mixing ratio, forming organic fertilizers and soil amendments through the aerobic fermentation in optimum conditions, free of phytotoxicity (no weeds, parasites, etc.), quantitative reduction and resource utilization [6].

Greening waste composting has several advantages. First, greening waste has plenty of mineral element and organic matter and its main component is cellulose, lignin and other biodegradable material, and greening waste has less pollution compared with other waste and does not contain heavy metals and other toxic substances. Second, the composting process basically does not produce odor pollution and has less restrictive factors for the location of the composting site. Third, the compost production has high market value, wide application scope and good economic benefits.

4.4.2. Composting process

Greening waste composting process is generally divided into 3 stages: pretreatment, raw material fermentation and post processing.

(1) Pretreatment: The composting interferent such as plastic bags has to be removed before greening waste is crushed by a crusher, and the particle size between 1.3-7.6 cm[7], this can increase its specific surface area and benefit to decomposition of microorganism.

To speed up the rate of heating and decomposition, it needs to adjust the various parameters that affect the quality of compost. The optimum water content for compost should be at 40%-60%; the adequate C / N ratio for compost is in the range of 25:1-35:1; during composting, pH changes frequently, but the pH of raw materials is close to 7;
microorganism plays an important role in composting such as heating rate, material transformation and pathogen inactivation, adding 2-5 kg/m³ of microbial strains and mixed in the good regulation of raw material[8].

(2) material fermentation: The type of composting process can be divided into aerobic composting and anaerobic composting on the basis whether oxygen is needed or not, because aerobic composting has many advantages such as a short cycle, good sanitary conditions and easy to be operated. Aerobic and anaerobic composting have been widely used in the composting of greening waste, sludge, municipal solid waste and animal manure. Two main types of aerobic composting system at home and abroad are summarized in Table 1.
Table 1 Comparison of different composting technologies

| Classification            | Basic principles                                                                 | Features                                                                 |
|---------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Open system               |                                                                                  |                                                                          |
| Windows composting        | Materials are stacked into piles, pile's cross-section is trapezoid or triangle, regularly using mechanical or manual pile-turning ways to ventilate. | Simple equipment, low investment costs and good product stability. But large area is occupied, long maturity period, requires a lot of pile-turning machinery and manpower. |
| Static forced-aeration composting system | Don't require pile-turning, the supply of oxygen by means of air blower or induced fan, to maintain the aerobic reactor body condition. | Lower investment cost, relatively short composting time, to better control temperature and ventilation, but influenced by the climate. |
| Agitated fixed-bed type   | The reactor usually consists of multi-layer structure, composting materials move from the top of the tower to bottom by a series of layers to complete the first fermentation, and mixing. | Automatic operation, materials by stirring constantly to make more uniform compost products, small area occupied, secondary pollution is small, but high investment, operation and maintenance costs. |
| Fermentation Room System  |                                                                                  |                                                                          |
| Parcel storage bin        | Materials fill up the whole fermentation room, the fermentation room has a air conduit of branch pipe at the bottom to ventilate the reactor materials. | Low cost, secondary pollution, a continued input-output, but the materials in bottom of the fermentation room may be compacted that is unfavorable to ventilation. |
| Rotary storage bin        | Materials in the belt conveyor of bin move along a certain direction to ferment, the move pattern of the material in the reactor can be divided into plug flow and separation type. | Better uniformity of compost products, secondary pollution is small, but large area occupied, complex equipment. |

The temperature of composting material will gradually decrease through high temperature fermentation, by then it needs a maturity phase to stabilize the physical and chemical properties of compost, this period should be at least one month. When the temperature is stable at below 40°C or the moisture content is down to 14%-15%, it can be considered as full maturity and the basic composting process is over.

The color of mature compost is dark brown or black, without unpleasant smell, with loose structure. Chemical assay methods can also be used to determine compost maturity, such as content variation of organic matter, humic acid and organic acid of compost, a change in pH and C/N[9].

