Comparative analysis of microplastics extracted from sewage sludge pretreated in a laboratory and a semi-pilot hydrothermal carbonization units

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Recently, it has been proven that sewage sludge is a major sink for microplastics (MPs) in wastewater treatment plants (WWTPs), capturing up to 90% of the MPs and thus serving as a key route for their release into the environment (Prus et al., 2024). The application of sewage sludge to agricultural land leads to elevated MP levels in the soil matrix, which may affect soil health and overall ecosystem functioning. Accordingly, it is crucial to examine how various sludge treatment methods affect the properties of MPs, including their size distribution, morphology, and concentration. Hydrothermal carbonization (HTC) has gained attention as a promising approach for reducing MPs in sewage sludge. During the hydrothermal reaction due to high temperature and pressure, plastic polymers undergo degradation, typically leading to substantial decreases in MP levels (often exceeding 70–90%) and causing marked structural alterations, causing the fragmentation of MPs into smaller particles or their partial dissolution (Wang et al., 2025). These transformations can decrease the environmental risks associated with MPs and simultaneously improve sludge quality for subsequent valorization pathways, such as bioenergy production (Prus et al., 2025).

This study compares the abundance of microplastics (MPs) in digested sewage sludge from two wastewater treatment plants in Poland. Corresponding hydrochars were produced by hydrothermal carbonization (HTC) at optimized conditions such as 210 °C for 3 h using two reactor scales: a laboratory-scale (1 L) reactor and a semi-pilot-scale (200 L) reactor. The graphical representation of methodology is depicted in Figure 1. Firstly, sewage sludge and hydrochar samples were lyophilized and then MPs were extracted from using chemical oxidation and density separation. After dying they were identified and characterized by microscopy. A comparison of hydrochars revealed scale-dependent differences in MP removal efficiency, providing new insight into microplastic behaviour during the upscaling of HTC sludge processing from laboratory to pilot scale.

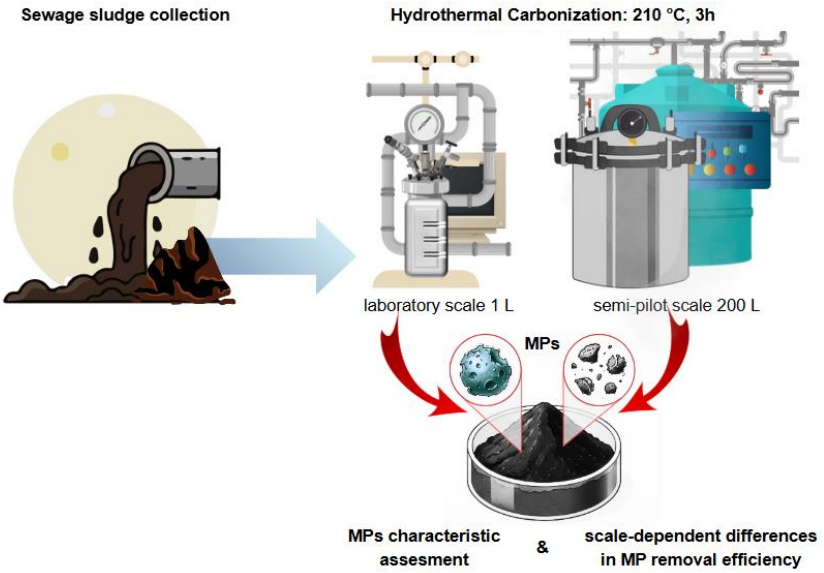

Figure 1. Schematic overview of the experimental design and analytical workflow applied to investigate microplastic behaviour during hydrothermal carbonization of sewage sludge.

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