PROJECT SUMMARY

Monitoring Environmental Effects at an Established Phytoremediation Site

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This study is a continuation of groundwater monitoring (contaminants and elevation), along with examination of mortality and estimated biomass production of hybrid poplars at an established phytoremediation site in Bancroft, WI in southern Portage County.

Background - Phytoremediation offers the prospect of using a low-cost alternative to degrade or sequester contaminants from soil and groundwater, and/or slow the movement of shallow groundwater. Sequestration of heavy metals and degradation of petroleum hydrocarbons and volatile organic compounds is well documented; however, the fate of many pesticides is unclear. If groundwater movement can be slowed, possibly so will the movement of contaminants off-site, and therefore, a greater likelihood they will be degraded or sequestered by biotic or abiotic processes on site.

The study site is an active aerial agricultural chemical facility, located near Bancroft, Wisconsin, and has a history of soil and groundwater contamination. Dinoseb (2, sec-butyl-4,6-dinitrophenol) is the primary contaminant of concern. At the time this study was initiated, dinoseb-contaminated soil was unacceptable for conventional landfill disposal or landspreading. Sandy soil, shallow groundwater, and other factors make this a prime site to study the effects of phytoremediation.

Objectives - The objectives of this research were:

1) Assess mortality and biomass production of the established trees at the site in both the source area and downgradient area.
2) Investigate possible relationships between hydrologic response and transpiration rates at various times through the project duration (both daily and seasonal changes).
3) Monitor changes in the groundwater contaminant profile through the source and downgradient areas.

Methods - A total of 834 hybrid poplars and willows were planted in June 2000. An irrigation system and electric fence were installed to help establish the plantation. Mortality and estimated biomass production were measured following each growing season since 2000. A network of groundwater monitoring wells had been installed for contaminant testing and groundwater elevation monitoring using electronic data loggers. Contaminant monitoring occurred in the spring and fall of each year. Down-well data loggers provided continuous monitoring of groundwater elevation throughout the growing season. A complete weather station was located within 500 meters and all pertinent weather data was available for this project.

Previous studies have examined: transpiration rates of the hybrid poplars, groundwater response to transpiration, presence of contaminants in biological tissues, aquifer characteristics, hybrid poplar mortality rates, biomass production, and groundwater quality. This study examines mortality and biomass production, hydrologic response, and groundwater quality trends.

Mortality is assessed in the fall by visual inspection of the trees and evidence of viable leaves or leaf buds. Biomass is estimated through direct measurement of trunk diameter and height as recommended by U.S. Forest Service North Central Experimental Station. The equation for this estimation is d^2*h where d = diameter breast height, and h = total tree height. Groundwater quality trends are evaluated by comparing dinoseb concentrations in monitoring wells across the study area. Hydrologic response is monitored with the use of groundwater elevation dataloggers (Aquarod – Sequoia Scientific) in three areas of the property. Elevation is logged once every 30 minutes with 1 mm of accuracy. Weather data is gathered using a Davis Instruments weather station that logs data every 30 minutes.

Results and Discussion - Following six growing seasons, there were no significant differences in mortality of the two key poplar clones, NM-6 (39%) and DN-34 (40%) in the plot as a whole, nor in the contaminated (source) area of the plot (45% and 46%, respectively). There were, however, substantial differences in mortality between the source and downgradient areas (45% and 16%, respectively). Estimated biomass produced by the two clones was also significantly different, with 75% of the biomass produced by NM-6.

Groundwater was analyzed for dinoseb, which has historically been the main contaminant of concern at this site. Dinoseb concentrations in groundwater have fluctuated considerably, likely due to flushing actions from the soil associated with precipitation events. Samples from downgradient piezometers have steadily decreased in dinoseb concentration and have been recorded at less than detection limits (5.0 µg/L) since October 2004.

Groundwater elevation declined steadily throughout the summer months with a maximum decline of 807 mm measured between May and September 2004. The majority of drawdown is most likely due to regional and local irrigation pumping systems. Groundwater recharge correlated with rainfall events. Diurnal water table fluctuations from transpiration were not observed due to rapidly rising (rainfall) and falling (groundwater pumping) of the water table.

Conclusions/Implications/Recommendations - Biomass calculations show that hybrid poplar NM-6 is more prolific than DN-34 in soil and groundwater severely contaminated with dinoseb, although similar morality levels were observed. A hybrid poplar plantation appears to have effectively reduced off-site migration of dinoseb with the groundwater; however, assimilation or a mechanism of degradation of dissolved dinoseb in relation to the trees was not established. Hybrid poplars were found to influence water table elevations; however, this influence was often obscured during periods of extensive groundwater pumping and large rainfall events that resulted in a rapidly rising and dropping water table.

Key words - dinoseb, phytoremediation, hybrid poplars, groundwater

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