ISSN: 2414-1895 DOI: 10.6919/ICJE.202312_9(12).0011

Research and Discussion on Alternative Soil Forming Materials

Haiou Zhang[1,2,3,4, a], Yingguo Wang[1,2,3,4, b], and Chenxi Yang[1,2,3,4, c]

[1] Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an 710075, Shaanxi, China

[2] Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an 710075, Shaanxi, China

[3] Key Laboratory of Degraded and Unused Land Consolidation Engineering, Ministry of Natural Resources, Xi'an 710075, Shaanxi, China

[4] Land Engineering Technology Innovation Center, Ministry of Natural Resources, Xi'an 710075, Shaanxi, China

[a]244254409@qq.com, [b]1223427823@qq.com, [c]academic_our@163.com

Abstract

The natural formation of soil materials is extremely long, and the problems and types of land remediation are extremely diverse. In the context of the urgent need to supplement the quantity of cultivated land and improve the quality of cultivated land, it is urgent to carry out research on the screening and allocation of "alternative soil forming materials", and pay attention to the research and development of materials for different land problems. To explore and develop alternative soil forming materials with good performance or function, it is necessary to proceed from the perspective of ecological protection and environment, and such materials for soil improvement and restoration should have the characteristics of low resource or energy consumption and coordination with the environment. Therefore, according to the characteristics of regional land environment and soil barrier factors, it is one of the main research tasks in the future to rationally select, develop and use alternative soil materials, improve soil traits, and improve land productivity and crop yield.

Keywords

Land Improvement Materials; Alternative Soil Forming Materials; Screening; Source; Apply.

1. Introduction

At present, the expansion of global desertification, the spread of land degradation, the decreasing of cultivated land and soil pollution are global problems, so increasing the area of cultivated land and improving the quality of cultivated land are the research goals of scholars. Since the middle of the 20th century, some developed countries, especially some foreign countries with relatively scarce land resources, have begun to explore and study artificial soil [1,2]. Therefore, according to the urgent needs of production practice and the development of international disciplines, it is urgent to carry out the research on the selection and allocation of "alternative soil forming materials". However, with the continuous improvement of the environmental performance requirements of the product itself, it is an inevitable trend of the development of human civilization to consider the choice of materials from a broader perspective. To explore and develop alternative soil forming materials with good performance or function, it is necessary to proceed from the perspective of ecological protection and

ISSN: 2414-1895 DOI: 10.6919/ICJE.202312_9(12).0011

environment, and such materials for soil improvement and restoration should have the characteristics of low resource or energy consumption and coordination with the environment.

With the continuous development and utilization of land, land is affected by human factors and soil forming factors, there are many obstacle factors, such as poor soil structure, saline-alkali acidification, weak water retention performance, etc., which makes land productivity low. People's production practice and research have found that putting specific materials into the soil with obstacles can improve soil properties and land productivity, so "alternative soil forming materials" or soil amendments have emerged [3]. As of 2020, there are 197 soil amendment (conditioner) products registered in the planting Management Department of the Ministry of Agriculture and Rural Affairs of China. The application effects of different soil amendments vary greatly. Generally speaking, their universal function is to improve the structure and physical and chemical properties of poor, inefficient or defective soil, which is conducive to the formation of soil aggregates and nutrient accumulation, so as to effectively improve the production capacity of land and crop yield [4,5]. Therefore, according to the characteristics of regional land environment and soil obstacle factors, reasonable selection and use of soil amendments is a prerequisite for effectively and economically improving soil physical and chemical properties and increasing crop yield.

Because the natural formation of soil materials is extremely long, and the problems and types of land engineering are extremely diverse, in carrying out land engineering, attaching importance to the research of materials for different land problems will be an inevitable choice to occupy the forefront and commanding heights of international land engineering science development. This paper mainly introduces the principle of selecting alternative soil forming materials in land engineering, and looks forward to the application prospect of materials in land engineering, in order to provide theoretical support for soil remediation and management.

2. Selection Principle of Alternative Soil Forming Materials

The research and screening of alternative soil forming materials are divided into natural materials, synthetic materials and waste utilization. First of all, all kinds of materials are treated, and after the treatment, the soil is reconstructed, and at the same time, the large amount, medium amount and trace elements required for the growth of organic organisms are added, that is, the organic soil reconstruction is carried out. It is necessary to continue to expand the scope of selection of alternative soil forming materials, to study the feasibility evaluation indicators and feasibility analysis of various materials as alternative soil forming materials, to study the treatment measures and matching schemes of materials, to study the application scope and application effects of materials, and to carry out systematic studies mainly from the aspects of sustainable utilization, plant yield and quality, and environmental effects [6].

