PCB Bioremediation: Finally Coming of Age?

Upal Ghosh (University of Maryland Baltimore County, MD USA)
Kevin Sowers, Trevor Needham, and Ray Payne

Background/Objectives. Microbial dechlorination of polychlorinated biphenyls (PCBs) has been reported in numerous studies in the last several decades, but these recalcitrant pollutants have persisted in the environment and continues to impact human health and the ecosystem. The underlying rate limitations of microbial dechlorination is not understood well enough to be able to engineer the process in the field. As a result, ironically, the site where microbial dechlorination was first documented by scientists nearly 40 years ago (Hudson River), had to be cleaned up recently by relocating sediments to a landfill costing several Billion US$.

Approach/Activities. Prediction of microbial bioremediation of PCB contaminated sediments has been challenging due to a lack of understanding of the true kinetic bottlenecks, and the difficulty in measuring the microbial kinetics at environmentally relevant aqueous concentrations. In the present work, we demonstrate a novel approach to measure the intrinsic dechlorination rate with respect to freely dissolved concentration and demonstrate that it is possible to predict the rate of dechlorination in sediments after correctly accounting for the sorption buffering capacity of sediments. The novelty of this approach lies in moving away from past description of microbial kinetics based on PCB concentration in sediment to a freely dissolved concentration basis. We show that for typical PCB-impacted sediments, low abundance of native organisms is the primary bottleneck for PCBs bioremediation which can be circumvented by bioaugmentation.

Results/Lessons Learned. We first demonstrated the proposed approach of bioaugmentation of PCB dechlorinating organisms in laboratory mesocosms with field sediments and followed it with a pilot-scale demonstration at a field site. Treatments with activated carbon (AC) agglomerate bioamended with PCB dechlorinating and oxidizing bacteria decreased the PCB concentration in the top 7.5 cm by up to 52% and the aqueous concentrations of tri- to nonachlorobiphenyl PCB congeners by as much as 95%. Coplanar congeners decreased by up to 80% in sediment and were undetectable in the porewater. The innovative aspects of the technology are: 1) identification of the true kinetic limitation for PCB degradation in sediments, 2) circumventing the threshold PCB concentration for growth by scaling up the organisms without PCBs in bioreactors, and 3) the application of anaerobic organohalide respiring bacteria and aerobic PCB oxidizing bacteria to sediments with a pelleted AC agglomerate as a delivery system. This pilot-scale field study shows the promise of bioremediation as a new strategy to reduce contamination of the aquatic food web from exposure to sediment-bound PCBs.