Physical soil development of two created wetlands at the Olentangy River Wetland Research Park

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Abstract

Soil development was evaluated at two 1-ha created riparian wetlands at the Olentangy River Wetland Research Park (ORWRP) at The Ohio State University campus in Columbus, Ohio. The wetlands were excavated in 1993 and water first added in March 1994. Using the results of soil analyses conducted in 1993 (after basin excavation but prior to water introduction) and 1995 (1.5 years after flooding), a 2002/2003 soil study evaluated the physical development of wetland soils 9 growing seasons after inundation. Soils were evaluated for physical characteristics including: percent soil organic matter (SOM), bulk density, soil color (based on Munsell Color Chart) and form. Soil development was greatest at the surface (0-8 cm) of the study site where SOM increased significantly ($p<0.001$) from 5.32±0.06% in 1993 to 8.75±0.44% in 2002. Bulk density decreased significantly ($p<0.001$) from 1.29±0.02cm in 1993 to 0.81±0.04 in 2002. Surface soils developed most substantially in the deep water and emergent vegetation zones of the wetlands and least in the transitional/upland zones. Sub-surface soils (8-16 cm depth) had less development of organic matter than did the surface soils.

Introduction

Most studies that have examined soils in created wetlands have determined that they are deficient in organic matter when compared to natural wetlands (Shaffer and Ernest, 1999; Campbell et al., 2002). In created wetlands, the accumulation of soil organic matter (SOM) has been identified as an indication of soil maturity because of the time required for it to develop (Nair et al., 2001; Craft, 2001). It is uncertain at what rate and under what conditions SOM accumulates in created wetlands over more than a few years.

An investigation on wetland soil development is being conducted at the Olentangy River Wetland Research Park on The Ohio State University campus in Columbus, Ohio (Figure 1). The first phase of this study is an evaluation of the physical development of soils within the two ‘kidney’ wetlands at the ORWRP. These 1-ha wetlands were excavated in 1993 and river water first added by pumps on March 4, 1994 (Mitsch, 1998). The western marsh (Wetland 1) was planted with 13 species of wetland plants and the eastern marsh (Wetland 2) was left unplanted. Since their creation in 1994, pumping to both wetlands has been continuous and both wetlands have developed into functional wetland ecosystems. The goal of this study was to examine how much and where physical soil development has occurred since creation. Soil development was compared between surface (0-8 cm) and subsurface (8-16 cm) depths, between Wetland 1 and 2, and among different flooding conditions in the experimental wetlands. Based on elevations, both wetlands have developed three general land cover zones: 1) a deep (>60 cm) Open Water Zone, 2) an Emergent Vegetation Zone, and 3) a Transitional/Upland Zone (Figure 1 and 2).

Methods

Soil sampling was based on a previously established 10-m grid system (Figure 1) established in 1993. One hundred and sixty-six samples were collected in December 2002 and compared to results from 102 soil samples in 1993 (after the excavation of the wetlands, but before inundation) and in 1995 (18 months after water was added) (Nairn, 1996). Soils were collected at two depths (0-8 cm and 8-16 cm in all studies). In 2002 a 6.5-cm open-bucket soil auger was used. Most soil samples were collected from 4-18 December 2002. Because some soils could not be extracted cleanly using a bucket auger, a cryogenic coring device (Cahoon et al., 1996) was used to collect soils at 6 sampling points on 24 March 2003. Soils were visually characterized, bagged and kept frozen until processed.

Soil processing was consistent with Nairn (1996). Each soil sample was air dried at 105 °C until constant mass was achieved. Samples were weighed and bulk density was calculated from the initial sample volume. Soil subsamples were weighed, combusted in a muffle furnace at 550 °C for 1 h to determine SOM.

Comparisons between soil data sets used a two-tailed t-test with $p<0.05$ considered a significant difference and $p<0.01$ considered a highly significant difference.

