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Characteristics and nutrient values of biochars produced from giant reed at different temperatures

Hao Zheng [a,b], Zhenyu Wang [a,*], Xia Deng [a], Jian Zhao [b], Ye Luo [a], Jeff Novak [c], Stephen Herbert [b], Baoshan Xing [b,*]

[a] College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100, China
[b] Stockbridge School of Agriculture, University of Massachusetts, Amherst, MA 01003, USA
[c] USDA-ARS Coastal Plain Soil, Water & Plant Research Center, 2611 W. Lucas Street, Florence, SC 29501, USA

HIGHLIGHTS

- Available N and P in biochar decreased with increasing temperature but K increased.
- Less-soluble crystalline P minerals were formed in high-temperature biochar.
- More NH_4^+, PO_4^{3-} and K^+ were released from the biochars at low pH ($\leqslant$5).
- Biochars released NH_4^+ slowly but released PO_4^{3-} and K^+ fast.
- Low-temperature biochars could be a good amendment for improving soil fertility.

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ABSTRACT

To investigate the effect of pyrolysis temperature on properties and nutrient values, biochars were produced from giant reed (*Arundo donax* L.) at 300–600 °C and their properties such as elemental and mineral compositions, release of N, P and K, and adsorption of N and P were determined. With increasing temperatures, more N was lost and residual N was transformed into heterocyclic-N, whereas no P and K losses were observed. P was transformed to less soluble minerals, resulting in a reduction in available-P in high-temperature biochars. A pH of $\leqslant$ 5 favored release of NH_4^+, PO_4^{3-} and K^+ into water. Low-temperature biochars ($\leqslant$ 400 °C) showed appreciable NH_4^+ adsorption (2102 mg kg^{-1}). These results indicate that low-temperatures may be optimal for producing biochar from giant reed to improve the nutrient availability.

1. Introduction

Biochar refers to the carbon-rich product from heating biomass in a closed system under limited oxygen supply. It is distinguished from charcoal by its use as a soil amendment (Lehmann and Joseph, 2009). It is a multifunctional material with environmental and agricultural applications (Atkinson et al., 2010; Beesley et al., 2011). Biochar is recognized as a high-efficient and low-cost sorbent for pollutants (Silber et al., 2010; Sun et al., 2011; Wang and Xing, 2007). Application of biochar to soil has been proposed as an approach to sequester carbon (Lehmann and Joseph, 2009) and to possibly reduce or suppress CO_2, CH_4 and N_2O emissions (Spokas et al., 2009). Most importantly, biochar may improve soil quality and nutrient availability to plants (Atkinson et al., 2010). Although information on biochar nutrient properties are available (Atkinson et al., 2010; Chan et al., 2009; Lehmann and Joseph, 2009; Silber et al., 2010), the mechanism of nutrient release from biochar is not fully understood. Furthermore, total N, P and K (TN, TP and TK) in biochars may not necessarily reflect the actual availability of these nutrients to plants (Spokas et al., 2012). The influence of pyrolysis temperature on the production of biochars that are suitable as soil fertilizer still needs to be elucidated. Although it has been shown that NO_3^- and NH_4^+ leaching was reduced from soils amended with biochars (Novak et al., 2010), the influence of time and pH on nutrient release from biochars produced at different temperatures remains to be explored.

Giant reed (*Arundo donax* L.) (GR), a perennial grass, is widespread in many aquatic ecosystems in China (Yan et al., 2005). Due to its fast growth rate and good resistance to drought and floods, GR may yield up to 45 tons per hectare and life cycle

* Corresponding authors. Tel.: +1 413 545 5212 (B. Xing).
E-mail addresses: wang0628@ouc.edu.cn (Z.Y. Wang), bx@umass.edu (B.S. Xing).

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