Analysis of several key factors in soil organic reconstruction

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Abstract: Soil organic reconstruction is the core of land engineering. Taking the Hancheng Xiayukou land consolidation project as an example, this paper discusses the application in the reconstruction of organic soil through four key aspects, namely the particle needs, profile reconstruction, soil chemical properties and nutrition support. The results showed that: (1) In searching of reconstruction materials, we should give priority to the soil particle needs; (2) In the soil profile reconstruction level, we should fully consider the local soil and hydrological conditions. In the same time, reasonable structure of profile should be designed guided by the target crop; (3) In the reconstruction process, we should consider the safety of reconstruction materials; (4) According to the target crop demand, we should adjust soil components to provide protection for biological nutrition after soil organic reconstruction.

1. Introduction

With the acceleration of urbanization and industrialization, the unreasonable development and predatory use of land by human beings lead to the lack of land resources, the increasingly tense relationship between human and land, and a series of serious ecological environment problems, such as environmental pollution, the degradation of land ecosystem function, the decline of biodiversity and so on. The survival of all things on the earth is seriously threatened. To solve these problems fundamentally, we need deep scientific research and engineering practice of land engineering. Land engineering is a process of using engineering means to solve land problems, turning unused land into usable land or making efficient use of used land, and actively coordinating the harmonious development of human land relationship [1].

Soil organic reconstruction is the core foundation of land engineering, that is to say, a certain depth of soil is taken as the research object. Through the research on the material, structure, biological nutrition and other aspects of the soil, by means of replacement, compounding, increase and decrease and other technical means, the degraded, polluted, damaged, inefficient and other defective soil or unused soil is rebuilt to carry organic life Provide necessary conditions [2]. The purpose of soil organic reconstruction is to fundamentally solve the land problem. Water, forest, road and electricity are supporting projects for improving the service function of land engineering, not the main project. In other words, the main works of soil engineering are how to build soil layers, how to control soil particles, how to increase or decrease soil elements, how to prevent and control soil toxic and harmful substances, and how to maintain soil bearing capacity.

Previous studies only focused on the single aspect of soil reconstruction. Wang Jinman et al. [3] studied the different particle composition and fractal characteristics of the reclaimed soil in the coal mine waste dump. Hu Zhenqi [4] put forward the basic principle and method of reconstructing the soil profile of Coal Mine Reclamation Based on the theory of soil science and the practice of open pit...
reclamation abroad. Moreover, previous studies have failed to put forward systematic solutions to the fundamental problem of organic reconstruction of soil mass, such as particle selection, mineral type, profile reconstruction, soil chemical properties, biological selection, topography and geomorphology reconstruction in the reconstruction process. Taking Xiayukou land remediation project in Hancheng as an example, this paper expounds the specific application of key elements in the organic reconstruction of soil mass, which provides a certain reference for the construction of land engineering projects and theoretical research.

2. Soil Particle demand

Soil is composed of several layers with different thickness and properties, which are combined in a specific order of upper and lower. It is widely distributed on the surface of the earth and is a very complex natural body. The soil layers that make up the soil are aggregates of all kinds of mineral particles. The soil at all levels is rarely composed of single size soil particles, but mostly composed of different size soil particles in various proportions. Different particle size distribution characteristics have different radiation transmission, water balance, heat balance and other characteristics. The particle size and shape, mineral composition and particle interaction with water and the relative content of pores in the pores are the main factors that determine the physical, chemical and mechanical properties of the soil, and play an important role in the organic reconstruction of the soil. Soil texture is an extremely important factor affecting soil fertility. It is one of the main factors determining the properties of soil, such as water storage, water diversion, water conservation, heat preservation, ventilation and cultivation. It has a very close relationship with crop cultivation. A good soil configuration should have the best proportion of clay, powder and sand [5].

The project area is located along the Yellow River in Xiayukou, Hancheng City, Weinan, Shaanxi Province, which is in the middle reaches of the Yellow River and in the east of Shaanxi Province. The terrain is basically flat, slightly inclined from north to south, and the ground slope is small (about 1‰). Most of the beach area is yellow sandalwood land with soft soil. The soil in this area is mostly sandy soil with low nutrient content and large leakage [6], which is not suitable for the sustainable development of agriculture. Therefore, it is necessary to reconstruct the soil body organically. On the basis of the original sandy soil, the organic reconstruction materials are added to improve the structure of the soil body, improve the nutrient content of the soil body, and make it meet the needs of agricultural planting.

