GREAT LAKES LEGACY ACT SEDIMENT REMEDIATION RESEARCH

Evaluation of Sorbents (Organoclay and Activated Carbon) as Active Cap Materials to Remediate Contaminated Sediment Sites

Introduction

Great Lakes contaminated sediment sites contain elevated concentrations of contaminants of concern (COCs): organic compounds and heavy metals. Organic COCs include primarily polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). Contaminated sediments pose long-term risks to the ecosystem and humans because they are a sink for large quantities of contaminants that remain long after the source of pollution has been removed. Over time, these hazardous compounds are released into the sediment porewater and overlying water column providing exposure to humans and wildlife. Benthic organisms living in and around the sediment are then able to uptake the contaminants. These organisms are at the bottom of the food chain and pass the COCs up the food chain where the COCs bioaccumulate, causing further ecological and human health concerns.

This factsheet is one of a series on the collaborative research efforts of EPA's Office of Research and Development (ORD) and Great Lakes National Program Office (GLNPO), the USACE Engineer Research and Development Center (ERDC), the University of Texas, Purdue University, and Tetra Tech EMI. This research supports the Great Lakes Legacy Act (GLLA) and its mission of cleaning up the most polluted areas in the Great Lakes.

This factsheet provides a brief summary of the evaluation of active capping technology that has the potential to reduce the exposure of humans and wildlife to contaminants of concern (COC) associated with contaminated sediment areas.

Contaminated sediments often cover large areas, and may be difficult to dredge, requiring consideration of a sediment cap. Sand caps provide a barrier to the release of contaminants and physical stability to sediment particulates. They are effective in many situations, but do not actively bind many of the COCs. A recent study was conducted to provide information on materials that can be used that are "active" in further minimizing transport of underlying COCs in porewater to the bioactive zone and water column, thus into food webs.

Activated carbon (AC) and organoclays (OC) are the two most common sorbents used in active sediment caps. OC is manufactured by replacing cations in layered clays, with cationic organic compounds, such as quaternary ammonium compounds (QACs), to create an organic phase along the surface of each layer in the molecular lattice. AC is composed of black granules of coal, wood, nutshells, or other carbon-rich materials. Contaminants sorb (stick) to the granules and are removed from the water. Both AC and OC can remove multiple contaminants from water solutions but their performance, cost, and removal mechanism are different. The AC removal method occurs by surface sorption, followed by diffusion into internal pores, whereas the OC removal method occurs by partitioning of the COCs into the clay interlayer space. Sorption effectiveness is typically reported as a partitioning coefficient (Kd). Cap models that are used to predict cap effectiveness use Kd as an important input variable.

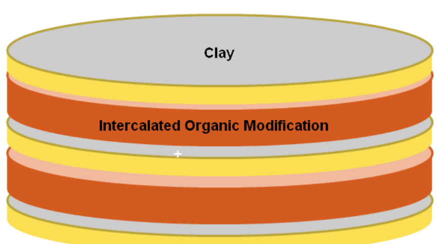
Methods

This project evaluated the performance of both AC and OC for removing various COCs, using laboratory-simulated sediment pore water as well as pore water from 5 GLNPO sites. The AC and OC performance evaluation involved bench-scale adsorption isotherm testing. An adsorption isotherm is the relationship between the amount of adsorbate (contaminant) on the adsorbent (AC or OC) as a function of COC concentration at a constant temperature. Isotherm testing was performed to evaluate portioning coefficients (Kd), kinetics, and pore water matrix effects (colloids, oil).

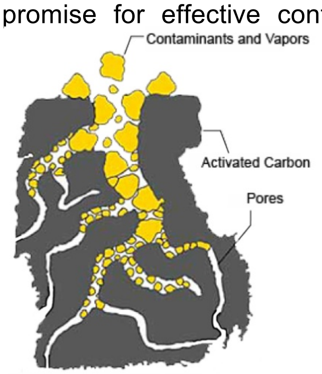
Results

Containment potential of the active cap material was contaminant-specific. The AC exhibited higher partitioning coefficients (Kd's) than OC for soluble organic PAHs such as benzene, toluene, napthalene, and chlorobenzene than OC. OC showed advantages over activated carbon for containment of NAPLs. The AC and OC had similar Kd's for less soluble non-aqueous phase liquids (NAPLs). The performance of AC was affected by interference substances such as pore water colloidal material and the presence of an oil phase, indicating that the sorption mechanisms of OC and AC are fundamentally different. The AC and OC performance for heavy metals depended upon the specific targeted metal.

The selection of a sorbent should not be strictly dependent upon sorption effectiveness (Kd). Low cost, weakly sorbing materials may exhibit a better cost/performance ratio than high cost strongly sorbing materials. The use of these materials at large contaminated sediment sites requires materials that are available in large volume and where use at these sites would not appreciably increase demand or price of the material. An effective cap or sediment amendment material should have appropriate physical chemical properties (such as sorption capacity, bulk density, shear resistance, and other properties). Since AC sorption is subject to interference, multiple layered cap designs with different sorbent material should be considered. This study showed that mixed caps of both sand and active sorbents like AC or OC also show promise for effective containment of sediment contaminants.



Organoclay capping material is layered and contaminants partitioned between the clay layers.



Contaminants initially sorb to the outer surface of AC particles, and then diffuse into the pores in these particles.

Impacts

Appropriate selection of cap material is necessary to effectively lower the risk to humans and wildlife from COCs in sediments. The interaction of COCs with capping materials is complex and each site is unique. Capping of large areas of sediments is expensive, so choosing the right materials is even more critical. Studies like this one provide guidance in choosing an effective, affordable capping material. With an accurate assessment of the

COCs present at a site, the information provided in this study can be used to choose cap materials that will maximize protection of human and ecological health and minimize costs.

References

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Yeardley, R.B., E.F. Barth, and D. Timberlake. 2011. Innovative Capping Technology to Prevent the Migration of Toxic Chemicals from Contaminated Sediments. EPA/600/F-11/009. U.S. Environmental Protection Agency.

For Further Information

- **http://epa.gov/greatlakes/aoc/torchlake/index.html**
- **http://www.erdc.usace.army.mil/**
- **http://www.epa.gov/nrmrl/**

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