Physics and Chemistry of the Earth 132 (2023) 103508

Contents lists available at ScienceDirect

Physics and Chemistry of the Earth

journal homepage: www.elsevier.com/locate/pce

Comprehensive assessment of biochar integration in agricultural soil conditioning: Advantages, drawbacks, and future prospects

Farah Amalina [a], Abdul Syukor Abd Razak [a], A.W. Zularisam [a], M.A.A. Aziz [b], Santhana Krishnan [c], Mohd Nasrullah [a,*]

[a] *Faculty of Civil Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA), Lebuhraya Tun Razak, 26300, Gambang, Kuantan, Pahang, Malaysia*

[b] *Faculty of Chemical and Process Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA), Lebuhraya Tun Razak, 26300, Gambang, Kuantan, Pahang, Malaysia*

[c] *Department of Civil and Environmental Engineering, Faculty of Engineering, Prince of Songkla University, Songkhla, 90110, Thailand*

ARTICLE INFO

Keywords:
Biochar
Heavy metals
Greenhouse gas emission
Anaerobic digestion
Crops productivity
Soil-plant system

ABSTRACT

Agriculture nowadays faces numerous issues because of the fast growth in food demand and environmental considerations. Due to the rapid depletion of agricultural areas and soil quality caused by a continuously growing population and the excessive addition of chemical fertilizers, rehabilitated consideration is required for sustaining viable crop production methods. Biochar (BC) use in agricultural soils has garnered considerable interest. BCs offer significant agricultural and environmental advantages, including improved soil health, enhanced crop growth and production, carbon sequestration, reduced greenhouse gas (GHG) emissions, and nutrient dynamics regulation. BC application in agricultural systems is influenced by various parameters, including pyrolysis temperature, feedstock composition, dosage and procedure, nature of the soil, crop varieties, and biotic interactions that substantially impact the efficacy of BC under varying environmental conditions. BC improved nitrogen mineralization and plant absorption by modifying the rhizosphere's abiotic and microbiological activities. Thus, BC increased the plant's resistance to pathogens, decreased the availability of heavy metals (HMs), and promoted the plant's tolerance to environmental challenges. Nonetheless, BC application is hazardous in certain circumstances. This review discusses the advantages, drawbacks, and future developments of applying BC to agricultural soils. By providing an extensive assessment of the advantages and limitations of BC integration in agriculture soil conditioning, this review is highly informative regarding the development of soil and crop-specific BC with the appropriate properties. It could help increase agriculture yield, ensure food security, and enhance environmental management. In addition, this review highlights knowledge deficits and proposes future perspectives for commercializing large-scale BC applications.

1. Introduction

Countries with varying degrees of economic development now emphasize food security, while the agricultural sector is crucial in increasing food availability (Kaini, 2020). Although farming practices have improved significantly since World War II, the global food demand is insufficient to satisfy demand adequately. In addition, the agriculture sector must deal with new issues such as climate change, desertification, and soil contamination (Hu et al., 2020; Jaroniec et al., 2020; Lok et al., 2018). Since the 1850s, industrialization has produced some industrial wastes that have degraded soil quality and agricultural productivity (Alkharabsheh et al., 2021; El-Naggar et al., 2019; Venkatesh et al., 2022). Similarly, soil contamination has intensified as pollutants, especially HMs, artificial nanomaterials, polycyclic aromatic hydrocarbons (PAHs), and persistent organic and inorganic compounds, have increased in quantity, which inhibits plant growth and development and ultimately result in low-yielding cultivation systems (Lee et al., 2018; Ringer, 2022; Wang et al., 2021). These anthropogenic causes have continuously impacted plant habitats, damaging the terrestrial food chain (Food and Agriculture Organization of the United Nations, 2018). Numerous studies have demonstrated that pollutants harm soil composition and biodiversity (Syuhada et al., 2018).

* Corresponding author.
E-mail address: nasrul.ump@gmail.com (M. Nasrullah).

https://doi.org/10.1016/j.pce.2023.103508
Received 6 July 2022; Received in revised form 1 September 2023; Accepted 9 November 2023
Available online 14 November 2023
1474-7065/