Assessing the Effectiveness of Reactive Amendment Protective Capping (RAPC) at Reducing the Mobility of Arsenic and Mercury in Wetlands Impacted by Historical Gold Mine Tailings

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BACKGROUND

- Historical gold mining in NS took place between 1860's to 1940's.
- Mining waste (tailings) contaminated with mercury (Hg) and arsenic (As) was deposited in wetland areas close to the mines, a legacy which still exists across Nova Scotia (1).
- Sediment at some of these sites is still toxic to sensitive organisms, and contaminants are bioaccumulating (2,3).
- Studies have shown success in reducing the mobility, toxicity, and availability of arsenic and mercury through the application of reactive amendments, like zero valent iron (ZVI) (3).
- Chemically active capping provides higher sorptive capacities and reduces the capping thickness needed for risk management (3).
- The purpose of this project is to assess the effectiveness of our reactive amendment (ZVI) and protective capping (RAPC) at reducing the mobility of arsenic and mercury in the sediments, as well as the overlying water column.

METHODS

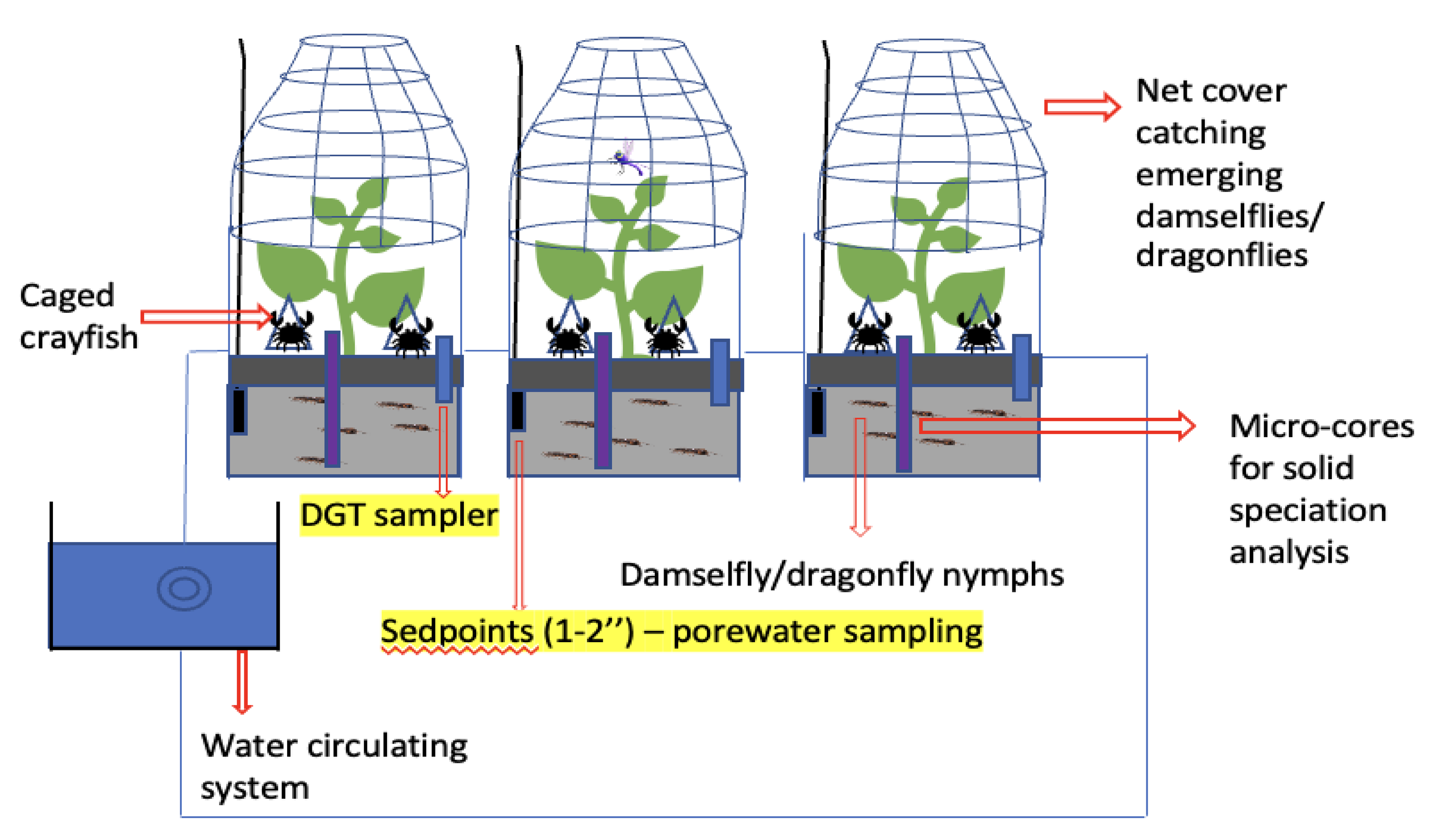

Figure 1: Bucket mesocosm setup including placement of porewater samplers and DGT devices.

