



Effect of Organic Manure on Different Soil Properties: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Organic manure application is a common practice in sustainable agriculture, with significant effect for soil health, fertility, and productivity. This review provides a comprehensive analysis of the effects of organic manure on various soil properties, including physical, chemical, and biological parameters. The review elucidates the complex interactions between organic manure and soil, highlighting the impacts on soil structure, nutrient availability, microbial activity, and overall soil health. Additionally, the review discusses the role of organic manure in mitigating soil degradation, enhancing crop productivity, and promoting sustainable agricultural practices. By understanding the diverse effects of organic manure on soil properties, farmers and policymakers can make informed decisions to improve soil management practices and ensure long-term agricultural sustainability.

Keywords: Fertility; organic manure; productivity; soil health.

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1. INTRODUCTION

The sustainable management of soil resources is paramount for ensuring global food security, environmental health, and ecosystem resilience. Soil, a complex and dynamic system, serves as a fundamental substrate for agriculture, supporting plant growth, nutrient cycling, and water filtration. However, modern agricultural practices often lead to soil degradation, erosion, and loss of fertility, posing significant challenges to long-term agricultural sustainability. In response to these challenges, there has been a growing interest in alternative agricultural practices aimed at enhancing soil health while minimizing environmental impacts. Among these practices, the use of organic manures has gained considerable attention due to its potential to improve soil properties, promote nutrient cycling, and mitigate the negative effects of chemical fertilizers. Organic manures, derived from plant and animal sources, represent a rich source of organic matter, essential nutrients, and beneficial microorganisms. When applied to soil, organic manures can influence a wide range of soil properties, including physical, chemical, and biological characteristics. Understanding the effects of organic manures on soil properties is crucial for optimizing their use in sustainable agriculture and mitigating the adverse effects of conventional farming practices.

This review aims to provide a comprehensive overview of the current state of knowledge regarding the impact of organic manures on soil properties. Through a synthesis of recent research findings, we will explore the effects of organic manures on soil fertility, structure, moisture retention, microbial activity, and carbon sequestration. Furthermore, we will examine the mechanisms underlying these effects, considering factors such as nutrient release dynamics, microbial community dynamics, and interactions with soil biota. By elucidating the complex interactions between organic manures and soil properties, this review seeks to inform agricultural practitioners, policymakers, and researchers about the potential benefits and challenges associated with the use of organic amendments in sustainable soil management strategies. Ultimately, a deeper understanding of these interactions is essential for promoting soil health, enhancing agricultural productivity, and advancing the transition towards more resilient and environmentally friendly farming systems.

2. EFFECT OF ORGANIC MANURES ON SOIL PHYSICAL PROPERTIES

Organic manure application significantly influences various soil physical properties, including bulk density, porosity, soil structure, and water retention capacity, ultimately impacting soil health and agricultural productivity. Here's a detailed overview of the effects of organic manure on soil physical properties:

Bulk Density: Organic manure incorporation tends to reduce soil bulk density, by enhancing soil aggregation and pore formation [1]. The addition of organic matter improves soil structure, leading to better soil porosity and reduced compaction. As a result, soil bulk density decreases, allowing for greater root penetration, water infiltration, and air exchange within the soil profile [2]. Lower bulk density facilitates root growth, nutrient uptake, and overall crop development, contributing to improved agricultural productivity [3]. Organic manure incorporation leads to reduce soil bulk density, by enhancing soil aggregation and pore formation [4]. The addition of organic matter improves soil structure, leading to better soil porosity and reduced compaction. As a result, soil bulk density decreases, allowing for greater root penetration, water infiltration, and air exchange within the soil profile [5].