In the field of land engineering, a wide range of alternative soil forming materials can be selected. Construction waste, including bricks and cement blocks and some soilgenerating building materials, has a large production volume in various places, and has become a public nuisance pile occupying a large amount of farmland. Its development and utilization can help reduce environmental pressure and protect cultivated land resources. Mineral waste, mainly for mining slag and tailings, only need to detect the metal content of which can be selected, some tailings have been crushed treatment, there is no problem from the particle size, more application value is coal gangue, which belongs to an organic mineral deposit, more conducive to soil formation and nutrient supply; Natural weathered loose shale, weathered shale is commonly used as a substitute soil forming material at home and abroad. In terms of organic materials, various planting materials and animal organic fertilizers are used as matching materials for soil formation [7].

The well-known "cosmic soil" is a typical artificial soil, which adds mineral fertilizer necessary for plant growth to the sand. It was developed by Russian scientists in the "Salyut 1" orbital scientific research station for the experiment of growing vegetables [8]. Israeli researchers used 40% of waste paper to improve soil, and this invention of new materials using waste paper to improve soil not only

ISSN: 2414-1895 DOI: 10.6919/ICJE.202312_9(12).0011

realized the recycling of resources, but also promoted the growth of certain plants [9]. Although there are a lot of controlling materials for soil properties and functions at home and abroad, and the research results are also extremely rich, these materials are established in a small range and small dose of use, and in land engineering, it is necessary to seek materials related to soil organic reconfiguration with similar functions, cheaper and easier to obtain [10]. It is necessary to carry out extensive research on calcium based preparations, silicon based preparations and iron preparations for soil reconstruction, especially to develop the application effect of waste iron in metal processing industry in paddy fields, sea cities and polluted soil remediation.

As people pay more and more attention to how to coordinate the development of materials and environment, ecological environmental materials come into being. Ecological environmental materials mainly refer to materials that have satisfactory performance and excellent environmental coordination at the same time, or can improve the environment. Ecological environmental materials should not only consider the basic performance requirements such as mechanical properties, physical and chemical properties, function and structure of materials, but also pay more attention to the environmental properties of materials [11]. Therefore, the material selection principle of product design first considers the environmental materials with excellent performance and small environmental load, one is to use recyclable materials in nature as much as possible, the second is to use non-recyclable materials in nature as little as possible, maximize the use of material resources and save energy, the principle of selection and use of materials mainly has the following aspects: (1) Use less shortage or rare raw materials, use waste, surplus or recycled materials as raw materials, and try to find alternative materials for shortage or rare raw materials to effectively improve the reliability and service life of products; (2) Minimize the types of materials in the product to facilitate the effective recycling of the product after waste; (3) Give priority to materials that can be reused or recycled; (4) Try to use compatible materials, do not use materials that are difficult to recycle or cannot be recycled; (5) as far as possible, use materials that can be naturally decomposed and absorbed by nature after waste; (6) Try to choose environmentally compatible coating materials; (7) Try to use less or do not use toxic and harmful raw materials.

3. Sources of Alternative Soil Forming Materials in Land Consolidation

The invention is an artificial soil manufacturing technology for agriculture and planting industry, which uses rock, solid waste of industry, mining and construction industry and various organic matter as raw materials, which is sorted, crushed, ground, mixed according to a certain proportion and fermented into soilmaking compost. Then, the compost and inorganic raw material powder (i.e. the mother material of soil making) are mixed in a certain proportion to make artificial soil with certain water storage, heat storage, air permeability, fertility and basic conditions required for plant growth [12]. This technology is easy to implement and can be industrialized and large-scale production. It can be used to combine and coordinate the development of agricultural economy with the treatment of industrial and mining waste, the pollution of rivers, lakes and seas, the treatment of urban solid waste and environmental protection, forming a virtuous cycle, especially for the development of barren mountainous areas, sandy areas, islands and other areas lacking in soil, which is more important and suitable for promotion and application.

For the new cultivated land, it is necessary to carry out extensive research on the screening and cultivation technology of pioneer crops. Plants include food crops, vegetables, fruit trees, Chinese medicinal materials, grass, green manure and seedlings. The selection range is based on local indigenous plants, and the introduction and propagation of plants from different places are combined [13].

