Study on the Technology of River Sediment Used as Planting Soil

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Abstract. This article conducted on-site experiments on improving river sediment to produce planting soil, using aerobic composting technology. The main composting parameters include carbon nitrogen ratio, moisture content, pH value, and temperature. In order to adjust the carbon nitrogen ratio of the sediment, auxiliary materials such as chicken manure, pig manure, rice straw, and wheat straw can be added according to the carbon nitrogen ratio of the sediment itself and relevant specifications. In this article, rice straw and rice husk are added. In the on-site test, a group of piles were maintained above 60 ℃ for 3 days, achieving harmless treatment of the sediment. However, when the carbon nitrogen ratio of the pile is less than 20, it is difficult for the sediment temperature to reach 60 ℃, and it cannot be guaranteed that the sediment can achieve harmless treatment. After the improvement, the obstacle factors of the sediment have been reduced, meeting the standard requirements. Nutrients increased, and among the 36 indicators after sediment improvement, only nitrogen was below the standard limit, while potassium and magnesium exceeded the standard limit. All other indicators met the standard requirements.

1 Introduction

In a river regulation project in Tangshan City, a large amount of river sediment was cleaned up, and a large amount of planting soil would laid at the bottom and slope of the river for plant growth. If the river sediment can be used as planting soil, the partial balance of earthwork can be achieved, which not only saves a lot of planting soil costs, but also reduces the amount of soil discarded in the project, resulting in huge economic and environmental benefits.

However, river sediment generally can't be directly used for planting plants [1-4], mainly due to the following reasons:

-River sediment is relatively sticky and heavy, with more fine particles. Directly applied into the soil, it is easy to cause soil compaction and hardening, resulting in poor soil aeration [5].

-River sediment contains heavy metals and fungal microorganisms. If directly applied into the soil, the content of some heavy metals in the soil will exceed the standard, which will affect the growth and yield quality of crops, and increase the possibility of breeding, infection and insect pests in the soil [6,7].

-The sediment is rich in nitrogen and has high fertility. If it is directly applied to the soil, for some plants that are not tolerant to fertilizer, it may cause excessive fertility in the soil and increase the risk of burning roots and seedlings of some crops [8].

-If sediment is directly applied to the soil, it may cause the soil temperature to drop in a short time, which is not conducive to promoting the decomposition of soil organic matter and maintaining the temperature of crops at night.

In view of this situation, field test was carried out, the river sediment was improved and made into planting soil before application.

2 Field test process

2.1 Sediment property testing

River sediment was sampled and its properties were tested referring to "Planting soil for greening" (CJ/T340-2016). Technical requirements of main control index of planting soil for greening before and after improvement were shown in Table 1. Technical requirements for fertility of planting soil for greening were shown in Table 2. Potential soil constraint factor of planting soil for greening were shown in Table 3. Technical requirements of heavy metal content of planting soil for greening were shown in Table 4.

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Table 1. Technical requirements of main control index of planting soil for greening.

No.	main control index	Sediment before improvement	Sediment after improvement	Specification requirements
1	PH	7.67	8.13	5.0~8.3
2	Salt content (g/kg)	3.0	0.508	≤1.0
3	Organic matter (g/kg)	13.9	30.8	12~80
4	Soil texture	Sandy loam	Sandy loam	Loamy soil(Some plants can use sandy soil.)
5	Soil infiltration rate (mm/h)	9.49	10.27	≥5

Table 2. Technical requirements for fertility of planting soil for greening.

No.	Nutrient control index	Sediment before improvement	Sediment after improvement	Specification requirements
1	Cati on exchange capacity (CED)/[cmol(+)/kg]	0.09	0.09	＜0.4
2	Organic matter (g/kg)	13.9	30.8	20~80
3	Available phosphorus (P)/(mg/kg)	20	92.3	5~60
4	Available potassium (K)/(mg/kg)	577	1460	60~300
5	Available sulfur (S)/(mg/kg)	58.4	162	20~500
6	Available magnesium (Mg) /(mg/kg)	4.81	559	50~280
7	Available calcium (Ca)/(mg/kg)	22.7	696	200~500
8	Available iron (Fe)/(mg/kg)	3.69	70.0	4~350
9	Available manganese (Mn) /(mg/kg)	0.83	14.4	0.6~25
10	Available copper (Cu)/(mg/kg)	1.14	1.62	0.3~8
11	Available zinc (Zn)/(mg/kg)	/	1.74	1~10
12	Available molybdenum(Mo) /(mg/kg)	/	0.444	0.04~2

Table 3. Potential soil constraint factor of planting soil for greening.

