

BIBLIOGRAPHY OF CRITICAL TISSUE NUTRIENT CONCENTRATIONS IN  
SUBMERSED AQUATIC MACROPHYTES AND TISSUE NUTRIENT CONCENTRATIONS  
IN SAGO PONDWEED (POTAMOGETON PECTINATUS L.)

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This bibliography is a compilation of critical tissue nutrient concentration information for submersed aquatic macrophytes, and for field observations of tissue nutrient concentration data for sago pondweed (Potamogeton pectinatus L.). In addition to providing data and literature sources, data are summarized to provide some indication of ranges observed in nature or in critical concentration studies. This bibliography was compiled as a companion volume to the manuscript "Seasonal tissue nutrient composition of Potamogeton pectinatus L. in Badfish Creek, Wisconsin."

DESCRIPTION OF TABLES:

APPENDIX 1. Critical nutrient concentrations for submersed aquatic macrophytes as observed in laboratory studies. Predominantly from research done over several years by Dr. Gerald Gerloff, Professor Emeritus at the University of Wisconsin-Madison.

APPENDIX 2. Summary of critical tissue nutrient concentrations for submersed aquatic macrophytes. Since so few species were studied, data for all species was summarized as one without distinguishing between species.

APPENDIX 3. Tissue nutrient concentrations of Potamogeton pectinatus. Data from 25 field studies of nutrient composition of this one species from around the world, in both flowing and still waters. Notes indicate status of plant, and if an average is given for that study.

APPENDIX 4. Summary of tissue nutrient concentrations in Potamogeton pectinatus. Gives an average and range of values for each constituent studied, as well as the number of studies in which a particular element was examined.

LITERATURE CITED. Literature sources for appendices 1 through 4.

APPENDIX 1.  
Critical Nutrient Concentrations for Submersed Macrophytes

Number	Species	N %	P %	K %	Ca %
1	<i>Ceratophyllum demersum</i>	1.3	0.1	1.7	0.22
2	<i>Ceratophyllum demersum</i>	1.3	0.13		
3	<i>Elodea occidentalis</i>	1.6	0.14	0.8	0.28
4	<i>Elodea occidentalis</i>	1.4	0.14		
5	<i>Heteranthera dubia</i>	1.3	0.12		
6	<i>Myriophyllum exalbescens</i>		0.08		
7	<i>Myriophyllum spicatum</i>	0.75	0.07	0.35	
8	<i>Najas flexilis</i>	1.3	0.13		
9	<i>Vallisneria americana</i>	1.3	0.13		
10	<i>Zannichellia palustris</i>	1.3	0.13		

APPENDIX 1 (cont.)  
Critical Nutrient Concentrations for Submersed Macrophytes

Number	Mg %	Zn ppm	B ppm	Mn ppm	Fe ppm	Cu ppm	Mo ppm
1	0.18		5				
2							
3	0.1	8	1.3	4	60		0.15
4							
5							
6							
7		1.8					
8							
9							
10							

APPENDIX 1 (cont.).  
Critical Nutrient Concentrations for Submersed Macrophytes

Number	Cl ppm	Al ppm	Na ppm	Reference	Notes
1				Gerloff 1975	
2				Gerloff and Krombholz 1966	Approx.
3				Gerloff 1975	
4				Gerloff and Krombholz 1966	
5				Gerloff and Krombholz 1966	
6				Wilson 1972	
7				Gerloff 1975	
8				Gerloff and Krombholz 1966	Approx.
9				Gerloff and Krombholz 1966	
10				Gerloff and Krombholz 1966	Approx.

APPENDIX 2.  
 Summary of Literature Values  
 Critical Nutrient Concentrations for Submersed Macrophytes

Nutrient	Mean	Max.	Min.	Count	S. D.
N%	1.28	1.6	0.75	9	0.211
P%	0.117	0.14	0.07	10	0.0237
K%	0.95	1.7	0.35	3	0.561
Ca%	0.25	0.28	0.22	2	0.03
Mg%	0.14	0.18	0.1	2	0.04
S%	0.08	0.08	0.08	1	0
Zn ppm	4.9	8	1.8	2	3.1
B ppm	3.15	5	1.3	2	1.85
Mn ppm	4	4	4	1	0
Fe ppm	60	60	60	1	0
Cu ppm				0	
Mo ppm	0.15	0.15	0.15	1	0
Cl ppm				0	
Al ppm				0	
Na ppm				0	