- Montague Gold Mines (Old Stamp Mill wetland) and Waverley Gold Mines (Muddy Pond wetland) are the two primary sites.
- 12 replicates from each site consisting of ~20 cm of sediment topped with freshwater were collected in five-gallon buckets.
- The buckets were divided into 4 treatments with 3 replicates each: (1) control (untreated), (2) thin layer of reactive amendment (RA - ZVI); and (3) a thin layer of RA with 2.5 cm of protective capping (sand, bentonite, zeolite); (4) and a thin layer of RA with 5 cm of PC.
- Sediment left exposed to RAPC for 16 weeks in parallel with ecotoxicology and bioaccumulation work described elsewhere (Fig. 1).

Diffusive Gradients in Thin Films (DGT)

- Our objective was to assess a 15-cm gradient in sediment of As(III), total Hg, and MeHg concentrations, including the 5-cm of overlying water.
- LSPB-AP DGT (DGT Research Ltd, UK) were deployed in all buckets for the last 4 days of the 16-week experiment (Figure 2).
- Exposed DGT resins cut into 5-cm sections (Figure 3 & 4).
- Each 5 cm section further divided into 3 cm for MeHg, 1 cm for Hg, and 1 cm for As(III) analysis (Figure 4).

Figure 2: Insertion of DGT device

Figure 3: Removal of resin section from DGT screen.

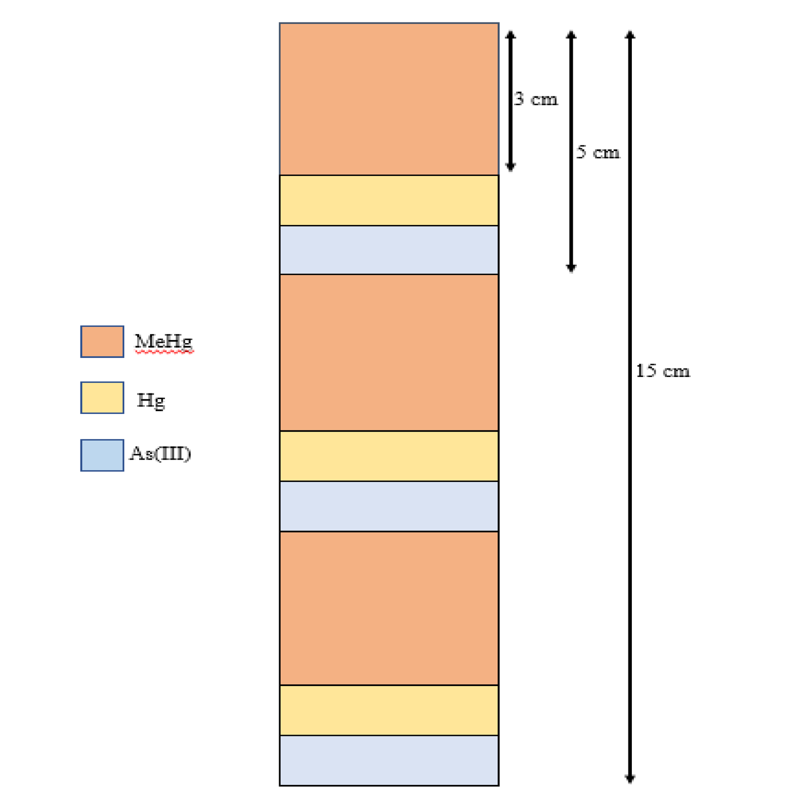

Figure 4: Analyte sections from DGT resin for MeHg, Hg, and As(III).

