Heavy Metal Phytoremediation Potential of Macroalgae, *Chara australis*

Cadmium removal from mixed-contaminant sediments from the Buffalo River

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CURCA

Introduction

This project investigates the potential of the macroalgae, *Chara australis*, for cost-effective phytoremediation of cadmium (Cd) in mixed-contaminant sediments in water bodies.

- Cd is a toxic heavy metal naturally occurring at less than 1 ppm in soils.
- Sources include industry, fertilizer application, fuel combustion and volcanic activity[1].
- Previous lab research has suggested *Chara*'s applicability to Cd remediation because of dense growth, environmental versatility, and bioconcentration factor (BCF) over 1.0[2,3].
- Application to modern Superfund remediation programs (CERCLA) would often require Cd phytoremediation in the presence of mixed contaminants.
- River sediment from the Buffalo River, a site of historic industrial usage, was collected as a model growth medium.
- Ten experimental tanks were prepared to examine effects of 10 ppm Cd-doped soil, a harvesting regimen, and growth in clean soil vs. contaminated river sediment.
- Following the one month experiment, *Chara* growth rate and Cd concentrations were recorded.

Figure 1. *Chara australis*[4]

Project Objectives

1. Characterize contamination of Buffalo River sediments.
2. Demonstrate ability of *Chara* to grow in these sediments.
3. Determine feasibility of *Chara* phytoremediation of Cd in mixed-contaminant soils and water bodies, typical at Superfund sites.
4. Find harvesting regimen effect on Chara growth and Cd uptake.

Methods

- Sediment was collected from the shore of the Buffalo River using several 5-gallon buckets.
- Samples were collected and analyzed for contaminants at an outside lab, TestAmerica.
- Ten experimental tanks were prepared, with approximately 10 *Chara* initially planted in each.

Figure 2. Laboratory Setup of *Chara* Growth Tanks

Table 1. Characterization of Growth Tank Setup

Tank #	Soil Source	Cd Doping (ppm)	Harvesting Regimen
1	Clean	0	No
2	Clean	10	No
3	Clean	0	Yes
4	Clean	10	Yes
5	River	0	No
6	River	10	No
7	River	0	Yes
8	River	0	Yes
9	River	10	Yes
10	River	10	Yes

- Plants were grown for one month, with three harvesting dates in the specified tanks.
- Four plants from each tank were extracted, oven-dried, and acid-digested according to EPA Method 3050B.
- Metal concentrations were found through inductively coupled plasma mass spectrometry (ICP-MS) and Excel analysis of data.

