Remediation of mining soils by addition of manure waste biochars

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Keywords: mining soil, biochar, manure waste
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Introduction

Mining activities modify the landscape producing soil degradation. For example, mining activities can increase soil erosion, modify the soil pH or increase the trace metal mobility reducing the success of the implantation of a vegetal cover once the mines are closure and must be restored. The addition of organic amendments can be beneficial to restore the soil and stimulate the plant growth. Traditionally, sewage sludges, urban wastes or manures have been used for this purpose arising news amendments in the last years. Between these new products distinguish the biochar. Biochar is a carbon-rich material obtained by pyrolysis of biomass that differs from charcoal, mainly used as fuel, as biochar act as carbon sinking in soils. Also, it has been largely demonstrated that biochar addition to metal polluted soils decreases the bioavailability and leachability of trace metals such as Cu, Ni, Cd, Pb, Cd and Zn (Puga et al. 2016). The effect of biochar on biological, chemical and physical soil properties depends on type of soil and biochar properties, which are mainly related with the preparation temperature and feedstock characteristics.

The objective of this study is to evaluate the effect of the application of four biochars in the CO_2 emissions, chemical and biological properties of ten mining soils located in different places of Spain.

Experimental

Biochars were prepared using two different manure wastes: poultry litter (PL) and rabbit manure (RM). Manures were obtained from farms located in the practice field of Technical University of Madrid (Spain). The four biochars were prepared by pyrolysis from raw materials at 450ºC (BPL 450; BRM 450) and 600ºC (BPLB 450; BRM 600). In all cases, the heating rate was 3 $ºC·min^{-1}$ and the residence time was 1 h. Later, biochars were sieved below 2 mm.

The ten mining soils were selected from three mining areas of Spain: Zarandas: R I-II; R III and R III-S; Mijarojos: GAM; PR and PZ; and Portman: SP-1; SP-2; L-30 and L-32. The soils were amended at a rate of 10% (w/w) with the four biochars and each treatment (100 g) was introduced into a 1 L airtight jar. After that, all treatments were incubated at constant temperature (25±2ºC) and humidity (60% Field Capacity) for 180 days. The CO_2 produced during incubation was collected in 50mL of a 0.3N NaOH solution which was titrated using 0.3N HCl after the $BaCl_2$ precipitation of the carbonates. All treatments were performed in triplicate. Also, the metabolic quotient (qCO_2) was calculated as the ratio between microbial respiration and microbial biomass. It was expressed as microgram of CO_2–C released per milligrams of biomass carbon per hour.

Treated mining soils (R I-II; R III; R III-S; GAM; PR; PZ; SP-1; SP-2; L-30 and L-32.) and biochars were widely characterised before and after incubation (pH, EC, metal content, cation exchange capacity, enzymatic activities).

Results and discussion

Figure 1 shows the cumulative CO_2 and Figure 2 shows the qCO_2 quotient of different treatments. The lowest emissions and qCO_2 quotient were obtained in Zarandas < Mijarojos ≈ Portman, probably due to the pH of this soil before amendment.

The BPL 450 addition increases basal respiration in all studied soils. In R III+BPL 600; R I-II + BPL 450; R I-II + BRM 600; SP-1+ BRM 600; L-32 + BPL 600; L-32 + BRM 450 and L-32 + BRM 600, the cumulative CO_2 is lower or without differences than in control soils indicating a possible carbon sequestration. In R I-II+ BPL 600; R III+ BPL450; R III+ BPL600; R III+ BRM 450; R III+ BRM 600;L-32+ BPL 450; L-32+ BPL 600; PZ+ BPL 450; PZ+ BRM 600, the qCO_2 quotient is lower than in control soils indicating a possible degradation efficiency from microbial community, a possible ability of biochar to protect microorganisms against disturbances or stress and a possible low microbial activity due to the presence of recalcitrant carbon (Zheng et al., 2016). In conclusion, the addition of amendments has different effects on the soil respiration and qCO_2 depending on the type of soil and biochar.

