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European Commission

Science for Environment Policy

Which factors make drugs persistent? A look at sulphonamides in Polish rivers

Up to 90% of consumed drugs enter the environment. This may have negative effects on wildlife, especially when the drugs take long periods to break down. This study assessed the breakdown of sulphonamides — a class of anti-bacterials — in samples from two rivers in Poland. The results showed that sulpha-methoxazole, a common veterinary antibiotic, was the most persistent and that various factors inhibit degradation, including low temperatures, heavy metal pollution and low pH.

Pharmaceutical pollution is a growing environmental concern in the EU, as the world's second biggest consumer of human medicinal products. Up to 90% of orally administered drugs are excreted in the urine of animals and people[1], which means medicinal products can infiltrate the aquatic environment, where they may have negative effects on wildlife.

This study focused on sulphonamides, a group of chemicals used mainly as anti-bacterial agents. Although sulphonamides are now rarely used in human medicine, they remain important in animal medicine; in agriculture, up to 58 milligrams of sulphonamide can be used to produce just 1 kilogram of meat. As a result, levels of these drugs can reach 400 milligrams per kilogram in manure. The presence of these chemicals in the environment could promote drug resistance in bacteria in soil. After leaching into nearby water bodies, the drugs could also have negative impacts on aquatic organisms.

Various factors are key to assessing the risk from a chemical, including its toxicological properties and how quickly it is broken down — the latter being the focus of this study. Chemicals that persist in the environment pose a risk because they can accumulate up the food chain, enabling them to reach potentially toxic levels. Some persistent chemicals can also move long distances, allowing them to travel far from their source.

According to the guidelines of the Stockholm Convention, substances with a half-life in the aquatic environment of over two months (i.e. it takes over two months for the chemical to break down to 50% of its original concentration) can be classified as persistent. Stockholm Convention parties, including the EU, are required to implement special procedures for such substances. Data suggest that the half-life of some sulphonamides is over two months, yet they are not considered persistent organic pollutants.

Many factors can affect the biodegradation rate of sulphonamides, such as the amount of light, the pH of the water and the presence of oxygen. This study investigated the biodegradability of four sulphonamides: sulphanilamide, sulpha-methoxazole, sulphadiazine and sulphathiazole. The researchers investigated the influence of weather conditions, water quality and experimental procedure on the breakdown of these sulphonamides in water samples collected from rivers in Poland.

A total of 19 water samples were collected from two highly polluted Polish rivers. Both rivers flow through one of the EU's largest urban areas (the Upper Silesian Industrial Region), which has over 12 active coal mines and metallurgical industries and a human population of around 3 million. Immediately after sampling, a concentrated solution of sulphonamides was added to the water. The researchers quantified the concentration of the drugs in each sample over 28 days.

Continued on next page.

1. http://ec.europa.eu/health/human-use/environment-medicines/index_en.htm

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Which factors make drugs persistent? A look at sulphonamides in Polish rivers *(continued)*

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Before commencing biodegradation experiments, the researchers assessed the effect of sulphonamides on microorganisms in the water. After 18 hours of incubation, significant growth inhibition was observed, but after two days this inhibition decreased. This suggests that microorganisms are inhibited by the drugs but, over time, adapt to their presence.

Next, the researchers looked at how each drug was broken down by microbes (biodegraded). Microbial activity and thus biodegradation can depend on the effect of individual chemicals as well as external conditions such as temperature, leading to complex interactions.

Sulpha-methoxazole was the most resistant to biodegradation, with an average half-life of 72 days — meeting the definition of a persistent organic pollutant. As sulpha-methoxazole is the most commonly used sulphonamide in veterinary medicine and the most frequently detected in environmental samples, this result could be of environmental concern. Sulphathiazole was the most biodegradable, and had similar rates of biodegradation to the other two drugs, which were also rapidly broken down.

It is not only the type of sulphonamide that affects biodegradation. The researchers found that the factor with the biggest effect on biodegradation was temperature, with rates of breakdown significantly lower during the colder, winter season.

In Central European areas, vegetation increases with temperature from spring to autumn, leading to more biodiversity, higher microbial activity and a higher rate of biodegradation. However, during wintertime, temperatures drop and vegetation is suppressed, leading to reduced microbial activity and thus reduced biodegradation. This suggests the environmental risk associated with sulphonamides could be higher in the winter.

The authors also found a connection with pH, with acidity reducing degradation, and salt content (salinity), with higher salinity also reducing degradation (suggesting that removing salt from wastewater entering rivers could increase drug breakdown). Lower turbidity (the cloudiness of water, caused by particles it contains) also reduced breakdown, because the particles found in water support microorganisms. Finally, heavy-metal contamination from nearby industrial sites also inhibited sulphonamide degradation.

This study shows that various factors can reduce the biodegradation of sulphonamides and that risk may be particularly acute during winter, although further research is needed to clarify the ecological risk these compounds pose under different conditions.

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