Results and Discussion

Buffalo River Sediment Characteristics

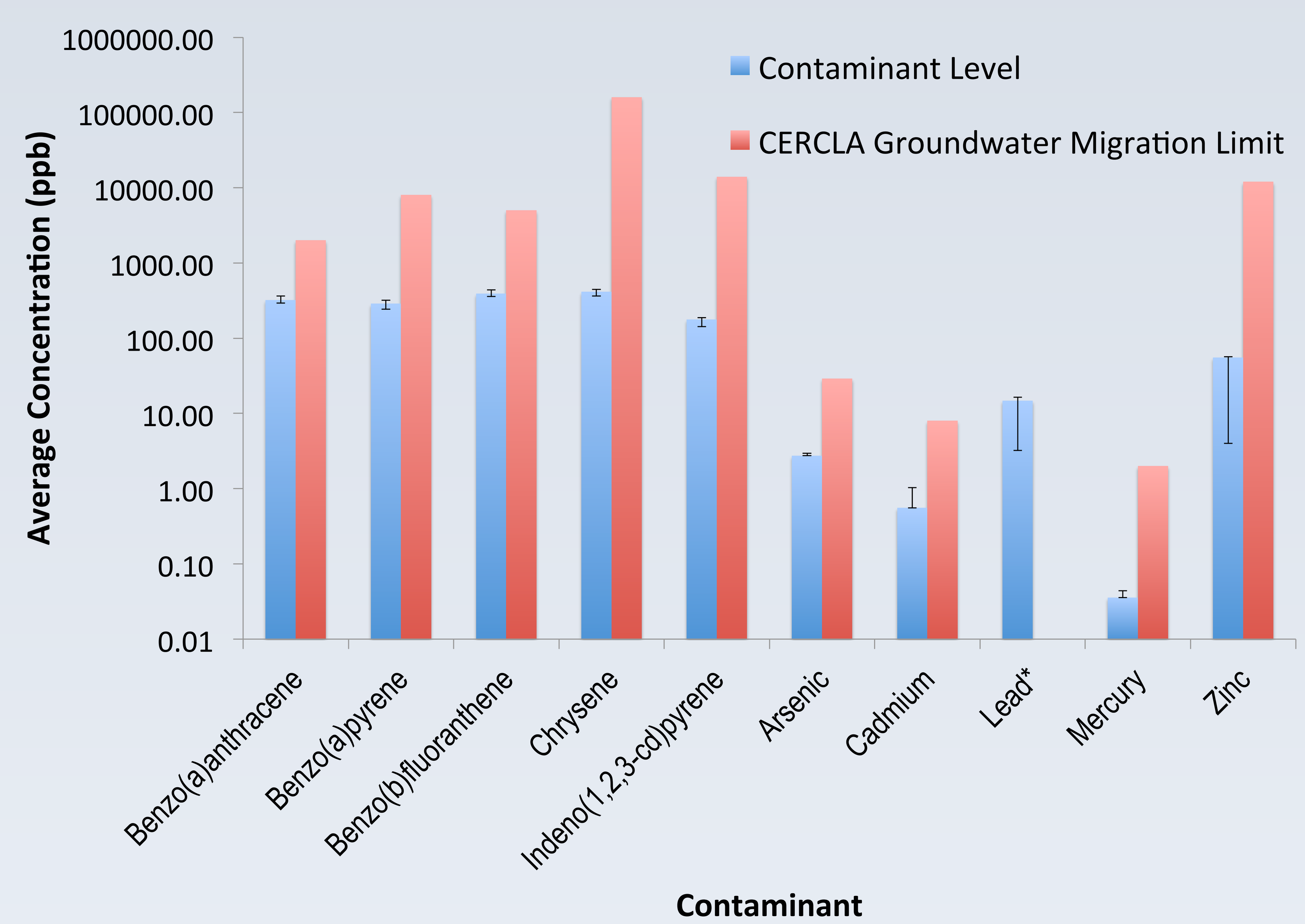

Figure 3. Concentrations of Mixed Contaminants in Buffalo River Shore Sediment
*No safe lead level has been established by the EPA

- Buffalo River shore sediments contained low levels of many polyaromatic hydrocarbons (PAHs) and metal contaminants, all below CERCLA regulatory levels for groundwater migration.
- The presence of multiple PAHs, a common combustion byproduct, is unsurprising considering the Buffalo River's industrial legacy.
- Cd levels in both River sediment and clean, store-bought soil were found to be less than 1 ppm before Cd-doping.

Cd Uptake in Doped Tanks

- *Chara* grown with clean soil showed much greater Cd uptake than those grown in the Buffalo River sediment, although all doped tanks achieved bioconcentration in the 10 ppm soil.
- Tanks with harvesting regimens showcased slightly less Cd concentration, insinuating that harvesting dates should be spread out to maximize Cd uptake efficiency.

