Phytoremediation of Heavy Metal Contaminants in Temperate Fens of Ontario - A Biogeochemical Analysis

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Introduction

Heavy metal pollution poses a significant threat to water bodies worldwide. Peat wetlands, like fens, offer a natural solution by serving as crucial sinks for pollutants. Their diverse plant life and unique peat structures purify water as it passes through the fens (Sahar et al., 2022; Wilken et al., 2003).

With collaboration from local NGO's and municipal conservation authorities, we studied three fens in Central Ontario to investigate changes in water quality and heavy metal concentrations of As, Cd, Cr, Cu, Ni, Pb and Zn.

The study aims to determine whether the flora and peat structure within fen ecosystems influence heavy metal removal. Such insights are vital for effective water quality management and wetland conservation.

Plants use various mechanisms to translocate or stabilize heavy metals. (Yan et al., 2022). (Fig 1)

Uptake and sequestering are influenced by biogeochemical mechanisms (Wang and Aghajani Delavar 2024).

Fig 1. Phytoremediation mechanisms

Method

Three sampling locations were chosen in Central Ontario based on their ease of access, and vascular plant communities (Figure 2.)

- Data collection took place in Spring, Summer, and Fall, 2023.
- Water, sediment, and plant samples were collected at four locations within the fens, the inlet, midpoint and the outlet (Fig. 3)
- The samples were analyzed for water parameters, dissolved organic carbon, heavy metals & nutrients of water, sediment and plants
- Other analyses included estimations of humification (Von Post), bulk density, root plaque determination (Pederson)

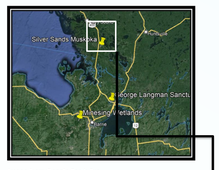


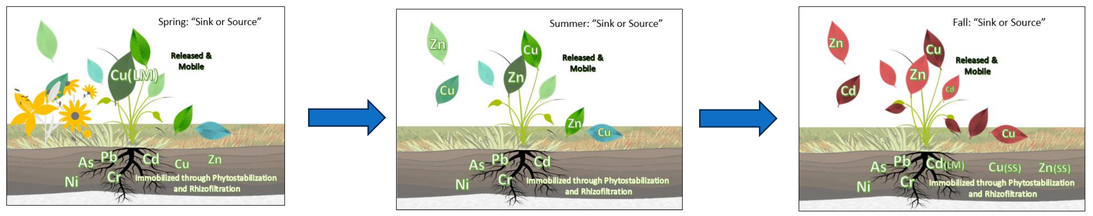
Fig. 2 Marks the locations of the three study sites in Central Ontario

Figure 3. Shows the sampling locations and transects of the Muskoka

Results

Source and sink?

- Various heavy metals decreased from the inlet to the outlet (p=0.05)
- Seasonal changes showed significant differences in some heavy metals.
- Zinc, Copper and Cadmium were often elevated at the outlet compared to the inlet thus the fens are seasonally a source, rather than a sink of these heavy metals (Figures 4a, b, c)



Figures 4.a,b,c Depict seasonal sink and source variations of seven heavy metals of concern

Phytoremediation

Bioaccumulation Factor (BAF) (Fig. 5) **and Translocation Factor (TF)** (Fig. 6) indicated that all plants in the study accumulated heavy metals in both the upper and lower biomass and were influenced by

- Fen (F=8.18, p=0.016), and
- Plant species (p=.001)
- Arsenic, Nickel and Lead were not found in the upper biomass of plants
- Site MW plants showed TF >1 and highest BAFs.
- Site SS had the highest number of metals with TF>1 and the lowest BAF
- Uptake of heavy metals by plants was not correlated to their concentrations in the soil or water (Fig. 7)

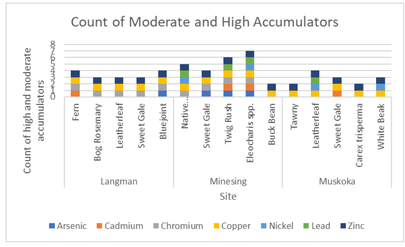


Figure 5. BAF values of the plants studied in their respective locations. Where BAF = Total plant concentration of metal *x*/ Total Concentration of metal *x* in Soil + Water. A BAF greater than 0.1 means the plant is a moderate accumulator of the metal and a BAF greater than 1 means the plant is a high or extreme bio accumulator

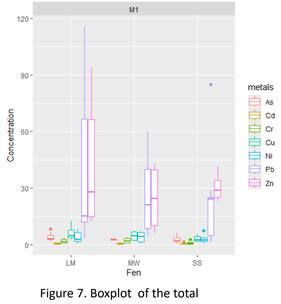


Figure 7. Boxplot of the total concentration of Heavy metals in the sediment within the fens

Biogeochemical Factors such as Lower pH, Lower Bulk Density, Increased Humification (F=7.36,p=0.025, F=27.1, p<0.001) and presence of root plaques (F=10.4, p=0.0155) influence uptake and translocation of heavy metals to the upper biomass of plants.

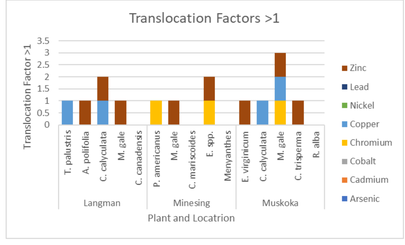


Figure 6. Plants studies with heavy metal TFs >1. TF equals the heavy metal concentration of metal x in the upper biomass/ heavy metal concentration of metal x in lower biomass. TF's greater than 1 means the plant is a hyperaccumulator and can phytoextract.

Conclusions

Water

- Water quality changed as it moved through the fen both with depth and distance from inlet to outlet and were associated with various biogeochemical factors.
- Fens can be a source and sink of various heavy metals which vary seasonally

Sediments

- Enrichment Factor and Geoaccumulation Index indicate that all sites are highly impacted by anthropogenic inputs of heavy metals
- Bulk Density and humification influence the retention of heavy metals in the sediment

Plants

- Several heavy metals (As, Ni,Cd, Pb) were undetected in any of the sampled plants at LM, despite higher concentrations of these heavy metals in the sediment (Fig 8.) and or in water
- Plants in MW sequestered a higher quantity of heavy metals but restricted them to the lower biomass
- Most plants in this study were not considered hyperaccumulators, they sequestered heavy metals within the lower biomass through Phytostabilization or Rhizofiltration.

References and Acknowledgments

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