For areas with limited soil sources, alternative soil forming materials need to be studied. At present, the materials of artificial soil in the world are mainly organic materials and domestic wastes which are degraded by mineralization. There are some successful cases in which scientists study new materials to replace soil. British soil scientist TimO 'Hare proposed that there are no more than three

ISSN: 2414-1895 DOI: 10.6919/ICJE.202312_9(12).0011

kinds of materials used in the study of garden soil, namely natural topsoil, waste recycling matrix and artificial topsoil [14]. Among them, the natural topsoil is the most abundant, from acidic soil, sandy soil, humus soil to peat soil, clay, which are taken from nature, and each index changes greatly. The recycled substrate is derived from various industrial and agricultural wastes. Field topsoil, subsoil, clay, waste from steel mills, collapsed building blocks, cement blocks, glass, metal, wood, and plastic are recovered in various ways and then processed into cultivation substrates. Although they have a high salinity, lack organic matter and nutrient elements, and are often mixed with other types of soil. Artificial topsoil is the deep mixing of two or more soil materials to meet the requirements of plant root growth and development, including artificial topsoil, bottom soil, sand soil, green mixed compost and biological cultivation substrate. Factors such as soil fertility (nutrient), structure, texture, pH value, water content and conductivity were proposed in the study of matrix indexes [15].

Sludge has always been regarded as a natural soil for agricultural production, and for a long time, human beings have used the sludge formed by urban waste, the sludge produced by sewage treatment plants, and the sludge generated by industrial waste treatment after processing and treatment, which is used for agricultural production. Japan has used waste to make an artificial soil that is odorless, rich in microbes and has the same composition as sludge. In the past, people used natural wood to grow mushrooms, which made resources wasted, and materials were expensive and inconvenient to transport. In recent years, people have built artificial media and used sawdust, rice bran and sucrose production waste as raw materials to cultivate mushrooms, and the waste has been recycled [16].

Peat nutritive soil is an ideal cultivation medium for urban greening and family flower cultivation. It is a kind of synthetic soil. At present, the preparation of peat nutritive soil in China is mainly made of high quality natural peat as raw material by adding proper amount of matrix material and a lot of nutrient elements. Peat nutritive soil has all the advantages of natural soil, such as non-toxic, pollution-free, light weight, long fertilizer effect, loose and breathable. Peat nutrient soil can be suitable for the seedling and growth of most flowers, seedlings and vegetables, and can advance the market time of vegetables by about l ~ 2 weeks. Peat nutrient soil has a wide range of applications, which can plant vegetables, flowers and crops in desert, island, salt farm and other areas to improve local living conditions and living environment [17]. Therefore, at present, peat nutritive soil is used as an economical and effective ideal substrate for the growth of flowers, seedlings and vegetables.

4. Application and Prospect of Materials in Land Engineering

Land engineering not only requires the addition of materials, but also can provide good materials for medicine, beauty, food, oil mining and other industries. Montmorillonite has the reputation of "saponite" and "multipurpose soil", and has strong adsorption, washing and flocculation capabilities. It is used for wool spinning washing, sewage treatment and purification. It is a fire-fighting and waterproof material, and is also used in the production industries of paper making, pencil manufacturing, composite fertilizer and feed [18].

With the development and continuous innovation of soil remediation technology, the remediation technology of nanomaterials (particle size of 1~100 nm), as an efficient and economical remediation technology of organic contaminated soil, provides new research opportunities for people. Compared with common organic contaminated soil remediation technologies, nanomaterials are characterized by large specific surface area, strong adsorption chelation ability and high catalytic activity, which enables nanomaterials remediation technology to overcome some shortcomings of traditional remediation technologies and show extremely high remediation efficiency in organic contaminated soil remediation [19,20]. In actual production practice, the selection of nanomaterials should be determined by the nature of pollutants, and in the design process of nanomaterials, the repair mechanism of nanomaterials and their actual behavior in the soil environment should be deeply studied, and the key groups of the soil repair process should be analyzed, so as to select suitable materials for soil repair. In recent years, the study of environmentally friendly nanomaterials for the remediation of organic contaminated soil has become a hot topic at home and abroad, mainly focusing

ISSN: 2414-1895 DOI: 10.6919/ICJE.202312_9(12).0011

on the preparation, structural characterization, pollutant removal mechanism and removal efficiency of nanomaterials [21].

5. Conclusion

The establishment of plant material research for land engineering and restoration will be one of the clear research tasks in the future. For plant materials, it is necessary to cultivate, screen and domesticate, and even carry out research on transgenic land restoration materials with the help of modern biotechnology, so as to obtain plant species or varieties that can improve soil quality. Microbial product development and research, the use of modern microbial engineering technology, from the relevant adverse land environment to separate, screen, expand the microbial strain resources with special functions, the use of factory production of microbial preparations, in order to promote the rapid ripening of raw soil in the land engineering. Gradually establish the land engineering microbial strain resource bank. Research and development of soil animal products, mainly carry out earthworm culture, use earthworms and crop stalks, dead leaves together to produce bio-organic fertilizer, treatment as domestic waste, pile production of high-quality soil biological amendments, and gradually establish animal specimen library.

