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Environmental Effects of Dredging Technical Notes

ROLE OF CONTAMINANT UPTAKE IN THE POTENTIAL USE OF *PHRAGMITES AUSTRALIS* (CAV.) TRIN. ON CONFINED DISPOSAL FACILITIES

PURPOSE: *Phragmites australis* (Cav.) Trin., common reed, is a plant species that is common to fresh- and brackish-water marshes of the world. *P. australis* has been recommended as one plant species that could survive and grow after being completely buried during dredged material disposal (Lee et al. 1976). *P. australis* can also serve as a physical barrier, because of its strong stems, to dredged material flow during hydraulic disposal. Decreasing dredged material flow helps to increase consolidation of hydraulically dredged material (Lee et al. 1976). *P. australis* is a plant species recommended for habitat development on dredged material disposal sites (Hunt et al. 1978). Plant establishment on marsh creation projects using uncontaminated dredged material poses little threat of increasing environmental cycling of contaminants. However, plant establishment or natural invasion of plants on contaminated dredged material has the potential for increased environmental cycling (mobility) of contaminants. Therefore, a literature review was conducted to determine contaminant uptake by *P. australis* since many dredged material disposal sites support lush stands of *P. australis* and contaminant uptake by this species was unknown.

BACKGROUND: Site management to favor colonization by desirable plant species can be used to minimize adverse environmental effects of contaminated dredged material. A desirable plant species is a species that minimizes contaminant uptake and subsequent environmental cycling (mobility) while providing dewatering and increased particle settling of the dredged material, as well as providing wildlife habitat. Two characteristics that a desirable plant species should have include a shallow rooting depth if a "clean cap" is used over contaminated dredged material and restricted uptake and translocation of contaminants. *Phragmites australis* may not be one of the desirable species due to its deep rooting behavior; also, virtually nothing is known about its contaminant uptake.

ADDITIONAL INFORMATION: This technical note is a summary of a contract report prepared under the Toxic Substances Bioaccumulation by Plants work unit in the Long-Term Effects of Dredging Operations Program. Dr. M. van der Werff of Vrije University, Amsterdam, The Netherlands, conducted the study. This note was written by Dr. Bobby L. Folsom, Jr., Environmental Laboratory, and Dr. M. van der Werff. For additional information, contact Dr. Folsom, (601) 634-3720, or the manager of the Environmental Effects of Dredging Programs, Dr. Robert M. Engler, (601) 634-3624.

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The common reed, *Phragmites australis* (Cav.) Trin., is a halophytic grass having a worldwide distribution. It generally inhabits wetlands, particularly in disturbed environments, and often comprises the sole or dominant plant species. The wide distribution, the ability to withstand extreme environmental conditions (e.g., deep burial, anaerobiosis, and salinity flux) and its aggressive growth make this plant important in the overall management of dredged material disposal sites.

The survival and reproductive strategies of *P. australis* make it one of the first colonizers in newly reclaimed wetlands such as dredged material disposal sites or lakes drained for agricultural uses. Despite its aggressive growth habit, *P. australis* does not normally invade established wetlands and does not generally displace other wetland plant species. Deep root and rhizome formation are important morphological characteristics of *P. australis* that could result in increased contaminant mobility through plant uptake and may preclude its use.

Many studies on the nutritional status of *P. australis* have been conducted during the past 20 to 30 years, but only a few have studied contaminant uptake. Most of the literature on contaminant uptake by *P. australis* has been concerned with trace metals essential for plant nutrition, especially copper, iron, manganese, and zinc. *P. australis* plays an important role in the cycling of nutrients in lakes (Wetzel and Allen 1972, Schroder 1973, Banoub 1975, Mason and Bryant 1975). However, very little is known about the role of *P. australis* with respect to heavy metal cycling (Schierup and Larson 1981). Schierup and Larsen (1981) investigated *P. australis* cycling of zinc, copper, lead, and cadmium in two Danish lakes--one polluted and one unpolluted. They found that uptake of these heavy metals by *P. australis* was greater in the unpolluted lake population than in the polluted lake population. Schierup and Larsen (1981) indicated that the difference in uptake was dependent on edaphic factors rather than on the amount of heavy metals present in the sediment. Two of the edaphic factors thought to influence heavy metal availability, sediment pH, and sediment oxidation-reduction (redox) status were sufficiently different between the lakes to explain the difference in uptake (i.e., uptake increased as redox increased or pH decreased). Auclair (1979) also found that tissue concentrations of several emergent hydrophytes (of which *P. australis* is one) were dependent on edaphic factors and indicated plant growth affected both nutrient and heavy metal tissue concentrations as well. A study of heavy metal uptake by marsh plants in Lake St. Clair (Mudroch and Capobianco 1978) revealed that increased plant growth during the growing season resulted in increased heavy metal concentrations in several plant species. Mudroch and Capobianco (1978) showed that plant concentrations of nickel, chromium, and copper increased during vegetative growth of *Typha latifolia*; cadmium and zinc increased during vegetative growth of *Myriophyllum heterophyllum*; cobalt and lead increased during vegetative growth of Chara spp.

