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Effects of Wastewater on Forested Wetlands

Cycling nutrient-enriched wastewater from holding ponds through natural, forested wetlands is a practice that municipal waste treatment managers are considering as a viable option for disposing of wastewater. In this wastewater cycling process, sewer effluent that has been circulated through aerated ponds is discharged into neighboring wetland systems. To understand how wastewater cycling affects forest and species productivity, researchers at the USGS National Wetlands Research Center conducted dendroecological investigations in a swamp system and in a bog system that have been exposed to wastewater effluent for many decades.

Dendroecology involves the study of forest changes over time as interpreted from tree rings. Tree-ring chronologies describe the pattern and history of growth suppression and release that can be associated with aging and disturbances such as hurricanes, floods, and fires. But because of limited monitoring, little is known about the potential for long-term effects on forested wetlands as a result of wastewater flooding. USGS researchers used tree rings to detect the effect of wastewater cycling on tree growth. Scientists expected to find that tree-ring width would be increased as a result of added nutrients.

Figure 1. A baldcypress and tupelo gum forest receives wastewater effluent from the aerated holding pond shown beside the Breaux Bridge Wastewater Treatment Plant.

Cypiere Perdue Swamp, Louisiana

Forested swamps of the Mississippi River deltaic plain have been cut off from the natural overflow of the Mississippi River and its distributaries. As a result, these systems have been starved of episodic sediment and nutrient replenishment from overbank flooding. Since 1953, a municipal treatment facility in Breaux Bridge, Louisiana, has been discharging wastewater effluent into the Cypiere Perdue Swamp, a baldcypress (*Taxodium distichum*) and tupelo gum (also known as water tupelo; *Nyssa aquatica*) forest community in the upper reaches of the Vermilion River watershed (fig. 1). Such introduction of wastewater effluent into the forested systems of Louisiana may have the added benefit of increasing forest productivity and slowing the regression of coastal swamp forests into marsh.

To determine the effects of wastewater cycling in the Cypiere Perdue Swamp, scientists from USGS and Louisiana State University selected and cored mature baldcypress trees of similar size and age from both a treated site and a control site in the same drainage system above and below sewage treatment plant outfall, or discharge location. Individual trees were tagged and measured, and duplicate core samples were taken for ring definition and dating. With the aid of a microscope, ring growth was measured to an accuracy of 0.01 mm (0.0004 inch) for the years 1920-92. This sampling period includes over 30 years of growth that predate wastewater cycling, as well as 30 years that show its effects. Growth chronologies were developed for each tree set from the treated and control sites. For analytical purposes, these chronologies were composited by tree and site into equal growth periods over the pretreatment interval of 1926-52 and the treatment interval of 1953-88.

Baldcypress in the treated site showed a pattern of enhanced growth that corresponded to the onset and duration of wastewater cycling. The treated group also exhibited greater growth following wastewater application unlike the control group, which exhibited greater growth prior to wastewater cycling. Despite the greater hydroperiod for the treated site, the addition of nutrient-enriched wastewater augmented tree growth for over 40 years and improved the health and productivity of the forested swamp ecosystem. These findings indicated that baldcypress is responsive to nutrient-rich wastewater and can sustain long-term exposure to effluent flooding.

Drummond Bog, Wisconsin

A municipal treatment facility near Drummond, Wisconsin, has been circulating wastewater effluent through a forested bog since 1979. In preparation for effluent discharge and retention, a weir was constructed to impound surface waters in the 9-ha (22-acre) peat bog. The forest vegetation is a fairly even mix of black spruce (*Picea mariana*) and tamarack (*Larix laricina*). USGS scientists selected dominant, mature trees of both species from a treated site and from a control site for coring to determine the effects of cycling wastewater in Drummond Bog (fig. 2). The treated site was located downslope of the flow of wastewater within 15 m (49 ft) of the wastewater discharge pipe. The control site, which is upslope more than 75 m (246 ft) from the discharge pipe, was distanced from any apparent influence of effluent flooding.

Figure 2. Thomas Doyle, a USGS scientist, is pictured in a Wisconsin bog coring a black spruce for tree-ring analysis.

Researchers used tree-ring analysis to document the effects of wastewater effluent on forest productivity. Individual trees and sets of pairs were measured for diameter at breast height, crown ratio, crown class, hummock area, and distance from discharge pipe. Duplicate core samples were taken, processed, and polished for ring definition and dating. Ring growth was measured for the entire lifespan to an accuracy of 0.01 mm (0.0004 inch) with the aid of a microscope. Growth chronologies were calculated by year and species for the treated and control sites. For analytical purposes, the chronologies were further composited by tree and site into equal growth periods over the pretreatment interval of 1964-78 and treatment interval of 1979-93.

Tree-ring data chronicled the establishment, disturbance history, and growth dynamics of a cohort, or age class grouping, of spruce and tamarack dating to the turn of the 20th century. Tree sample sets were of similar age and size. Findings showed that treated tamarack responded favorably to increased nutrient levels in contrast to the control group, while black spruce was negatively affected by a raised water table and prolonged flooding on both treated and control sites.

Conclusions

Growth chronologies of species from the Cypiere Perdue Swamp and Drummond Bog sites showed that nutrients from wastewater application over several decades can enhance forest productivity in both swamp and bog systems. In cases where wastewater stays impounded, such as in controlled ponds, bogs, or other depressional wetlands, less flood-tolerant tree species may be negatively impacted by prolonged flooding. Results indicate that natural, forested wetlands respond favorably to long-term wastewater cycling and thus, provide municipalities with a cost-effective alternative for disposing wastewater in a beneficial manner for humans and nature.

Reference

Hesse, I.D., Doyle, T.W., and Day, J.W., 1998, Long-term growth enhancement of baldcypress (*Taxodium distichum*) from municipal wastewater application: Environmental Management, v. 22, n. 1, p. 119-127.

For more information, contact

T.W. Doyle
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500
thomas_doyle@usgs.gov
http://www.nwrc.usgs.gov