Biogeochemical patterns of created riparian wetlands: Ninth-year results (2002)

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Introduction

As part of a long-term, large-scale experiment on self-design, two wetland basins at The Olentangy River Wetland Research Park were set up as a planting experiment, i.e., one basin was planted in 1994 with 2400 individuals of macrophytes representing 12 species while a second wetland basin remained unplanted (Mitsch et al., 1998). The basins have gone through 8 growing seasons that have been characterized as follows:

• Year 1 (1994) – Wetland 1 (W1) was planted in May with Wetland 2 (W2) as unplanted control. Essentially both basins were algal ponds with few macrophytes.

• Year 2 (1995) – Wetland 1 plants developed, particularly around the perimeter to about 13% macrophyte cover in August, compared to essentially no macrophyte cover in Wetland 2. Floods in late June and early August brought in large carp with waters remaining turbid through much of the rest of the year.

• Year 3 (1996) – Wetland 1 continued to develop in vegetation cover with about 39% cover. Unplanted Wetland 2, particularly after spring drawdown in both wetlands to install sedimentation markers, developed to about 35% macrophyte cover by August, essentially catching up with the planted wetland within 3 growing seasons.

• Year 4 (1997) – Macrophyte growth continued to increase in both wetlands with about 54% cover in Wetland 1 and 58% cover in Wetland 2.

• Year 5 (1998) – Macrophyte cover was similar in the two basins but Wetland 2 began to be dominated by highly productive *Typha* spp. while Wetland 1 still had a wider diversity of cover and was not dominated by *Typha* spp. In other words, Wetland 1 plant cover was now more diverse.

• Year 6 (1999) – Wetland 2 was dominated by *Typha* while Wetland 1 continued to be dominated by 3-4 of the planted species.

• Year 7 (2000) – Similar to 1999 except muskrats developed in the winter of 2000 and began to have a dramatic effect on ecosystem function.

• Year 8 (2001)—Muskrat activity in the winter of 2000-2001 was extreme and vegetation cover was only a small percentage of what it was in previous years (see vegetation chapters in this report). This can be considered the year of maximum muskrat impact and vegetation cover was lower than any period since 1995.

Year 9 (2002)—Drawdown from April through June to allow plants to recover. Weekly water quality was not resumed after pumping began because of laboratory missing assignment,

This study reports water quality results for the 9th year (2002). Other studies of the water quality of these wetlands are reported for Year 1 (Mitsch et al., 1995), Year 2 (Wehr and Mitsch, 1996; Mitsch and Nairn, 1996; Nairn and Mitsch, 1997), Year 3 (Mortensen et al., 1997; Mitsch and

Table 1. Water quality sampling at Olentangy River Wetland site in 2002.

Sample frequency	# Sampling stations	Period in 2000	Equipment	Parameters measured
twice daily	3 (inflow-W1; two outflows)	Jan-Apr; Jul-Dec	YSI probe	temperature dissolved oxygen pH redox conductivity
			Hach turbidimeter(Lab)	turbidity
weekly	7 (river; 1 inflow-W1; 2 middles; 2 outflows; swale)	Jan-Apr	YSI probe	temperature dissolved oxygen pH conductivity
			Hach turbidimeter(Lab)	turbidity
			LACHAT QuikChem IV(Lab)	total phosphorus soluble reactive P $NO_3 + NO_2$

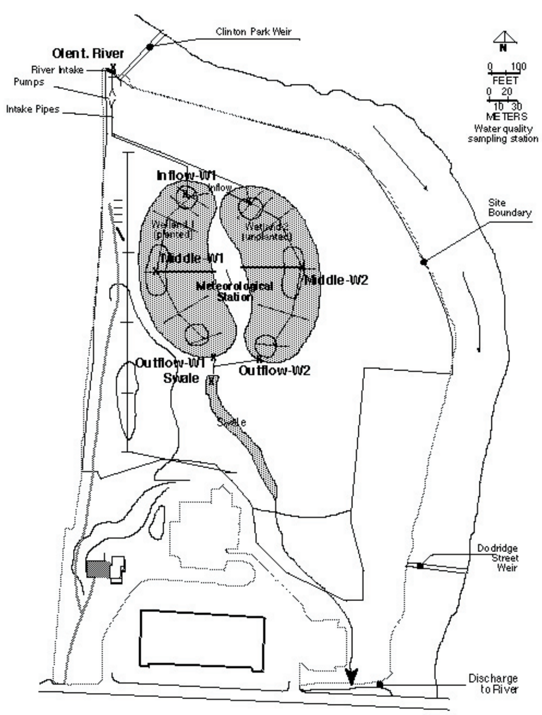
Carmichael, 1997; Nairn and Mitsch, 1997; Vorwerk and Mitsch, 1998), Year 4 (Mitsch and Montgomery, 1998; Spieles and Mitsch, 1998), and Years 5-8 (Mitsch et al., 1999, 2000, 2001, 2002). Two undergraduate honors theses (Wehr, 1995; Vorwerk, 1997), one Master's thesis (Harter, 1999), two Master's theses from Europe (Mortensen and Lanzky, 1996; Kang, 1999) and four dissertations (Nairn, 1996; Spieles, 1998; Liptak, 2000; Ahn, 2001) have also investigated aspects of water quality at the site. Five journal articles (Mitsch et al., 1998; Kang et al., 1998; Nairn and Mitsch, 2000; Spieles and Mitsch, 2000; Ahn and Mitsch, 2002) have been published on water quality of these experimental wetlands.