## APPENDIX 3.

Tissue Nutrient Concentrations of Potamogeton pectinatus

Number Site	N %	P %	K %	Ca %
1 Badfish Creek, WI 1983	3.63	1.11	2.88	1.06
2 Badfish Creek, WI 1984	4.16	0.72	1.66	0.58
3 Cheshire Lk, England	2.4	0.49	1.44	0.76
4 Cheshire Lk, England	3.2	0.65	2.27	4.32
5 Cheshire Lk, England	1.2	0.31	0.98	0.37
6 Co. Ditch 59, MN	1.68	0.38		
7 Dal Lake, India	2.44	0.125	2.04	3.03
8 Fish Pond, Czeck.	3.08	0.54	2.29	2.6
9 Fish Pond, Czeck.	2.34	0.52	1.66	2.1
10 Forfar Loch, Scotland	5.01	0.65	3.92	1.52
11 Forfar Loch, Scotland	6.01	0.81	4.27	1.88
12 Forfar Loch, Scotland	4.04	0.46	3.65	0.99
13 Fox Lake, ND	0.58	0.2		
14 Fox Lake, ND	1.52	1.96		
15 Germiston Lake, SA		0.395		
16 Germiston Lake, SA		0.86		
17 Germiston Lake, SA		0.591		
18 Germiston Lake, SA		0.41		
19 Golden Canal, Czeck.	4.23	0.82	2.39	0.46
20 Halverson Lk, WI	2.34	0.3	0.4	
21 Iliff Lk, NJ	1.46	0.2	1.35	5
22 Iliff Lk, NJ	1.98	0.33	2.1	0.25
23 Impoundments, Ont.	1.68	0.13		
24 Impoundments, Ont.	2.6	0.36		
25 India	1.05			
26 India	1.42			
27 Lk Warniak, Poland	1.61	0.04	1.21	5.9
28 Loch Leven, Scotland		0.53		
29 Loch Leven, Scotland		0.3		
30 Loch Leven, Scotland		0.46		
31 Loch Leven, Scotland		0.25		
32 Mikolajskie Lk, Poland	3.12	0.8	1.95	
33 Mikolajskie Lk, Poland	3.6	0.8	2.1	
34 Mikolajskie Lk, Poland	3.1	0.5	2.5	
35 Mikolajskie Lk, Poland	3.2	0.9	3	2.7
36 NJ Waters	1.72	0.26	1.73	2.63
37 NY Marsh	2.65	0.25	1.27	3.3
38 Oak Orchard Creek, NY	2.97	0.44	1.61	4.6
39 Oak Orchard Creek, NY	3.06	0.7	1.93	2.42
40 PA Rivers		0.3	1.33	0.85
41 Ponds, Cheshire, England	2.6			
42 Reservoir, England	2.4		3.6	
43 Stillwater, KS	1.98	0.16	3	
44 Swartvlei, SA		0.1		

## APPENDIX 3 (cont.).

Tissue Nutrient Concentrations of *Potamogeton pectinatus*

Number	Mg %	Zn ppm	B ppm	Mn ppm	Fe ppm	Cu ppm	Mo ppm
1	0.55	232	383	1443	1603	14.5	
2	0.41	124	43.6	860	2835	17.5	
3							
4							
5							
6							
7	2.43						
8	0.93						
9	0.49						
10	0.41				1010		
11	0.52				1360		
12	0.31				820		
13	0.24						
14	0.68						
15							
16							
17							
18							
19	0.2				108		
20							
21	0.56						
22	0.05						
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35	0.7	40		400	1000		
36	0.3	0.81		300	16700	74	
37	0.59			1040	2140		
38	0.32	130			5800	17	
39	0.46	170			3500	15.8	
40	0.38	161	170	2866	1100	103	
41							
42							
42							
44							

## APPENDIX 3 (cont.).

Tissue Nutrient Concentrations of Potamogeton pectinatus

Number	Cl ppm	Al ppm	Na ppm	Reference	Notes
1		920	18900	MMSD unpubl. data	
2		1644	7751	Madsen 1986	
3	17000		11700	Allenby 1981	Ave.
4	26200		22700	Allenby 1981	Max.
5	10000		7200	Allenby 1981	Min.
6				Hill 1986	
7			2120	Kaul et al. 1980	
8			9100	Dykyjova et al. 1985	Max.
9			7400	Dykyjova et al. 1985	Min.
10			13400	Ho 1979	Ave.
11			14400	Ho 1979	Max.
12			12000	Ho 1979	Min.
13				Kollman and Wali 1976	
14				Kollman and Wali 1976	
15				Vermaak et al. 1983	Spring
16				Vermaak et al. 1983	Summer
17				Vermaak et al. 1983	Autumn
18				Vermaak et al. 1983	Winter
19			9000	Dykyjova et al. 1985	
20				Engel 1985	
21			11100	Riemer and Toth 1969	
22			1000	Riemer and Toth 1969	
23				Wile and McCombie 1972	
24				Wile and McCombie 1972	
25				Vyas and Das 1978	Flowering plant
26				Vyas and Das 1978	Vegetative plant
27				Bernatowicz 1969	
28				Jupp and Spence 1977	Leaves, max.
29				Jupp and Spence 1977	Leaves, min.
30				Jupp and Spence 1977	Roots, max.
31				Jupp and Spence 1977	Roots, min.
32			16000	Ozimek 1978	Heavily polluted
33			11500	Ozimek 1978	Heavily polluted
34			10000	Ozimek 1978	Slightly polluted
35	8000		7200	Ozimek 1978	Unpolluted
36	9300		6000	Riemer and Toth 1968	
37				Lathwell et al. 1973	
38		2700		Peverly 1985	Year 1
39		1000		Peverly 1985	Year 2
40		1100	1950	Adams et al. 1973	
41				Allenby 1968	
42				Brooks and Edwards 1973	
43				Harper and Daniel 1934	
44				Howard-Williams and Allanson 1981	

APPENDIX 4.  
 Summary of Literature Values  
Potamogeton pectinatus Tissue Nutrients

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Nutrient	Mean	Max.	Min.	Count	S. D.
N%	2.72	6.01	0.8	31	1.14
P%	0.472	1.11	0.04	38	0.253
K%	2.04	4.27	0.4	28	0.917
Ca%	2.23	5.9	0.2	25	1.56
Mg%	0.554	2.43	0.05	19	0.484
S%	0.643	1.28	0.09	7	0.367
Zn ppm	123	232	0.81	7	73.1
B ppm	199	383	43.6	3	140
Mn ppm	1152	2866	300	6	857
Fe ppm	3165	16700	108	12	4335
Cu ppm	40.3	103	14.5	6	35.1
Mo ppm				0	
Cl ppm	14100	26200	8000	5	6810
Al ppm	1473	2700	920	5	664
Na ppm	10021	22700	1000	20	5343

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