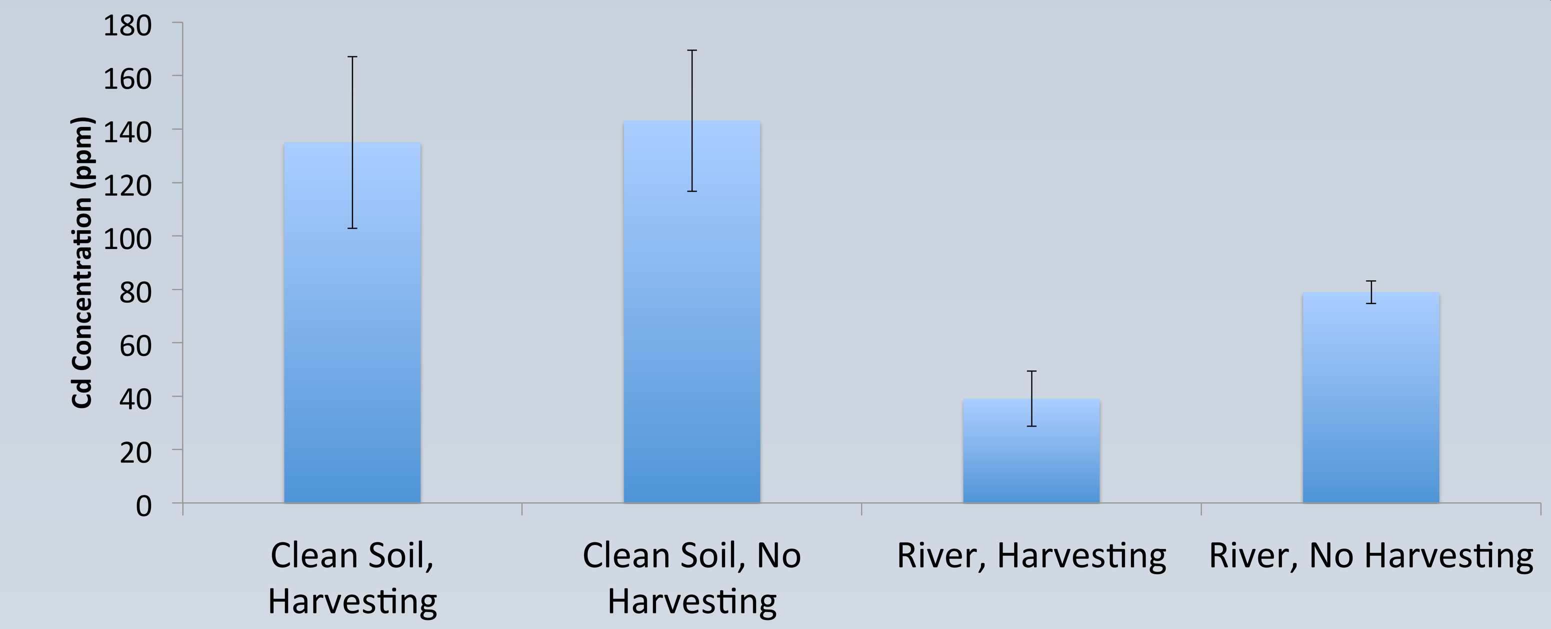

Figure 4. Concentrations of Cadmium in 10 ppm-doped Experimental Tanks

Chara Growth Rates

- *Chara* in the River sediment tanks (5-10) all showcased greater growth rates than clean soil tanks, despite lower Cd concentration.
- All tanks with Cd-doping had suppressed growth, especially those in the clean, store-bought soil.

