http://www.aaees.org/e3competition-winners-2015honor-universityresearch.php

2015 Excellence in Environmental Engineering and Science™ Competition Winner

2015 Honor Award - University Research

Development of In-Situ Remediation of Contaminated Sediments with Activated Carbon and Transition to Practice

Entrant: Department of Chemical, Biochemical, and Environmental Engineering, University of Maryland Baltimore County
Engineer in Charge: Upal Ghosh
Location: Baltimore, Maryland
Media Contact: Upal Ghosh, 410.455.8665

Entrant Profile

Dr. Upal Ghosh has MS and Ph.D. degrees in Civil and Environmental Engineering from the State University of New York at Buffalo and a B.Tech.in Chemical Engineering from the Indian Institute of Technology, Bombay. He worked at Carnegie Mellon University and Stanford University before moving to the University of Maryland Baltimore County (UMBC) in 2002 to start his academic career. He is currently a Professor in the Department of Chemical, Biochemical, and Environmental Engineering at UMBC. His group performs research in environmental engineering and science with a focus on the fate, effects, and remediation of toxic pollutants in the environment. They apply multidisciplinary tools to investigate exposure and bioavailability of organic and metal pollutants to organisms and use this new understanding to develop novel remediation technologies and site-specific remediation goals. Recent projects have focused on pollutants such as PCBs, PAHs, pesticides, dioxins, and mercury. A recent innovation from Dr. Ghosh's lab is the development of an in-situ sediment remediation technology using activated carbon amendment to sediment. The technology has been transitioned to the field through a novel patented delivery technology names SediMite™ which has been commercialized though a startup company named Sediment Solutions. Dr. Ghosh also serves as the President of Sediment Solutions.

This research effort has been made possible through collaboration with several individuals:

1. Graduate students at UMBC: Hilda Fadaei Khoei and Eli Patmont
2. Research collaborators: Charles A. Menzie, Allen Place, Richard W. Greene, and John Cargill

Project Description

Introduction

Traditional approaches for remediation of contaminated sediments include dredging and capping which are disruptive of the natural ecosystem, often do not achieve risk reduction goals, and can be expensive. This research developed and demonstrated a novel in-situ management approach for contaminated sediments that is based on reducing pollutant bioavailability. While, the transition into the field is a culmination of several years of work carried out by Dr. Ghosh, graduate students, and several collaborators, the focus of this award application is the recent research effort at UMBC that: 1) demonstrated for the first time in the laboratory and in the field that in-situ treatment of sediments can reduce uptake of bioaccumulative pollutants in fish, and 2) developed and demonstrated in the field an innovative engineering approach to deliver in-situ treatment amendments for contaminated sediments. The key findings are summarized in this project description with detailed results described in the supplemental research report.

Background

Aquatic sediments form the ultimate repositories of past and ongoing discharges of hydrophobic organic compounds (HOCs) such as PCBs, PAHs, many pesticides, dioxins, as well as mercury and methylmercury. Uptake of HOCs by aquatic or benthic organisms is complex and depends on the bioavailability of contaminants in sediment, which is controlled by how strongly the contaminants are bound to the sediment particles. Novel research by Dr. Ghosh has demonstrated that the natural binding of pollutants in sediments can be greatly enhanced by the addition of strong sorbents such as activated carbon (AC) into sediments. Laboratory tests with a range of field sediments showed that AC amendment in the range of 2-5% reduces equilibrium porewater concentration of PCBs, PAHs, DDT, dioxins, and furans in the range of 70-99%, thus reducing the driving force for the diffusive flux of HOCs into the water column and transfer into benthic/aquatic organisms. Most of the studies using benthic organisms show a reduction of biouptake of HOCs in the range of 70-90% compared to untreated control sediment (Ghosh et al. 2011).

Key Results from Laboratory and Field Studies

While our past work demonstrated how AC amendment to sediment reduces bioavailability to benthic organisms, there is limited experimental or modelling assessment of how bioavailability changes in sediments impact bioaccumulation in fish - the primary risk driver for exposure to humans and top predators in the aquatic ecosystem. In the present study supported by the NIEHS Superfund Research Program, we performed laboratory aquaria experiments and modeling to explore how PCB sorption in sediments impacted exposure pathways and bioaccumulation in fish. Results showed that total porewater PCB concentration in impacted sediment was reduced by 99% upon amendment with 4.5% powdered AC. The amendment did not change PCB concentration in sediment, but reduced the PCB uptake in fish by 87% after 90 days. Freely dissolved concentrations, measured by passive sampling, were incorporated in equilibrium and kinetic bioaccumulation models for predicting uptake by fish. Uptake prediction with the kinetic model was generally within a factor of 2 compared to observed values for dominant PCB congeners. Our results indicate that by tracking changes in freely dissolved porewater and overlying water PCB concentrations, it is possible to predict effectiveness of sediment remediation in reducing PCB uptake in the food chain, including fish. These laboratory studies and modeling results have been instrumental in building the scientific basis for activated carbon

amendment as a new technology for management of contaminated sediments (Patmont et al. 2014) and has led to the consideration of this technology in the USEPA proposed remedial action for the Superfund site in Housatonic River (EPA 2014).

Another important aspect of the research involved scaling up and transitioning the technology to the field in partnership with practitioners. In collaboration with Dr. Charles A. Menzie we developed a low-impact delivery technology for activated carbon amendment to sediments. AC is a highly porous material with a low bulk density and application to sediment through the water column is challenging due to the potential of the carbon to be entrained and washed away during application. The research was able to address this challenge by blending AC with sand and clay to make engineered pellets named SediMite™ (www.sedimite.com) that has sufficient strength and density to be handled in bulk and deployed through water. The material composition allowed the pellets to slowly disintegrate in sediments over days and get incorporated by natural mixing processes. This work has led to a US patent (#7,824,129) and is being demonstrated in several pilot-scale research projects funded by the DoD, NIEHS, and private industry. As part of the technology transition effort, Dr. Ghosh and Dr. Menzie co-founded a small business named Sediment Solutions that has licensed the technology and has produced and marketed the product in bulk for full-scale field applications. Sediment Solutions recently worked with partners to implement the first full-scale application of the SediMite™ technology in a 5-acre lake in Dover, DE, in Nov 2013. The successful application of SediMite™ in the lake has resulted in a reduction of PCB concentration in sediment porewater, the water column, and in the fish based on monitoring performed in 2014 by UMBC.

This research program has been successful in transitioning fundamental understanding of pollutant bioavailability into an innovative application for sediment remediation. In-situ remediation with AC amendment provides several advantages over traditional remediation methods, including less disruption to benthic habitats in sensitive rivers and wetlands, amenability to shallow or constricted locations, and potential for much lower cost.

Refererences

1. Ghosh, U., Luthy, R.G., Cornelissen, G., Werner, D., Menzie, C.A., 2011. In-situ sorbent amendments: A new direction in contaminated sediment management. Environ. Sci. Technol. 45, 1163-1168.
2. Patmont, C, U. Ghosh, et al. 2014. In Situ Sediment Treatment Using Activated Carbon: A Demonstrated Sediment Cleanup Technology. In press. Integr Environ Assess Manage.
3. USEPA 2014. Statement of Basis for EPA's Proposed Remedial Action for the Housatonic River "Rest of River" Region 1 Report.