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# Pharmaceutically Active Compounds (PhACs): A Threat for Aquatic Environment?

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## Introduction

Nowadays, the increasing use of pharmaceutical compounds in human and in animals is becoming a new environmental problem and, because of that, the interest in having information about their presence in the environment and their possible adverse effects on human and on ecological systems is considerably increasing. This class of compounds includes substances that are widely used in agriculture, medicine and biotechnology, such as antibiotics, drugs and hormones. The occurrence and fate of PhACs compounds has become a major issue of concern and research for the 21st century. The investigations carried out in developed countries such as USA, Canada, Japan, Korea, Australia and many countries in Europe, more than 80 compounds have been detected in the aquatic environment. It is estimated that worldwide consumption of active compounds amounts to some 100 000 tons or more per annum. The ubiquitous use of pharmaceuticals in various settings has resulted in a continuous discharge of pharmaceuticals and metabolites into the environment, leading to their "pseudo persistence" in the environment. Their presence in water, even at these very low concentrations, has raised concerns among stakeholders, such as drinking-water regulators, governments, water suppliers and the public, regarding the potential risks to human health and aquatic ecosystems from exposure to traces of pharmaceutical. The issue becomes of increasing concern as population density and consumption of pharmaceuticals continue to increase.

PhACs can find their way into the aquatic environment through several paths including: excretion from human and animal systems; leaching from landfill, manure or biosolids applications; and improper disposal. In some instances, some PhACs have been measured at concentrations that may cause adverse effects to resident populations in the aquatic environment. The occurrence and fate of pharmaceutically active compounds (PhACs) in the aquatic environment has been recognized as one of the emerging issues in environmental chemistry. Some of the most representative pharmaceuticals found in sewage, surface and ground water samples are antibiotics, anti-inflammatory drugs, lipid regulators, beta-blockers and X-ray contrast media. PhACs have been detected in surface waters, groundwater and treated water (drinking water). Studies have been carried out in streams, rivers, effluents of WWTPs, hospital wastewater and effluents of pharmaceutical production sites. Concentration of pharmaceuticals in the environment, their temporary evolution and their possible synergic and antagonist effects depend not only in the amount discharged from WWTPs but also on the geographical area and climate conditions. Domestic waste streams carry these compounds to municipal wastewater treatment plants, private septic systems, or in some cases, directly to receiving water without treatment. Photodegradation in the aquatic environment could also play an important role in the persistence of these pharmaceuticals. Based on lab experiments, a wide range of rates of photodegradation of pharmaceuticals have been reported. Photodegradation and biodegradation have been identified as the two major sinks for PhACs.

Removal efficiencies of PhACs during wastewater and drinking-water treatment are dependent on their physical and chemical properties. It is important to consider and characterize the efficiency of processes for the removal of pharmaceuticals during wastewater and drinking-water treatment. Conventional wastewater treatment processes are not specifically designed to remove pharmaceuticals, so they often do not eliminate them efficiently. Conventional wastewater treatment processes have demonstrated varying removal rates for pharmaceuticals, ranging from less than 20% to greater than 90%. Factors influencing removal include sludge age, activated sludge tank temperature and hydraulic retention time. Comparatively, advanced wastewater treatment processes, such as activated carbon, ozonation, membranes (e.g. nanofiltration, reverse osmosis) and advanced oxidation technologies, can achieve higher removal rates for pharmaceuticals. However, none of the wide range of drinking-water treatment processes available has been designed specifically to remove pharmaceuticals that may be present in source waters. Current studies prove that there is a higher risk for impact on the environment and this makes it necessary to employ a treatment process that is capable of removing and/or destroying residual pharmaceutical compounds. In India, most of the waste water treatment plants are conventional water treatment scheme consisting of aeration, chemical coagulation, flocculation, sedimentation, filtration and disinfection. Thus, these TPs may not remove the PhACs of the effluents.

Accurate and sensitive methods are necessary for the determination of pharmaceuticals in wastewater and, in that way, evaluate the amount of pharmaceuticals that are being discharged into the aquatic environment. The increase in detection is largely attributable to the advances in analytical techniques and instrumentation. High performance liquid chromatography–mass spectrometry (HPLC–MS) and gas chromatography–mass spectrometry (GC–MS) have been used to determinate pharmaceuticals in water samples. Most of the published articles provide the current information on PhACs in the aquatic environment in developed countries. The information might be different in developing countries due to lack of proper treatment facilities for sewage and unused pharmaceutical compounds. Also, the amount and type pharmaceuticals used in developing countries might show a completely different picture on this topic. Metabolites of pharmaceuticals has not yet detected due to lack of analytical standards for identification. Thus, analytical tools have to be developed to identify degradation products in the environment in the low and

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even sub-ng/l-range. Sampling and analysing pharmaceuticals would help to facilitate the comparison of data. Preventive measures, such as policies promoting or regulations governing disposal practices at concentrated point sources can reduce the amount of pharmaceutical waste entering water bodies. The currently available data on the chronic toxicity of pharmaceuticals is insufficient to decide whether such chemicals pose a significant threat to the environment. Therefore more research is critically needed. PhACs are not considered in any drinking water quality standard up to now. Also, there is a need to raise public awareness and encourage consumers to adopt proper disposal practices for unwanted pharmaceuticals. Further, the models have to be developed to describe the processes and to predict the fate of PhACs in the aquatic environment.

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