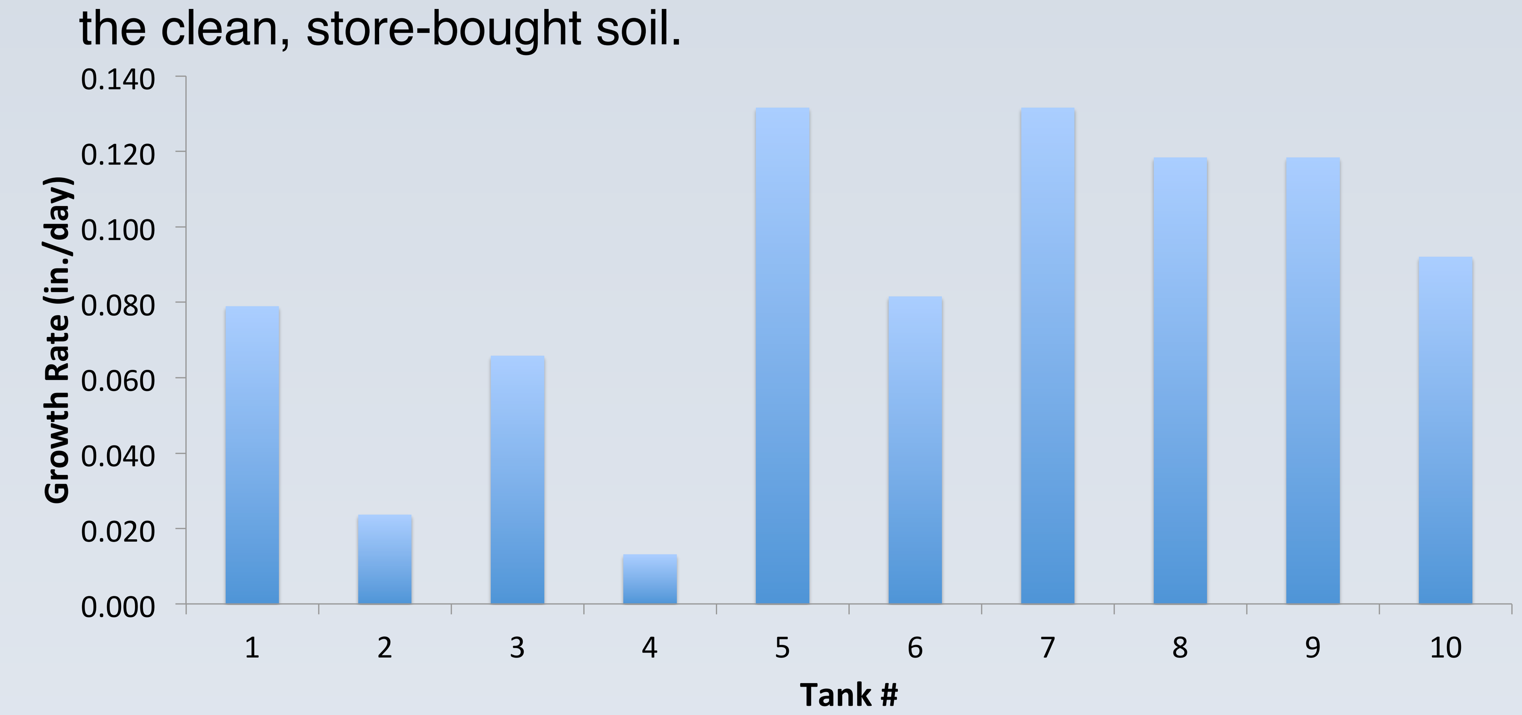

Figure 5. Growth Rates of Experimental Tanks in Inches per Day

Conclusions

- The sampled area of the Buffalo River revealed only low-levels of contaminants, making it suitable as a mixed-contaminant growth medium to model *Chara* phytoremedial potential.
- *Chara australis* is a viable option for Cd phytoremediation in mixed-contaminant soils, as it reached a BCF of about 4.0 when subject to a harvesting regimen. In clean soils doped with Cd, a BCF of almost 14 was achieved. A BCF of 1.0 is the critical value for heavy metal hyperaccumulators.
- Higher growth rates in River sediment, despite lower Cd uptake, suggest preference for the fine particle sized, high-organic soil type found in the Buffalo River.

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References

1) "Cadmium Toxicological Profile." Atsdr.gov. CDC, n.d. Web. 14 Apr. 2014. <http://www.atsdr.cdc.gov/toxprofiles/tp5-c6.pdf>.
2) Clabeaux, B. L., D. A. Navarro, D. S. Aga, and M. A. Bisson. "Cd Tolerance and Accumulation in the Aquatic Macrophyte, Chara Australis: Potential Use for Charophytes in Phytoremediation." National Center for Biotechnology Information. U.S. National Library of Medicine, 13 May 2011. Web. 14 Apr. 2014.
3) Clabeaux, B., D. Navarro, D. Aga, and M. Bisson. "Combined Effects of Cadmium and Zinc on Growth, Tolerance, and Metal Accumulation in Chara Australis and Enhanced Phytoextraction Using EDTA." ScienceDirect. Ecotoxicology and Environmental Safety, n.d. Web. 14 Apr. 2014.
4) "Chara Australis." N.p., n.d. Web. 14 Apr. 2014. <http://www.joy.hi-ho.ne.jp/nitella/setumei/australis.html>.