Increased heavy metal uptake resulting from increased plant biomass production appears to be real and may significantly contribute to heavy metal cycling by marsh plants, especially *P. australis*. Various investigators have shown that *P. australis* has a great potential for increased biomass production through increased nutrient uptake from nutrient-enriched sediments (Wile, Palmeteer, and Miller 1981, Pratt and Andrews 1981, Bjork 1967). Ulrich and Burton (1985) found that *P. australis* responded to nitrogen and phosphorus but not to potassium. They determined that both biomass production and the concentration of nitrogen and phosphorus in the plant tissue increased with increasing availability of nitrogen and of phosphorus in the sediment. In a study on seasonal effects of heavy metal concentrations in *P. australis*, Larsen and Schierup (1981) showed that plant concentrations of zinc and copper increased as plant biomass increased. The implications of this behavior are significant. If edaphic factors of a polluted lake become equal to those of a nonpolluted lake, then there is greater potential for increased contaminant uptake due to increased plant biomass production. Most contaminated dredged material contains elevated quantities of nitrogen and phosphorus and is capable of high plant biomass production. Increased plant biomass production from *P. australis* (or other plant species) growing on contaminated dredged material may result in increased contaminant cycling into the food web. Enhanced biomass production/contaminant cycling combined with factors known to increase contaminant availability (e.g., oxidized sediment redox conditions, oxidation of organic matter, and low pH) may result in significant contaminant cycling (mobility). *P. australis* cannot be recommended as a desirable plant species until the relationship between increased plant growth and increased contaminant uptake can be determined.

The relationship between increased plant biomass production (growth) and increased contaminant uptake is important and needs to be addressed. Understanding this relationship may prove to be a key factor in predicting environmental cycling of contaminants by plants grown in contaminated dredged material. The work unit, Toxic Substances Bioaccumulation by Plants, in the Long-Term Effects of Dredging Operations Program is an ongoing work unit that could address the relationship between increased plant growth and increased contaminant uptake.

References

Auclair, A. N. D. 1979. "Factors Affecting Tissue Nutrient Concentrations in a *Scirpus-equisetum* Wetland," *Ecology*, Vol 60, pp 337-348.

Banoub, M. W. 1975. "The Effect of Reeds on the Water Chemistry of Gnadensee (Bodensee)," *Archiv fur Hydrobiologie*, Vol 75, pp 500-552.

Bjork, S. 1967. "Ecologic Investigations of *Phragmites communis*; Studies in Theoretic and Applied Limnology," *Folia Limnologica Scandinavica*, Vol 14, pp 1-248.

Gambrell, R. P., Khalid, K. A., and Patrick, W. H., Jr. 1978. "Disposal Alternatives for Contaminated Dredged Material as a Management Tool to Minimize Adverse Environmental Effects," Technical Report DS-78-8, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hunt, L. J., et al. 1978. "Upland Habitat Development with Dredged Material: Engineering and Plant Propagation," Technical Report DS-78-17, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Larsen V. J., and Schierup, H.-H. 1981. "Macrophyte Cycling of Zinc, Copper, Lead and Cadmium in the Littoral Zone of a Polluted and Non-Polluted Lake; II, Seasonal Changes in Heavy Metal Content of Above-Ground Biomass and Decomposing Leaves of *Phragmites australis* (Cav.) Trin.," *Aquatic Botany*, Vol 11, pp 211-230.

Lee, C. R., et al. 1976. "Feasibility of the Functional Use of Vegetation to Filter, Dewater, and Remove Contaminants from Dredged Material," Technical Report D-76-4, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Mason, C. F., and Bryant, R. J. 1975. "Production, Nutrient Content and Decomposition of *Phragmites Communis* Trin. and *Typha angustifolia L.*," *Journal of Ecology*, Vol 63, pp 71-95.

Mudroch, A., and Capobianco, J. 1978. "Study of Selected Metals in Marshes on Lake St. Clair, Ontario," *Archiv fur Hydrobiologie*, Vol 84, pp 87-108.

Pratt, D., and Andrews, N. 1981. "Research in Biomass/Special Energy Crop Production in Wetlands," In: B. Richardson, ed., *Proceedings of the Midwest Conference on Wetland Values and Management*, Minnesota Water Planning Board, St. Paul, pp 71-81.

Schierup, H.-H., and Larsen, V. J. 1981. "Macrophyte Cycling of Zinc, Copper, Lead and Cadmium in the Littoral Zone of a Polluted and Non-Polluted Lake; I, Availability, Uptake and Translocation of Heavy Metals in *Phragmites australis* (Cav.) Trin.," *Aquatic Botany*, Vol 11, pp 197-210.

Schroder, R. 1973. "Die Freisetzung von Pflanzennahrstoffen in Schilfgebiet und ibr Transport in das Freiwasser am Beispiel des Bodensee-Untersees," *Archiv fur Hydrobiologie*, Vol 71, pp 145-158.

Ulrich, K. E. and Burton, M. 1985. "The Effects of Nitrate, Phosphate and Potassium Fertilization on Growth and Nutrient Uptake Patterns of *Phragmites australis* (Cav.) Trin., Ex Steudel," *Aquatic Botany*, Vol 21, pp 53-62.

Wetzel, R. G., and Allen, H. L. 1972. "Functions and Interactions of Dissolved Organic Matter and the Littoral Zone in Lake Metabolism," In: Z. Kajak and A. Hillbricht-Ilkowska, ed., *Productivity Problems of Freshwater*, Polish Scientific Publishers, Warsaw, pp 333-347.

Wile, I., Palmeteer, G., and Miller, G. 1981. "Use of Artificial Wetlands for Wastewater Treatment," In: B. Richardson. (ed.), *Selected Proceedings of the Midwest Conference on Wetland Values and Management*. Minnesota Water Planning Board, St. Paul, pp 255-272.

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