Methods

A summary of the water quality monitoring protocol for the two experimental wetlands in 2002 is shown in Table 1. Locations of the various sampling stations are shown in Figure 1.

Weekly Sampling

Weekly water sampling, instituted in late April 1994 continued through the first part of 2002. Samples were taken at 7 stations in 2000 as in the previous 5 years. One 1000 ml sample was collected at each of the 7 sites. Water samples were taken to the Ecosystem Analytical Laboratory at Ohio State University where subsamples were filtered and frozen for later measurement of soluble reactive phosphorus. Unfiltered samples were preserved with concentrated H_2SO_4 (2 ml/liter sample) and frozen for later analysis of total phosphorus and nitrate+nitrite (NO_3+NO_2). A raw sample was also stored for any new or additional analyses to be added. Sample preparation and preservation was completed within 48 hours of original collection.



2002 for the experimental wetlands.

Daily Sampling

Two-per-day water sampling, also initiated in 1994, continued through 2002 by the staff and students of the Wetlands Program at Ohio State University. Inflow of Wetland 1 (determined after several studies to represent the inflow to both basins) and the outflows of Wetland 1 and Wetland 2 were monitored in 2001 for temperature, dissolved oxygen, pH, conductivity, and redox with a YSI probe. Instruments were calibrated and checked for battery power frequently. Each time a 100-ml Nalgene bottle was used to take a sample for later measurement of turbidity in the lab at each of the three stations.

Sample Analysis

Standard Methods for the Examination of Water and Wastewater, 17th Edition (APHA, 1989) and EPA Methods for Chemical Analysis of Water and Wastes (U.S. EPA, 1983) were followed. Total phosphorus, soluble reactive phosphorus, and nitrate+nitrite were analyzed on a quarterly or more frequent basis on a Lachat QuikChem IV automated system and Lachat methods (U.S. EPA, 1983). Both total phosphorus and soluble reactive phosphorus methods employed the ascorbic acid and a molybdate color reagent method. For soluble reactive phosphorus and total phosphorus, total phosphorus samples were first digested by adding 0.5 ml of 5.6N H_2SO_4 and 0.2 g NH_3SO_4 to 25 ml of sample and exposing the samples to a heated and pressurized environment for 30 minutes in an autoclave. Nitrate+nitrate, run on the Lachat QuikChem IV automated system, used the cadmium reduction method.

Results and Discussion

Water quality results for 2002 weekly and two-per-day sampling are summarized in Table 2 while percent change through the wetlands and statistical significance are summarized in Table 3. A comparison of percent change in water quality for each of the 6 basic water quality indices for the entire 9-year period is given in Figure 2. Too few nutrient samples were taken for any analysis.

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Table 2. Summary of water quality measurements at Olentangy River experimental wetlands, 1996 through 2002. Two -per-day sampling refers to dawn-dusk sampling done almost every day that water is flowing. Numbers are average ± std. error (# of samples).