Results and Discussion

Soil Development

Soils have developed significant hydric features since the wetlands were created in 1994. Most soil development was observed at the surface where accumulation of organic

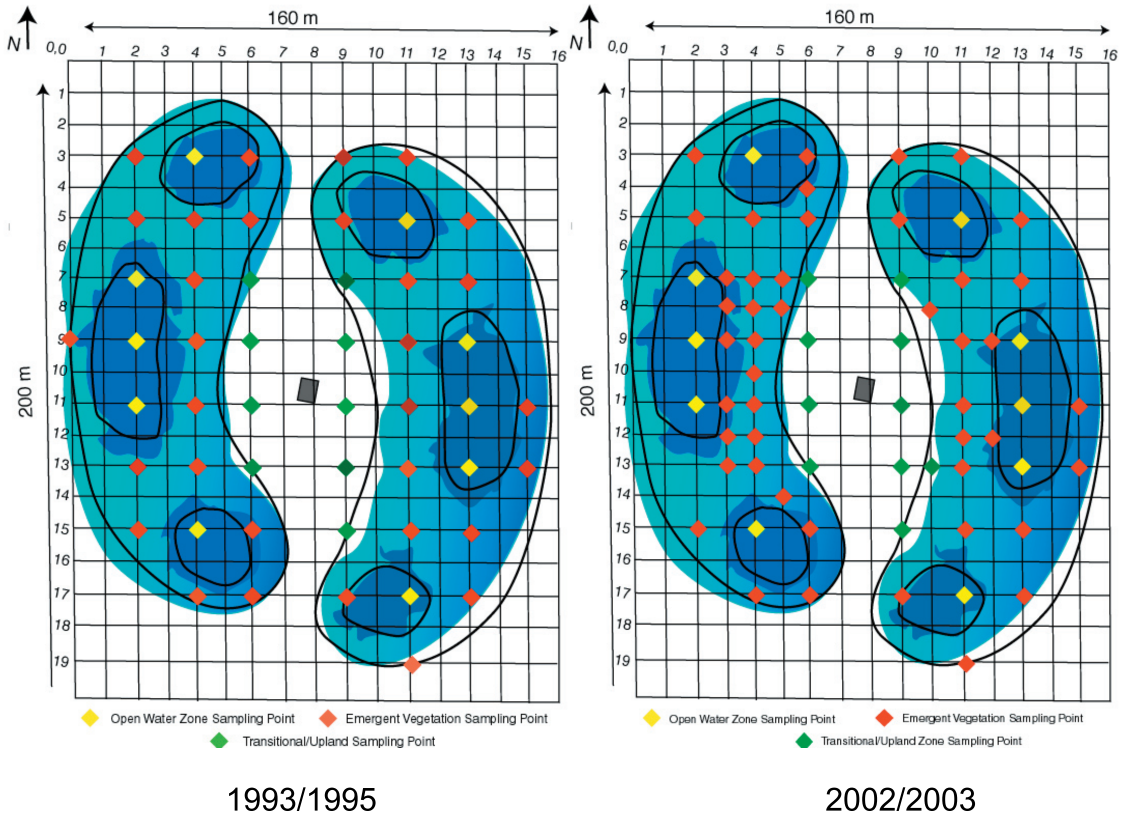

Figure 1. Experimental wetland soil sampling locations at different cover zones in 1993/1995 and 2002/2003. Data from 1993/1995 from Nairn (1996).

