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A Review of the Current Status of Soil Organic Matter in China's Arable Land

Wen Sun[1,2,3,4,5,*], Lulu Zhang[1,2,3,4,5]

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

[2] Shaanxi Key Laboratory of Land Consolidation, Chang'an University, Xi'an, Shaanxi, China

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

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

[5] Land Engineering Quality Testing of Shaanxi Land Engineering Construction Group Co,, Ltd. , Xi'an, Shaanxi, China

Abstract

Soil organic matter (SOM) in China's arable land is a critical foundation for maintaining agricultural productivity and ecosystem health. However, in recent years, the content of SOM has shown a declining trend due to unsustainable agricultural practices, excessive use of chemical fertilizers, and land degradation. This decline has adversely affected soil fertility, water retention capacity, biodiversity, and carbon sequestration. Although certain regions have seen improvements through the application of organic fertilizers, straw return, and conservation tillage, the overall SOM levels remain low. Therefore, there is an urgent need to develop comprehensive management strategies to increase SOM content, promote sustainable agricultural development, and protect the ecological environment.

Keywords

Soil Organic Matter; Soil; Arable Land; Agricultural.

1. Introduction

China possesses the largest area of arable land in the world, and agriculture plays a critical role in ensuring food security and supporting economic development. SOM, as a key indicator of soil health, directly affects soil fertility, crop yields, and the sustainability of agricultural practices. In recent years, China's arable land has faced the challenge of declining SOM content due to population growth and agricultural intensification. This decline is primarily attributed to long-term unsustainable agricultural practices, such as excessive use of chemical fertilizers, burning of crop residues, soil erosion, and over-cultivation. Additionally, climate change and land degradation have further exacerbated the loss of SOM. Against this backdrop, understanding the current status of SOM in China's arable land and the factors influencing it is essential for developing effective soil management policies and achieving sustainable agricultural development and environmental protection goals.

2. Definition of Soil Organic Matter (SOM)

Soil organic matter is the most fundamental and essential driver that promotes soil development and enhances soil functions. It is one of the foundational and core theoretical concepts in soil science. The accumulation and stabilization of SOM improve soil quality and

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promote soil functionality, which is particularly evident in the areas of agricultural productivity and sustainable soil management [1-3]. As a critical component of the soil, SOM plays a vital role in initiating and regulating various soil processes through its dual control over soil structural development (biophysical processes) and biogeochemical cycles. This dual control ensures that the soil provides a range of ecosystem services, including biomass production, energy generation, biodiversity maintenance, water retention, and carbon sequestration for emission reduction [4] (Figure 1).

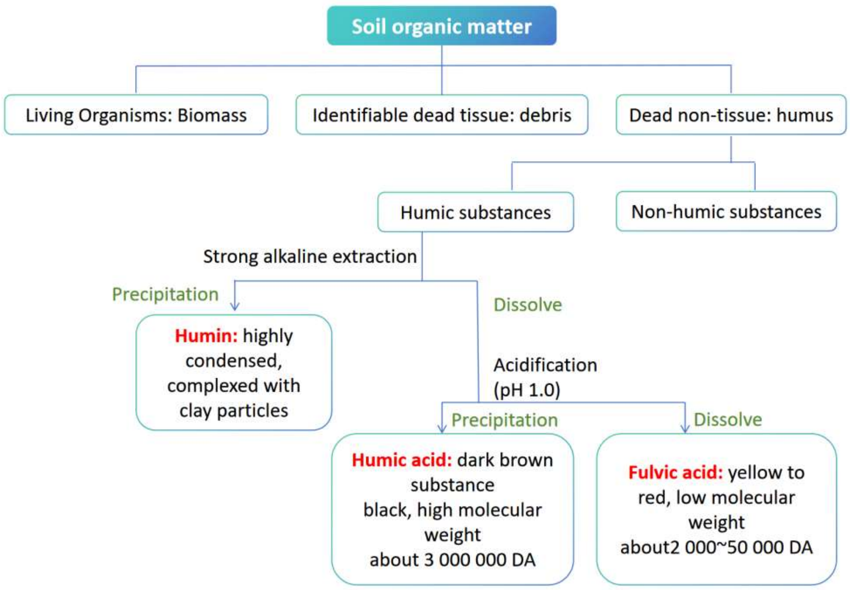
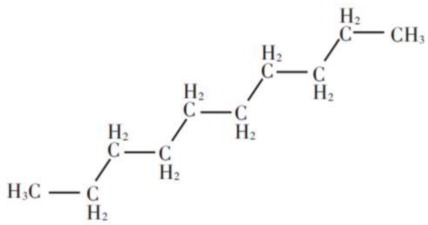
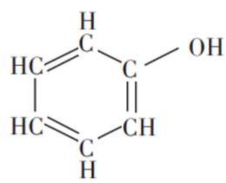
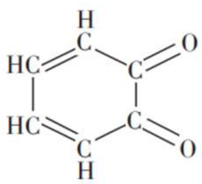
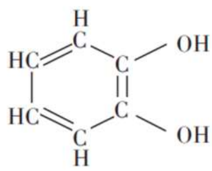
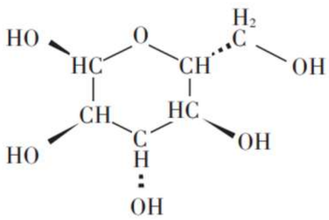


Figure 1. Concept and composition of soil organic matter

Table 1. Common chemical groups of humic substances

Chemical groups	Schematics	Chemical groups	Schematics
Hydrocarbon		Phenol	
Quinone		Cateshol	
Sugar			

Humic substances are the primary components of soil organic matter, accounting for 70% of the total soil organic matter and 80% of the total soil organic carbon [5]. They are widely distributed in natural water bodies, charcoal, peat, and marine sediments. The humification of

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soil organic matter under microbial activity is considered the second largest global process, following photosynthesis [6], and plays a crucial role in soil fertility and its physical and chemical properties. The chemical composition and functional groups of humic substances depend on factors such as the origin and age of the extract, as well as the climatic and environmental conditions during extraction. As a result, humic substances do not have a strictly constant chemical composition, and their molecular weight varies according to the extraction method used [7].