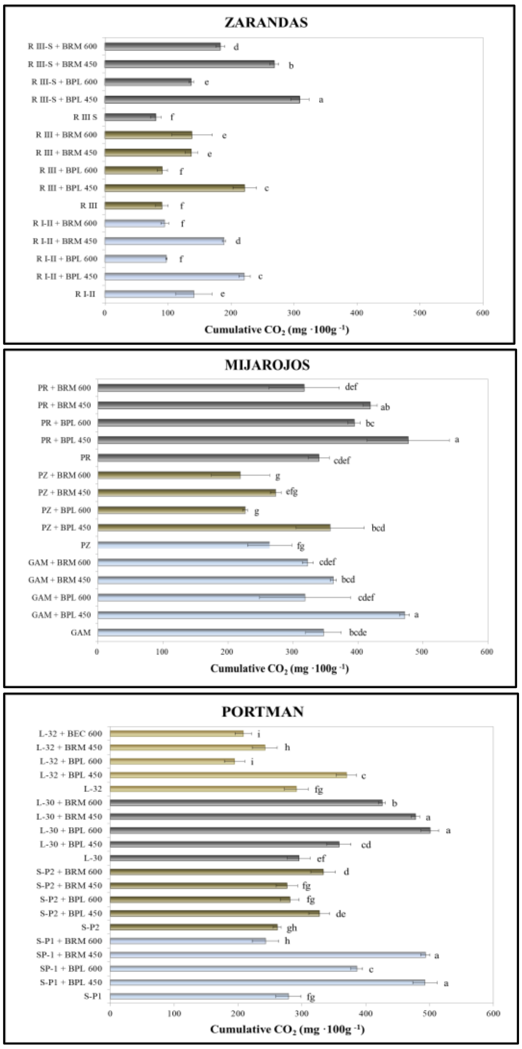

Figure 1. Cumulative CO_2 of all samples

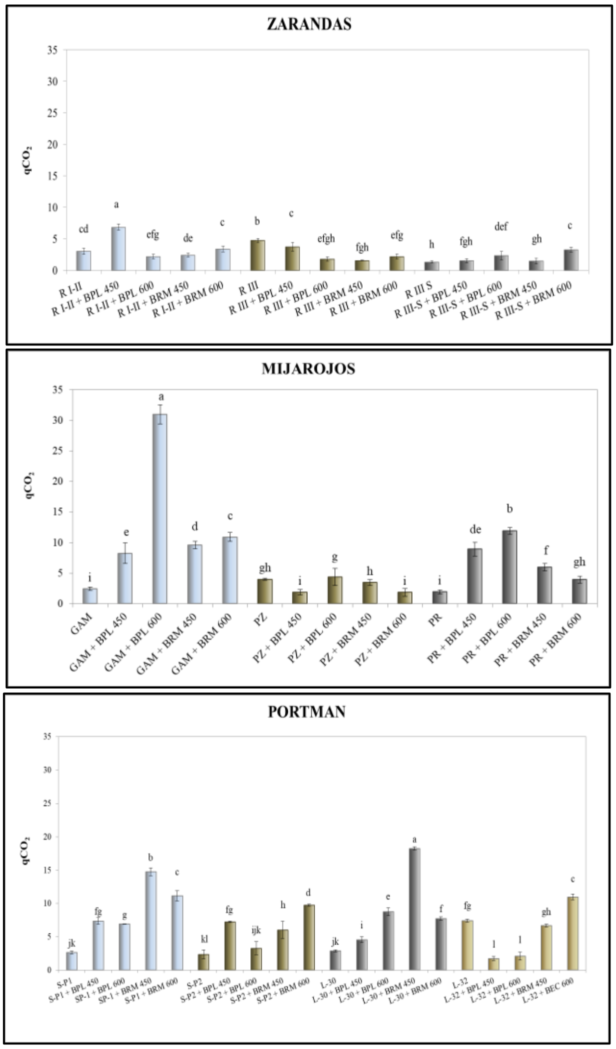

Figure 2. Metabolic quotient (qCO_2) of all samples

Finally, addition of biochars increases pH of acid mining soils and greatly affect enzymatic activities in selected soils. The effect was different depending on mining soil and biochar properties.

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Acknowledgements
Authors wish to thank to Spanish Ministerio de Economía y Competitividad for economic support (CGL2014-58322-R).