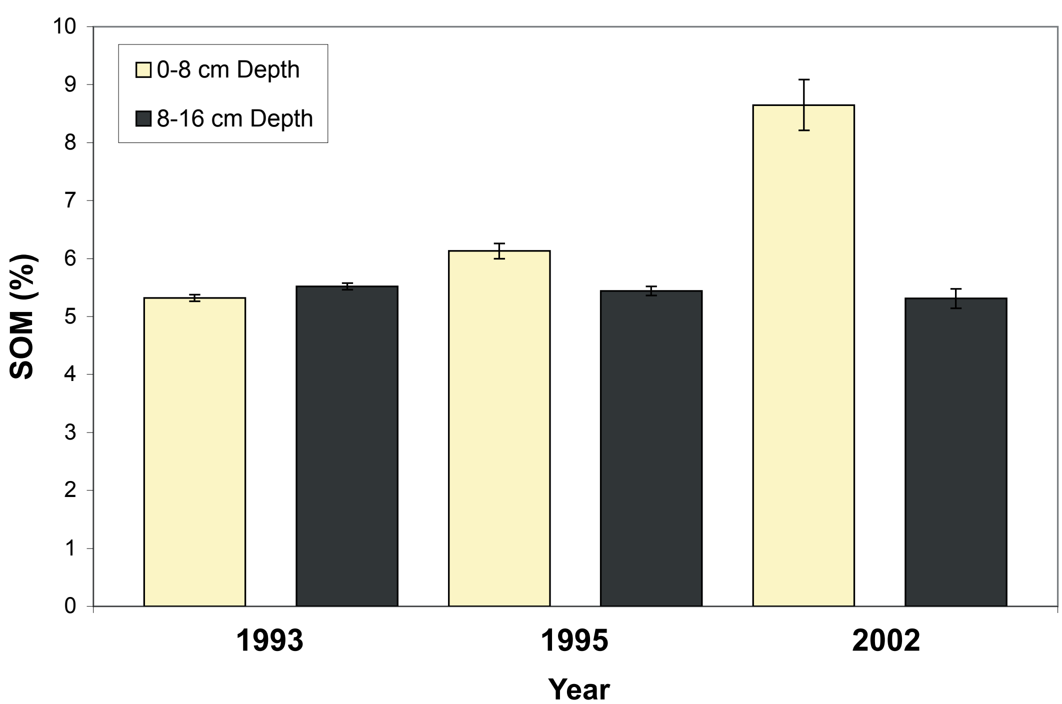

Figure 2. Experimental wetland soil organic matter in 1993, 1995 and 2002. Data from 1993 and 1995 from Nairn (1996).

matter and mineral sediments was greatest. Soil organic matter (SOM) increased significantly ($p<0.001$) at the 0-8 cm depth from 5.32+0.06% in November 1993 to 8.75±0.28% in December 2002 (Figure 2). Soil bulk density decreased significantly ($p<0.001$) from 1.29±0.02 g/cm^3 in 1993 to 0.81±0.04 g/cm^3 in 2002. Soils at the 8-16 cm depth had minimal changes in SOM and bulk density increased significantly ($p<0.001$) from 1.17±0.01 g/cm^3 in 1993 to 1.34±0.03 g/cm^3 in 2002. Much of the soils at the 8-16 cm level were likely original site soil (non-hydric); their 2002 SOM and bulk density values are very similar to the 1993 values recorded for the 0-8 cm depth.

Soil Color

Soil colors in 2002 were compared to data from 1993 and 1995 (Figure 3). None of the soil samples had a chroma of 2 or less (a hydric soil indicator) in 1993 (Nairn, 1996). By 2002, 94% of the soil samples (0 - 8 cm and 8 - 16 cm) had a chroma of 2 or less. One hundred percent of the samples in the Open Water and Emergent Vegetation Zones had chromas of 2 or less. All 2002 soils with chroma values >2 were located in the upland/transitional zones.

Hydrologic Zones

The most substantial changes in soil development among the land cover types occurred at the Open Water Zones and the Emergent Vegetation Zones. At the 0-8 cm depth, these zones had SOM of 8.65±0.58% and 9.16±0.59%, respectively (Figure 4). A moderate increase of SOM was also noted in the Transitional/Upland Zone between 1993 and 2002. Appearance and form of the organic matter varied between the three zones (Figure 4). SOM in the Open Water Zone consisted of much more humified muck than SOM in the other two zones. These areas annually support large quantities of filamentous algae and other submerged/floating vegetation. Because of their low-lignin properties, these materials decay quicker than emergent plants once they settle to the bottom. Harter and Mitsch (2003) tentatively concluded that these deep water areas may be dominant sinks for suspended organic and mineral matter that settles out of the water column. Organic matter in the Emergent Vegetation Zone also contained surficial muck but appeared to be equally influenced by the accumulation of root and emergent macrophyte detritus that was much less decomposed.

