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Ozonation as an Effective Method to Remove Pharmaceuticals from Biologically Treated Wastewater of Different Origin

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Abstract : Pharmaceutical pollution in aquatic environments has become a growing concern. Various active pharmaceutical ingredient (API) residues: hormones, antibiotics, or/and psychiatric drugs, have already been discovered in different environmental compartments. Due to ineffective wastewater treatment technologies, an underestimated amount of APIs can enter the ecosystem by discharged treated wastewater. Especially, psychiatric compounds, such as carbamazepine (CBZ) and venlafaxine (VNX), persist in effluent even post-treatment. Therefore, these pharmaceuticals usually exceed safe environmental levels and pose risks to the aquatic environment, particularly, to sensitive ecosystems such as the Baltic Sea. CBZ, known for its chemical stability and long biodegradation time, accumulates in the environment, threatening aquatic life and human health through the food chain. As the use of medication rises, there is an urgent need for advanced wastewater treatment to reduce pharmaceutical contamination and meet future regulatory requirements. In this study, we tested advanced oxidation technology using ozone to remove two commonly used psychiatric drugs, carbamazepine, and venlafaxine, from biologically treated wastewater effluent. Additionally, general water quality parameters (SPM, DOC, COD) and bacterial contamination were analyzed. Three wastewater treatment plants (WWTPs) were selected to represent varying dominant anthropogenic activities: 1) resort, 2) resort and residential, and 3) residential, industrial, and resort. Wastewater samples for the experiment were collected during the summer season after mechanical and biological treatment and ozonated for 5, 10, and 15 minutes. Pharmaceutical levels in this study exceeded the predicted no-effect concentration (PNEC) of 500 and 90 ng L−1, for CBZ and VNX, respectively in all WWTPs, except CBZ in WWTP 1. Initial CBZ contamination was found to be lower in WWTP 1 (427.4 ng L-1), compared with WWTP 2 (1266.5 ng L-1) and 3 (119.2 ng L-1). VNX followed a similar trend with concentrations of 341.2 ng L-1, 361.4 ng L-1, and 390.0 ng L-1, respectively, for WWTPs 1, 2, and 3. It was determined that CBZ was not detected in the effluent after 5 minutes of ozonation in any of the WWTPs. Contrarily, VNX, was still detected after 5, 10, and 15 minutes of treatment with ozone, however under the limits of quantification (LOD) (<5ng L-1). Additionally, general pollution of SPM, DOC, COD, and bacterial contamination was reduced notably after 5 minutes of treatment with ozone. Although initial pharmaceutical levels exceeded PNECs, indicating ongoing environmental risks, ozonation demonstrated high efficiency in reducing pharmaceutical and general contamination in wastewater with different pollution matrices.

Keywords : Baltic Sea, ozonation, pharmaceuticals, wastewater treatment plants.
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