Porewater & Surface Water

- Porewater extracted using SedPoints (M.H.E Products Ltd., USA)
- Sampling events took place in the first and last week of the 16-week experiment.
- Analyses included dissolved As, As(III), dissolved Hg, dissolved organic carbon (DOC), and MeHg (last week only).

Figure 5: SedPoint screen.

Figure 6: Tip of SedPoint with black vinyl cap after insertion into bucket.

PRELIMINARY RESULTS

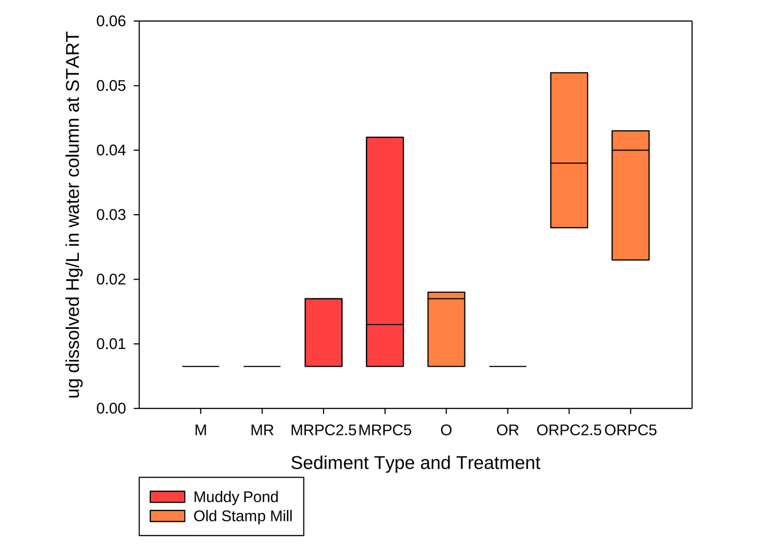

Figure 7: Dissolved mercury concentrations in water columns for bucket sediment & treatment type in week 1 of experiment.

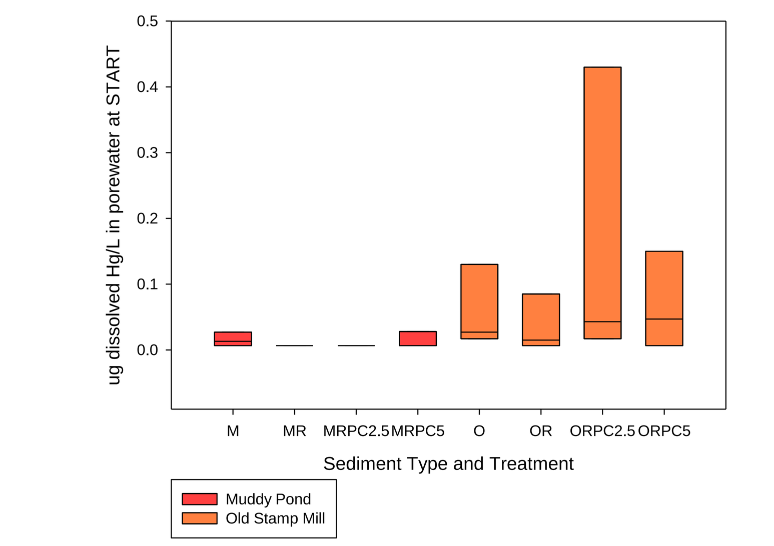

Figure 8: Dissolved mercury concentrations in porewater for bucket sediment & treatment type in week 1 of experiment.

