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Perspective

Biodegradation, Photolysis and Sorption in Aquatic Environments

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INTRODUCTION

Antibiotics in surface waters are a possible source of antibiotic resistance and consequently a source of worry for human and environmental health. The persistence and movement of antibiotics in rivers and lakes are important variables influencing their potential impact. Following a scoping review technique, the purpose of this work was to describe the peer-reviewed published literature on the photolysis (direct and indirect), sorption and biodegradation of a selected group of antibiotic compounds. From 2000 to 2021, primary research was conducted to gather information on these processes for 25 antibiotics from six classes.

After compiling and evaluating the relevant parameters, the results show that information is available to forecast the rates of direct photolysis and reactivity with hydroxyl radical (an indirect photolysis process) for the majority of the antibiotics tested.

For majority of the targeted antibiotic chemicals, there is insufficient or conflicting information to include alternative indirect photolysis processes, biodegradation or removal by sorption to settling particles. Rather than pseudo-first order rate constants or sorption equilibrium constants that apply only to specific conditions/sites, future research should focus on collecting fundamental parameters such as quantum yields, second-order rate constants, normalized biodegradation rates and organic carbon or surface area normalized sorption coefficients.

DESCRIPTION

Antimicrobial Resistance (AMR) is a worldwide public health issue.

Antibiotics and their metabolites are released into the natural environment, particularly aquatic systems, from sources such as wastewater treatment plants, antibiotic manufacturing plants, hospitals or animal farms, with the potential to exert selection pressures on bacteria and exacerbate AMR.

A growing number of studies have assessed and quantified the presence of antibiotics in the natural environment. This includes the medications' persistence in various environmental matrices. Understanding the breakdown and stability of antibiotic compounds in the environment can help inform actions to reduce the impact of these medications on the spread of AMR. Despite the numerous studies published in recent years, there is a need to summarize what evidence is available to define critical parameters in the peer-reviewed literature and to identify current knowledge gaps regarding the processes that remove or degrade antibiotics in aquatic systems in order to meaningfully guide new work.

Scoping reviews offer a replicable method for describing and summarizing the literature on a specific research issue, as well as identifying knowledge gaps. Scoping reviews are built by following a protocol that specifies the search phrases, constraints and method for charting and extracting important data. This is done to reduce biases in the literature search and data interpretation. However, one shortcoming of this technique is that the procedure limits the scope of the literature. The end result is a clear data display with an analysis of the gaps.

Micro plastics have lately been identified as significant environmental contaminants due to their presence in many ecosystems, including the most pristine.

Tyre Wear Micro plastics (TWM) are particles created by tyre abrasion that, together with recycled tyre crumbs and polished tyre repairs are one of the most common sources of micro plastics. Globally, it is estimated that around 6,000,000 tonnes of TWM are discharged into the environment each year. However, rather than field samples or monitoring studies, the release of TWM into the environment has generally been predicted based on assumptions such as driving distance, vehicle weight, speed, tyre type and road surface.

Summary of evidence

The data available on the persistence and degradation of antibiotics in surface waters, including photolysis (direct and indirect), biodegradation and sorption to settling particles, in order to inform geospatial and mathematical modelling on the fate and dissemination of antibiotic compounds. In terms of photolysis, there is solid and fairly consistent data on direct photolysis for some antibiotics, but not others (e.g., beta-lactams).

CONCLUSION

Antibiotic persistence and availability in the aquatic environment play a significant role in the development of AMR and the retention of antibiotic resistance genes in bacteria. To estimate the environmental fate of antibiotic chemicals, it is critical to have strong rate constants and partition coefficients. According to this scoping review, the important photochemistry parameters for direct photolysis (quantum yield) and reaction with hydroxyl radical (second-order rate constants).