Traditionally, humic substances are classified into three categories: humic acid (HA), which is soluble in alkali but insoluble in acid; fulvic acid (FA), which is soluble in both alkali and acid; and humin (Hu), which is insoluble in both alkali and acid [8]. The chemical composition of humic substances is inherently variable; humic substances from different sources or fragments with different molecular weights from the same source may exhibit distinct chemical compositions. Regardless of their origin, humic substances share a range of common chemical groups, as shown in Table 1 [9].

3. Organic Matter Policy

Since 2008, the central government of China has allocated special funds annually to implement projects for farmland protection and soil quality improvement. By 2016, a total of 5.5 billion RMB had been invested to support farmers in adopting a range of integrated techniques, such as increasing the application of organic fertilizers, planting green manure, and enhancing soil fertility through soil improvement measures, all aimed at increasing the organic matter content in arable soils. In 2013, the Ministry of Agriculture introduced a subsidy policy for enhancing soil organic matter as part of the "National Policy Measures to Support Grain Production and Farmers' Income." In 2015, the Ministry of Agriculture issued the "Action Plan for the Protection and Improvement of Farmland Quality," which aimed to increase the average soil organic matter content in arable land by 0.2 percentage points by 2020. The 2024 No. 1 Central Document further emphasized the strict enforcement of farmland protection regulations and the implementation of initiatives to enhance soil organic matter.

4. Techniques for Enhancing Organic Matter

4.1. Materials for Enhancing Organic Matter

Organic Fertilizers:Organic fertilizers are a crucial method for increasing soil organic matter content. Common organic fertilizers include livestock and poultry manure, crop residues, and green manure. These fertilizers contain rich organic substances that, after microbial decomposition, can be converted into soil organic matter.

Biochar:Biochar is a carbon-rich material produced through the pyrolysis or gasification of biomass. It possesses excellent adsorption properties and stability, making it an effective soil amendment for enhancing soil organic matter content. Biochar not only provides a substantial amount of organic material and nutrients but also improves soil aeration, water retention, and nutrient status. When applying biochar, it is important to ensure the appropriate amount and uniform distribution to prevent seedling burning due to excessive application.

4.2. Tillage Methods for Enhancing Organic Matter

Straw Return:Straw return is a method where crop residues are directly incorporated into the soil or applied after treatment. During the decomposition process in the soil, straw releases significant amounts of organic matter and nutrients, while also improving soil structure, aeration, and water retention. Methods for straw return include direct incorporation, in-situ decomposition through livestock digestion, and composting. The appropriate method should be selected based on specific conditions. It is important to properly treat the straw beforehand,

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such as by shredding or fermenting, to accelerate its decomposition and improve the effectiveness of straw return.

Proper Crop Rotation:Proper crop rotation is a technique that involves planting different types of crops to increase soil organic matter content. Different crops have varying nutrient requirements and absorption capacities, and through appropriate rotation, it is possible to prevent excessive nutrient depletion by any particular crop while simultaneously increasing organic matter inputs and improving soil structure. When implementing crop rotation, factors such as crop growth cycles, nutrient requirements, and pest and disease management should be considered to select suitable crops for rotation.

5. Conlusion

The enhancement of SOM is pivotal for improving soil health, agricultural productivity, and ecosystem sustainability. In China, where agriculture plays a crucial role in food security and economic development, addressing the decline in SOM due to unsustainable practices has become a significant focus. The integration of various strategies and materials to increase SOM is essential for restoring and maintaining soil quality.Organic fertilizers, such as livestock manure, crop residues, and green manure, are fundamental to replenishing SOM. These materials, rich in organic matter, contribute to the formation of humic substances through microbial decomposition, which enhances soil fertility, improves structure, and boosts water retention capabilities. Additionally, biochar has emerged as a valuable amendment due to its stability and capacity to enhance soil properties. By improving aeration, water-holding capacity, and nutrient availability, biochar serves as a beneficial tool for SOM management.Incorporating practices such as straw return and proper crop rotation further complements SOM enhancement efforts. Straw return, whether through direct incorporation or after pre-treatment, helps in adding organic material back into the soil, thus supporting SOM accumulation and improving soil structure. Similarly, crop rotation prevents nutrient depletion and promotes organic matter input, leading to a more balanced and resilient soil ecosystem.Despite these efforts, challenges remain, including the need for effective policy implementation and the adaptation of SOM management practices to diverse regional conditions. The ongoing investment in research and development, along with the adoption of innovative techniques, is crucial for overcoming these challenges.

Overall, a comprehensive approach that combines organic material application, improved tillage practices, and supportive policies is necessary to achieve sustainable soil management. By enhancing SOM, we not only improve soil health and productivity but also contribute to broader environmental goals, including carbon sequestration and biodiversity preservation. Continued efforts in these areas will be essential for ensuring the long-term sustainability of China's agricultural systems and the health of its natural ecosystems.

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