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Changes in the Biological Degradability and Toxicity of Sulfonamide Antibiotics in Activated Sludge and River Water due to Ionizing Radiation Treatment

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During conventional wastewater treatment, the removal of pharmaceutical compounds is usually inadequate as most of the xenobiotics show high resistance to biological decomposition by activated sludge. This deficiency can be counteracted by application of ionizing radiation treatment that leads to oxidation of organic molecules mainly by reactions of hydroxyl radicals. Oxidation may result in a complete solution to the final disposal of pollutants with no further purification steps required, but may also contribute to formation of biodegradable, less harmful transformation products.

The biodegradability and toxicity have been examined on 10^{-4} mol/dm^3 sulfonamide antibiotic solutions with considerably different chemical structure (sulfanilamide, sulfaguanidine, sulfathiazole and sulfamethoxazole) and their products at different stages of oxidative decomposition. The biodegradability in activated sludge and freshwater has been specified by the ratio of the biological and chemical oxygen demand (BOD/COD), while the toxic properties have been evaluated by activated sludge respiration inhibition tests and acute toxicity experiments done on *Vibrio fischeri*, *Pseudokirchneriella subcapitata* and *Daphnia magna*. Test organisms were placed under the exposition of same loads of test substances and the interfering effects of H_2O_2 forming during irradiation procedure have been eliminated.

Initial sulfonamide solutions inoculated with activated sludge showed low BOD/COD (0.16–0.21), while complete resistance has been observed when river water was used as inoculum. The biodegradability continuously increased as a function of absorbed dose in both matrices and ready biodegradability (BOD/COD $\sim$ 0.7) has been reached at 1.5 kGy and 2.0 kGy in case of activated sludge and river water, respectively. This difference in absorbed doses means that higher degree of oxidation is needed, when sulfonamides are subjected to river water community, to achieve same biodegradability level under same time as in case of activated sludge. Nevertheless, already a few tenth kGy of absorbed dose led to increment in biological availability. Activated sludge respiration inhibition tests showed no toxic effects of both initial and treated solutions. Growth inhibition on *Pseudokirchneriella subcapitata* has been reduced during treatment. *Vibrio fischeri* was susceptible to treated solutions, as the inhibition increased in case of sulfamethoxazole and sulfathiazole. Mortality of *Daphnia*

magna considerably reduced in treated solutions, with the exception of early products of sulfathiazole.

It can be concluded that biological treatment at conventional wastewater treatment plants is not adequate for removal of sulfonamide antibiotics. Nevertheless, ionizing radiation led to formation of products biologically degradable by activated sludge.

Notable toxic effects of initial sulfonamides have been observed on *Daphnia magna* and *Pseudokirchneriella subcapitata*. These effects generally reduced in treated solutions, but increased toxicity has been also detected in some cases. Experiments done on natural water samples showed that there is a possibility of transformation product removal by biological processes taking place under natural conditions. However, this process may take a long time that ensures probability for manifestation of adverse effects on the state of biological community, or ecosystem.

Country/Organization invited to participate

Hungary

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