It can be seen from Table 1 that the texture of sand soil in sand bar and river beach is sandy loam, and the soil particles are mainly sand particles, with serious water leakage and fertilizer leakage, so it is not suitable to plant crops [7]. Therefore, in the selection of reconstruction materials, the materials with high clay and silt content should be selected, and considering the engineering cost, the soil field around the project area is selected as the source of guest soil. According to the indoor analysis and test, the soil (loess) texture of the three soil fields is silty loam, the soil particles are mainly silt, and the clay content is higher than that of sandy soil, so it is more suitable for planting crops. Therefore, adding the field soil as the reconstruction material to the sandy soil can effectively improve the properties of the sandy soil and meet the requirements of crop growth.

| Sampling point | Particle size composition (%) | Texture (USDA) |
|----------------|------------------------------|----------------|
|                | Clay (<0.002 mm) | Silt (0.05-0.002 mm) | Sand (0.05-2 mm) |                |
| Sand bar       | Range 0.86~6.25 | 10.54~73.07 | 22.01~88.49 | Sandy loam soil |
|                | Mean value 2.87 | 40.79 | 56.35 |                |
| River Beach    | Range 0.95~2.58 | 2.74~42.10 | 55.32~97.26 | Loam sandy soil |
|                | Mean value 1.30 | 22.55 | 76.16 |                |
Table 2. Texture analysis of out-soil.

| Sampling point | Clay (<0.002 mm) | Silt (0.05-0.002 mm) | Sand (0.05-2 mm) | Texture (USDA) |
|----------------|------------------|----------------------|------------------|----------------|
| No. 1 Soil dump |                  |                      |                  |                |
| 0~2 m          | 8.6              | 67.8                 | 23.7             | Silty loam     |
| 2~4 m          | 10.0             | 79.4                 | 10.6             | Silty loam     |
| under 4 m      | 10.1             | 69.5                 | 20.5             | Silty loam     |
| No. 2 Soil dump |                  |                      |                  |                |
| 0~1 m          | 5.9              | 50.8                 | 43.2             | Silty loam     |
| 1~2 m          | 6.6              | 52.4                 | 40.9             | Silty loam     |
| under 2 m      | 8.9              | 71.6                 | 19.6             | Silty loam     |
| No. 3 Soil dump |                  |                      |                  |                |
| 0~2 m          | 12.2             | 77.5                 | 10.3             | Silty loam     |
| 2~4 m          | 9.3              | 62.2                 | 28.5             | Silty loam     |
| under 4 m      | 8.3              | 60.5                 | 31.1             | Silty loam     |

3. Reconstruction of soil profile

The profile of soil is formed in the process of soil occurrence and development, which is influenced by the environment such as bioclimate for a long time. In the land engineering, the suitable soil profile configuration refers to the profile configuration with suitable natural conditions, strong water permeability, ventilation, water and fertilizer conservation capacity and good soil production performance, or the non-agricultural stratum structure suitable for human production and life under the geographical environment of farmland soil. The profile configuration of soil directly affects the fertility of water, fertilizer, gas and heat and the movement of water and salt. Good soil profile is not only closely related to crop yield, but also closely related to the construction of buildings and human activities. If there is no suitable soil profile hierarchy in agricultural land, it may hinder crop root growth, affect water and fertilizer infiltration and absorption, and reduce land productivity.

In order to build the sand land in the project area into a high standard rice rape rotation planting area, the soil reconstruction project was carried out in the project area. In addition to the basic leveling engineering, the key is to construct the profile structure of the sandbank (paddy field), i.e. the plough bottom and the plough layer. The project uses the surrounding soil reconstruction materials, i.e. loess, through a series of technologies such as leveling, covering, rolling, loosening, beating, etc., to build a dense bottom layer of artificial plough and a loose cultivation layer, effectively improving the soil's water and fertilizer conservation performance and water and fertilizer utilization efficiency.

