PRELIMINARY VEGETATIVE ANALYSES TO ASSESS MINE DRAINAGE IMPACTS ON MARSHES[1]

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Abstract. The ecology of *Typha*-dominated marshes at the Tar Creek Superfund Site, northeast Oklahoma, was evaluated during the summers of 2000 and 2001. Since 1979, unabated discharges of contaminated mine water (pH 5.9, alkalinity 414 mg/L as $CaCO_3$, 170 mg Fe/L, 11 mg Zn/L) into a former pasture has led to the development of an extensive volunteer wetland. Study sites included the impacted marsh receiving mine drainage (East Marsh) and an adjacent reference site receiving storm water (West Marsh). Vegetation sampling transects and quadrats were established and monitored for percent cover, species richness, and growth metrics. Above- and below-ground biomass, culm lengths, and culm densities were determined. Ash free dry weight, organic matter content, and Fe, Zn, Pb, and Cd concentrations were measured in roots, stems, leaves, and inflorescences. Percent cover ranged from 75-95%, and although dominated by *Typha spp*., 11 different species of vegetation were identified in East Marsh. In 2001, West Marsh was co-dominated by *Scirpus spp*. West Marsh demonstrated the highest total biomass with belowground biomass consistently higher than aboveground biomass. Culm densities in West Marsh were lower than East Marsh, and in 2000, cumulative stem lengths were directly related to densities. Ash free dry weights showed the highest amounts of inorganic matter in roots and lower amounts in above ground foliage. Concentrations of Fe and Zn were greatest in roots, but were also greater than background levels in stems, leaves, and flowers. Vegetation in West Marsh was metal-impacted, most likely due to back flow of mine water during low flow conditions. Variability in ecological metrics for the two summers is likely due to climatic differences (especially precipitation) between years.

Additional key words: environmental impact, ecological engineering, bioaccumulation

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Introduction

Natural wetlands perform a water quality function by cleansing ground and surface waters before they return to flowing surface waters or aquifers (Dennison and Berry, 1993; Mitsch and Gosselink, 2000). Not only is it important to determine how well a specific wetland is ameliorating water pollution, but also how that pollution is affecting ecosystem structure and function.

In wetlands contaminated by heavy metal pollution, only certain species of plants can tolerate the metals that can make the environment uninhabitable for other organisms. Some species of freshwater vascular plants, floating or rooted, can remove and concentrate high amounts of selected heavy metals (Brooks, 1998). One taxon in particular is *Typha spp*., a plant that often dominates wetlands. *Typha spp*. are capable of invading degraded habitats including mine drainage impacted areas and unvegetated areas near smelters, thus indicating that *Typha spp*. boast a general resistance to heavy metals (McNaughton et al. 1974).

The site examined in this study provided consistent flows of heavy metal polluted waters into a resultant *Typha*-dominated volunteer wetland ecosystem. The main purpose of this study was to examine wetland vegetation growth metrics as part of a larger whole-ecosystem study.

Methods

Study site

The study site was a volunteer wetland located in the Tar Creek Superfund Site, Ottawa County, OK. This region was part of the Picher Mining field that had once been a substantial lead and zinc mining area. Elevated lead levels have been recorded in human blood, soil, mining wastes, and surface water leading to designation as an EPA Superfund site in 1983. The current wetland site had been a horse pasture until 1979, when discharges began flowing from abandoned boreholes, inundating the land and forming the present day wetland. Two hydrologically-connected wetlands exist (Figure 1). East Marsh (approximately 1 ha) has formed around the boreholes and along the flow of the mine drainage discharges. West Marsh (approximately 0.2 ha) is up-gradient of the discharges and formed due to storm water flows.

