PHYTOTECHNOLOGY APPLIED TO A SEVERELY OILED SHORELINE

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ABSTRACT

Northwest Indiana has been the home of oil refining since 1890. Historic practices of dumping waste oil into the ground, releases from aged and/or abandonned infrastructure, and reoiling from groundwater, and oil sediments have created a shoreline comprised of 15-35% oil. Conventional wisdom has been that oil can be neither bioremediated nor phytoremediated if the oil exceeds 8%.

This three year study was conducted in both the green house and the field. Trees, grasses and tuberous plants were investigated to determine if any of them would grow, if they would stay alive and if they actually were able to degrade oil.

The field study determined that plants could survive living in this environment, although certain cultivars as well as certain species performed much better than others. We chose the strongest cultivars and planted larger sections with them in the second year. We were able to show that biological activity in the soil was augmented by between 2-5 orders of magnitude. We were also able to show similar biological activity at the waters edge in the rhizosphere of native, naturally occuring tuberous plants.

The green house portion of the study allowed us to compare the oil degradation rates of the different plants and trees.

In the third year, we have a mixed planting to simulate a more natural habitat. This mixed planting scheme also seeks to use the most appropriate plants in order to treat the oil at multiple interfaces: the top foot of soil with grasses, the deeper soil and groundwater with trees, and the water's edge with tuberous plants.

This approach, although more time-consuming, is substantially less expensive than tradiational means of oil removal.. It provides habitat to the birds and animals already using the area. It rapidly creates a barrier of plant litter, and creates soil thereby buffering wildlife from casual oil contamination.

PAPER

The Indiana Harbors Canal (IHC) in northwest Indiana is an industrial area where releases from many industries to canal waters have left residual shoreline TPH levels of ~25% in the upper few feet of riparian soils along its banks. (Figure 1) Over many years releases from various industries have accumulated in sandy layers along the shores of the canal system. These soils have a heavily oiled appearance, texture, and odor, dominated by larger molecule, relatively recalcitrant hydrocarbons, and by widespread areas of blackened sands devoid of vegetation. These shorelines release stored contaminants to the canal waters shown by an occasional sheen on the waters, resulting in harm to aquatic life, waterfowl,

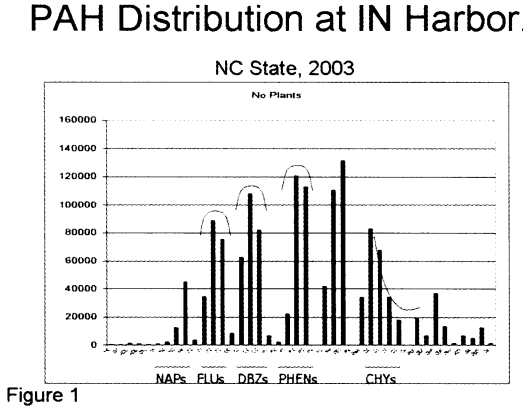

Figure 1

and decreasing the water quality flowing into Lake Michigan. The goal of establishing vegetation along the shoreline is to decrease the impact on the environment of these stored contaminants by cleaning or containing while at the same time establishing a higher value ecosystem for habitat.

Phytotechnologies are a set of techniques for using growing plants for a variety of environmental clean-up goals. For this site there are two goals for the plants: phytoremediation to slowly clean the contaminants and containment of the contaminants in the shore soils until the degradation can take place. Phytoremediation of spilled oil is well documented, but for aged petroleum product such as are present along the shores of the IHC, the rate of contaminant degradation is very slow, likely measured in decades. Containment can be at least partly achieved if the plants can establish a root mass that forms a vegetative cover in the top few centimeters of shore material. Such plantings can trap floating debris as the canal waters rise and fall, drop vegetative litter, catch windblown dust and seeds, and provide anchorage for local opportunistic plants. All these process build a non-contaminated soil layer on top of the oiled sand. This soil both acts to filter the contaminants from the surface water, and it provides habitat and nutrients for microbial consumers of oil. Establishing dense vegetation along the contaminated shoreline simultaneously prevents resuspension and begins to clean the deposited oil.

