Whole Lake Chemical Additions in the Experimental Lakes Area, 1984-1985

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ABSTRACT

Cruikshank, D.R. 1986. Whole lake chemical additions in the Experimental Lakes Area, 1984-1985. Can. Data Rep. Fish. Aquat. Sci. 580: iv + 10 p.

Acidification of four basins in the Experimental Lakes Area continued in 1984 and 1985. Lakes 223, 114 and 302S received sulfuric acid and L302N nitric acid. In addition, aluminum additions were made to L114. Nitrogen and phosphorus were added to L227 in continuation of a 16 year eutrophication experiment.

Key words: acidification; fertilization; lake manipulations.

RÉSUMÉ

Cruikshank, D.R., 1986. Whole lake chemical additions in the Experimental Lakes Area, 1984-1985. Can. Data Rep. Fish. Aquat. Sci. 580: iv + 10 p.

L'acidification de quatre (4) bassins dans la Région des lacs Expérimentaux s'est poursuivie en 1984 et 1985. De l'acide sulfurique a été versé dans les lacs 223, 114 et 302S et de l'acid nitrique dans le lac 302N. On a également ajouté des sels d'aluminum dans le lac 114. Dans le cadre d'un programme expérimental d'eutrophisation de 16 ans, on a ajouté de l'azote et du phosphore dans le lac 227.

Mots-clés: acidification; fertilisation; manipulations dans les lacs.

INTRODUCTION

This report is the second in a series of reports on whole lake chemical additions in the Experimental Lakes Area. Data on additions from 1969-1983 inclusive was presented in the first report (Cruikshank 1984). Equipment and methodology remained unchanged, and were described in the first report.

The acidification of L114 and fertilization of L227 remained unchanged from previous years. However, during 1984, aluminum in the form of aluminum sulfate was added to L114. This study involved the effects of aluminum on aquatic invertebrates and minnow populations (Playle 1985).

The acidification of L223 entered the first two years of its recovery stage in 1984 and 1985. The target pH for L223 was 5.4 in both years up from 5.0 (1981-83).

L302 entered its third and fourth years of acidification with target pH's of 5.5 in L302S in 1984 and 5.3 in 1985.

Tables 1 to 5 summarize quantities of acid and nutrients added to lakes. Appendix 1 indicates corrections to the first report necessary because of misinformation supplied by the chemical suppliers. The nitric acid used has a specific gravity of 1.381 $kg \cdot L^{-1}$ not 1.5 $kg \cdot L^{-1}$ as previously reported. The sulfuric acid has a specific activity of 1.81 $kg \cdot L^{-1}$ and is 93.29% pure, not 99% as first reported.

Appendices 2 to 4 show daily pH measurements and acid additions.

METHODS

Acid additions to L114, L223 and L302 were made using the "Prop-tube mix" method and fertilizer additions to L227 were made using the "barrel method" (Cruikshank 1984).

Aluminum sulfate additions to L114 were made using the "barrel method". Quantities of alum were dissolved in the barrel on a continuous basis between 08:00 and 18:00 h daily. The dissolved solution then drained by gravity through a tube into the inflow of the lake. It then dissipated through the lake according to the surface and internal water movements of L114. Summer Al additions were made to a point 30 m offshore from the dry, lake inflow using a floating plastic pipe (Playle 1985).

SOURCES OF CHEMICALS

All chemicals were purchased from two Winnipeg firms (C.I.L. Ltd. and Harrisons & Crossfield Ltd.). Prices and packaging were similar to the previous report. Aluminum sulfate was obtained in 40 kg bags, in ground powder form, for $0.38/kg.

SAFETY MEASURES

Dusts or solutions made from aluminum sulfate have acidic properties and cause irritations in the throat, nose and eyes. Use of respirators and protective clothing are recommended.

ACKNOWLEDGMENTS

I would like to thank Stefan Himmer, Mark Lyng, Geoff Tomlinson, Brian Kotak and Tim Cooper who made most of the acid and fertilizer additions; Rick Playle for his aluminum data and Lillian Wilson who typed this report. Garry Linsey and staff supplied the pH data.

REFERENCES

CRUIKSHANK, D.R. 1984. Whole lake chemical additions in the Experimental Lakes Area. 1969-1983. Can. Data Rep. Fish. Aquat. Sci. 449: iv + 23 p.

PLAYLE, R.C. 1985. The effects of aluminum on aquatic organisms: 1) alum additions to a small lake and 2) aluminum-26 and tracer experiments with minnow. M.Sc. thesis, University of Manitoba, Winnipeg, MB. 176 p.