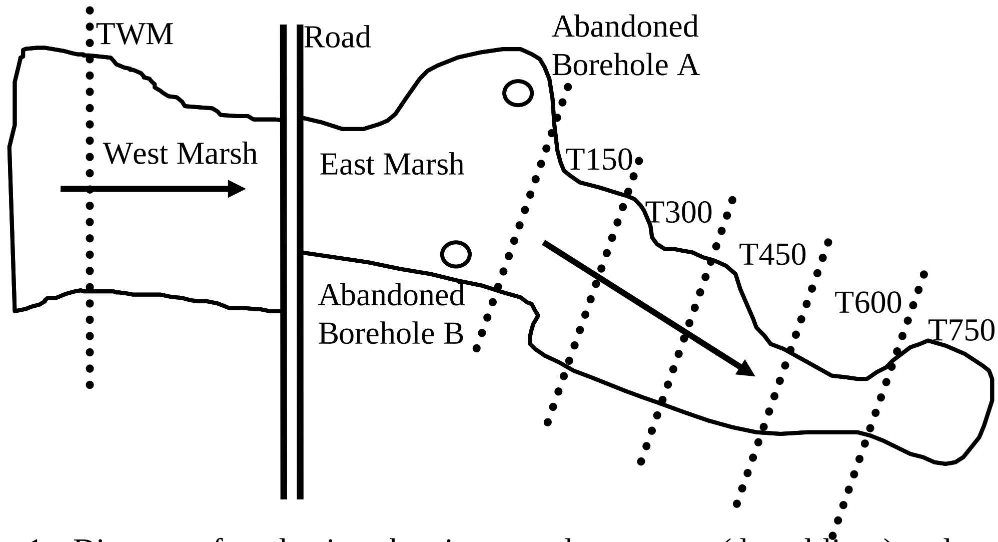

Figure 1. Diagram of study site, showing sample transects (dotted lines) and water flow paths (arrows).

Field sampling and laboratory analyses

Five vegetation sampling transects were established in East Marsh 150 feet apart in the southwest/northeast direction (T150, T300, T450, T600, and T750). In West Marsh, one transect was established in the north/south direction (TWM). These transects were used for both years the study was performed. Plant diversity and coverage were determined by walking each transect, identifying all plants along the transect, and estimating the percentage of visible vegetative coverage (Barko et al. 1977).

Quadrats were also randomly established along each transect. In 2000, only 6 quadrats were randomly located: two on T150 (T150N and T150S), and one each on T300, T600, T750 and TWM. In 2001, 20 quadrats were randomly established: four on T150, T300, and TWM; three on T450 and T600; and two on T750. Number of quadrats per transect were based on the relative length of each transect. For each transect, all plants were identified and cover was estimated by the line intercept method. Other data were collected in 0.5-m^2 quadrats as follows. All stems within the quadrat were cut at the soil surface, counted and measured. Cumulative stem length was determined as the sum of all stems in a quadrat. For each quadrat, all plant matter above the soil surface was collected for determination of aboveground biomass. For determination of belowground biomass, roots and rhizomes were removed to a sufficient depth at which root mass was negligible. All plant matter was rinsed with wetland water and set to air dry. All biomass was then transported to the Ecosystem Biogeochemistry and Ecology Laboratory at the University of Oklahoma, where they were rinsed completely with deionized water using stainless steel and brass sieves to prevent loss of biomass (Kalra, 1998). They were placed in aluminum foil and dried in ovens at 60^oC (aboveground biomass) or 105^oC (belowground biomass) for 24 hours, after which they were weighed every hour until constant mass was achieved.

Dry ashing was accomplished by weighing 10 g of sample from the biomass determination. Samples were ashed at 550^oC for 24 hours. After the plant material had been completely ashed, inorganic matter content was determined by weighing again. Roots, stems, leaves and flowers of *Typha spp*. were separated for analysis of iron, zinc, lead, and cadmium. Plant parts were randomly selected from each quadrat, dried and crushed in a stainless steel blender. The ground plant material was passed through a brass 40-mesh sieve and digested according to the High-Temperature Oxidation: Dry Ashing Digestion procedure in Kalra (1998). Iron, zinc, lead, and cadmium concentrations were determined with a Perkin Elmer 5100 Atomic Absorption Spectrophotometer. Data analysis of this information is still ongoing and will not be presented.