In the reconstruction design of sand bar soil profile, because the plough bottom is too thick, it may lead to the obstruction of soil ventilation, while the plough bottom is too thin, it may lead to soil leakage and fertilizer leakage. According to the good soil configuration requirements of paddy field, and according to the surrounding soil composition, the plough bottom thickness of paddy field is designed as 5 cm, and the unit weight is 1.6~1.7 gcm\(^{-3}\). After the construction of artificial plough bottom by rolling engineering, the results of preliminary trial planting in the project area confirmed that when the thickness of cultivation layer reached 20 cm, it could meet the requirements of rice growth. When the thickness of soil cover is more than 30 cm, the yield increase effect of rice is not significant, which directly leads to the overall yield investment ratio of the project greatly reduced. In addition, after years of cultivation, the clay in the plough layer continues to move downward, and gradually accumulates after being blocked by the bottom of the artificial plow. The clay content in the bottom of the plow increases continuously, which will cause excessive viscosity in the bottom of the plow and affect the ventilation of the soil. Therefore, in order to form a plough bottom that is more suitable for rice growth, considering that there is a gap between the clay and organic matter content in the bottom of the artificial plough and that there will be a certain degree of erosion with years of cultivation management, it is necessary to appropriately increase the thickness of the plough layer, and in the later cultivation, the natural plough bottom of 3 ~ 5cm will be formed by the sinking of clay particles to supplement the artificial plough bottom. Therefore, in the soil reconstruction design, the soil reconstruction of rice field covers 30 cm of soil, which is divided into 5 cm of lower artificial
plough bottom and 25 cm of upper plough layer. As shown in Figure 1.

![Soil reconstruction design of sandbank (rice paddies)](image)

Figure 1. Soil reconstruction design of sandbank (rice paddies)

### 4. Soil chemical properties

Soil is a three-phase complex of solid, liquid and gas, with many biological and chemical components and complex properties. In the process of soil organic reconstruction, the biological and chemical characteristics of the soil must be considered to control the soil composition within the life safety bearing limit. The soil organic reconstruction of both agricultural and non-agricultural land should be based on the characteristics of the soil material itself, the current situation of the soil and the target value to be treated. Therefore, the pH value of soil should be controlled within the appropriate range, and the toxic and harmful substances of soil should be controlled within the safety limit, so as to ensure the safety of microorganisms, plants, animals and human beings.

In Xiayukou land remediation project, it is necessary to consider the safety of reconstruction materials, and analyze and test the heavy metal content in sandbank soil, river beach land and soil field soil. The results are shown in Table 3 and Table 4. The average content of heavy metal chromium, nickel, copper, zinc, arsenic, cadmium and lead in sandbank soil, river beach land and soil field soil conforms to the soil environmental quality standard of China (GB 15618-1995) It can be used for crop planting, and the soil quality basically does not cause harm and pollution to plants and the environment.

| Heavy metals (mg kg⁻¹) | Sandy soil | River Beach soil | Grade II standard for soil environment |
|------------------------|------------|------------------|---------------------------------------|
| Cr                     | 62.3±10.8  | 47.3±9.3         | 350                                   |
| Ni                     | 38.1±10.5  | 46.2±4.7         | 60                                    |
| Cu                     | 51.4±18.4  | 33±9.8           | 100                                   |
| Zn                     | 278.2±19.3 | 252.6±37.9       | 300                                   |
| As                     | 6.5±1.9    | 4.6±1.2          | 20                                    |
| Cd                     | 0.3±0.1    | 0.2±0.0          | 0.6                                   |
| Pb                     | 14.2±3.9   | 9.4±2.0          | 350                                   |
Table 4. Soil heavy metal content of out-soil.

| Sampling point  | Heavy metals (mg kg\(^{-1}\)) |
|----------------|--------------------------------|
|                | Cr    | Ni    | Cu    | Zn    | As    | Cd    | Pb    |
| No. 1 Soil dump| 43.75 | 17.65 | 10.57 | 27.94 | 8.58  | 0.16  | 14.72 |
| 0–2 m          | 48.61 | 15.08 | 12.54 | 55.48 | 7.82  | 0.20  | 15.88 |
| 2–4 m          | 37.66 | 11.93 | 7.71  | 44.72 | 5.60  | 0.15  | 14.44 |
| 0–1 m          | 42.52 | 17.25 | 12.38 | 42.29 | 9.49  | 0.15  | 14.01 |
| 1–2 m          | 44.77 | 14.93 | 8.83  | 22.40 | 7.01  | 0.18  | 14.21 |
| 2–4 m          | 41.86 | 17.32 | 10.99 | 29.71 | 9.12  | 0.18  | 15.85 |
| 0–2 m          | 34.22 | 15.22 | 9.74  | 21.38 | 9.23  | 0.14  | 12.46 |
| 2–4 m          | 35.34 | 16.51 | 10.54 | 25.54 | 8.63  | 0.13  | 12.52 |
| 0–2 m          | 34.78 | 15.87 | 10.14 | 23.46 | 8.93  | 0.14  | 12.49 |
| Grade II standard for soil environment | 350 | 60 | 100 | 300 | 20 | 0.6 | 350 |