Table 1. L114 sulfuric acid and aluminum sulfate additions.

		Sulfuric acid				Aluminum sulfate	
Year	Dates	Litres added	kg H_2SO_4* added	kg H^+ added	Time-weighted mean pH	kg alum added	kg Al added
1984	Mar 31 - Sep 27	168	283.68	5.84	5.65	630	53.93
	(5 additions H_2SO_4) (20 additions $Al_2(SO_4)$						
1985	May 24 - Oct 10 (6 additions)	201.6	340.41	7.02	5.88		

* Corrected for purity.

† Manufacturer's specifications state that $Al_2(SO_4)_3 \cdot (H_2O)$ where x may range between 14 and 18. For these calculations an average of 16 H_2O was used.

Table 2. L223 sulfuric acid additions.

Year	Dates	Litres added	Sulfuric acid kg H_2SO_4* added	kg H^+ added	Target epilimnion pH	Time-weighted mean epilimnion pH
1984	May 21 - Oct 8 (14 additions)	680.4	1148.80	23.66	5.40	5.44
1985	May 13 - Nov 6 (34 additions)	3671.1	6198.80	127.67	5.40	5.53

* Corrected for purity.

Table 3. L227 fertilizer additions.

		Sodium nitrate $NaNO_3$				Phosphoric acid					
		$kg \cdot wk^{-1}$	Total kg	$kg\ N \cdot wk^{-1}$	Total kg N	$L \cdot wk^{-1}$	Total litres	$kg \cdot wk^{-1}$	Total kg P	kg P wk^{-1}	Total kg P
1984	May 8 - Sep 18 (20 weekly additions)	34.0	680.4	5.61	112.15	2.5	50.0	4.25	85.0	1.14	22.83
1985	May 7 - Sep 24 (20 weekly additions)	34.0	680.4	5.61	112.15	2.5	50.0	4.25	85.0	1.14	22.83

Table 4. L302N nitric acid additions.

Year	Date	Nitric acid Litres added	kg HNO_3* added	kg H^+ added	Time-weighted mean epilimnion ph
1984	May 9 - Sep 25 (25 additions)	2804.4	2433.72	39.00	6.24
1985	May 14 - Oct 9 (21 additions)	3050.4	2647.20	42.43	6.02

* Corrected for purity.

Table 5. L302S sulfuric acid additions.

Year	Date	Litres added	Sulfuric acid kg H_2SO_4* added	kg H^+ added	Target pH	Time-weighted mean epilimnion pH
1984	May 9 - Oct 8 (24 additions)	1152.9	1946.73	40.09	5.50	5.60
1985	May 14 - Oct 8 (21 additions)	1247.4	2106.30	43.38	5.30	5.31

* Corrected for purity.

Appendix 1. Corrections for acid additions reported in Cruikshank, D.R. 1984. Whole lake chemical additions in the Experimental Lakes Area, 1969-1983. Can. Data Rep. Fish. Aquat. Sci. 449: iv + 23 p.

1a. Corrections to Table 1 L114 sulfuric acid additions

Year	kg H_2SO_4 added (corrected for purity)	kg H^+ added
1979	226.94	4.67
1980	397.15	8.18
1981	340.41	7.02
1982	340.41	7.02
1983	340.41	7.02
Total	1645.32	33.91

1b. Corrections to Table 2 L223 sulfuric acid additions

Year	kg H_2SO_4 added (corrected for purity)	kg H^+ added
1976	9350.84	192.58
1977	4914.69	101.22
1978	6378.32	131.36
1979	4755.12	97.93
1980	5233.83	107.79
1981	5999.75	123.57
1982	5840.18	120.28
1983	3765.80	77.56
Total	46238.55	952.29

Also, 1978 should read 31 additions

1c. Corrections to Table 8 L302N nitric acid additions

Year	kg HNO_3 added (corrected for purity)	kg H^+ added
1982	1981.15	31.75
1983	2134.84	34.21
Total	4115.99	65.96

1d. Corrections to Table 9 L302S sulfuric acid additions

Year	kg H_2SO_4 added (corrected for purity)	kg H^+ added
1982	2074.38	42.72
1983	1870.41	38.52
Total	3944.79	81.24

1e. Correction to Table 11 L304 fertilizer additions. In 1975 and 1976 total kg N should be 524.0 kg.

1f. No corrections for purity were made in Appendix.

