ABSTRACT:

The poor management of faecal sludge (FS), agro processing straw and rice husks (RH) materials in Uganda contributes to greenhouse gas emissions, nutrient loading, and heavy metal contamination. Converting these wastes into biochar offers a sustainable route for waste valorization, pollution control, and resource recovery. This study investigated the co-pyrolysis of faecal sludge (FS) and rice husks (RH) into biochar, optimized post-pyrolysis milling conditions, evaluated the adsorption potential of the resulting biochar for copper and lead in real wastewater, and assessed its environmental impact through life cycle assessment (LCA). FS and RH were co-pyrolyzed at temperatures of 350–550 °C and mixing ratios of 100:0, 75:25, and 50:50. The produced biochar was further subjected to varying milling times (5, 10 and 15 minutes) and ball-to-powder ratios (4.533g/g, 9.067g/g and 10.5g/g) to determine their influence on biochar quality and metal sorption capacity. Sorption experiments were conducted as batch adsorption tests at 25, 35 and 45 °C (RCF = 0.1006), varying contact time (1, 5, 10, 15 and 20 h) and biochar dose (0.05, 0.10 and 0.15 g per 50 mL wastewater), after which residual Cu and Pb concentrations were analysed. Kinetic data were fitted to the pseudo-first-order, pseudo-second-order, and Elovich models. FS-RH biochar was characterized (proximate analysis, BET surface area, FTIR, SEM) and LCA was done using SimaPro (ReCiPe 2016). Results showed that blending FS with RH significantly improved fixed carbon content of the char, increased on porosity, and surface functionality compared to mono-feedstocks. Optimal milling (10 min, BPR ~9:1) enhanced SA and pore accessibility, resulting in superior adsorption performance. FS–RH biochar removed Pb^{2+}, Cu^{2+}. LCA revealed a production burden of ~2.65 kg CO_2-eq/kg biochar but demonstrated net-positive impacts due to avoided eutrophication (–0.84 kg PO_4^{3-}-eq), human toxicity (–1.35 kg 1,4-DB eq), and ecotoxicity (–2.12 kg 1,4-DB eq). In conclusion, FS–RH biochar produced under optimized conditions is a multifunctional, low-cost, and environmentally beneficial adsorbent for decentralized wastewater treatment. Scaling to pilot and municipal levels is recommended, alongside energy-efficient pyrolysis innovations and regeneration studies to extend biochar lifespan. Future work should expand life cycle boundaries to include end-of-life uses and compare performance with conventional adsorbents.

Keywords: Faecal sludge, Resource recovery, Pyrolysis, biochar, Wastewater, Adsorption, Heavy metals.