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New microbes as causative agents of Ibuprofen degradation capabilities in the hyporheic zone of a lowland stream

Cyrus Njeru (1), Malte Posselt (2), Marcus A. Horn (1,3)

(1) Universität Bayreuth, Department of Ecological Microbiology, Bayreuth, Germany, (2) Stockholm University, Department of Environmental Science and Analytical Chemistry, Stockholm, Sweden, (3) Leibniz Universität Hannover, Institute of Microbiology, Hannover, Germany (horn@ifmb.uni-hannover.de)

Ibuprofen is a non-steroidal anti-inflammatory pain reliever and among pharmaceutical residues detected in aquatic environments. Widespread use of the drug and incomplete removal during waste water treatment results in its persistence in effluents and receiving waters. Potential total removal by microbial activity in the hyporheic zone (HZ) of rivers downstream of wastewater treatment plant discharge sites has been hypothesized. Ibuprofen degradation associated microbial communities in are essentially unknown. To address this hypothesis, two sets of oxic HZ sediment microcosms spiked with ibuprofen only (5, 40, 200 and 400 μM), or ibuprofen and 1 mM acetate were set up under laboratory conditions. Ibuprofen degradation in non-sterile relative to autoclaved sediments indicated removal by microbial degradation. Ibuprofen was completely consumed in the absence and presence of supplemental acetate after approximately 11 and 16 days, respectively. Refeeding of ibuprofen and acetate after the first depletion resulted in complete degradation within 24 hours in all treatments. Metabolites of ibuprofen included 1-, 2-, 3-hydroxy- and carboxyibuprofen. Quantitative real-time PCR revealed no pronounced differences in copy numbers of 16S rRNA gene or transcripts between non-spiked controls and treatments. Time resolved triplicate amplicon Illumina MiSeq sequencing targeting the 16S rRNA genes and transcripts revealed increased relative abundances of Proteobacteria, Acidobacteria, Actinobacteria and Firmicutes in treatments with compared to those without ibuprofen. Alpha-, Beta- and Deltaproteobacteria were most active as indicated by RNA based analyses. Enrichment and isolation yielded new Alphaproteobacteria utilizing ibuprofen as sole carbon and energy source. The collective results indicated that (i) HZ sediments sustain efficient biotic (micro-)pollutant removal and (ii) are a reservoir of hitherto unknown microbial diversity associated with such ecosystem services, including the genera Fodinicola, Hyphobacterium, and subgroup 6 Acidobacteria.