Negative impacts observed with sediment samples and macroinvertebrate communities from the East Branch of the Little Calumet River

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Evaluating toxicity of sediments from the Little Calumet River, Indiana

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Introduction

- The East Branch of the Little Calumet River (EBLCR), located in Porter County, Indiana flows through Indiana Dunes National Park before entering Lake Michigan.
- Limited data from the EBLCR and Burns Waterway system had indicated a depauperate benthic invertebrate community while limited evidence from Qualitative Habitat assessments were not explanatory (Morris and Simon 2011).
- Ammonia and metals have been identified as potential contaminants of concern in this section of the river.
- The objectives of the study were to evaluate sediment toxicity and macroinvertebrate communities at 12 sites of the EBLCR (Figure 1), and to support the development of concentration response relationships between sediment chemistry and sediment toxicity.

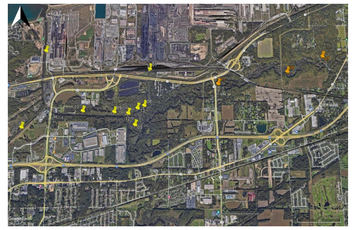

Figure 1. Location of 12 sampling sites from the Little Calumet River study area in northern Indiana. Orange pins mark reference sites.

Methods

- Sediments were collected by petite ponar from 12 locations of the LCR which included three reference sites, between June 28 to July 1, 2021 (reference sites 06 and 11 were porewater sites only).
- Sediments were subsampled in the field for sediment toxicity testing as well as the following chemical analyses: (1) total organic carbon; (2) metals, including simultaneously extracted metals (SEM) and acid volatile sulfide (AVS); (3) organochlorine pesticides (OCs); (4) pesticides; (5) polycyclic aromatic hydrocarbons (PAHs); and (6) polychlorinated biphenyls (PCBs).
- Metals, PAHs, OCs and PCBs were evaluated using probable effect concentrations (PEC) and the combined effects of chemicals were evaluated by calculating the PEC quotient (PECQ) (MacDonald et al. 2000).
- Porewater was prepared by centrifugation and analyzed for metals, major ions, and water quality. Porewater metals were evaluated by determining the interstitial water benchmark units (USEPA 2005). Interstitial porewater metals were evaluated using interstitial water benchmark units (IWBU) and ΣSEM-AVS/ƒoc (USEPA 2005).
- Laboratory bioassays were conducted with amphipods, midge, and mussels (Figure 2; ASTM 2021, USEPA 2000). Test duration for the exposures was 10 days for midge and 28 days for amphipods and mussels.
- Survival, growth, and biomass were evaluated by one-way analysis of variance (ANOVA) followed by Holm-Sidak's or Dunn's multiple comparison test. Test sediments were compared to the reference site (Site 07).
- Macroinvertebrates were collected using Hester-Dendy multiple-plate artificial substrate samplers to evaluate the biological integrity of surface waters (Figure 3; USPEA 1990)
- Samplers (3 samplers/site) were deployed for 42-45 days, retrieved, and placed directly into a plastic jar with 70% ethanol for later disassembly and macroinvertebrate retrieval.
- Picked samples were identified to the lowest practical taxonomic level (usually genus or species level, if possible) by contracted experts and quantified using simple macroinvertebrate metrics (Figure 4).

Hyalella azteca

Chironomus dilutus

Lampsilis siliquoidea

Figure 2. Test Organisms - Photos by Doug Hardesty, USGS

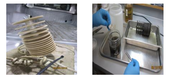

Figure 3. (a) Hester-Dendy macroinvertebrate sampler, (b) Processing Hester-Dendy macroinvertebrate samplers.

Results and Conclusions

Chemical Analysis

- Concentrations of metals, PAHs, PCBs, and OC pesticides in sediments were typically below concentrations that would be expected to be toxic to all three test organisms based on comparisons to PEC values. While some sites had elevated levels of contaminants, the concentrations of metals, PAHs, OCs, and halogenated organics in sediments did not exceed a sum probable effect concentration quotient (PECQ) of 1.0 and therefore, would be classified as low risk (Figure 4).
- ΣSEM-AVS/f_{OC} values were below 130 µmols/goc in 10 of 12 Little Calumet sediments (Table 1). Sites 01 and 08 exceeded 130 µmols/g_{OC} and may result in adverse biological effects to aquatic species. Porewater unionized ammonia concentrations ranged from 0.007 mg/L (Site 05, SC) to 0.365 mg/L (Site 1, SD). Interstitial porewater metal concentrations were below concentrations expected to be toxic to test organisms based on IWBU analysis.

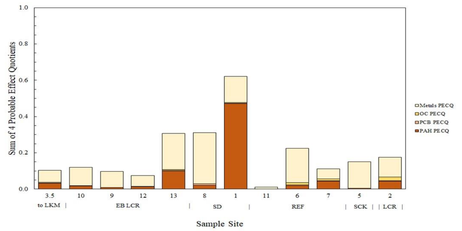

Figure 4. Sum of probable effect concentration quotients (PECQ, normalized to 1% TOC) for the four classes of compounds for Little Calumet River sediments. Abbreviations are Lake Michigan (to LKM), East Branch Little Calumet River (EBLCR), Samuelson Ditch (SD), Reference Sites (REF), Salt Creek (SCK), Little Calumet River (LCR).

