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Influence of mesophilic and thermophilic on enrichment and chemical speciation of toxic and valuable elements in digestate

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Bioharvesting of toxic and valuable elements by growing high biomass crops in the regions with low-grade mining ores and metal-polluted soils is a new concept in the area of mining termed phytomining. The biomass is used in anaerobic digestion to produce biogas and digestate. To the best of our knowledge, there are limited studies on the enrichment and distribution of heavy metals and economically valuable elements in digestate, obtained from mesophilic and thermophilic fermentation conditions. This study conducted a laboratory experiment to recover and enrich toxic elements (Zn, Cd, Pb, As) and economically valuable elements (Ge and rare earth elements REEs) at mesophilic (37ºC) and thermophilic (55ºC) conditions. To analyze the distribution of these elements in the liquid and solid-state of digestate a three-step sequential extraction procedure was carried out. Microfiltration (0.2µm) was used to separate elements in the solid and liquid phases. The solid digestate was extracted with ammonium acetate (pH 7) and ammonium acetate (pH 5) to determine exchangeable and acid-soluble elements. As a result, we found that thermophilic conditions significantly enriched Zn (3%), Cd (48%), Pb (25%), As (21%), Ge (40%), and REEs (22%) compared to mesophilic conditions. The following elements were enriched in decreasing order Cd > Ge > Pb > REEs > As > Zn. This enrichment may be due to differences in availability of substrates to microorganisms and higher gas production with increased temperature. The sequential extraction revealed that the concentration of elements in dissolved form was significantly increased in thermophilic conditions. While the concentrations in exchangeable are decreased indicating that previous elements bound on exchangeable sites were removed and transferred in solution. Furthermore, the element concentration in the residue fraction was not affected by temperature. Possibly the release of secondary metabolites from microorganisms triggered by higher temperature improved the solubility of elements which is an important prerequisite for element separation and recovery.