Parameter	Year	Olent. River	Inflow	Middle-W1	Middle-W2	Outflow-W1	Outflow-W2	Swale
Total P, μg-P/L	1996	185±15 (40)	191±18 (30)	85±11 (33)	77±9 (34)	68±8 (34)	64±9 (35)	62±9 (33)
	1997	149±16 (46)	146±17 (45)	99±7(39)	113±13 (38)	125±20 (41)	120±12 (43)	94±7 (44)
	1998	244±28 (47)	186±16 (46)	129±15 (47)	133±14 (47)	98±10 (47)	98±11 (47)	31±7 (47)
	1999	194±35 (48)	126±11 (44)	99±11 (43)	138±22 (41)	92±17 (44)	76±12 (45)	70±9 (45)
	2000	159±19 (49)	138±12 (48)	137±30 (41)	148±32 (40)	72±16 (46)	90±19 (47)	86 ±14 (46)
	2001	122±7 (43)	112±6 (42)	86±8 (38)	87±8 (36)	69±7 (41)	83±7 (43)	80±9 (40)
SRP, μg-P/L	1996	58±8 (38)	70±11(29)	19±4 (33)	16±4 (33)	8±1 (33)	9±2 (33)	9±2 (32)
	1997	50±6 (48)	67±12 (47)	23±3 (40)	25±3 (39)	26±3 (37)	23±3 (40)	37±13 (39)
	1998	89±11 (47)	82±10 (46)	45±9 (47)	45±9 (47)	27±6 (47)	31±7 (47)	31±7(47)
	1999	97±10 (47)	94±10 (43)	46± 8 (45)	33±6 (44)	27±4 (47)	24±4 (46)	23±4 (48)
	2000	83 ±9 (46)	82±9 (46)	27±4 (39)	27±4 (40)	19±4 (45)	27±5 (46)	31±6 (44)
	2001	67±9 (42)	60±8 (41)	38±6 (34)	22±3 (33)	23±5 (36)	25±6(37)	35±8 (36)
NO_3 + NO_2, mg-N/L	1996	4.60±0.41 (38)	4.42±0.42 (29)	3.08±0.38(34)	2.89±0.32(34)	2.97±0.40(34)	3.30±0.38(34)	3.19±0.47(31)
	1997	4.89±0.97 (48)	4.23±0.75 (47)	2.92±0.62 (39)	3.02±0.69 (39)	3.51±0.71 (42)	3.55±0.71 (42)	3.45±0.71 (44)
	1998	2.79±0.39 (47)	2.72±36 (46)	2.06 ±0.35 (47)	2.02 ±0.33 (47)	1.83±0.32 (47)	1.67±0.34 (47)	1.82±0.33 (45)
	1999	1.94±0.24 (47)	1.91±0.24 (44)	1.51±0.29 (42)	1.46±0.25 (44)	1.33±0.28 (45)	1.28±0.24 (45)	1.20±0.23 (47)
	2000	4.74±0.63 (49)	4.35±0.48 (48)	3.63±0.55 (41)	2.93±0.44 (42)	2.85±0.62 (45)	2.42±0.34 (46)	2.68±0.62 (43)
	2001	3.24±0.36 (42)	3.32±0.33(41)	2.42±0.37 (36)	2.26±0.38 (36)	2.14±0.34 (40)	2.56±0.37 (42)	2.41±0.32 (40)
Turbidity, NTU [1]	1996		35±3 (319)			21±2 (404)	20±2 (407)	
	1997		28±2 (453)			26±2 (426)	27±2 (447)	
	1998		25±2 (446)			16±1 (459)	16±1 (462)	
	1999		25±2(493)			19±1 (524)	20±1 (521)	
	2000		29±2 (436)			17±1 (442)	19±1 (449)	
	2001		17±1 (359)			17±1 (358)	18±1 (370)	
	2002*		22±3 (80)			29±2 (77)	30±2 (77)	
D.O., mg/L [1]	1996		9.69±0.19 (278)			10.55±0.21(336)	10.48±0.18(338)	
	1997		9.90±0.2 (454)			11.38±0.28 (412)	11.32±0.29 (430)	
	1998		9.40±0.14 (430)			11.98±0.26 (433)	11.66±0.25 (436)	
	1999		8.70±0.15 (463)			9.12±0.24 (486)	8.59±0.21 (489)	
	2000		9.96±0.18 (417)			10.81±0.24 (432)	9.46±0.21 (431)	
	2001		10.23±0.19 (353)			11.29±0.28 (353)	11.07±0.28 (362)	
	2002		10.72±0.33 (157)			11.07±0.43 (139)	10.82±0.39 (151)	
Temp, °C [1]	1996		14.9±0.5 (302)			15.5±0.4 (373)	15.7±0.4 (373)	
	1997		13.2 ±0.4 (476)			13.7±0.4 (443)	13.7±0.4 (464)	
	1998		14.6±0.4 (456)			15.0±0.4 (471)	15.1±0.4 (475)	
	1999		14.9±0.4 (488)			14.8±0.4 (512)	14.6±0.4 (509)	
	2000		13.6±0.4 (478)			14.5±0.4 (487)	14.3±0.4 (486)	
	2001		14.0±0.4 (413)			14.7±0.5 (402)	14.9±0.4 (411)	
	2002		11.8±0.77 (159)			11.3±0.8 (141)	12.1±0.8 (153)	
Cond., μS/cm [1]	1996		535±6(282)			452±5(349)	454±5(350)	
	1997		621±7 (401)			576±7 (364)	593±7 (385)	
	1998		539±6 (450)			487±5 (462)	502±6 (467)	
	1999		550±8 (488)			527±8 (513)	533±8 (512)	
	2000		454±5 (479)			421±4 (485)	441±5 (486)	
	2001		568±9 (410)			519±7 (400)	536±7 (410)	
	2002		651±11 (159)			631±10 (139)	631±12 (152)	
pH [1]	1996		7.91±0.02(300)			8.17±0.03(367)	8.19±0.03(368)	
	1997		7.94±0.03 (443)			8.24±0.04 (412)	8.20±0.04 (431)	
	1998		8.18±0.04 (365)			8.47±0.04 (374)	8.38±0.04 (375)	
	1999		7.74±0.02 (480)			7.87±0.03 (502)	7.80±0.02 (502)	
	2000		7.73±0.01 (425)			7.93±0.02 (438)	7.76±0.02 (433)	
	2001		7.94±0.02 (412)			8.33±0.04 (402)	8.20±0.02 (411)	
	2002		7.90±0.05 (148)			8.14±0.05 (128)	7.98±0.05 (136)	
Redox, mV[1]	1996		394±4(213)			387±3(263)	384±3(265)	
	1997		433±3 (338)			433±3 (352)	430±4 (377)	

