

The Occurrence, Risk, and Treatment Methods of Pharmaceuticals in Aquatic Systems

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Abstract

Over the last two decades, the introduction of pharmaceutically active compounds (PhACs) into aquatic systems has captured the attention of many environmental scientists and engineers. The chronic effects of these compounds at low doses are unknown to researchers and toxicologists. This paper aims at defining the sources of PhACs into the environment, potential risks to humans, animals and the ecosystem, as well as the analysis of several treatment methods that show promising results for eliminating PhACs in aquatic systems. Analysis methods to be discussed include oxidation via ozonation and sand filtration with activated carbon adsorption. A conventional flocculation treatment method will also be discussed briefly, to determine if it is suitable for PhAC removal.

Keywords

Pharmaceutically active compounds (PhAC), ozonation, expected introductory concentration (EIC), predicted environmental concentration (PEC)

Introduction

There have been many efforts to determine the concentrations of pharmaceuticals in aquatic systems over the last 25 years. Many developed countries including the United States, Germany, Britain, Switzerland, and the Netherlands have found more than 80 PhACs in the aquatic environment (Heberer, 2002). There are currently no regulatory guidelines to govern the potential presence of pharmaceuticals at trace concentrations in drinking water supplies. This is true for both the United States and the European Union (FDA-CDER, 1998; CPMP, 2001). Of the approximately 170 drinking water standards of the Environmental Protection Agency (EPA) pertaining to organic compounds in potable water supplies, none of them concern pharmaceuticals (EPA, 2002). PhACs are produced and used in very large volumes worldwide, and their occurrence in drinking water supplies will be a potential problem in the future. Some of these compounds pose no serious threat, however compounds such as natural estrogenic hormones and synthetic female steroid hormones are very potent biologic chemicals. This paper will analyze how PhACs enter aquatic systems, potential dangers to humans and the environment, several treatment methods to eliminate PhACs, and possible prevention of PhAC occurrence within aquatic systems.

Sources of Pharmaceuticals in the Aquatic Environment

The possible pollution of aquatic and terrestrial environments by pharmaceuticals can be attributed to several different sources. Emission from production sites, direct disposal of excess drugs in households, excretion after application for human and animal medical care, therapeutic treatment of livestock on fields, and effluents of fish farms are all major sources of pharmaceuticals in aquatic environments. Upon consumption of an active drug by a patient, the pharmaceutical and its metabolites are excreted and reach the sewage system. Depending upon which drug is taken, the discharge may or may not be pharmaceutically active.

A study in Germany revealed that some individual pharmaceuticals are used in quantities of more than 100 tons/year (Schwabe, 1999). These pharmaceuticals are excreted via feces and urine, and are thus present in domestic wastewater. Although the disposal of unused or expired pharmaceuticals via toilets is common, it is very difficult to quantitatively estimate the contribution because reliable data is not available (Ternes, 2002). Another contributor to the contamination of rivers and streams are point discharges from pharmaceutical manufacturers. Groundwater can be contaminated by PhACs by infiltration of surface water containing pharmaceutical residues as