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Evaluation of Anaerobic Digestion Process from Phalaris arundinacea with Special Consideration to Enrichment of Germanium and Rare Earth Elements in Digestate

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Germanium and rare earth elements (REEs) are very valuable raw materials. The demand of the industry is rising steadily because they are being used in high-tech products. It is predicted that the germanium market will grow at an annual rate of 7% over the period 2018-2022 and demand for rare earths will increase by 3.9% from 120,000 t in 2014 to 150,766 t in 2020. Unlike other raw materials, Ge and REEs occur widespread in soils with concentrations comparable to some essential elements. Therefore, a promising way to improve supply of these elements is phytomining. Phalaris arundinacea (Reed canary grass) may offer the opportunity to get the elements from soil. This perennial, herbaceous and fast growing plant shows high biomass yield coupled with a moderate to high accumulation potential of these target elements.
The aim of this study was to evaluate process for biogas production from Phalaris arundinacea with focus on the recovery and enrichment of germanium and rare earth elements in the digestates. In a lab-scale experiment hay from the genotype PX 9160013 was used for biogas production in anaerobic digestion (AD) process in a continuous reactor at pH 7-7.3 and temperature of 39 °C. The effect of different organic loading rates (different mixtures of hay with water and cow manure) on biogas production, methane yield, element amount and concentration before or after AD were studied. The used biogas-digestate was obtained after the anaerobic digestion and concentrations of trace elements were analyzed by ICP-MS. In continuous reactor, anaerobic digestion process affect the biogas production at different organic loading rate. In this study biogas production was 1.64 m3/(m3FV*d) and methane yield was 0.33 m3/kgVS which means 63.8 vol % methane. Increasing the organic loading rates from 20/80 (manure/hay) to a ratio of 40/60 lead to increasing biogas production. Due to the high concentrations of both Ge (0.96 μg/g) and REEs (12.26 μg/g) in the manure used in the experiment, increasing the ratio 40/60 of hay/manure lead to decreasing concentrations of these elements (Ge 0.46 μg/g and REEs 1.6 μg/g) in the digestate. Concentrations of both Ge and REEs were significantly increased by a factor of 2-3 in the digestate and this increase clearly depends on the organic loading rate. Moreover, the higher the organic loading rate (ratio of hay/manure) the higher was the enrichment of the elements in the digestate, possibly due to differences in the availability of the substrates to microorganisms and changes in the chemical binding forms of elements in the digestate. However, we also observed markedly losses of roughly 50% of the elements during the processes. Based on this, ongoing studies aim to optimize the processes with regard to elemental recovery, enrichment, biogas production and identification of changes in chemical binding forms of the target elements in the digestate.