Chapter

Introductory Chapter: Is Biochar Safe?

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1. Introduction

Biochar is a carbon-rich product resulted from the pyrolysis of organic biomass in the absence of oxygen or at relatively low-oxygen conditions [1]. Such a process transforms the easily oxidized carbon fractions presented in the organic residues into more stable forms [2] that can persist in soils for years, probably 7 [3] to 10 [4] years. This amendment reduces, therefore, the emissions of greenhouses gases [5] and can be considered as a climate change mitigation [6]. On the other hand, required amounts of this conditioner to improve soil productivity might be less comparable with compost or other organic amendments on the long run. Accordingly, biochar is presented as a promising soil amendment of high economic and environmental value. It is also named as "the black diamond" [7]. However, many environmental aspects should be considered while using this amendment. The first one considers its manufacturing process. During the pyrolysis process of biochar, significant emissions of CO_2 are produced, and this probably raises the levels of greenhouse gases (GHGs) in air [8]. The second important issue is related to the biochar degradation in soil. Under warm climate conditions, its degradation was reported to be relatively high [9, 10], and therefore, further emissions of greenhouse gases might take place from biochar-amended soils. The third topic concerns ethylene, which is a by-product of the pyrolysis process of biochar [11]. This gas is increased considerably in biochar-amended soils to suppress several soil microbial processes [12]. Many researches considered this point a positive one that increases the stability of biochar in soil while reduces the emissions of greenhouse gases produced upon its degradation in soil [13], yet biochar affects negatively soil biota [14]. This is because this product contains a small part of bioavailable C [15] as the labile C is already degraded [16]. Thus, the sustainability of crop production in soil referred by soil health (or soil quality) which "reflects the capacity of a soil to provide ecosystem services" [17] may also be affected. Soil biota not only affects the physical and chemical properties of soil but also improves plant health [18]. Further pros and cons of amending soils with biochar will be discussed briefly in the following section.

Several studies demonstrated the positive impacts of amending soils with biochar on increasing crop productivity. For example, amending soils with biochar improves significantly macro- and micronutrients availability [9], in spite of the fact that many biochar additives have an alkaline nature [19], and consequently raises soil pH [7–20]. Nevertheless, soil nutrients strongly are adsorbed on biochar which serves as a slow release fertilizer [21]. It is then thought that the better utility of biochar can be detected on acid soils, rather than alkaline or calcareous soils. Moreover, this amendment reduces NO_3^- loss through leaching as well as the gaseous loss through release of nitrous oxide [22]; hence; this amendment can positively enhance plant growth [23]. Also, this product, which is characterized by its porous structure and high surface area [24], recorded indirect impacts on soil physical characteristics; for example, this amendment increases significantly water retention [10–25], hydraulic conductivity [26], and the total porosity of sandy soils while decreasing soil bulk density [27]. However, the impacts of amending soils with biochar are not always the same and depend mainly on the characteristics of the used biochar such as its grain size and pyrolysis temperature. According to [28], fine biochar decreases soil hydraulic conductivity, while the coarse biochar (particles were coarser than sand) did not affect the hydraulic conductivity of soils. Also, the pyrolysis temperature seems to have a significant impact on ash content in biochar, its pH, EC, and basic functional groups as well as carbon stability which increases in biochar with increasing pyrolysis temperature [29]. Generally, the effect of biochar on soil physical properties was comparable with the effect of compost [30]. On the other hand, other reports indicate that this amendment recorded unfavorable changes in chemical, physical, and biological properties of soil and consequently reduced crop yield [31]. Also, its application to soil hinders root penetration into soil depth [32]. Moreover, its negative impacts were also considerable on earthworm populations even on the short range [33]. It seems that the environmental and health risks due to biochar applications in agricultural soils are not well explored.

Another positive point for using biochar as a soil conditioner is related to its success to mitigate salinization of arable lands [34]. Additionally, biochar plays positive significant impacts on controlling the contaminants presented in water and soils [35, 36]. However, many contaminants may also originate from biochar [37]. Moreover, herbicides, e.g., atrazine and acetochlor, are sorbed on biochar [8], and this may reduce its efficacy [38] .

Furthermore, biochar has a remarkable effect on minimizing the emissions of greenhouse gases, especially CO_2 [39, 40] vs. the traditional organic amendments [13]. Although biochar played important positive roles on sustaining the environment, there is a lake of knowledge concerning the recommended application rates of biochar to soils to avoid its negative potential impacts on the environment.

In this book, we will investigate the major techniques followed in the production and characterization of biochars. Their roles in sustaining agricultural productivity and environmental cleanup will be also a matter of concern. Finally, we will try to draw a legalization mode of biochar applications to the environment in order to ensure its safe applications.

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