Long Term Monitoring of Activated Carbon Amendment to Reduce PCB Bioavailability in Sediments at an Active Shipyard: ER18-5079

Gunther Rosen[1], Bart Chadwick[2], Jason Conder[3], Meg Jalalizadeh[3], Alice Wang[3], Jay Word[4]

[1]Naval Information Warfare Center Pacific, San Diego, CA; [2]Coastal Monitoring Associates, San Diego, CA; [3]Geosyntec Consultants, Huntington Beach, CA; [4]Ecoanalyts, Inc., Port Gamble, WA, USA

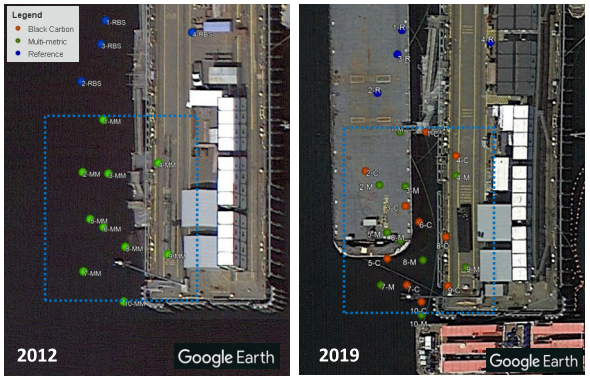
INTRODUCTION

This project focused on long-term performance of an activated carbon (AC)-based amendment (AquaGate+PAC™) that was placed in 2012 on sediments adjacent to Pier 7 at the Puget Sound Naval Shipyard & Intermediate Maintenance Facility (PSNS & IMF) towards validation of the sequestration of polychlorinated biphenyls (PCBs). The placement and earlier monitoring were supported under ESTCP project ER-201131, which was awarded ESTCP Project of the Year in 2016.

Under this follow on project, demonstration of long term (~7 year) stability and effectiveness of the amendment, and potential impacts to benthic ecological resources, were evaluated. This 82-month post placement monitoring, conducted in 2019, involved a range of physical, chemical, and biological parameters using a suite of largely *in situ* technologies, modelled primarily on ER-201131, with additional characterization of the remaining presence of the amendment. The primary benefits of this project were to build scientific, stakeholder, and regulatory confidence in the long-term persistence of AC amendments as an effective, safe, and long-term approach towards in situ remediation of moderately contaminated sediments, particularly under relatively deep-water or otherwise challenging conditions (e.g. adjacent to or under pier areas) within active DoD harbors.

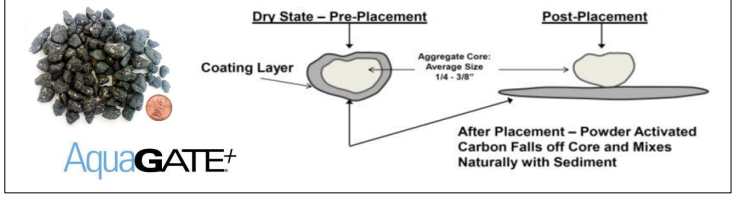
SITE DESCRIPTION

Puget Sound Naval Shipyard and Intermediate Maintenance Facility (PSNS&IMF), Pier 7, Bremerton, WA, USA



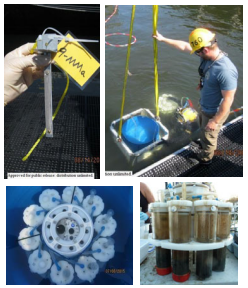
- Amended area
- Multi-metric Stations (2012-2019)
- Additional stations for black carbon (2019)
- Benthic reference locations (2012-2019)

TECHNOLOGY DESCRIPTION - AC AMENDMENT



TECHNOLOGY DESCRIPTION – MONITORING TOOLS

PCB Bioavailability

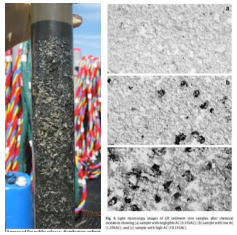


(Above) Bioavailability of PCBs are being assessed using both *in situ* bioaccumulation approaches (e.g. SEA Ring technology; (Rosen et al, 2017; ER-201130) and passive sampling with Solid-Phase Microextraction (e.g. Kirtay et al. (2017); ER-201131)

Activated Carbon Presence

(Below) Black Carbon, which reduces contaminant bioavailability more than other types of organic matter, was quantified using chemical oxidation[1] and petrographic carbon[1] methods from cores for lateral and vertical characterization of AC presence

[1]Grossman and Ghosh, 2009
[2]Ghosh et al., 2003



Benthic Community

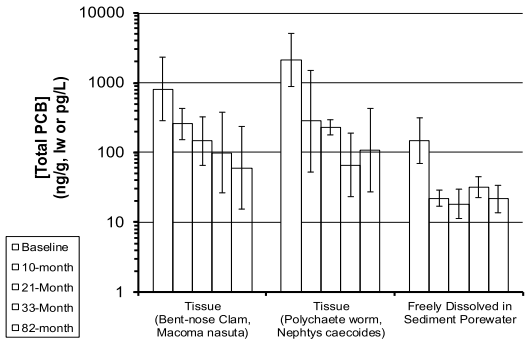
(Above) Benthic census (common present shown) assessment at 10 stations in the amended area and 4 reference stations

