SMWG Sediment Management Work Group

SWMG meeting – 03/26/2024

Washington, D.C.

Laboratory scale evaluation of combining advanced oxidation process with sediment stabilization for beneficial use in construction

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US Army Corps of Engineers
Engineer Research and Development Center

TIPPING POINT RESOURCES GROUP

Project Team

Member	Organization	PIs/Student- Responsibilities
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Background & Study Motivation

- Disposal of dredged sediment can be expensive
- Strategies that can make sediment amenable for beneficial use is needed
- Advanced Oxidation Process (AOP) treatment have shown potential to destroy PoPs
- Studies on AOP efficacy for treating PoPs in contaminated sediment is limited

<u>Hypothesis testing</u>

Optimized AOP treatment can significantly reduce PoPs in sediment thereby reducing disposal risks (including material handling) & making beneficial use of such sediment feasible meeting a regulatory criteria.

AOP – literature review

- Chemical based AOP – Hydroxyl (•OH), persulfate (SO_4^{-}•) and permanganate (MnO_4^{-}) treatment
  - Iron (Fe2+/Fe(0)) based activation of H2O2 (Fenton) and $S_2O_8^{-}$/SO_5^{2-} common strategy employed for •OH and SO_4^{-}
  - Most studies focused on wastewater and soils – limited on sediments
- Optimize treatment conditions
  - Removal dependent on oxidation type, dosage (e.g., 10^2:1 to 10^6:1 Oxidant/PAH), TOC, DOC, activator type (Fe based vs. heat/light/high pH), presence of C based sorbents, etc.
- Evaluate treatment efficacy and potential byproducts for variety of contaminants
  - 2-ring PAHs showed lower removal efficiency while >2 ring removal were comparable– one study showed inconsistent removal among individual PAH for same ring #
  - PCB removal dependent on # and position of Cl with better removal rates for lower PCB homologs
    - Zero-valent Iron (ZVI)/nZVI used for activating •OH and SO_4^{-}• based AOP may induce synergistic effect through de-chlorination
    - Potential dioxin/PFAS formation from precursors should be assessed
  - Byproducts of PAH-AOP treatment include alcohols, aliphatic acids, quinones that may be amenable for further microbial degradation

Objectives & Tasks

I. Evaluate the use of ex-situ advanced oxidation process (AOP) through laboratory experiments with and without sorbent to test the hypothesis that AOP shall reduce the risks associated with contaminated sediments

II. Evaluate feasibility of AOP treated sediment to stabilization using binding materials (e.g., Portland cement) for beneficial use in the construction and maritime industries.

III. Perform theoretical techno-economic assessment which includes evaluating multiple cost-benefit application scenarios

Task-1: Sediment screening to target high risks contaminated sites.

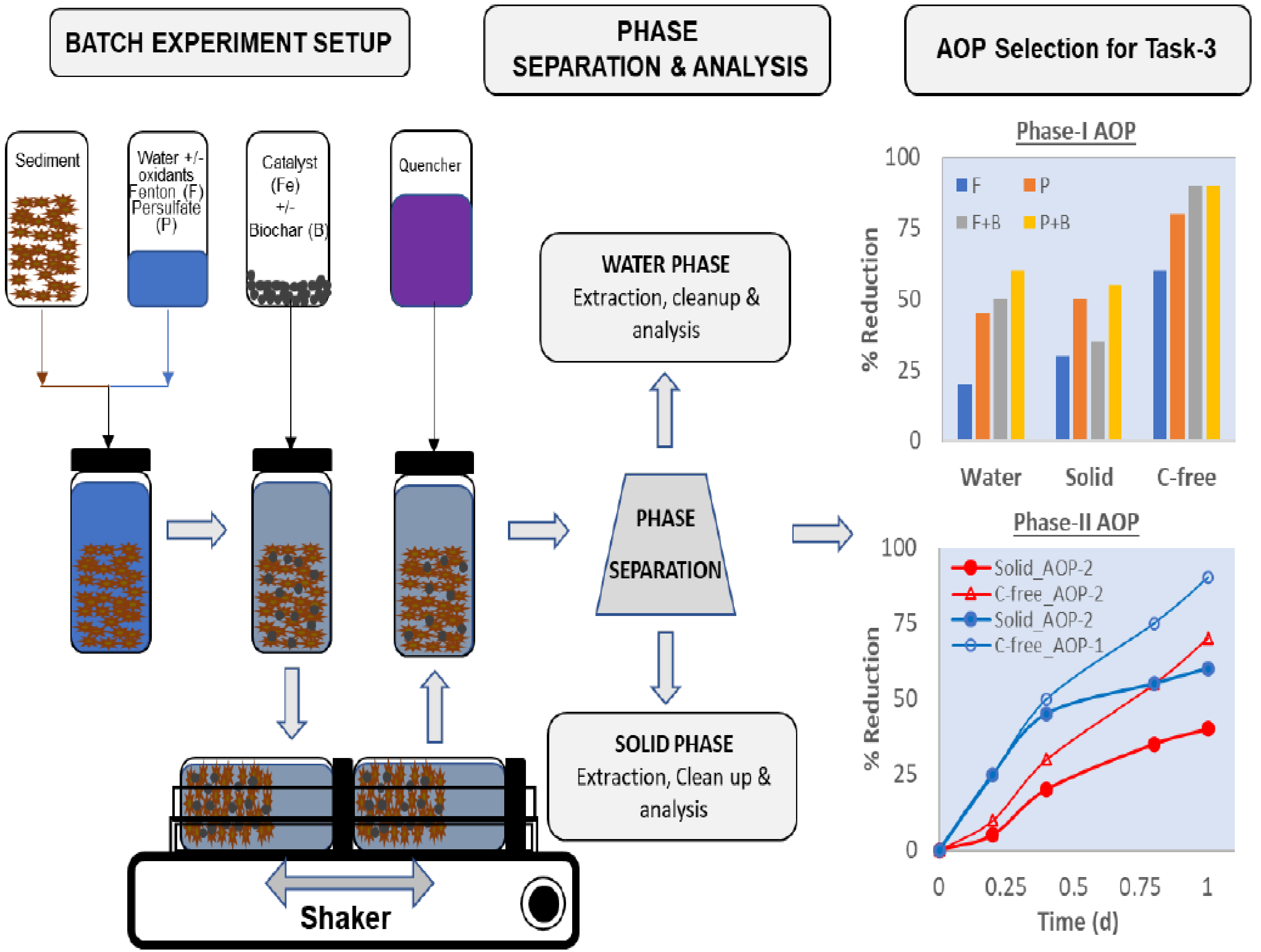
Task-2: Laboratory scale experiments to optimize AOP and sorbent parameters.