No.	Potential soil constraint factor	Sediment before improvement	Sediment after improvement	Specification requirements
1	Density (Mg/m^3)	1.34	0.36	≤1.35
2	Non-caplllary porosity (%)	30	21.42	5~25
3	Moisture (g/kg)	3	21.0	＜85
4	Maximum wet density (Mg/m^3)	1.92	0.44	≤0.8
5	Gravel content with particle size ≥2mm (%)	0.58	11.5	≤ 20
6	Germination index (GI)/(%)	133	133	＞80
7	Exchangea-ble sodium，(mg/kg)	80.9	47.8	＜120
8	Sodium adsorption ratio，(SAR)	7.85	0.687	＜3
9	Soluble boron，(mg/L)	/	/	＜1

Table 4. Technical requirements of heavy metal content of planting soil for greening.

No.	Heavy metal elements （mg/kg）	Sediment before improvement	Sediment after improvement	Specification requirements
1	Cd	0.09	0.09	＜0.4
2	Hg	No	0.044	＜0.4
3	Pb	3	21.0	＜85
4	Cr	14	58	＜100
5	As	7.9	3.54	＜30

6	Ni	12	37	＜40
7	Cu	13.5	18	＜40
8	Zn	64	52	＜150

2.2 Improved test process

The key steps of the improvement test are as follows:

-It can be seen from Table 1~Table 4 that before improvement, nutrients such as Mg, Ca, Fe, Zn, Mo, Organic matter, Cation exchange capacity are less than the regulations of planting soil, which does not meet the specification requirements. Eight kinds of heavy metals, such as cadmium, mercury and lead, are far less than the regulations of planting soil and meet the requirements of the specification. Constraint factors such as density, salt content, non-capillary porosity, maximum wet density and Sodium adsorption ratio do not meet the requirements of the specification and need to be improved.

-According to the related research [9], the main parameters for sediment improvement are shown in Table 5. According to the content of total nitrogen and organic matter in the test results, it is estimated that the carbon-nitrogen ratio of the sediment before improvement is 16.4, which does not meet the requirements in Table 5 and needs to be adjusted. If C/N of the sediment is high, it can be adjusted by adding chicken manure, pig manure and pig manure. If C/N is low, it can be adjusted by adding straw, wheat straw, sawdust and bark. "Quality Requirements for Agricultural Compost" (DB13/T 5373-2021) gives the ratio of carbon to nitrogen of common auxiliary materials. Comprehensively refers to the difficulty of obtaining various auxiliary materials at the project site, it is decided to add rice straw and rice husk into the sediment.

-In the experiment, six groups of experiments with different proportions were carried out, and the ratio of ingredients in each group is shown in Table 6. Among the six groups, C/N ratios of the first and fourth groups meet the requirements in Table 5, and C/N ratios of other groups are all less than 20.

-The sediment was screened to remove particles exceeding 20 mm. The water content of the sediment is detected. If the water content is high, the auxiliary additives such as leaves and straw powder need to be dry. If the water content of the sediment is low, water can be added appropriately.

-After the completion of the pile body, the pile turning operation will be started on the 3rd day, and then it will be carried out once every 1-2 days until the 4th time, and then it will be turned once every 4d or 5d, and it needs to be maintained above 50℃ for 5-10d and above 60℃ for 1d. Three thermometers are buried in each pile, and the thermometers are buried at least 30cm below the surface of the pile. When the temperature of the pile exceeds 70℃, it is advisable to turn over the pile to reduce the temperature, otherwise it will turn into anaerobic fermentation. The composting process site is shown in Figure 1.

-According to the temperature monitoring results, the temperature generally increases first and then decreases. When the temperature basically does not change, composting is completed. The improved sediment was detected and the improvement effect of each group was analyzed.

Table 5. Main control parameters of composting.