(3) post processing: Post processing is required for the user or market on selective processing of the compost. Compost allocated with other raw materials can be broadly divided into three series: soil amendment, nutrition medium and bio-organic fertilizer. Soil amendment made by adding raw materials to compost as diverse as organic acids, rooting hormone and microbial strains and so on; special nutrition medium made by adding peat coal, yellow mud and perlite, etc. to compost; and bio-organic fertilizer made by adding antagonistic microbial strains and liquid protein to compost. And it also needs to carry out inspecting and controlling quality of compost products, such as the product of physicochemical properties, pathogenicity and nutritional components and so on, which for the purpose of quality control.

4.4.3. Compost products

At present, Guangzhou greening company established landscape matrix plant, which added the beneficial microbial strains to milled litter to produce a series of products of nutrition medium that go through the high temperature fermentation, they are returned to the soils of landscape and garden. Greening waste consumption base has been established in Chaoyang District, Beijing which produce three series of products, such as organic substrate, bio-organic fertilizer and landscape mulch by using garden organic waste; Xicheng District use garden organic wastes to produce the soil improvement substrate; Fengtai District has established plant litter disposal plants to produce flowers and trees matrix and organic fertilizer, etc. [10].

Compost products are applied as the soil amendment in seedling process of landscape engineering such as Guangzhou Higher Education Mega Centre public greening four bids, many school districts bids, Oriental Resort, New Kau south road, Ke Yun road, 37 road upgrading and the Baiyun International Conference Center, the application of soil amendments is accounted for 5%-30% of the original soil, the results showed that garden plants has more than 98% survival rate, plant growing vigorously and improving the ecological benefits of the landscape greening, building down greening indirect costs[8].
Guangdong Agricultural Machinery Institute developed a complete equipment for organic-inorganic compound fertilizer production line that is suited to mechanization treatment of landscape branch composting, and it has put into production and used in Shenzhen Municipal Bureau of Parks in 2007, the disposing scale is waste branches of 150,000 m³ each year, and it can produce 10,000 t organic compound fertilizer to meet the Shenzhen processing requirement of the branch of the waste in the next decade. The entire production process is continuous, mechanization, automation, short production time, high output and highly valued by the users[11].

Greening waste contains a large number of mineral elements and organic matter, it is being studied and developed for concentrated and effective substituting to the cultivation of raw materials of peat coal matrix[12]. Urban green area mulch could reduce the toxicity of lead in urban soil, garden waste compost is used for the urban soil remediation of the organic pollution[13].

5. The countermeasures and suggestions of greening waste recycling utilization

Although some developed cities have begun to value the treatment and disposal of greening waste in China such as Beijing, Shenzhen, Guangzhou and Shanghai and so on, there are big gaps in regional distribution, and there is a lack of corresponding policy support and management requirement of greening waste utilization in China, so based on the real situation in China, the countermeasures and suggestions of greening waste recycling utilization suitable for China were put forward by learning from the foreign successful experience and policy in this paper.

5.1 Formulating relevant policies and regulations

Although it has already promulgated policies and regulations of resource re-utilization of urban garden waste in China at present, such as on August 30, 2007, The Ministry of Construction of the People's Republic of China, promulgating [2007] No.215 "On comments of building economization-based urban landscape greening" that pointed out[14] "to encourage the development of biomass fuels, organic nutrition medium and deep-processing approach through composting to deal with sheared branches, then to reduce the storage capacity occupied by landfill and realize cyclically using." But there are unspecific and inexhaustive ways of treatment measures of highway greening waste, according to the actual situation, formulating corresponding policy prohibits the burning of greening waste or increasing landfill costs, to deal with the root of the problem of resource re-utilization of greening waste and improve land utilization.

5.2 Choosing right location and making scientific planning

It should be combined with the geographical environment and the nature of green waste of highway, making scientific and comprehensive layout plans, such as choose rational factory site, technical route and transport routes, etc. Thereby it can reduce processing costs, the combinations of the nearest and concentrated treatment.

5.3 Increasing government support dynamics and scientific research

To provide all kinds of practical preferential policies, such as the Government can provide special funding for a compost plant and allowance for waste collector on both sides of the road, and to promote the government give priority to purchasing recycling of greening waste products. Foreign garden machinery technology is studied to improve the products quality of highway greening waste, to reduce operating costs of greening waste treatment and disposal, to encourage and fund scientific research units and institutions to carry out greening waste composting research, so as to make breakthrough as soon as possible in key technologies and popularizing application demonstration of resource re-utilization of greening waste.
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