1998	333±6 (440)	309±6 (450)	307±6 (456)
1999	302±7 (436)	283±7 (460)	281±7 (457)
2000	289±2 (376)	274±2 (386)	283±2 (383)
2001	233±6 (263)	235±5 (234)	236±5 (242)
2002	177±8 (81)	165±9 (75)	166±9 (80)

Table 3. Water quality changes (+ indicates increase through wetland) and statistical significance at Olentangy River experimental wetlands, 1999-2001. W1 = planted wetland; W2 = unplanted wetland; In = inflow; Out = outflow.

Parameter and year	% change W1	% change W2 (+ = increase; - = decrease)	Paired t-test, p-value In v. Out W1	In v. Out W2	Out W1 v. Out W2
Temp 99	-1.1	-2.1	nd	nd	0.0070
Temp 00	+6.0	+5.1	0.0000	0.0134	0.0000
Temp 01	+5.6	+7.0	0.0000	0.0000	nd
Temp 02	-3.9	+2.9	0.267	0.0067	0.0314
DO 99	+4.9	-1.2	nd	0.0438	0.0001
DO 00	+8.5	-5.0	0.0000	0.0010	0.0000
DO 01	+10.4	+8.1	0.0000	0.0000	nd
DO 02	+3.3	+1.0	0.7830	0.8087	nd
Cond 99	-4.2	-3.1	0.0002	nd	0.0014
Cond00	-7.2	-2.9	0.0000	0.0000	0.0000
Cond01	-8.5	-5.5	0.0000	0.0000	0.0001
Cond 02	-3.0	-3.1	0.1068	0.1582	nd
pH 99	+ 1.7	+0.7	0.0001	0.0020	0.0001
pH 00	+2.7	+0.4	0.0000	0.0040	0.0000
pH01	+4.9	+3.2	0.0000	0.0000	0.0000
pH 02	+3.0	+1.1	0.0000	0.0000	0,0004
Redox 99	-6.3	-6.8	0.0001	0.0001	nd[1]
Redox 00	-5.1	-2.3	0.0000	0.0000	0.0000
Redox01	1.0	1.5	0.0000	0.0000	0.0000
Redox 02	-6.9	-6.5	0.0365	0.0602	nd
Turbidity 99	-24.3	-18.2	0.0001	0.0070	0.0044
Turbidity 00	-42.7	-35.2	0.0000	0.0000	0.02751
Turbidity01	-0.6	8.2	nd	nd	nd
Turbidity 02	+29.2	+31.9	0.0085	0.0177	0.788
Total P 99	-27	-40	0.0128	0.0001	nd
Total P 00	-47	-34	0.0000	0.0184	nd
Total P 01	-39	-26	0.0000	0.0001	0.0115
SRP 99	-71	-75		0.0001	0.0001
nd					
SRP 00	-77	-67	0.0000	0.0000	nd
SRP 01	-62	-59	0.0000	0.0000	nd

