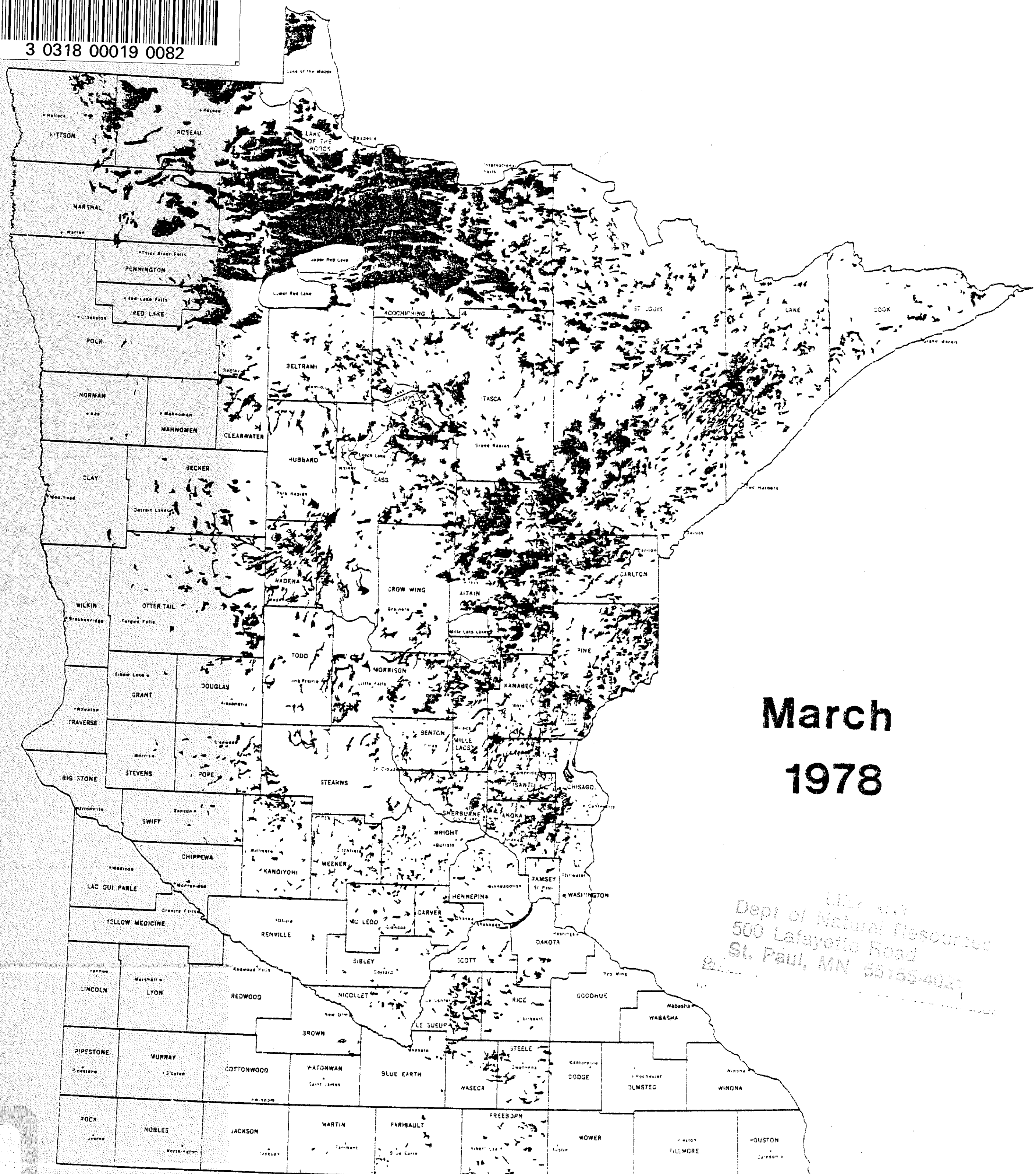
EFFECTS OF PEAT UTILIZATION ON WATER QUALITY IN MINNESOTA



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SUBMITTED TO MINNESOTA DEPARTMENT OF NATURAL RESOURCES

EFFECTS OF PEAT UTILIZATION ON WATER QUALITY IN MINNESOTA

Final Report and Recommendations, 3/78

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I. Results of literature survey and experimental work:

There is a large volume of scientific literature concerning water chemistry as it relates to waters present in peat bogs. We have assembled several hundred papers concerned with this topic, covering research carried out between about 1890 and 1977. Unfortunately, we have found much redundancy in this literature. Also, only a very small fraction of the total is directly relevant to the task at hand - prediction of water quality effects that might result from extensive mining of peat resources. Main, relevant points gleaned from our literature search are presented in the following.

A. Micronutrients found in typical peat land waters

Micronutrients are defined here as chemical substances required in small amounts by plants and animals for their optimal growth. These micronutrients include principally ions such as Ca^{++}, Mg^{++}, Na^{+}, K^{+}, Cl^{-}, $SO_4^{=}$, HCO_3^{-}, $PO_4^{=}$, and various soluble forms of nitrogen. Micronutrient concentrations of representative bog waters are summarized in Tables 1 and 2.