Table 1. Sediment and porewater chemistry data. Shaded boxes indicate potential adverse effects due to metals. Abbreviations are to Lake Michigan (to LKM), East Branch Little Calumet River (EBLCR), Samuelson Ditch (SD), Reference Sites (REF), Salt Creek (SCK), Little Calumet River (LCR)

Location	Site	Probable Effects Concentration Quotient	SEM-AVS/foc	Unionized Porewater Ammonia (mg/L)	Interstitial Toxic Units[1]
To LKM	3.5	0.026	-64.89	0.074	0.084
EBLCR	10	0.030	-53.67	0.051	0.108
EBLCR	09	0.025	68.03	0.164	0.146
EBLCR	12	0.019	12.71	0.066	0.181
EBLCR	13	0.076	120.94	0.076	0.147
SD	08	0.078	207.87	0.021	0.168
SD	01	0.155	185.10	0.365	0.096
REF	11	0.003	0.97	0.029	0.159
REF	06	0.056	30.02	0.015	0.119
REF	07	0.028	-230.81	0.034	0.092
SC	05	0.038	20.26	0.007	0.108
LCR	02	0.044	37.48	0.100	0.065

[1]= sum of porewater metals (cadmium, copper, lead, nickel, silver, and zinc)

Results and Conclusions

Sediment Toxicity

- All exposures met ASTM (2021) and USEPA (2000) test acceptability criteria in all exposures for all three species.
- Survival for all three species was not reduced compared to the reference site and was ≥80% with the exception of midge survival from site 12 which was significantly reduced compared to the reference site.
- A total of 78% of the sediments (7 of 9 sites) were identified as toxic to at least one species as determined as a significant reduction relative to the reference site (Site 07) (Figures 5).
- Amphipods identified 56% of the sediment samples (5 of 9 sites), midge identified 11% (1 of 9) and mussels identified 22% (2 of 9) of the samples as toxic based on a significant reduction of at least one endpoint relative to the reference site.
- Amphipod biomass was the most responsive endpoint (44% of the sediments significantly reduced biomass relative to the reference site, Figure 5).

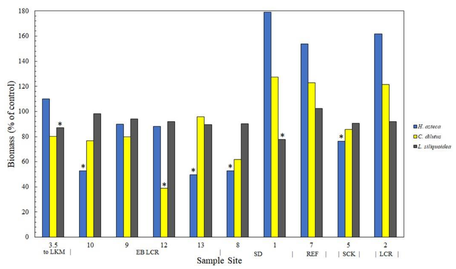

Figure 5. Biomass of the three test organisms exposed to sediments from the Little Calumet River. An * designates a significant reduction compared to the reference site. Abbreviations are Lake Michigan (to LKM), East Branch Little Calumet River (EBLCR), Samuelson Ditch (SD), Reference Sites (REF), Salt Creek (SCK), Little Calumet River (LCR).

Macroinvertebrate Analysis

- The mean abundance and mean species richness metrics were reduced relative to reference sites (Figures 6 and 7). The percent intolerant individuals metrics was also reduced compared to reference sites (data not shown).
- The metric mean Percent Tolerant Individuals is increased relative to reference sites (Figure 8).

Future Directions

- Further analysis will be completed to establish concentration response relationships between test organisms and potential contaminants of concern.
- Compare the concordance between biomass data and macroinvertebrate metrics (species number and density) data.

Results and Conclusions

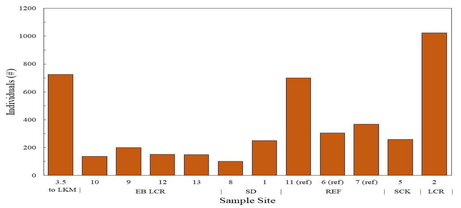

Figure 6. Mean macroinvertebrate abundance in samples from the Little Calumet River. Abbreviations are Lake Michigan (to LKM), East Branch Little Calumet River (EBLCR), Samuelson Ditch (SD), Reference Sites (REF), Salt Creek (SCK), Little Calumet River (LCR).

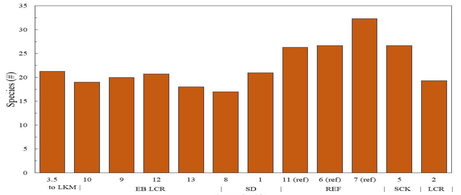

Figure 7. Mean species richness from samples collected from the Little Calumet River. Abbreviations are Lake Michigan (to LKM), East Branch Little Calumet River (EBLCR), Samuelson Ditch (SD), Reference Sites (REF), Salt Creek (SCK), Little Calumet River (LCR).

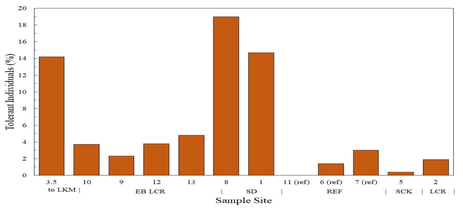

Figure 8. Percent tolerant macroinvertebrates collected from samples from the Little Calumet River. Abbreviations are Lake Michigan (to LKM), East Branch Little Calumet River (EBLCR), Samuelson Ditch (SD), Reference Sites (REF), Salt Creek (SCK), Little Calumet River (LCR).

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