Article 92

*Technical Note #53 from Watershed Protection Techniques. 1(4): 210-213*

# Pollutant Dynamics Within Stormwater Wetlands: Plant Uptake

Plants in a constructed wetland function to physically slow the flow of water and cause suspended particles to fall out; provide a substrate on which associated microbes assimilate organics, metals, and nutrients; and take up pollutants from the sediment into the roots. It is arguable whether this last function is really desirable in either constructed or natural wetlands.

A key management question is whether pollutants that are deposited in wetland sediments are incorporated into wetland plant tissue. Will toxic metals and hydrocarbons interfere with plant growth and nutrient uptake? Pollutants that are deposited in the stormwater wetland can remain in the pond muck, be taken up by plant roots below ground, or be taken up into the shoots (Figure 1). Will nutrients be released back into the water when the plants die back in the fall? Is there a risk that waterfowl that feed on wetland plants will be affected? Which plants are most sensitive to metal pollutants and which are most efficient at accumulating pollutants? A study by the city of Seattle (1993) addresses some of these questions.

The South Base bus maintenance site is a good example of a hydrocarbon "hotspot" in the sense that while good stormwater practices are in place and the site is well managed, it is an area of high impervious cover and vehicular traffic: 18.5 acres of vehicle maintenance area and parking lots. The city converted a dry detention pond to a 0.56 acre constructed wetland in 1988 in order to improve outflow water quality and study plant uptake of zinc, lead, and total petroleum hydrocarbons (TPH). Five plant species were chosen for intensive study: common cattail *(Typha latifolia)*, water flag *(Iris pseudacorus)*, burreed (*Sparganium* sp. ), blunt spike-rush *(Eleocharis ovata)*, and hardstem bulrush *(Scirpus acutus)* which grew in monospecific stands in the pond.

Both the amount of pollutants taken up and the area covered by the different species were measured in order to find the species that is most efficient for pollutant removal (having highest uptake per area of cover). Daily and seasonal changes in water level, rainfall, and plant biomass were recorded. During the summer, whole plant specimens were harvested, and samples of above- and below-ground tissue and surrounding soil underwent chemical analysis. Samples were analyzed for lead, zinc, TPH, nitrogen, and phosphorus.

The data were analyzed separately for roots and shoots and pooled for whole plant uptake. South Base Pond plants and sediments were compared with uncontaminated controls. Summarized results for cattail are presented in Table 1.

Of the five species at South Base wetland, cattail was most efficient at taking up pollutants. While concentrations of lead, zinc, and TPH were actually highest in bureed tissue, cattail was more vigorous and therefore had the greatest pollutant uptake per area of cover. Pollutant concentrations were also high in spike-rush tissue but this species ranked fourth in vigor. Whether this or any species was growing at less than full potential because of its high pollutant uptake is a question not addressed in this study.

Previous research has indicated that metal uptake is species specific, and for most aquatic plants the bulk of pollutants are stored in the roots and not the stems and leaves (although zinc is more mobile than lead (Lepp, 1981)). This finding was confirmed for the five wetland plants at South Base. The key result of this study is that concentrations of TPH, zinc, and lead were higher in the root than the shoot (Figure 2). Biofiltration by plants only works if the pollutants are settling to the bottom—plants do not take up appreciable amounts from the

Sediments, nutrients, trace metals, and hydrocarbons enter the pond during storms. The pollutant load varies depending on the land use near the pond. Pollutant particles are deposited in the muck layer, where they are usually bound (1). Some pollutants may migrate further. Studies show that plants uptake metals in the sediments into the roots (2). A very small concentration of metals enters via the water column and a small concentration leaves the roots to enter the shoots (3).