Task-3: Performance evaluation of AOP treated vs. untreated sediments for stabilization.

Task-1: Sediment screening

- Comprehensive characterization of sediment
  - Solid/porewater - PoPs & metals
  - TOC, BC, DOC, pH & anions
  - Particle size distribution (PSD)

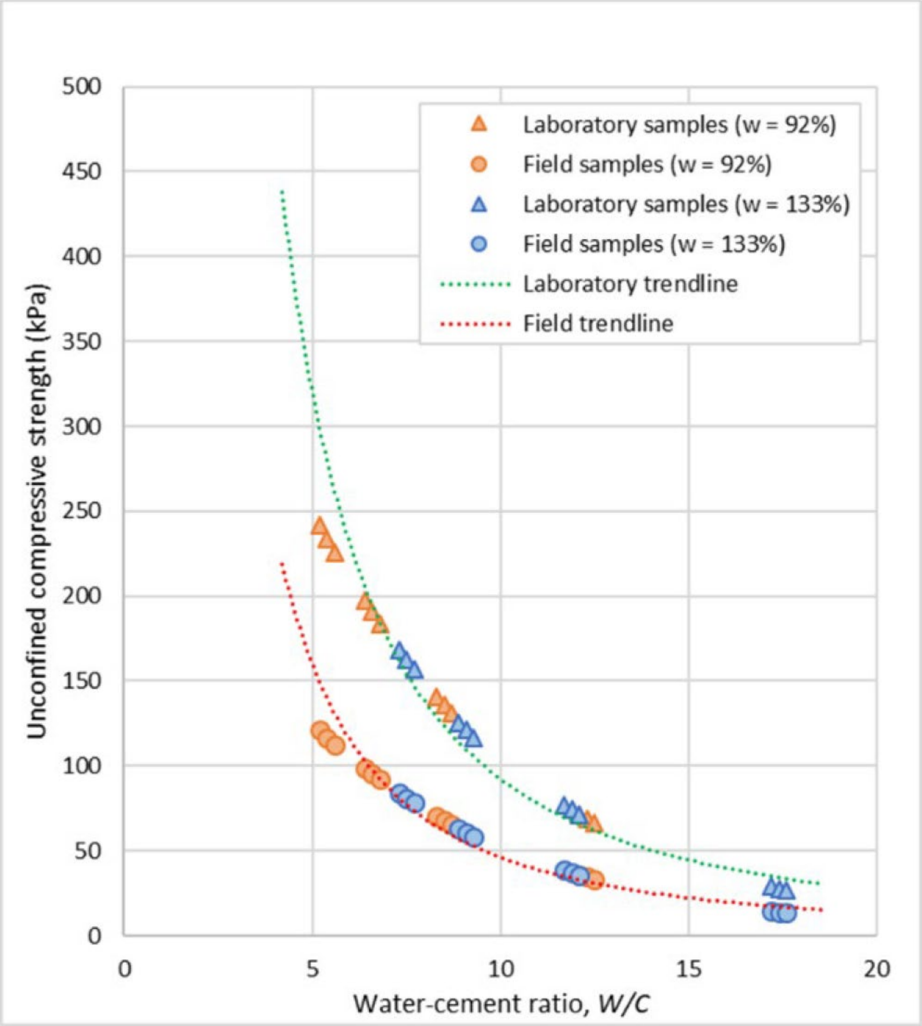
Task-2: Sediment Treatment



- Evaluate Fenton, persulfate and permanganate oxidation process for PoPs destruction
- Compare metal and residual PoP availability post-treatment
- Potential for volatile loss of CoCs during treatment
- Select 'best' performing treatment/s for task-3

