

# Occurrence and seasonal variations of 25 pharmaceutical residues in wastewater and drinking water treatment plants

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**Abstract** Thousands of tons of pharmaceuticals are introduced into the aqueous environment due to their incomplete elimination during treatment process in wastewater treatment plants (WWTPs) and water treatment plants (WTPs). The presence of pharmacologically active compounds in the environment is of a great interest because of their potential to cause negative effects. Furthermore, drugs can undergo different processes leading to the formation of new transformation products, which may be more toxic than the parent compound. In light of these concerns, within the research a new, rapid and sensitive analytical procedure for the determination of a wide range of pharmaceuticals from different classes using solid phase extraction (SPE) and high-performance liquid chromatography tandem mass spectrometry (HPLC-MS/MS) technique in different water samples was developed. This methodology was applied to investigate the occurrence, removal efficiency of 25 pharmaceuticals during wastewater and

drinking water treatment, and seasonal variability in the amount of selected pharmaceuticals in WWTP and WTP over a year. The most often detected analytes in water samples were carbamazepine (100 % of samples) and ibuprofen (98 % of samples), concluding that they may be considered as pollution indicators of the aqueous environment in tested area. Highly polar compound, metformin, was determined at very high concentration level of up to 8100 ng/L in analyzed water samples. Drugs concentrations were much higher in winter season, especially for non-steroidal inflammatory drugs (NSAIDs) and caffeine, probably due to the inhibited degradation related to lower temperatures and limited sunlight. Carbamazepine was found to be the most resistant drug to environmental degradation and its concentrations were at similar levels during four seasons.

**Keywords** Pharmaceuticals · Wastewater · Drinking water · Removal efficiencies · Seasonal variations

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## Introduction

Development of new technologies and the increase of industrialization became the main sources of chemicals in the environment. In the last decade, persistent organic pollutants (e.g., pesticides, insecticides, fungicides, PCB) have been of a great concern. However, the twenty-first century brought no improvement in the environment quality and revealed a new group of compounds classified as so-called emerging contaminants, which include pharmaceutically active compounds