For HNO_3 HNO_3 (L) x 0.6284 x 1.381 = kg HNO_3.
For H_2SO_4 H_2SO_4 (L) x 0.9329 x 1.81 = kg H_2SO_4.

Appendix 2. Daily L223 pH measurements and H_2SO_4 additions.

Date	1984 pH	1984 kg H_2SO_4 added	1985 pH	1985 kg H_2SO_4 added	Date	1984 pH	1984 kg H_2SO_4 added	1985 pH	1985 kg H_2SO_4 added	Date	1984 pH	1984 kg H_2SO_4 added	1985 pH	1985 kg H_2SO_4 added
May 7	5.39				6	5.44				Aug 29	5.35			
9	5.41				8			5.68		Sep 2			5.40	
11	5.32				9	5.38				3	5.31		5.35	127.65
13				382.96	10	5.42		5.74	127.65	4	5.51			
14	5.41				11	5.38				5	5.52	63.82		
15	5.35		5.59	95.74	13	5.34				6	5.64			
16	5.64				15	5.44		5.57	191.40	9				127.65
21	5.36		5.94	159.57	16			5.59		10	5.55		5.43	
23	5.39		5.59	95.74	17	5.56	63.82			11	5.54		5.45	
25	5.61				20	5.44				12	5.57	95.74		
27			5.64		22	5.04		5.80	223.40	16			5.49	
28	5.30			159.57	23	5.31				17			5.50	
29	5.34				24					18	5.66			
30	5.38				25			5.58	159.57	19	6.05	127.65		
31			5.62		26			5.46		20				95.74
Jun 1	5.58				27			5.37		23			5.61	255.17
3			5.53	191.48	29			5.48	95.74	24	5.63	127.65	5.55	
4	5.72		5.54	191.48	30	5.33		5.43		25	5.54			319.14
5	5.41	95.74	5.35		31	5.53	31.91	5.05		26			5.45	
7	5.28		5.41		Aug 1	5.39				30				191.48
10			5.79		2	5.32				Oct 1	5.53		5.55	
11	5.40			255.17	5			5.45		2	5.55	63.65	5.59	191.48
12			5.54		6	5.42		5.41		3	5.59		5.55	
13	5.40			95.74	7	5.51		5.42		4			5.61	
14			5.29		10	5.59	63.82		63.82	8		127.65	5.71	255.17
17			5.41		12			5.46		9			5.80	
18	5.53		5.63		13	5.37		5.49		10			5.76	
19	5.53		5.51	95.74	14	5.37		5.53		15			5.72	127.65
20	5.47				15	5.32			159.57	17	5.55			
21	5.55				17	5.58	31.91			22		127.65	5.71	
22	5.53				19			5.45	95.74	23			5.83	287.22
24					20	5.36		5.53		24			5.69	
25	5.50		5.41		21			5.55		29			5.72	247.39
26	5.50	31.91	5.94		22	5.43				30			5.62	
27	5.58		5.67	95.74	23	5.43				31			5.61	
Jul 1			5.67	95.74	26				191.48	Nov 6				574.44
2	5.37		5.56		27					7			5.26	
3				159.57	28	5.56	31.91	5.30		8			5.37	

Appendix 3. Daily L302N pH measurements and HNO_3 additions.

Date	1984 pH	1984 kg HNO_3 added	1985 pH	1985 kg HNO_3 added
May 1	5.87			
7	6.21			
9		170.79	6.22	
10	6.00	384.27	6.05	
11	5.73			
14	6.38			426.97
15	6.04			
16			5.68	
17	6.09			
21	6.33			
22	6.28	128.09		170.79
23			5.38	
25	6.67			159.57
28	6.31	42.70	5.97	
29	6.08			42.70
30	6.24			
31		85.39	5.55	
Jun 1	6.27			
4		85.39	5.89	
5	6.22			
6	6.09		5.82	
7	6.23			
9		85.39		
11			6.07	42.70
12	6.10			
15	6.45			
17			6.08	
18			6.06	85.39
19	6.61		6.28	
20		42.70		128.09
21	6.72			
24			5.87	
25	6.96		5.93	
26	6.41			
30		42.70		
Jul 2			6.35	
3		42.70		85.39
4	6.43		6.00	
6	6.51			