Task-3: Treated Sediment Stabilization

- Select set of optimally treated sediments will undergo stabilization/solidification
- Bench-scale test to develop binder rating curves comparing stabilized sediment to water/cement ratio
- TCLP and SPLP test on stabilized sediment



Schedule & Deliverables

Tasks	2023		2024												2025					
	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
1. Sediment screening																				
2. AOP experiments																				
3. Stabilization experiments																				
Deliverables/Report	a				b				c		d			c						e

Monthly project meetings with ERDC presonnel to update project progress

a Project FACT sheet & Story board
b Sediment Workshop in DC
c Interim Technical report/Peer-reviewed paper
d go/no-go decision - represented by red star
e final report

Task-1: Sediment screening

Sediment	Description
Indiana Harbor	Confined Disposal Facility
Newtown Creek, NY	Old industrial- coal tar sites
Brooklyn Naval Yard	Combined Sewer Outflow
Bayway Creek, NJ	d/s of Bayway Refinery
Newark Bay, NJ	Dioxin impacted site

Results so far…

mg/kg-dry sediment

Locations	TOC (%)	pH	Cr	Mn	Ni	Cu	Zn	Cd	Pb	As	Ag	Co	Fe
Indiana Harbor R1	13.4	7.4	663	2023	89	293	4263	10.20	739	83	3	7	221034
											J		E
			>ERM	NA	>ERM	>ERM	>ERM	>ERM	>ERM	>ERM			
Newtown CR-S	19.6	6.0	1167	237	800	3488	6084	203	1623	68	31	19	39439
			>ERM	NA	>ERM	>ERM	>ERM	>ERM	>ERM	>PEL			
Newtown CR-F	18.9	5.9	1236	248	830	3627	6451	214	1676	72	30.0	19.5	42146
			>ERM	NA	>ERM	>ERM	>ERM	>ERM	>ERM	>ERM			
Newark Bay D	3.0	6.7	94	441	35	104	223	0.55	105	13	1.6	9.1	33826
								J		J	J		
			>TEL	NA	>TEL	>TEL	>TEL	<TEL	>TEL	>TEL			
Newark Bay K	3.1	6.9	96	448	36	104	226	0.58	106	14	1.6	9.4	34920
								J		J	J		
			>TEL	NA	>TEL	>TEL	>TEL	<TEL	>TEL	>TEL			
Bayway Creek CR-P	8.3	6.8	122	396	41	479	524	2.48	747	56	1.7	9.8	33644
											J		
			>TEL	NA	>TEL	>ERM	>ERM	>TEL	>ERM	>PEL			
Bayway Creek CR-X	8.3	6.1	127	422	43	498	566	2.51	756	59	1.7	9.9	34503
											J		
			>TEL	NA	>PEL	>ERM	>ERM	>TEL	>ERM	>PEL			
Brooklyn Naval Yard W	6.7	6.5	87	409	42	200	474	3.49	166	14	2.3	11.4	43892
										J	J		
			>TEL	NA	>TEL	>PEL	>ERM	>TEL	>PEL	>TEL			
Brooklyn Naval Yard N	6.2	6.7	74.1	384.9	35.4	168.6	413.4	2.1	148.5	12.5	1.9	10.1	40561.1
										J	J		
			>TEL	NA	>TEL	>PEL	>PEL	>TEL	>PEL	>TEL			

TEL: Threshold effective level, PEL: Probable effective level, ERM: Effective median range (NOAA sediment screening values)

- High trace metal in bulk
  - High Fe – implications to AOP
- ΣPAH-18: 15-250 mg/kg* (*estimates)
- Complete characterization ongoing

Ongoing work

- *Task-1 – sediment screening:*
  - *Pending characterization: PCBs, Dioxins, Hg, Fe(II), PSD, PFAS and porewater*

- *Task-2 – Sediment AOP treatment: Initiated in March; expected completion September*

- *Task-3: Expected initiation – October 2024*

Select References

1. Arreola, Diana, et al. "Dredged Material Decision Tool (DMDT) for Sustainable Beneficial Reuse Applications." Journal of Marine Science and Engineering 10.2 (2022): 178.
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4. Quiroga, J. M., A. Riaza, and M. A. Manzano. "Chemical degradation of PCB in the contaminated soils slurry: Direct Fenton oxidation and desorption combined with the photo-Fenton process." Journal of Environmental Science and Health Part A 44.11 (2009): 1120-1126
5. Vallejo, M., San Román, M. F., Ortiz, I., & Irabien, A. (2015). Overview of the PCDD/Fs degradation potential and formation risk in the application of advanced oxidation processes (AOPs) to wastewater treatment. Chemosphere, 118, 44-56.
6. https://frtr.gov/matrix/Dredged-Material-Processing-Technologies/#Cost

QUESTIONS?