Results and Discussion

In 2000, 11 different species of plants were found in the two marshes (Table 1), but both marshes were dominated by *Typha spp*. Due to the *Typha* dominance, growth measurements were determined for this species only. In 2001, only five species of plants were identified. East Marsh was once again dominated by *Typha spp*. but West Marsh was co-dominated by *Typha spp*. and *Scirpus spp*. Once again, growth measurements were determined for *Typha spp*. with the exception of transect TWM, which was completely *Scirpus spp*. dominated.

Percent vegetative coverage, estimated from transects, varied slightly between marshes but varied much more between years. In 2000, 75-95% coverage was recorded for transects TWM, T300 and T750. All other transects demonstrated coverage greater than 95%. In 2001, percent vegetative coverage was lower, ranging between 65 and 85% with T450 at 65%, TWM and T300 at 70%, T150 and T750 at 80% and T600 at 85%.

Table 1. Vegetation taxa identified along transects in both East and West Marshes during the summers of 2000 and 2001. Data for families indicates a single unidentified species of that family.

Taxa	2000	2001
Asclepias incarnata	X	
Bidens spp		X
Catalpa spp.	X	
Cephalanthus occidentalis	X	
Cornus drummondii	X	
Brassicaceae family		X
Cyperaceae family	X	
Eupatorium perfoliatum	X	
Graminacea *family*		X
Hibiscus noscheutos	X	
Juncus effusus	X	
Populus deltoides	X	
Scirpus spp.		X
Typha angustifolia	X	X
Typha latifolia	X	X

MSL for *Typha spp*. only was 122 cm and for all species was 97 cm. Cumulative stem lengths (CSLs) in 2000 were similar across all quadrats and transects and ranged from 1186-3721 cm. In 2001, greater variability was evident, but the only apparent trend was for larger values in West Marsh. CSLs ranged from 416 to 34,314 cm.

Stem density in 2000 ranged from 12-44 culms/m^2 and demonstrated no trend between marshes. In 2001, however, stem densities showed much greater variability, ranging from 4-476 culms/m^2, with both the lowest and highest values in West Marsh. West Marsh was dominated by *Scirpus spp*. in 2001 and not *Typha spp*. In 2000, a significantly positive relationship was found between stem density and CSL (r^2 = 0.96).

In 2000, total biomass for all 5 quadrats in East Marsh was lower than that found in West Marsh. For all sampling sites, belowground biomass was consistently lower than the aboveground biomass. Biomass demonstrated a negative relationship with stem density (r^2=0.71) but again, this relationship was not apparent in 2001. In 2000, aboveground biomass (AGB) ranged from 308-1072 g/m^2 and belowground biomass (BGB) ranged from 896-1388 g/m^2. However, in 2001, AGB ranged from only 68-660 g/m^2 and BGB ranged from only 280-964 g/m^2.

Overall, significant differences in growth measurements existed between years. Biomass measures (AGB, BGB, and total) were different between summers (ANOVA, F>.01 value). Also, belowground and aboveground ash free dry weights were significantly different between years. MSL was also significantly different. Culm density was not significantly different either year. During the summer 2000, there were a number of large storm events, but in 2001 there was much less precipitation. Therefore, it is hypothesized that significant differences in the growth measurements may be due to the weather differences each summer.

Conclusions

Despite exposure to substantial metal contaminant loadings, the wetlands examined in this study appear to be healthy and functioning based upon their vegetative growth measures. Additional data analysis will be forthcoming. Individuals of the dominant species, *Typha*, appeared to be stressed due to lack of adequate water in summer 2001 when compared to summer 2000. Comparisons of seasonal growth rates to precipitation status and seasonal monitoring of growth measures and metal concentrations will help to elucidate the function of these wetlands. Water quality analyses for the boreholes and locations within the marshes indicate substantial metal retention (Coffey et al., 2002). Additional analyses of vegetation metal concentrations will assist in determining metal fate.

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