

Changes in Heavy Metals Bioavailability in Manure-Derived Digestates and Subsequent Hydrochars to Be Used as Soil Amendments

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Abstract : Digestates are residual by-products, rich in nutrients and trace elements, which can be used as organic fertilisers on soils. However, due to the non-digestibility of these elements and reduced dry matter during the anaerobic digestion process, metal concentrations are higher in digestates than in feedstocks, which might hamper their use as fertilisers according to the threshold values of some country policies. Furthermore, there is uncertainty regarding the required assimilated amount of these elements by some crops, which might result in their bioaccumulation. Therefore, further processing of the digestate to obtain safe fertilizing products has been recommended. This research aims to analyze the effect of applying the hydrothermal carbonization process to manure-derived digestates as a thermal treatment to reduce the bioavailability of heavy metals in mono and co-digestates derived from pig manure and maize from contaminated land in France. This study examined pig manure collected from a novel stable system (VeDoWs, province of East Flanders, Belgium) that separates the collection of pig urine and feces, resulting in a solid fraction of manure with high up-concentration of heavy metals and nutrients. Mono-digestion and co-digestion processes were conducted in semi-continuous reactors for 45 days at mesophilic conditions, in which the digestates were dried at 105 °C for 24 hours. Then, hydrothermal carbonization was applied to a 1:10 solid/water ratio to guarantee controlled experimental conditions in different temperatures (180, 200, and 220 °C) and residence times (2 h and 4 h). During the process, the pressure was generated autogenously, and the reactor was cooled down after completing the treatments. The solid and liquid phases were separated through vacuum filtration, in which the solid phase of each treatment -hydrochar- was dried and ground for chemical characterization. Different fractions (exchangeable / adsorbed fraction - F1, carbonates-bound fraction - F2, organic matter-bound fraction - F3, and residual fraction - F4) of some heavy metals (Cd, Cr, Ni, and Cr) have been determined in digestates and derived hydrochars using the modified Community Bureau of Reference (BCR) sequential extraction procedure. The main results indicated a difference in the heavy metals fractionation between digestates and their derived hydrochars; however, the hydrothermal carbonization operating conditions didn't have remarkable effects on heavy metals partitioning between the hydrochars of the proposed treatments. Based on the estimated potential ecological risk assessment, there was one level decrease (considerate to moderate) when comparing the HMs partitioning in digestates and derived hydrochars.

Keywords : heavy metals, bioavailability, hydrothermal treatment, bio-based fertilisers, agriculture

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