

Abstract

Microplastics (MP) are present throughout the environment, yet standardized extraction and characterization methods for their quantitative assessment are still lacking. One of the recipients of MP are municipal wastewater treatment plants (WWTPs), where during the treatment process, most MPs are retained in the excess sludge (up to 90%). In this study, we focused on MP present in waste sludge, their impact on biogas production during anaerobic digestion (AD), and on developing a method for MP extraction from organic rich samples. Since sludge can also be applied to agricultural land after treatment, we additionally examined, using a column experiment, how deep MP can migrate into the soil.

Using the OxiTop® system, we measured the impact of MP on biogas production and the CH₄/CO₂ ratio. We added MP of various types and concentrations (0.01–10 g L⁻¹) and investigated the effect of ozone pre-treatment of waste sludge prior to AD. The results on the impact of MP presence in AD, with and without ozonation, indicate that MP in waste sludge influence the process through mechanisms that are not yet fully understood. Based on our findings, it can be concluded that the presence of MPs influences the AD process, as well as biogas and methane production. However, the observed effects could not be directly correlated with the applied MP concentrations, highlighting the complexity of MP interactions within the AD process.

We aimed to develop a method for MP extraction from waste sludge. We employed an oil extraction method, preceded by pre-treatment with Fenton's reagent to remove organic matter. The method's efficiency was tested by adding various types and sizes of MP to sludge samples. The combination of Fenton's reagent and oil extraction proved to be an economically accessible and reliable approach for MP quantification and characterization. Fenton's reagent effectively removed organic matter without damaging, degrading, or altering the polymers. The efficiency of oil extraction from sludge depended on several factors, including MP type, size, and concentration. Higher concentrations of MP and larger particles (1–5 mm) yielded better recovery rates, while the method was less effective for certain MP types and shapes (PVC pellets and PA microbeads).

The column experiment examined how different factors (MP type, MP shape, rainfall amount, etc.) affect MP migration. Results showed that smaller particles (< 1 mm) migrated the furthest in depth. Higher rainfall intensity led to deeper MP migration compared to lower rainfall. We conclude that rainfall intensity, soil type, as well as MP type, size, density and shape, play a crucial role in MP migration and distribution in soils.

Keywords: biogas, characterization, microplastic, (oil) extraction, quantification, waste sludge, wastewater treatment plant