Acknowledgments

This paper was supported by the Shaanxi Province Key R&D Program (2023-ZDLNY-48, 2022NY-082), Shaanxi Provincial Land Engineering Construction Group internal research project (DJNY-YB-2023-32, DJNY2022-17).

References

[1] Lehmann J, Joseph S. Biochar for environmental management science and technology. London: Earthscan, 2009.

[2] Aller M F. Biochar properties: Transport, fate, and impact, Crit Rev. Env. Sci. Tec., vol. 46 (2016), 1183-1296.

[3] Zhao Y L, Xue Z W, Guo H B, et al. Effects of tillage methods and straw returning on soil respiration and its mechanism, Trans CSAE, vol. 30(2014), 155-165.

[4] Lehmann J. Bio-energy in the black, Front. Ecol. Environ., vol. 5(2007), 381-387.

[5] Bao S D. Soil and agricultural chemistry analysis, 3rd ed. Beijing: China Agriculture Press, 2000.

[6] Chen B, Chen Z. Sorption of naphthalene and 1-naphthol by biochars of orange peels with different pyrolytic temperatures, Chemosphere, vol. 76(2009) , 127-133.

[7] Gupta V K, Saleh T A. Sorption of pollutants by porous carbon, carbon nanotubes and fullerene: An overview, Environmental Science and Pollution Research International, vol. 20(2013), 2828-2843.

[8] He T T, Wang J, Fu Y P, et al. Effects of equal carbon addition of straw and biochar on soil respiration and microbial biomass carbon and nitrogen, Environmental Science, vol. 42(2021), 450-458.

[9] Lukic B, Huguenot D, Panico A, et al. Importance of organic amendment characteristics on bioremediation of PAH-contaminated soil, Envi-ronmental Science and Pollution Research , vol. 23(2016),15041-15052.

[10] Mohmood I, Lopes C B, Lopes I, et al. Nanoscale materials and their use in water contaminants removal: A review, Environmental Science and Pollution Research, vol. 20(2013),1239-1260.

[11] Xu M, Wu J, Zhang X H, et al. Impact of biochar application on carbon sequestration, soil fertility and crop productivity, Acta Ecologica Sinica, vol. 38(2018), 393-404.

[12] Han S, Wu J, Li M, et al. Deep tillage with straw returning increase crop yield and improve soil physicochemical properties under topsoil thinning treatment, Journal of Plant Nutrition and Fertilizers, vol. 26(2020), 276-284.

[13] Bauder J W, Brock T A. Crop species, amendment, and water quality effects on selected soil physical properties, Soil Science Society of America Journal, vol. 56(1992), 1292-1298.

[14] Stamford N P, Silva A J N, Freitas A D S, et al. Effect of sulphur inoculated with Thiobacillus on soil salinity and growth of tropical tree legumes, Bioresource technology, vol. 81(2002), 53-59.

[15] Tu C, Wang J, Guan Q, et al. Effect of straw mulching on soil respiration, crop yield, economy environment benefit in rainfed winter wheat fields, Chinese Journal of Eco-Agriculture, vol. 21(2013), 931-937.

[16] Cai S, YAO W W, et al. Current situation and ecological effect of crop straw returning, Northern horticulture, vol. (2023), 121-127.

[17] Wang Q J, Liu F, Jiao F, et al. Effects of strip-collected chopping and mechanical deep-buried return of straw on physical properties of soil, Transactions of the Chinese Society of Agricultural Engineering, vol. 35(2019), 43-49.

[18] Lipiec J, Walczak R, Witkowska-Walczak B, et al. The effect of aggregate size on water retention and pore structure of two silt loam soils of different genesis, Soil and Tillage Research, vol. 97(2007), 239-246.

[19] Leng N, Deng Y S, Lin L W, et al. Characteristics and stability of soil aggregates developed from different parent materials in the south subtropical region, Journal of Soil and Water Conservation, vol. 35(2021), 80-86.

[20] Nadler A, Perfect E, Kay B D K. Effects of two polymers and water qualities on dry cohesive strength of tree soils, Journal of Soil Science, vol. 60(1996), 556-561.

[21] Woodbouse J, Johnson M S. Effect of supper absorbent polymers on survival and growth of crop seedling, Agricultural Water Management, vol. 10(1991), 63-70.