5. Soil nutrition guarantee

Physical, chemical and biological reconstruction complement each other in the organic reconstruction of soil mass. The common goal is to construct a good living environment for organisms in the soil mass, to ensure the nutritional needs of plants, animals and microorganisms, so as to regulate the structure of biological community in the soil mass, and to achieve a virtuous cycle of the ecosystem. In agricultural land management, to meet the nutritional needs of plants, animals and microorganisms is one of the main measures to achieve the sustainable improvement of arable land capacity and high and stable grain production.

The Yellow River Beach soil is basically composed of silty sand, with large sand content, coarse sand, lack of good aggregate structure, especially less water stable aggregate, and poor soil maturity. In this area, the groundwater level is high, the water leakage is fast, and the nutrient content in the soil is low, which is not conducive to the growth and development of crops. According to the indoor test and analysis, see Table 5, the contents of organic matter, total nitrogen, available phosphorus and available potassium in Loess and sandy soil are lower than the design target of soil nutrients in paddy field.

The covering soil used in soil reconstruction is not cultivated soil for many years. There is a certain gap between the soil composition in the initial stage of soil reconstruction and the demand of high standard paddy field, so it is necessary to adjust the soil composition. In order to avoid too much fertilizer added to the soil in a short period of time and insufficient buffering performance of the soil, resulting in soil hardening and nutrient loss, the adjustment of soil composition should be carried out step by step, not overnight. Therefore, in the initial stage of soil reconstruction, in order to meet the basic growth needs of crops as the principle, the soil composition was adjusted and designed.

Therefore, in the process of rice field regulation, first of all, through the application of organic and inorganic fertilizers, including a large number of elements such as nitrogen, phosphorus and potassium, as well as the application of trace elements such as silicon and calcium, the first year "China soil nutrient classification standard" in which the nutrient index is not lack of level is the design goal to regulate the soil composition, so that the nutrient content in the sandbank can basically meet the normal growth level of rice. After a certain number of years of continuous cultivation, the soil quality of the new cultivated land of Hancheng paddy field project was adjusted to the standard of high yield paddy field. In the design of paddy soil nutrients for many years, following the principle of high fertilizer efficiency and stable yield increase, the soil nutrient content was gradually increased. After 3-5 years of cultivation, the soil nutrients reached the soil quality standard of high yield paddy field.
Table 5. The target value of soil basic physical and chemical index.

| Soil type     | Before planting | Design goal |
|--------------|----------------|------------|
|              | Sand           | Loess      | Loam       |
| Texture      | Sand           | Silty      | Loam       |
| Organic matter g kg⁻¹ | 4.25          | 5.09      | 2%~4%      |
| Total nitrogen g kg⁻¹ | 0.86          | 1.05      | 1.3~2.3    |
| Available phosphorus mg kg⁻¹ | 4.14          | 6.12      | ≥50        |
| Available potassium mg kg⁻¹ | 70            | 92        | ≥150       |

6. Conclusions

(1) In the selection of reconstruction materials, priority should be given to the particle requirements of soil. At the same time, we need choose a reasonable proportion of clayey silt according to the specific target crops in the later stage.

(2) In the process of soil profile level reconstruction, the local soil and hydrological conditions should be fully considered, and the reasonable profile structure should be designed with the target crop as the guide.

(3) After organic reconstruction, the chemical characteristics of soil, including acid-base, salt content and heavy metal content, should meet the requirements of agricultural crops and other life activities.

(4) After the organic reconstruction of soil, it is necessary to adjust the soil composition gradually according to the needs of the target crops, so as to provide nutrients for the organisms.

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