As reported in a prior IOSC conference (Phytoremediation Treatability Study at the Indiana Harbors Canal: First Year Summary, 2003) IHC has been the subject of several studies. Due to the accessibility of the site and the high levels of contaminants, the potential for phytoremediation of the site is currently under study from EPA Office of Research and Development (ORD), Purdue University,

Central State College, North Carolina State, and the Ohio State University. These studies have produced detailed characterization of the soil, the microbial population, and the viability of various plants to survive in the material. (Figure 2)

Field Site – Total Microbes and PAH Degraders

(Purdue, September, 2003)

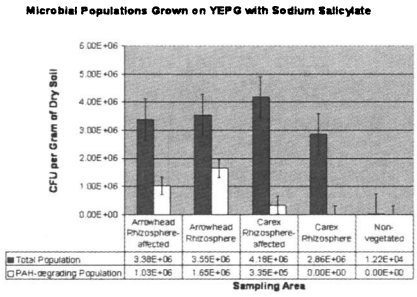

Figure 2

The first treatability studies were conducted at the EPA ORD National Risk Management Research Laboratory in Cincinnati, OH. Four hybrid poplar and 8 willow clones were planted into homogenized material from IHC. All ten replications of that initial planting failed to thrive. Subsequent plantings in the chambers and greenhouse explored different planting techniques, including coring the IHC material and planting into a hole filled with clean sand, and layering clean and IHC material.

The most successful clones from the growth chamber study were planted at the site in the spring of 2002. Non-tree plantings were also initiated at the same time. The following year a more extensive planting of poplar and willow cuttings was conducted along the IHC, using the lessons learned from the previous planting. By Summer of 2004 the general vegetative cover on the areas in 2002 was nearly 100%, while the 2003 plantings were less extensive but covered to a much greater degree than prior to planting. Visual assessment of the sheen from the shore during the growing season showed a marked improvement from the site visits prior to planting.

A large percentage of the plants now growing on the site are opportunistic volunteers that are not highly desired for aesthetics or wildlife habitat. These plants have begun to flourish on the site as a result of the revegetation efforts of 2002 and 2003. Among the plants that have moved onto the site are such invasive species as reeds, *Phragmites australis*, cattails, *Typha latifolia*, and the somewhat more welcome arrowhead, *Saittara latifolia*. One of the reasons these plants are less welcome on the site of a restoration project is that they tend to provide less valuable habitat, particularly in that they provide no food to local animals. The benefit of this for a restoration site is that the plants tend to have an easier time establishing themselves when compared to plants that have a high habitat food value, which tend to be eaten. Approximately 75% of the poplars and willows planted have suffered beaver damage to date. Some of the non-planted species have extensive root systems, penetrating the IHC oily sand much more vigorously than any of the planted trees. These field observations were subsequently confirmed in greenhouse tests; *Phragmites* produced significantly more roots in the contaminated material than any other plants tested to date.

Soil samples were collected across the site in 2003 and 2004. There was no discernable difference in the sites before planting or after the first growing season. There were some initial correlation between type or extent of vegetation and contaminant concentration in the field observations. The North Carolina State analysis shows that the areas with *Phragmites* are lower in high molecular weight material than in any other planted or unplanted areas. (Figure 3) Areas with *Typha* have more high molecular weight material, and less low molecular weight material. The Purdue greenhouse tests indicate more degradation in planted areas than in unplanted areas. (Figure 4)

PAH distribution by Plants

NC State, 2003

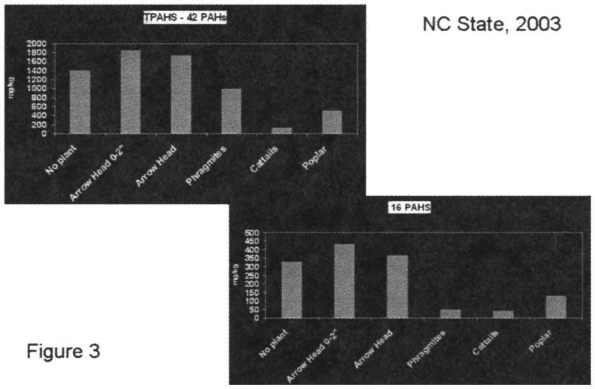

Figure 3

Greenhouse Study – TPH Analysis

Purdue, 2004

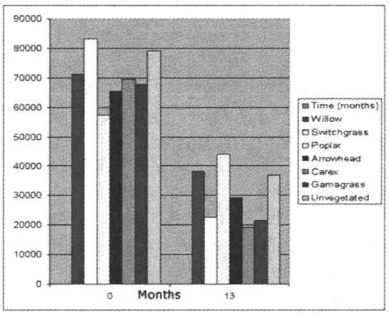

Figure 4

There has been neither quantification of the containment value of increasing the vegetation along the IHC shore, nor any evidence beyond random observation of animals and animal sign on site that habitat is significantly improved. Nonetheless, the site has undergone a dramatic transformation in three years. It has also provide a wealth of knowledge on planting techniques for heavily impacted sites, and provided some indications on planting and other changes that can enhance colonization by local plant species. While IHC a long way from being a clean site, it is much farther along the twin paths of remediation and eco- restoration than before these treatability studies and remediation efforts were conducted.