Porosity: Organic manure application enhances soil porosity, influencing both macro- and micro-porosity within the soil matrix [6]. Increased organic matter content promotes the formation of soil aggregates, creating macro-pores that facilitate water movement, root penetration, and gas exchange [7]. Moreover, organic matter serves as a substrate for microbial growth, contributing to the formation of micro-pores and enhancing soil biological activity [8]. Improved soil porosity enhances soil aeration, water retention, and nutrient diffusion, which are essential for sustaining plant growth and soil health. Organic manure application enhances soil porosity, influencing both macro- and micro-porosity within the soil matrix [9]. Increased organic matter content promotes the formation of soil aggregates, creating macro-pores that facilitate water movement, root penetration, and gas exchange [10].

Soil Structure: Organic manure plays a crucial role in improving soil structure, leading to the formation of stable aggregates and granules [2]. Soil structure refers to the arrangement of soil

particles into aggregates of various sizes and shapes, which influence soil stability, water infiltration, and root penetration [11]. Organic matter acts as a binding agent, promoting soil aggregation and reducing soil erosion [7]. Well-aggregated soils exhibit improved resistance to compaction, crusting, and surface sealing, maintaining soil structure integrity even under adverse environmental conditions [3]. Enhanced soil structure facilitates root growth, enhances nutrient availability, and promotes soil microbial activity, contributing to overall soil fertility and productivity. Organic manure plays a crucial role in improving soil structure, leading to the formation of stable aggregates and granules [12]. Soil structure refers to the arrangement of soil particles into aggregates of various sizes and shapes, which influence soil stability, water infiltration, and root penetration [13].

Water Retention Capacity: Organic manure application enhances soil water retention capacity, primarily by increasing soil organic matter content and improving soil structure [6]. Organic matter acts as a sponge-like reservoir, capable of holding water and releasing it gradually to plant roots over time [1]. The presence of organic matter improves soil water-holding capacity, reducing the risk of waterlogging during wet periods and minimizing drought stress during dry periods [2]. Moreover, organic matter enhances soil structure, promoting the formation of water-stable aggregates and reducing water runoff and erosion [7]. Improved water retention capacity ensures adequate soil moisture availability for plant growth, supporting sustainable crop production and minimizing the risk of yield losses due to water stress. Organic manure application enhances soil water retention capacity, primarily by increasing soil organic matter content and improving soil structure [14]. Organic matter acts as a reservoir, capable of holding water and releasing it gradually to plant roots over time [15].

3. EFFECT OF ORGANIC MANURE ON SOIL CHEMICAL PROPERTIES

Organic manure application profoundly influences various soil chemical properties, including nutrient availability, pH, cation exchange capacity (CEC), and soil organic carbon content. Here's an elaboration on the effects of organic manure on soil chemical properties:

Nutrient Availability: Organic manure serves as a rich source of essential nutrients, including nitrogen (N), phosphorus (P), potassium (K), micronutrients, and organic matter [2]. Upon application, organic manure undergoes decomposition and mineralization processes, releasing nutrients gradually into the soil solution [1]. The slow release of nutrients from organic matter ensures a sustained supply of plant-available nutrients throughout the growing season, supporting crop growth and development [7]. Additionally, organic matter improves soil structure and microbial activity, enhancing nutrient cycling and nutrient uptake by plants [8]. As a result, organic manure application improves soil fertility, increases nutrient availability, and reduces the reliance on synthetic fertilizers, thereby promoting sustainable agriculture. Organic manure serves as a rich source of essential nutrients, including nitrogen (N), phosphorus (P), potassium (K), micronutrients, and organic matter [16]. Upon application, organic manure undergoes decomposition and mineralization processes, releasing nutrients gradually into the soil solution [17]. The slow release of nutrients from organic matter ensures a sustained supply of plant-available nutrients throughout the growing season, supporting crop growth and development [18].