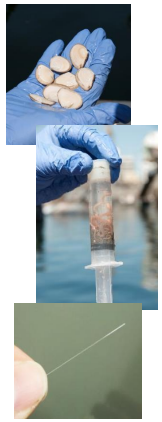
Metrics include:

- Total Abundance
- Shannon-Wiener (H')
- Taxa Richness
- Pielou's J' Evenness
- Swartz's Dominance Index
- Abundance of the Five Most Abundant Taxa

RESULTS - BIOAVAILABILITY

2012 – 2019 Availability

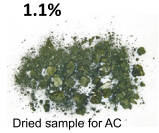




RESULTS – BLACK CARBON PRESENCE

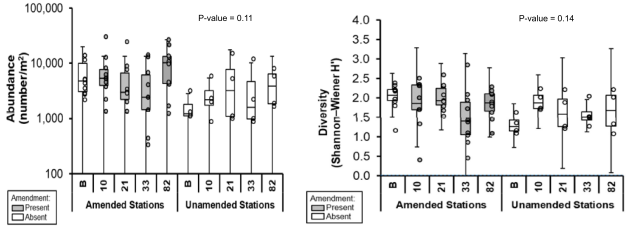
Aggregate Present	TOC (EPA Lloyd Khan Method)			Black Carbon[1] (Grossman and Ghosh 2009)			Activated Carbon[2] (Carbon Petrography)		
	n	Average	SD	n	Average	SD	n	Average	SD
Samples with Aggregate	56	2.9%	1.7%	58	1.3%	1.2%	26	1.3%	0.9%
Samples with No Aggregate	32	2.6%	1.4%	30	0.3%	0.2%	6	0.3%	0.2%
Overall					**1.0%**			**1.1%**	

(Above) Summary of Total Organic Carbon, Black Carbon (Chemical Oxidation), and Activated Carbon (Petrography) from up to 88 samples characterizing lateral and vertical presence of material at 82-months. Aggregate was a good indicator of presence of AC. Overall, chemical oxidation and petrography results were similar, and BC/AC presence at 82-mo was 1.0 to 1.1%, which was not statistically different from Baseline concentrations.



Dried sample for AC analysis with aggregate

RESULTS - BENTHIC COMMUNITY ANALYSIS



(Above) Example benthic community indices at amended and unamended stations from 2012-2019. As with other indices, no statistical differences relative to baseline or unamended stations, except one reference location (not shown) at T=82 mo which showed enhanced taxa richness in the amended area.

SUMMARY AND KEY POINTS

- Multiple monitoring technologies were used to assess long-term persistence of an activated carbon (AC) amendment 82-months post placement.
- Monitoring approach consistent with multiple lines of evidence approach used in ER-201131 (Kirtay et al. 2017), with greater sampling intensity (both lateral and vertical) of BC and AC in surface sediments using chemical oxidation and carbon petrographic methods.
- PCB availability continued to be statistically lower than baseline concentrations based on clam and polychaete tissue, and porewater concentrations.
- Activated carbon presence was tied to presence of aggregate, and results from chemical oxidation and carbon petrography were comparable.
- Use of carbon petrography could be a good baseline measurement at sites where activated carbon treatment is planned and native presence is unknown.
- Continued lack of differences among multiple benthic community indices suggests no long-term adverse effects associated with the amendment.

REFERENCES

Ghosh et al., Environ. Sci. Technol. 2003, 37, 2209-2217.
Grossman A, Ghosh U, 2009. Measurement of activated carbon and other black carbons in sediments. Chemosphere 75: 469-475.
Kirtay V, Conder J, Rosen G, Magar V, Grover M, Arblaster J, Fetters K, Chadwick B, 2018. Performance of an in situ carbon treatment to reduce PCB availability in an active harbor. *Environ. Toxicol. Chem.* 37:1767-1777. https://doi.org/10.1002/etc.4121.
Rosen G, Chadwick DB, Colvin M, Stransky C, Burton A, Radford J, Bailey H, Cibor A, Grover M, Greenberg M, 2017. Demonstration and commercialization of the Sediment Ecosystem Assessment Protocol. Space and Naval Warfare Center Pacific Technical Report #3052, for the Department of Defense's Environmental Security Technology Certification Program, January 2017. 278pp. http://www.dtic.mil/dtic/tr/fulltext/u2/1031479.pdf

ACKNOWLEDGEMENTS

Molly Colvin, Joel Guerrero, Nick Hayman, John Frew (NIWC Pacific), Trevor Richardson (PSNS&IMF), John Collins (AquaBlock), Katie Kowal (SDSU Research Foundation), Brian Hester (Ecoanalysts), and multiple others from the above affiliations.

Approved for Unlimited Distribution (Dist A). Presented (Virtual) at the DoD's SERDP & ESTCP Symposium 2020: Enhancing DoD's Mission Effectiveness, Washington, DC (Virtual), December 1-4, 2020.
This project is funded by ESTCP under project ER18-5079, with leveraged funding provided by Phil Nenninger, NAVFAC NW. Principal Investigator/POC: rosen@spawar.navy.mil