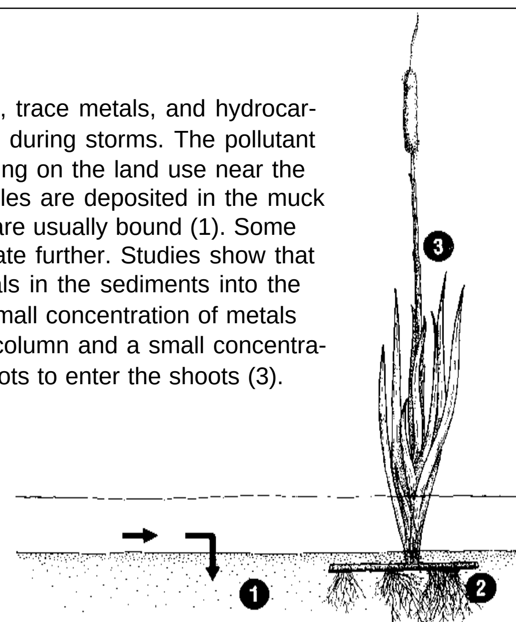



**Figure 1: Pollutant Pathways in a Wetland**

**Table 1: Pollutant Concentrations in Cattail (ppm)**

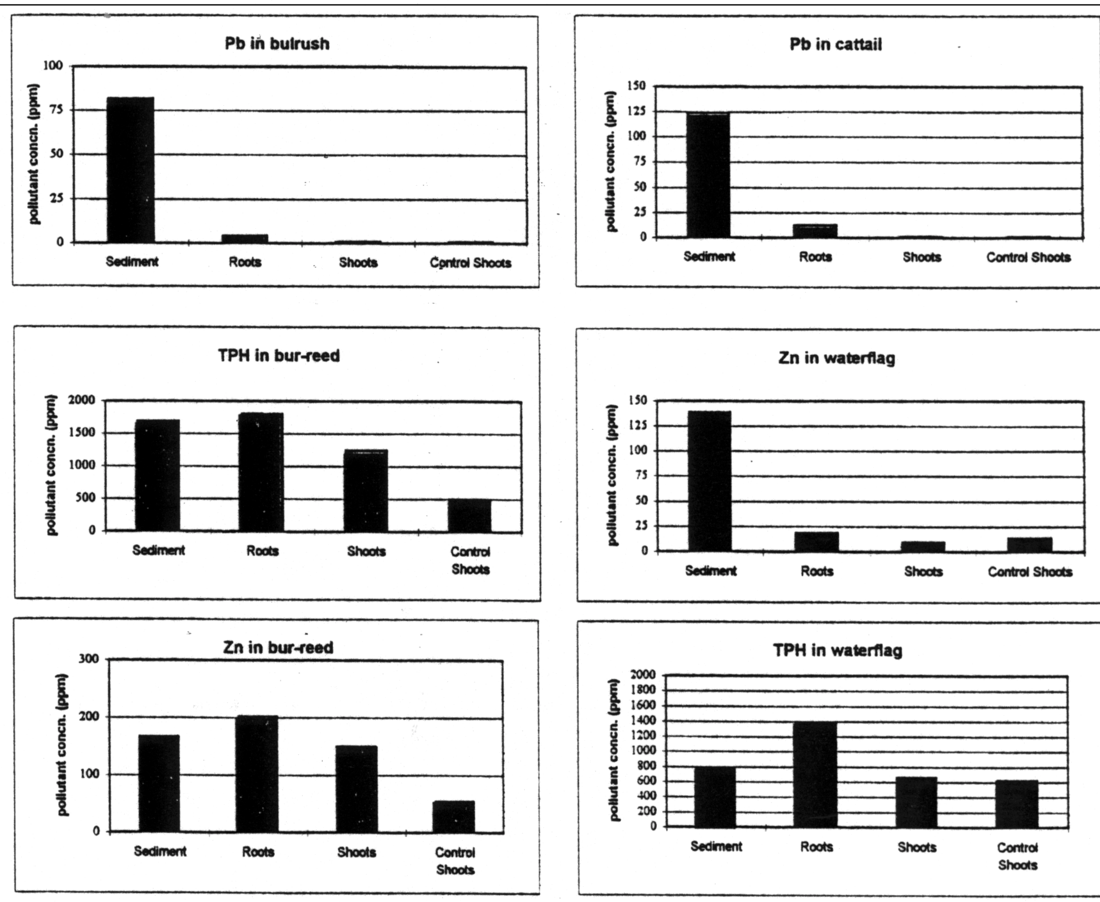
| | TPH | Lead | Zinc |
|---|---|---|---|
| Roots* | 2,867 | 17.2 | 125 |
| Shoots* | 516 | 1.37 | 31 |
| Soils* | 3,907 | 107 | 292 |
| Pond muck from typical urban wetland** | ND | 330 | 163 |