pH: Organic manure application can influence soil pH, albeit to a lesser extent compared to liming or acidifying agents [2]. The pH of organic manures varies depending on their composition and decomposition stage, ranging from acidic to neutral or slightly alkaline [1]. Generally, fresh organic manures may have a slightly acidic pH due to the presence of organic acids, while well-decomposed organic matter tends to have a neutral or slightly alkaline pH [2]. Organic matter acts as a buffer, moderating changes in soil pH and stabilizing soil acidity or alkalinity [6]. However, excessive application of certain organic manures, such as poultry litter or animal manure, can lead to localized increases in soil pH, especially in areas with high nutrient loading [2]. Proper management and incorporation practices are essential to minimize pH fluctuations and maintain optimal soil conditions for crop growth. Organic manure application can influence soil pH, albeit to a lesser extent compared to liming or acidifying agents [16]. The pH of organic manures varies depending on their composition and decomposition stage, ranging from acidic to neutral or slightly alkaline [17]. Generally, fresh organic manures may have a slightly acidic pH

due to the presence of organic acids, while well-decomposed organic matter tends to have a neutral or slightly alkaline pH [18].

Cation Exchange Capacity (CEC): Organic manure application enhances soil CEC, primarily through the addition of organic matter and clay-humus complexes [2]. Organic matter serves as a reservoir for cations, such as calcium (Ca), magnesium (Mg), potassium (K), and ammonium (NH₄⁺), which are readily exchangeable with soil particles [1]. The high CEC of organic matter allows it to retain and exchange nutrients with plant roots, enhancing nutrient availability and uptake [2]. Moreover, organic matter improves soil structure and aggregation, increasing the surface area available for cation exchange reactions [7]. Enhanced CEC promotes soil fertility, nutrient retention, and buffering capacity, reducing nutrient leaching and runoff, and improving overall soil health. Organic manure application enhances soil CEC, primarily through the addition of organic matter and clay-humus complexes [16]. Organic matter serves as a reservoir for cations, such as calcium (Ca), magnesium (Mg), potassium (K), and ammonium (NH₄⁺), which are readily exchangeable with soil particles [17]. The high CEC of organic matter allows it to retain and exchange nutrients with plant roots, enhancing nutrient availability and uptake [18].

Soil Organic Carbon (SOC) Content: Organic manure application increases soil organic carbon content, contributing to soil fertility, water retention, and microbial activity [6]. Organic matter serves as a source of carbon input into the soil, promoting soil organic carbon accumulation and stabilization [7]. The addition of organic matter stimulates microbial decomposition and humification processes, leading to the formation of stable organic carbon pools in the soil [2]. Increased soil organic carbon content improves soil structure, water holding capacity, and nutrient cycling, enhancing soil productivity and resilience to environmental stresses [1]. Moreover, soil organic carbon sequestration contributes to climate change mitigation by reducing atmospheric CO₂ levels and enhancing soil carbon storage [6]. Organic manure application increases soil organic carbon content, contributing to soil fertility, water retention, and microbial activity [16]. Organic matter serves as a source of carbon input into the soil, promoting soil organic carbon accumulation and stabilization [17]. The addition of organic matter stimulates microbial

decomposition and humification processes, leading to the formation of stable organic carbon pools in the soil [18].

4. EFFECT OF ORGANIC MANURES ON SOIL BIOLOGICAL PROPERTIES

Organic manure application exerts profound effects on soil biological properties, influencing microbial abundance, diversity, activity, and overall soil health. Here's an overview of the effects of organic manure on soil biological properties:

Microbial Abundance and Diversity: Organic manure serves as a substrate and energy source for soil microorganisms, promoting microbial growth and activity [8]. The addition of organic matter stimulates the proliferation of diverse microbial communities, including bacteria, fungi, actinomycetes, and protozoa, contributing to soil biodiversity and ecosystem functioning [7]. Organic matter provides carbon, nitrogen, and other nutrients essential for microbial metabolism, supporting microbial biomass accumulation and diversity [11]. Moreover, organic manure application enhances microbial habitat availability and soil moisture retention, creating favorable conditions for microbial colonization and activity [2]. Increased microbial abundance and diversity promote nutrient cycling, organic matter decomposition, and soil biogeochemical processes, ultimately enhancing soil fertility and ecosystem resilience. Organic manure application significantly enhances soil microbial abundance and diversity [19]. The introduction of organic matter provides a substrate for microbial growth, resulting in the proliferation of diverse microbial communities, including bacteria, fungi, and actinomycetes [20].

