

Dissertation summary

Title: Occurrence of pharmaceuticals and personal care products in the water environment of selected areas in southern Poland

1. Motivation for the selection of research issues

Emerging contaminants in the water environment, such as pharmaceuticals and personal care products (PPCP), have gained more interest worldwide in recent years. However, research on PPCPs in Poland is still rarely conducted. It mainly concerns the environmental aspects, where the occurrence and migration of PPCPs in surface water and groundwater are investigated. So far, Polish research has been limited to single studies carried out over the past few years. The possibility of the PPCPs occurrence in the aquatic environment of Poland is supported by the national statistics on drug consumption, usage of cosmetics and detergents, and the widespread unawareness of the public about the appropriate disposal of unused and expired products. Due to highly urbanised areas occurring in southern Poland, contamination of the water environment with PPCPs seems very likely in this region.

2. Scientific purpose of the doctoral dissertation

The aim of this study was to assess the contamination of the water environment with pharmaceuticals and personal care products (PPCP) in selected areas of southern Poland, mainly within the Silesian Province. In selected study sites, an attempt was made to identify factors affecting the occurrence of detected PPCPs in aquifers and track the migration of these compounds in water, particularly as a result of groundwater recharge by surface water infiltration. The interpretation was based on the results of chemical analyses, characteristics of the study areas (land use, hydrogeological conditions), and physicochemical properties of the analysed substances.

In this study, a hypothesis was formulated that PPCPs are present in the water environment of southern Poland. The main source of surface water contamination with PPCPs is wastewater discharges from wastewater treatment plants due to inefficient removal of microcontaminants using conventional treatment technologies. Therefore, the highest level of water contamination with PPCPs is associated with those areas in the Silesian Province where rivers receive wastewater discharges. In addition, surface water infiltration contributes to the migration of microcontaminants to groundwater, especially in areas with managed aquifer recharge, where surface water is the main source of PPCPs.

3. Methodology

The research included desk studies, fieldwork, and laboratory analyses. Desk studies comprised collection and analysis of existing documents, information, and archival data on the study areas as well as gathering data on the physicochemical properties of PPCPs, such as solubility, volatility, adsorbability, and degradability. During the fieldwork, water samples were taken for chemical analyses, and basic physicochemical parameters of water were measured using portable meters. In the laboratory, 109 compounds belonging to 31 PPCP groups were analysed using the liquid chromatography coupled with tandem mass spectrometry method. Moreover, the chemical composition of water samples was determined, including analyses of major ions and several minor ions.

4. Research area

The research on the PPCPs occurrence in the water environment was performed in selected areas of southern Poland. The study was conducted in two stages:

- 1) Pilot studies, which involved sampling of raw and treated wastewater from four wastewater treatment plants as well as sampling of surface water and groundwater in seven pilot areas: Wierzchowisko, Tarnowskie Góry, Katowice, Tychy-Urbanowice, Kobiernice, Gliwice-Zbroślawice, and Skoczów-Pogórze.
- 2) Detailed research in selected study areas, which included a continuation of research in two pilot areas (Gliwice-Zbroślawice and Skoczów-Pogórze) and investigation in two other study sites (Kozłowa Góra and Tarnów).

5. Synthetic presentation of the most important results and conclusions

The results indicate that pharmaceuticals and personal care products are present in the water environment of southern Poland, and the level of contamination depends on land use and the presence of potential contamination sources.

Wastewater discharges from wastewater treatment plants are a significant source of river water contamination due to inefficient removal of PPCPs using conventional treatment methods. The highest level of water contamination with analysed compounds was observed in the areas where rivers are the recipients of wastewater discharges from wastewater treatment plants. Other sources of PPCPs in the water environment of the studied areas included domestic wastewater (illegal discharges to streams, leaking septic tanks), agricultural activities, industry, landfills, an airport, and maintenance of forests.

In the raw wastewater samples, the highest concentrations were observed for metformin (393,000 ng/L), caffeine (156,000 ng/L), paraxanthine (145,000 ng/L), and iohexol (110,000 ng/L), while in treated wastewater for iopromide (50,600 ng/L), oxypurinol (47,300 ng/L), and iohexol (14,100 ng/L). The most frequent PPCPs in the sampled rivers were DEET, metformin, 1H-benzotriazole, and carbamazepine. The most often detected substances in groundwater samples were DEET, acesulfame, oxypurinol, and carbamazepine. In the surface water samples, the highest maximum PPCP concentrations were observed for iohexol (55,400 ng/L), oxypurinol (32,100 ng/L), and iopromide (23,700 ng/L), while in groundwater for caffeine (1,130 ng/L), paraxanthine (832 ng/L), and methylparaben (668 ng/L).

Surface water infiltration contributes to the migration of the analysed substances to aquifers within the studied areas. In the case of the areas with managed aquifer recharge, surface water is the main source of PPCPs in groundwater. The water contamination with PPCPs is controlled by both environmental conditions (hydrological, hydrogeological, physicochemical parameters of water) and the physicochemical properties of the microcontaminants.