

NRP Endocrine Disruptors

Final Summary

Original project title Phenolic substances with estrogenic disruptor potential as contaminants in the aquatic environment (PHENCON)
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Metabolism, fate, and effects of endocrine disrupting phenols

Lead

Nonylphenolic and other substituted phenolic compounds, such as bisphenol A and parabenes, are known endocrine disruptors that can affect aquatic environments. Here, bacterial metabolism as well as environmental fate of such chemicals was studied in the laboratory as well as in the Glatt river.

Project description (not exceeding 2000 characters):

Research questions

The main objective of PHENCON was to provide basic information on biotransformation, environmental fate, and effects of phenolic pollutants, such as nonylphenol mixtures, single nonylphenol isomers, bisphenol A, and parabens – information that can be used to improve environmental risk assessments of these compounds for aquatic environments. Technical nonylphenol mixtures are composed of more than 100 isomeric components that share a common general structure but differ in the exact spatial arrangement of the bulky alkyl side chain. This phenomenon is known as the "isomer problem" because biodegradability and biological effects may strongly depend on the exact structural arrangement of the isomers. Other pollutant classes, such as polybrominated flame retardants and PCBs, also show this phenomenon. Here, we intended to investigate the influence of different isomeric structures on metabolism and endocrine disrupting potential.

A detailed field study in the Glatt River watershed aimed at yielding information about concentrations and mass fluxes in wastewaters and in the Glatt River. One goal was to elucidate the rela-

tive importance of the target chemicals and their behaviour in wastewater treatment and in the Glatt River.

Results

Experiments with a bacterial strain that is able to metabolize various nonylphenol isomers showed that the exact chemical structure of the alkyl side chain strongly affects the degradation rate. Isomers with more highly branched side chains are turned over much faster. This unusual finding led to the discovery of a completely novel pathway for the metabolism of alkylphenolic compounds. Furthermore, the detailed mechanism of the degradation pathway was elucidated and the mechanism well explains the effects of the different isomeric structures on the degradation rate.

Degradation experiments with technical nonylphenol mixtures indicated that the relative isomeric composition of such materials will change upon degradation in the environment. Measurements of estrogenic activity with the YES-assay showed that the estrogenic activity of different isomers vary, with the more branched ones being more potent than the less branched or unbranched ones. Together, these two findings indicate that specific potencies of material deposited in the environment might change over time when it undergoes partial degradation - a state of affairs that needs to be further elucidated and taken into account for future risk assessments.

The field measurements provided a detailed picture of the abundancies of the targeted contaminants with 4-nonylphenoxy acid being the most abundant substance. The behaviour of nonylphenolic compounds in municipal wastewater treatment could be thoroughly evaluated and rationalized based on the most important mechanisms being biotransformation processes.

Perspectives

It is planned to further investigate the enzymes of the novel degradation pathway. Especially the initial hydroxylation step is of great importance, because here reactive metabolites with a high potential for cellular toxicity might be formed from substrate analogs.