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Effect of GAC Addition and Application of Voltage on the Performance of Anaerobic Digestion and the Removal of Persistent and Mobile Substances

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Abstract

Benzotriazoles (BTRs) as well as per- and polyfluoroalkyl substances (PFAS) are partially removed during conventional wastewater treatment (Stasinakis et al., 2013) while they are often accumulated in sewage sludge (Arvaniti et al., 2012; Arvaniti and Stasinakis, 2015; Zhang et al., 2022). These substances are two different groups of manufactured chemicals that are widely used in several application and they are considered as environmental contaminants of emerging concern (Menger et al., 2022). Few studies are, so far, available on their fate during conventional sludge anaerobic digestion, AD (Thompson et al., 2023) while there is no information for the role of the addition of conductive materials in the anaerobic digesters or/and the application of voltage on their removal. The main objective of this study was to examine PFAS and BTRs fate during sludge thermophilic anaerobic digestion and to study the application of granulated active carbon (GAC) and voltage in this process. For this reason, four lab-scale reactors were used in parallel. They were fed on a mixture of primary and secondary sludge and operated at thermophilic range. From the group of BTRs, the studied micropollutants were 1H-BTR, 5TTR, CBTR, XTR, while from the group of PFAS analyses were conducted for PFOA, PFDA, PFPeA, PFNA, PFUdA, and PFOS. The reactors were monitored for 100 days for major pollutants removal, biogas production, methane content and micropollutants elimination. Four lab-scale reactors (1 L) operated in parallel under thermophilic conditions (55 ℃). Anaerobic sludge was used as inoculum and a mixture of primary and secondary (30:70) sludge was used as feed. The investigated compounds were spiked every day at a concentration of 100 μg/L. Reactor 1 was a typical AD reactor, in Reactor 2 voltage was also applied at 0.8V, Reactor 3 contained GAC, while in Reactor 4 GAC + voltage (0.8V) were applied. The studied AD reactors operated for a period of 100 days with an HRT of 20 days. The temperature and pH were monitored on a daily basis, while biogas volume and methane content were measured twice a week. Samples were taken twice a week from the influents and effluents for COD, TS,VS and once a week for the target microcontaminants. PFAS were analyzed using a LC-MS/MS. The solid phase extraction for PFAS was based on a previously developed method by Arvaniti et al. (2012). BTRs analysis were based on the method reported by Asimakopoulos et al.

(2013). The operation of all reactors was stable during the experimental period, the pH values in the reactors ranged between 7.2-7.3 while the average VS removal for all four reactor was 49.7%. The average production of biogas was 155-262 mL/Lreactor/day, and the average methane content was 45-59%. Regarding the target compounds, AD reactor containing only GAC achieved high removal of BTRs (91%), in the AD reactor GAC+voltage the removal was 87%, while the conventional AD reactor achieved removal of 65% and the AD reactor using only voltage had the lowest removal of BTRs (55%). PFAS did not show any removal during the experiment. The results of this study show that most of BTRs are significantly removed during thermophilic sludge anaerobic digestion. The addition of GAC enhances BTRs removal, while there is no clear effect of voltage addition. From the current results we conclude that the conditions in which the experiments were performed are not suitable for PFAS removal.

Keywords: anaerobic digestion; methane; electron transfer; PFAs, benzotriazoles

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