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The impact of ozonation on PET and PVC microplastics in model urban wastewater

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Abstract In the field of environmental pollutants, microplastics (MPs) present one of the biggest challenges. Several studies investigated different removal options of MPs and investigated its toxic impacts on the environment. One of the main sources of MPs pollution is wastewater. Different advanced oxidation processes (AOPs) are being investigated regarding MP treatment in wastewater, especially ozonation. Several studies found that it caused degradation of certain MPs. Therefore, a study was run using polyethylene terephthalate (PET) and polyvinyl chloride (PVC) MPs in model wastewater. 6 h ozonation was accomplished at two different ozone doses. Total organic carbon (TOC) and chemical oxygen demand (COD) were determined for samples during ozonation. It was found out that in both MPs-containing model wastewater, TOC and COD increased. This indicates that ozonation has led to the degradation of MPs. Wastewater containing PET had up to 85% higher TOC values compared to PVC containing wastewaters. After ozonation PET-containing wastewater had up to 29% higher COD values than the PVC-containing one. It can be concluded that the higher ozone dose, the more effective MPs degradation is.

Keywords: degradation, microplastics, ozonation, PET, PVC, wastewater

1. Introduction

Today, microplastics (MPs) present one of the biggest challenges when environmental pollutants are discussed. Several studies investigated different removal strategies for MPs and determined their potential impact in various ecosystems. Sources of MPs pollution can be divided into primary and secondary ones. However, once the MPs are detected in the environment, it is almost impossible to determine its exact source. The most concerning sources are municipal wastewater treatment plants. While more than 98 % of MPs could be removed during wastewater treatment, the remaining MPs in treated wastewater could still end up in surface water and groundwater. Removed MPs mainly sink in the sludge during the treatment process. Since there is, no specific treatment process to remove MPs from sewage sludge, the composting and use of sewage sludge in agriculture could also lead to the release of MPs into the soil (An et al., 2020; Kye et al., 2024)).

Recently, different advanced oxidation processes (AOPs) are being investigated regarding MPs treatment in wastewater. One of those AOPs is ozonation which has been used for disinfection and oxidation for years. Because ozone easily reacts with organic and inorganic compounds due to its high reduction potential and reactivity, its potential to change the physical and chemical properties of MPs has been lately investigated. Several studies found that the ozonation caused the degradation of MPs. However, some research about the ozonation process optimal conditions and how the MPs degradation during ozonation influences the water in which MPs are, still needs to be done (de Aragão Belé et al., 2021; Ziembowicz and Kida, 2024).

The aim of our study was to determine optimal conditions for ozonation of selected MPs-containing wastewaters to prevent and reduce further MPs pollution in the environment.

2. Materials and Methods

Polyethylene terephthalate (PET) and polyvinyl chloride (PVC) MPs with a diameter of less than 1 mm were used. Tap water was used as model wastewater. Before the ozonation, 500 mL of the model wastewater with MPs concentration of 1 g L^{-1} was prepared in the glass ozone reactor for each type of MPs separately. The reactor was put onto a magnetic stirrer. The ozone generator Wedeco Modular HC was used for ozone production. The ozonation time was 6 h. The first sample model wastewater with PET was ozonated with an ozone dose of 3.5 g L^{-1}, while the second sample was ozonated with an ozone dose of 4.5 g L^{-1}. The same conditions were used for the ozonation of model wastewater with PVC. Total organic carbon (TOC) and chemical oxygen demand (COD) were

determined in the collected samples during the ozonation process. TOC was determined using TOC Analytikjena multi N/C 3100, while the COD was determined according to ISO 6060:1989.

3. Results and Discussion

According to the TOC and COD results, both PET and PVC MPs particles contribute to the quality of the model wastewater. Regardless of the ozone dose, in both MPs model wastewater samples, TOC increased (Fig. 1). This indicates that ozonation caused the increase in organic content due to the degradation of the MPs or leaching of components present. PET-containing wastewater samples had 65 to 85% higher TOC values compared to PVC-containing wastewater samples. Similar to TOC results, the COD values (Fig. 2) for both MPs-containing wastewater increased with time and were higher at a higher ozone dose of 4.5 g L^{-1}. Comparison of COD values of both MPs-containing wastewater between the higher and lower ozone dose showed that samples ozonated at a higher ozone dose for 6 h had almost 3 times higher COD than at the beginning of the ozonation process. PET-containing wastewater had from 7 to 29% higher COD values than the PVC-containing wastewater.

4. Conclusions

Based on the results, ozonation is more effective in PET degradation than in PVC degradation. Higher ozone dose increased MPs degradation. While ozonation of PET MP appeared to have great potential, some additional research needs to be done to improve the PVC MP degradation.

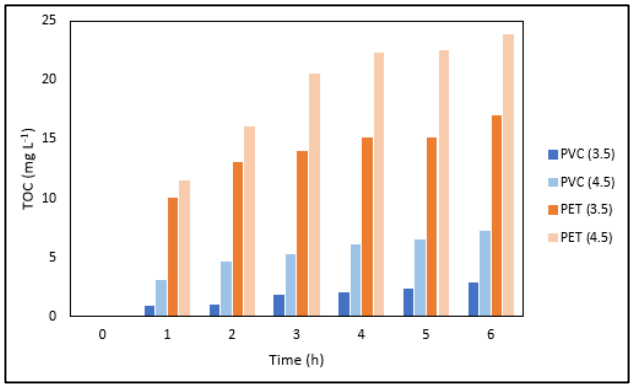

Figure 1. TOC of model wastewater with PVC and PET MPs during ozonation at two ozone doses (3.5/4.5 g L^{-1}).

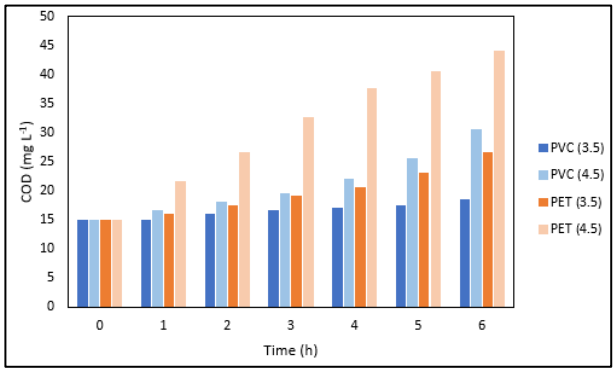

Figure 2. COD of model wastewater with PVC and PET MPs during ozonation at two ozone doses (3.5/4.5 g L^{-1}).

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