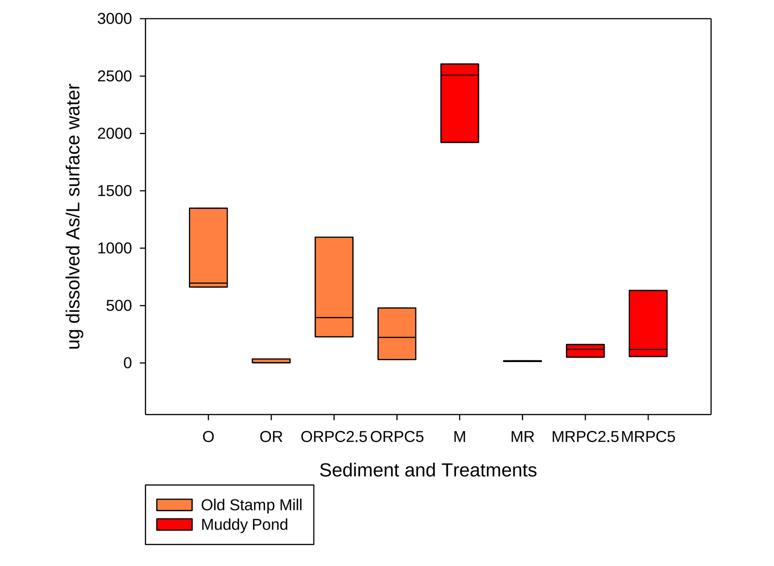

Figure 9: Dissolved arsenic concentrations in water columns for bucket sediment & treatment type in week 1 of experiment.

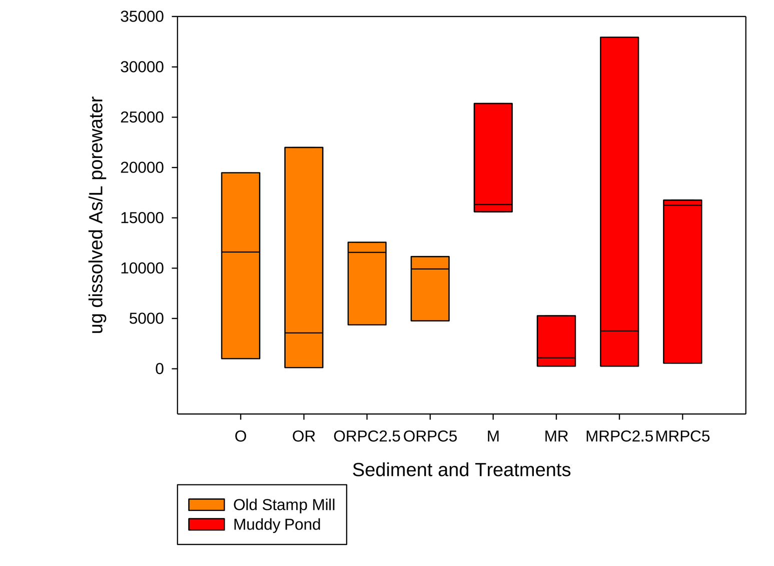

Figure 10: Dissolved arsenic concentrations in porewater for bucket sediment & treatment type in week 1 of experiment.

- **Muddy Pond (M) sediment**: treatments with reactive amendment only (R), as well as treatments with reactive amendment and protective capping (RPC2.5 and RPC 5) all showed significantly lower concentrations of dissolved As in the overlaying water column at start (Figure 9).
- **Old Stamp Mill** (O) sediment: At the start of the experiment, for the treatment with reactive amendment only (R) showed significantly lower concentrations of dissolved As in the overlaying water column (Figure 9).
- In both sediment experiments (M and O), dissolved Hg in the water column and porewater were not impacted significantly by treatments, but dissolved Hg in the water column appears associated with DOC.

References:

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Acknowledgements:

- Atlantic Mining Nova Scotia (AMNS)
- DEEHR Research Group, Saint Mary's University
- Jessica Younker (ENVS Technician, Saint Mary's University)
- William Bennet (Griffith University, Australia)