Control parameter	C/N	Moisture (%)	pH	Temperature (℃)
Suitable range	20~30	45~70	5.5~8.5	50~70
Control target	25	60	7	60

Table 6. Composition of each group of test materials.

No.	Material quality (kg)			
	Sediment	Rice stalk	Rice hull	Compost inoculant
1	1500	577	231	0.9
2	1500	300	200	0.8
3	1500	88	176	0.7
4	1500	577	231	0
5	1500	300	200	0
6	1500	88	176	0

Fig. 1. Composting process site.

3 Analysis of improvement effect

The temperature change curve during composting is shown in Figure 1.

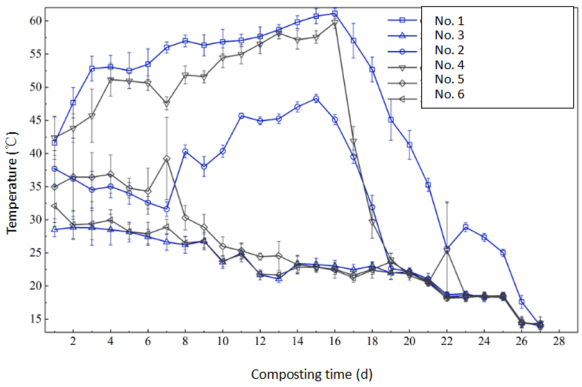

Fig. 2. Temperature change curve in composting process.

According to China's experience [10], if the composting process can be maintained above 60℃ for 24 hours, pathogenic bacteria, parasite eggs and weed seeds in the compost can be killed, thus achieving harmlessness. As can be seen from Figure 2, the material pile 1 (sediment: rice stalks: rice husk =65:25:10, adding 0.9kg compost inoculant) was kept above 60℃ for 3 days, and the sediment was harmless.

When there are few auxiliary materials and the ratio of carbon to nitrogen is less than 20, the temperature of the material pile is difficult to reach 60℃, and it is impossible to ensure that the material pile can be harmless.

When compost inoculant is added, the temperature of the pile increases rapidly at the initial stage, decreases slowly at the later stage, and the high temperature lasts for a long time, which can play a good auxiliary role in the composting of sediment.

The properties of the improved sediment are shown in Table 1~Table 4. It can be seen from the table that the mud barrier factors such as soluble chlorine, exchangeable sodium, sodium adsorption ratio, soluble boron, non-capillary porosity and salt content of the improved sediment have all been reduced, which meets the requirements of the specification. Nitrogen, phosphorus, potassium, available sulfur, available magnesium, available calcium, available iron and other nutrients increased; Among the 34 indexes after the improvement of sediment, only nitrogen is lower than the standard limit, potassium and magnesium exceed the standard limit, and others meet the standard requirements.

4 Conclusion

In this paper, the field test of making green planting soil by improving river sediment was carried out, and conclusions were as follows:

-This paper provides a set of techniques for improving river sediment to make green planting soil. The sludge improved by aerobic composting technology in this paper basically meets the requirements of green planting soil specification.

-In the test, rice stalks and rice husks were added in the sediment. Then the C/N of sediment was adjusted to 20~30, which ensures the composting effect.

-When the ratio of sediment: rice straw: rice husk is 65: 25: 10, and 0.9kg compost inoculant is added, the pile can be kept above 60℃ for 3 days, and the sediment is harmless. However, when the auxiliary materials are less and the C/N is less than 20, the temperature of material pile is difficult to reach 60℃. And it is impossible to ensure that the material pile can be harmless.

-When compost inoculant is added, the temperature of the pile increases rapidly at the initial stage, decreases slowly at the later stage, and the high temperature lasts for a long time, which can play a good auxiliary role in the composting of sediment.

-After improvement, mud barrier factors such as soluble chlorine, exchangeable sodium, sodium adsorption ratio, soluble boron, non-capillary porosity, salt content and so on are all reduced, which meets the requirements of the specification. Nitrogen, phosphorus, potassium, available sulfur, available magnesium, available calcium, available iron and other nutrients increased. Among 34 indexes after the improvement of sediment, only nitrogen is lower than the standard limit, potassium and magnesium are higher than the standard limit, and others meet the standard requirements.

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