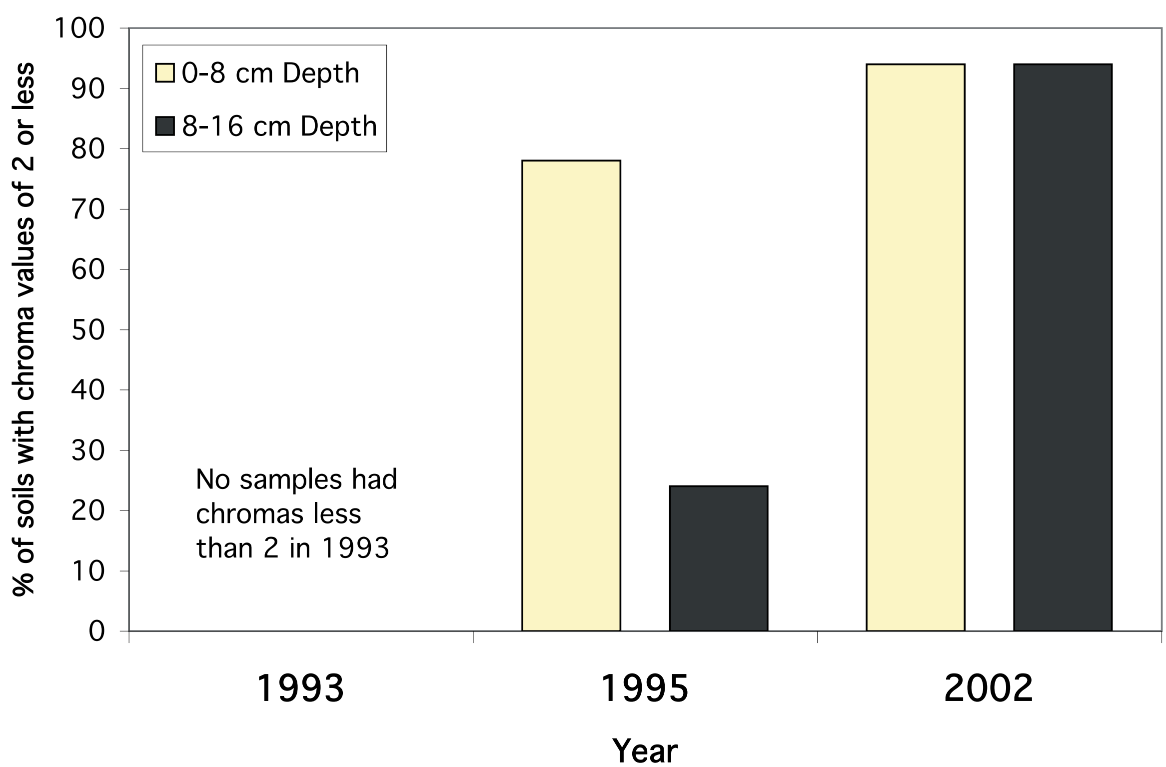

Figure 3. Percent of ORW experimental wetland soils sampled that exhibited chroma values of 2 or less in 1993, 1995 and 2002. Data from 1993 and 1995 from Nairn (1996).