*average of means from three sampling dates
**Schueler, 1995

water column. Roots not only directly take up pollutants but also oxidize surrounding soil, enabling microbes to assimilate pollutants.

It might seem that because these pollutants are stored in the roots and rhizomes of plants, we need not be concerned about risks to animals that consume the vegetation (unless the roots are eaten) or export of pollutants to water supplies when the shoots die back. However, it must be noted that South Base Pond is a newly constructed wetland, and few studies exist concerning pollutant fate in aged wetlands. It is not known what happens to root pollutants as perennial plants age. The whole plant, including the root, eventually dies, and pollutants may be given off along with the decaying material. Even before decay, a point may be reached where living root tissue begins to leak. Indeed, root leakiness (membrane permeability to ions) is aggravated by uptake of zinc (Lepp, 1981).

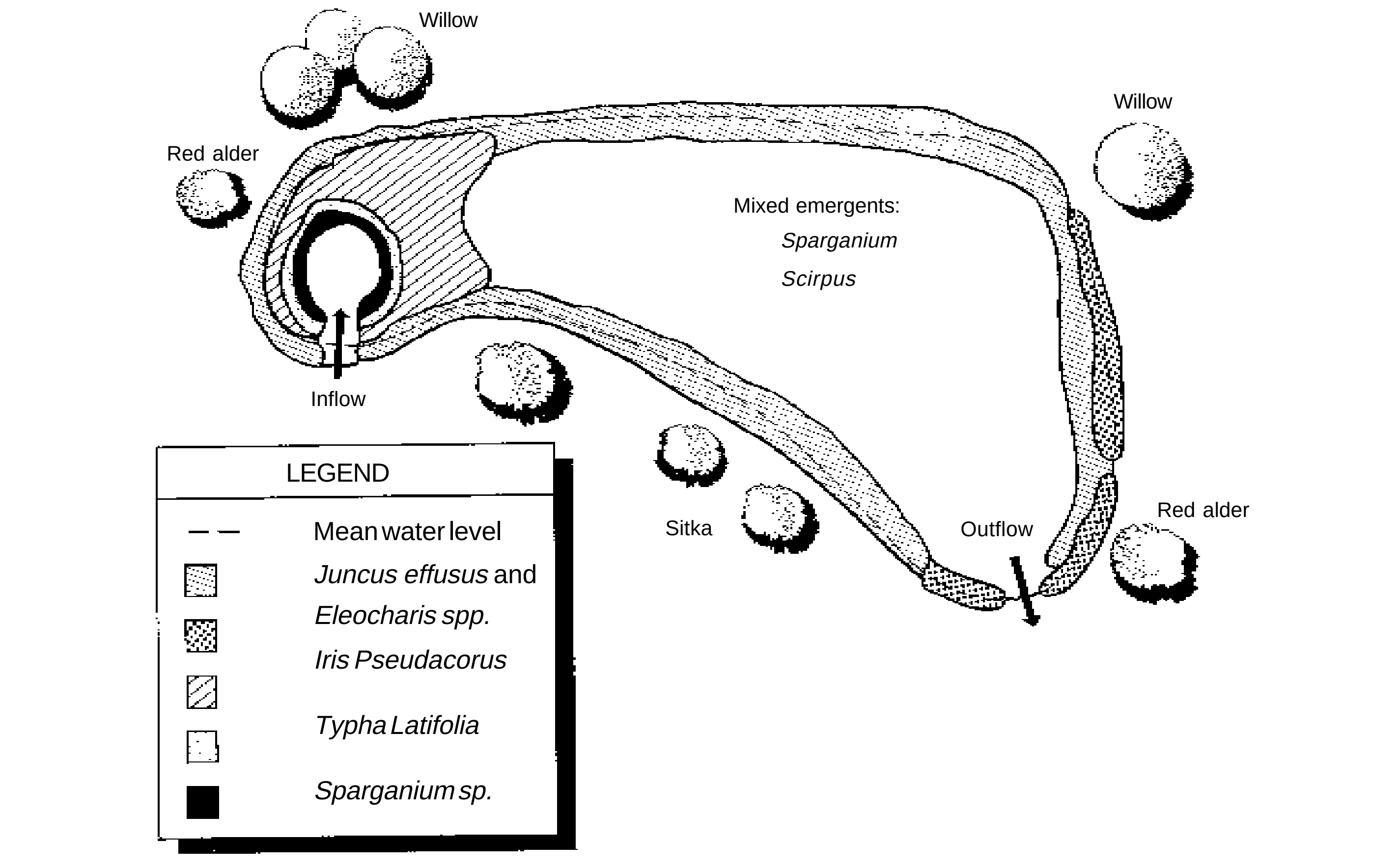
According to Shutes *et al.* (1993), pollutant-laden plants need not be harvested because the pond muck will be covered by less-polluted incoming sediment. This cannot be expected at a hotspot site like South Base where incoming sediment is always contaminated. Sites like these must undergo periodic dredging of at least the forebay to remove overly polluted sediment. If a particular site is known to receive heavy metals and petrochemicals then some thought should be given to whether it is desirable to attract wildlife by providing food plants—especially edible roots. At any rate, it is generally agreed that wetlands not be used as the first




