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Amelioration of soil PAH and heavy metals by combined application of fly ash and biochar

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Generation of electricity through coal combustion produces huge quantities of fly ash. Sustainable disposal and utilization of these fly ash is a major challenge. Fly ash along with other amendments like biochar could be used for amelioration of soil. In this study, fly ash and biochar were used together for amelioration of polycyclic aromatic hydrocarbon (PAH) contaminated soil. Field experiment was conducted to investigate the effects of fly ash and biochar on the amelioration of soil PAH, and the yield of Zea mays. The treatments were control, biochar (4 t/ha), fly ash (4 t/ha), ash + biochar (2 + 2 t/ha). Soil samples were collected after the harvest of maize crop and analysed for chemical and biological parameters. Thirteen PAHs were analysed in the postharvest soil samples. Soil PAHs were extracted in a microwave oven at 120 °C using hexane : acetone (1:1) mixture. The extracted solutions were concentrated, cleaned and the 13 PAHs [Acenaphthene (Ace), fluorene (Flr), phenanthrene (Phn), anthracene(Ant), pyrene(Pyr), benz(a)anthracene (BaA), chrysene (Chy), benzo(b)fluoranthene (BbF), benzo(k)fluoranthene (BkF), benzo(a)pyrene, benzo(g,h,i)perylene (BghiP), dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene)(Inp)] were analysed using GC-MS. The mean pH increased from 6.09 in control to 6.64 and 6.58 at biochar and fly ash treated soils, respectively. N content was not affected, whereas addition of biochar alone and in combination with fly ash, has significantly increased the soil organic carbon content. P content was almost double in combined (9.06 mg/kg) treatment as compared to control (4.32 mg/kg). The increase in K due to biochar was 118%, whereas char + ash increased soil K by 64%. Soil heavy metals were decreased: Zn (−48.4%), Ni (−41.4%), Co (−36.9%), Cu (−35.7%), Mn (−34.3%), Cd (−33.2%), and Pb (−30.4%). Soil dehydrogenase activity was significantly increased by ash and biochar treatments and the maximum activity was observed for the combined treatment. Peroxidase, phenol oxidase, and catalase activities were not affected by these treatments. Acid phosphatase activity decreased, whereas alkaline phosphatase activity increased due to biochar and fly ash treatment. Microbial biomass carbon increased significantly ($P < 0.05$) with biochar (+27.9%), fly ash (19.8%), and char + ash (+27.9%) applications. Maize grain yield was increased by biochar (+11.4%) and char + ash (+28.1%) treatments. The total PAH concentration decreased from 4191 μg/kg in control to 1930 μg/kg in fly ash; 1509 μg/kg in biochar and 1011 μg/kg in ash + char treatments. Among the different PAHs the concentration was higher for BkF, which decreased from 713 μg/kg in control to 139 – 315 μg/kg under different treatments. Overall, combined application of fly ash and biochar was found to be effective in amelioration of soil quality parameters and improving crop yield.