Date	1984 pH	1984 kg HNO_3 added	1985 pH	1985 kg HNO_3 added
Jul 9	6.26	85.39	6.46	
10	6.26			
12		42.70		
13	6.20			
16		42.70	6.68	85.39
17	6.30			
19		85.39		
20	6.30			
22			6.58	85.39
23	6.45		6.62	
24		128.09		
25	6.30		6.72	
26	6.47		6.29	
27	6.79			
29			6.50	
30	6.49		6.61	42.70
31	6.37			
Aug 1			6.38	42.70
2	6.71			
6	6.42		6.25	
7	6.40	42.70	6.76	
9	6.51			
10		426.97		
11	6.25			
12			6.43	
13	6.30		6.26	85.39
15		128.09		
16	6.16			
17		85.39		
19			6.25	
20			6.33	170.79
21	6.31			
22		85.39		
23	6.18			
26			6.27	
27	6.22		6.42	170.79
28	6.30	85.39		
29				
30	6.15			

Date	1984 pH	1984 kg HNO_3 added	1985 pH	1985 kg HNO_3 added
Sep 2			6.00	
3	6.42		6.16	128.09
4		85.39		
5	6.32			128.09
9			6.16	
10	6.34		6.13	
11	6.34			
12				85.39
17	6.21		6.03	
18		85.39		
20				128.09
23			5.97	
24	6.04		5.92	170.79
25		85.39		
26	6.04			
30			6.02	
Oct 1	6.08		6.09	
2	6.10			170.79
7			6.04	
8	6.25	170.79	6.11	
9				170.79
15	6.33			
16	6.26			
17			6.02	
19	5.95			
21			6.10	
22	5.95		6.04	
28				
29	6.19		6.10	
30	6.17			

Appendix 4. Daily L302S pH measurements and H_2SO_4 additions.

Date	1984 pH	1984 kg H_2SO_4 added	1985 pH	1985 kg H_2SO_4 added
May 1	5.89			
7	6.27			
9		478.70	5.93	
10	5.23		5.69	
11	5.44			
14	5.53			319.14
15	5.40			
16			5.43	
17	5.68			
21	5.74			
22	5.76	95.74		127.65
23			4.96	
25	5.82			
28	5.66	31.91	5.34	
29	5.70			31.91
30	5.74			
31		63.82	5.31	
Jun 1	5.47			
4	5.86		5.48	
5	5.55	63.82		
6	5.35		5.36	
7	5.78			
11		63.82	5.45	31.91
12	5.38			
15	5.44			
17			5.66	
18			5.66	95.74
19	5.65		5.59	
20		31.91		95.74
21	5.54			
24			5.26	
25	5.84		5.14	
26	5.69			
30		31.91		
Jul 2			5.63	95.74
3	5.70	31.91		
4			4.90	
6	5.88			
9	5.85	63.82	5.37	

Date	1984 pH	1984 kg H_2SO_4 added	1985 pH	1985 kg H_2SO_4 added
Jul 10	5.62			
12	5.72	31.91		
16		31.91	5.56	63.82
17	5.60			
19		63.82		
20	5.67			
22			5.60	63.82
23	5.83		5.53	
14		95.74		
25	5.45		5.47	
26	5.47		5.29	
27	5.69			
29			5.37	
30	5.58		5.37	31.91
31	5.60			
Aug 1			5.32	
2	5.62			
6	5.61		5.38	31.91
7	5.77	31.91	5.26	
9	5.91			
10		63.82		
11	5.69			
12			5.42	
13	5.78		5.40	63.82
15		95.74		
16	5.66			
17		63.82		
19			5.54	
20			5.54	127.65
21	5.86			
22		95.74		
23	5.72			
26			5.43	127.65
27	5.85		5.47	
28	5.78	95.74	5.33	
29	5.42			
30	5.48			
Sep 2			5.36	
3	5.57		5.39	95.74

Date	1984 pH	1984 kg H_2SO_4 added	1985 pH	1985 kg H_2SO_4 added
Sep 4		63.82		
5	5.59			95.74
9			5.35	
10	5.59		5.27	
11	5.53			
12				63.82
17	5.58		5.30	
18		63.82		
20	5.50			95.74
23			5.47	
24	5.62		5.52	127.65
25		63.82		
26	5.62			
30			5.40	
Oct 1	5.50		5.42	
2	5.57			191.48
3			5.22	
7			5.27	
8	5.71	127.65	5.47	127.65
10			4.93	
14			5.10	
15	5.28			
16	5.41		5.06	
19	5.41			
21			5.16	
22	5.40		5.11	
28			4.14	
29	5.56		5.16	
31	5.55			