For some pollutants and some species the combined pollutant concentration from the whole plant—root plus shoot—is still significantly less than what is left in the surrounding soil while in other cases just the reverse is true. Pollutant uptake is species specific However, note that in all cases, including those not shown, pollutant concentration was higher in below-ground material (roots) than in the emergent vegetation (shoots). In most cases the level of pollutants in shoots from the stormwater pond were not much different from unpolluted controls; Zn in burreed is an exception. TPH, total petroleum hydrocarbons.

**Figure 2: Selected Data Sets for Wetland Plants at South Base Pond**

**Figure 3: Vegetation Plan for South Base Pond, Seattle (Seattle Metro, 1993)**




interceptor of stormwater. Constructed wetlands in high-hydrocarbon sites should be placed in series after other devices such as the coalescing plate or API water/ oil separators at this site.

The following recommendations emerged from the South Base study:

1. Control the source of pollutants (especially oil spills) where possible. Place a primary treatment system, such as a sand filter or detention pond, prior to the marsh and install floating booms on the deep forebay of the marsh. Create a deep forebay that can be accessed for future dredging if necessary.
2. Create a gentle pond slope for good plant establishment and diversity. Design for moderate water level fluctuations. Most wetland plants thrive in consistently shallow water.
3. Plant primarily rhizomatous perennials with long growing seasons.
4. Use cattail near the inflows. Prevent this species from taking over the whole marsh by thinning and harvesting immature fruit. Choose adjacent species that are not likely to be shaded out (Figure 3).

## Update

Plans are being made for the harvesting and dredging of South Base and an overall management of King County Metro's 11 constructed wetlands. Vegetation is well established. Permanent and transient wildlife—ducks, songbirds, mammals, reptiles - have been observed using the pond. There are no amphibians and fish as the pond dries up in September.

Three years of outflow monitoring show consistently low concentrations of TPH and Pb and Cu. Zn is as high as 330 ppb but averages 80 ppb; fluctuations are non-seasonal. The pond becomes anaerobic and odiferous in dry periods.

***—JMC***

## References

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