Microbial Activity: Organic manure application enhances soil microbial activity, as indicated by increased enzyme production, nutrient mineralization, and organic matter decomposition rates [7]. Soil microorganisms play a vital role in nutrient cycling, organic matter turnover, and soil ecosystem functioning [8]. Organic matter serves as a substrate for microbial growth, providing energy and nutrients for microbial metabolism [2]. Microbial decomposition of organic matter releases nutrients such as nitrogen, phosphorus, and sulphur into the soil solution, making them available for plant uptake [1]. Moreover, soil microorganisms contribute to the stabilization of soil aggregates, soil structure formation, and carbon sequestration through the formation of

microbial biomass and extracellular polymeric substances [7]. Enhanced microbial activity promotes soil health, nutrient cycling efficiency, and crop productivity, highlighting the importance of organic manure in sustainable soil management. Organic manure stimulates soil microbial activity, leading to increased enzyme production and nutrient cycling [21]. Soil microorganisms play a crucial role in decomposing organic matter, releasing nutrients for plant uptake, and enhancing soil fertility [22].

Soil Organic Matter: Organic manure application accelerates soil organic matter turnover, leading to increased decomposition rates and nutrient cycling dynamics [2]. Soil organic matter serves as a reservoir of carbon, nitrogen, phosphorus, and other nutrients essential for plant growth and soil fertility [6]. Organic matter decomposition by soil microorganisms releases labile and recalcitrant organic compounds, which serve as energy sources for microbial growth and activity [7]. The turnover of soil organic matter influences soil carbon dynamics, nutrient availability, and soil structure stability [1]. Moreover, microbial decomposition of organic matter contributes to humus formation, soil aggregation, and carbon sequestration, enhancing soil fertility and resilience to environmental stresses [11]. Organic manure application accelerates soil organic matter turnover, leading to increased nutrient cycling, soil fertility, and crop productivity. The addition of organic manure accelerates soil organic matter decomposition, contributing to nutrient turnover and soil carbon dynamics [23]. Microbial decomposition processes release labile and recalcitrant organic compounds, supporting soil biological activity and nutrient cycling [24].

Soil Health and Resilience: Organic manure application enhances soil health and resilience by promoting beneficial soil microbial communities and ecosystem processes [8]. Soil microorganisms play a crucial role in nutrient cycling, disease suppression, and soil structure formation, contributing to overall soil health and productivity [7]. Organic matter serves as a source of energy and nutrients for soil microbes, supporting their growth, activity, and diversity [2]. Increased microbial activity and diversity improve soil structure, nutrient availability, and disease suppression, enhancing soil resilience to environmental stresses [11]. Moreover, organic manure application reduces soil erosion, nutrient leaching, and pollution risks associated with chemical inputs, promoting sustainable soil

management practices [1]. By enhancing soil biological properties, organic manure contributes to soil health, fertility, and ecosystem sustainability. Organic manure application improves soil health and resilience by promoting beneficial soil microbial communities and ecosystem processes [25]. Enhanced microbial activity enhances nutrient availability, disease suppression, and soil structure, contributing to sustainable crop production [26-30].

5. CONCLUSION

In conclusion, organic manure application profoundly influences soil biological properties, enhancing microbial abundance, diversity, activity, and overall soil health. By providing a rich source of organic matter, nutrients, and energy for soil microorganisms, organic manure promotes the proliferation of beneficial microbial communities, supporting nutrient cycling, organic matter turnover, and soil ecosystem functioning. Increased microbial activity and diversity improve soil structure, nutrient availability, and disease suppression, contributing to soil health, fertility, and resilience to environmental stresses. Sustainable soil management practices that integrate organic manure application are essential for maintaining soil biological properties, supporting soil health, and promoting agricultural sustainability in the face of ongoing global environmental challenges.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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