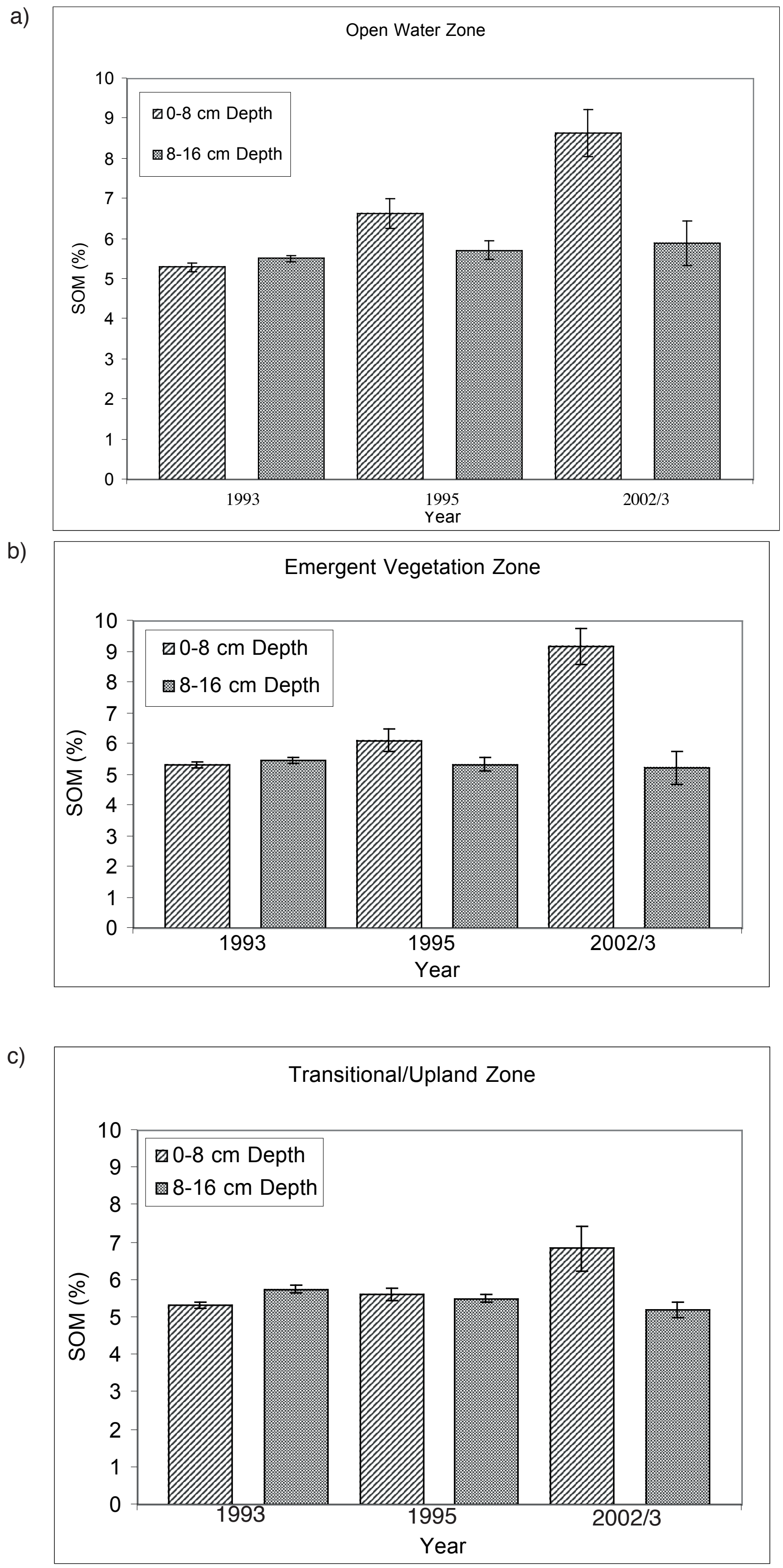

Figure 4. Experimental wetland soil organic matter in 1993, 1995, and 2002 in a) Open Water Zones, b) Emergent Vegetation Zones and c) Transitional/Upland Zones. Data from 1993 and 1995 from Nairn (1996).

Acknowledgements

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