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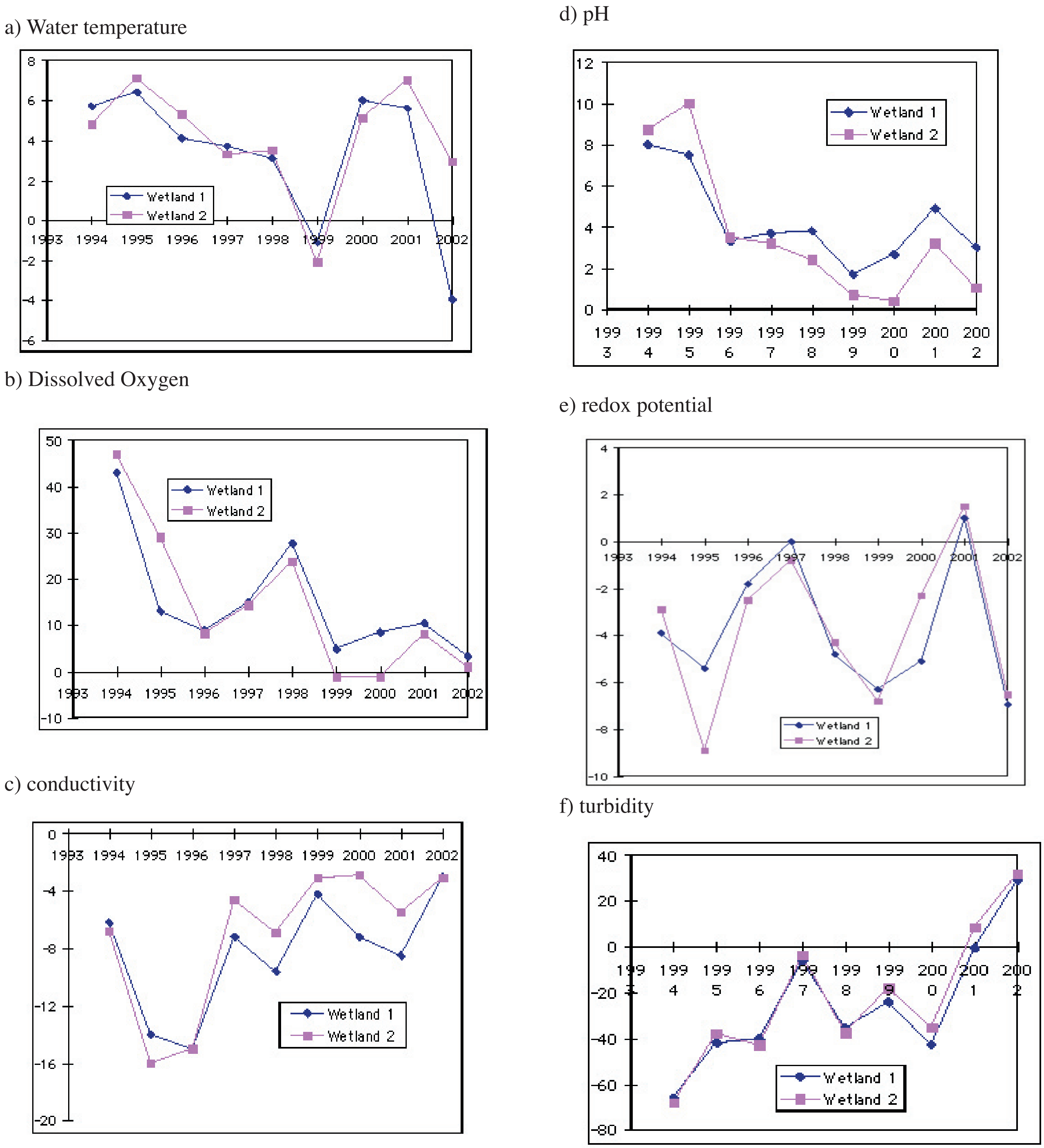

Figure 2. Changes in water quality 1994-2002 in experimental wetland basins. Values are expressed as percent change from inflow to outlfow.

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