Table 1: Some Chemical Properties of Representative Bog Waters

BOG (Reference)	Ions, mg/liter Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	$SO_4^{=}$	HCO_3^{-}	pH	Optical Density 320 nm	350 nm	Total Cations	Total Anions	Specific Conductivity*
Red Lake Bog (1) Station #4, USA	6.6	3.8	1.1	0.4	0.32	5.9	32.4	7.87	–	–	–	–	51
Red Lake Bog (1) Station #2, USA	4.3	2.4	1.0	0.5	0.25	4.8	20.9	7.87	–	–	–	–	35
Red Lake Bog (1) Station #9, USA	4.1	0.6	0.7	0.7	0.43	6.9	6.9	5.85	–	–	–	–	21
Red Lake Bog (1) Average**, USA	0.22	0.04	0.05	0.04	0.02	0.3	0.002	3.97	1.435	1.075	0.458	0.329	14
Myrtle Lake (1) Upper Drain, USA	3.2	0.3	–	–	–	–	–	3.95	–	–	–	–	–
Myrtle Lake (1) Lower Drain, USA	3.8	1.5	–	–	–	–	–	4.60	–	–	–	–	–
Hudson Bay (2)	1.7	0.5	0.3	0.1	2.0	–	0.0	4.75	–	–	–	–	16
Falkland Tsls. (2)	2.1	5.4	38.6	1.6	72.0	13.4	–	4.1	–	–	2.35	–	–
Lowland East (2) West Ireland	0.8	1.8	12.5	0.5	20.6	7.7	–	4.4	–	–	0.783	–	–
Sutherland (2)	0.5	1.1	13.9	0.6	23.6	5.3	–	4.51	–	–	0.760	–	–
Coon Ribb (2), North England	1.0	1.1	5.3	0.05	9.3	10.9	–	3.90	–	–	0.508	–	–

Table 1 continued:

BOG (Reference)	Ions, mg/liter Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	$SO_4^{=}$	HCO_3^{-}	pH	Optical Density 320 nm	350 nm	Total Cations	Total Anions	Specific Conductivity*
Moor House (2) North England	0.9	0.6	3.4	0.3	5.0	11.4	–	3.91	–	–	0.371	–	36
Rannoch Moor (2) West Scotland	0.3	0.3	2.2	0.1	4.3	2.7	–	4.5	–	–	0.169	–	40
Eastern Sudeten (2) Poland	0.5	0.3	0.2	0.2	0.3	7.7	–	3.92	–	–	0.169	–	–
Surface Peats (2) Irish Bogs, Average	1.4	0.9	30	8	70	11	–	4.3	–	–	–	–	–
Bog Pools (2) "Wet Weather" North England	0.3	0.2	1.7	0.17	3.2	4.0	–	4.21	–	–	–	–	–
Bog Pools (2) "Dry Weather" North England	1.17	0.8	4.3	0.33	5.9	15.2	–	3.85	–	–	–	–	–
Mountain Bog (2) USA	2.2	0.6	3.6	1.05	7	3	15	5.6	–	–	–	–	36.3

1 = Hofstetter, R.H. 1969. Ph.D. Thesis, University of Minnesota.

2 = Gorham, E. 1955. Geochemica et Cosmochimica Acta 7:129-150.

Table 2: Concentrations of Nitrogen and Phosphorus in Representative Bog Waters

BOG (Reference)	Total* P	Total* N
Ombotrophic Peat (1), Finland	0.127	8.17
Minerotrophic Peat (1), Finland	0.147	8.24
Mire Water Pools (1), Finland	0.122	8.72
Shagnum Hollows (1), Finland	0.128	7.78
Mud Hollows (1), Finland	0.149	7.44
High Moor Sphagnum Bog (1), Sweden	0	1.6
Surface Peat (2), Scotland	180**	11,100**
German Bog (2)	120**	-

1 = Gorham, E. 1955. Geochemica et Cosmochimica Acta 7:129-150.

2 = Wheatley, et al. 1976. Soil Biol. Biochem. 8:453-460.

* = mg/liter.

** = ppm of oven dry peat.

Conclusions concerning micronutrients in representative peat bog waters:

1. The cations of bog waters are often dominated by Na^+, those of fen waters by Ca^{++} (cf. Gorham, 1955).

2. Bog waters generally may be considered as oligotrophic with respect to minerals (Ca, Mg, Na, K, $SO_4^=$, etc.).

3. Bog waters are most often quite acidic (with occasional exceptions). This acidity results from a combination of factors, including: the presence of considerable amounts of CO_2 (usually not a principal cause); the presence of small quantities of organic acids in these waters; the presence of humic acids (usually considered as a major cause of bog acidity) in bog waters; metabolic activities of bog plants, particularly sphagnum; unknown factors.

4. Bog waters may be considered as being eutrophic with respect to N and P concentrations (P concentrations generally exceed 100 μg/liter, cf. Table 2). Bog waters are thus a potentially significant source of P and N to receiving waters.

B. Effects of Bog Humic Substances on Plants and Animals in Receiving Waters

There is a substantial volume of literature attesting to the toxicity of aqueous humic substances toward plants and animals. This observation is in fact so reproducible that it should be of significant concern to officials concerned with drainage of Minnesota's peat lands. The following is a compendum of representative examples of experiments demonstrating bog water toxicity.

1. Polyphenolic humic acids are known to be strong chelating agents for inorganic ions, and may prevent their uptake by aquatic plants, including phytoplankton (Janzen, D.H. 1973. Biotropica 6:69-103).

2. Humic substances in natural waters decrease light penetration and thereby reduce primary productivity (Janzen, D.H. 1973. Biotropica 6:69-103).

3. M.M. Brinson (1973; Ph.D. Thesis, University of Florida) and L.G. Brinson (1973; M.S. Thesis, University of Florida) found that water forced out of peat swamps is highly toxic and repellent to fish that inhabit receiving lake water. This is a significant warning with respect to drainage of Minnesota peat lands.

4. Tevanidov (1949; Acad. Sci. USSR Proc. Biol. Soc. 1:100-117) reported that water slaters (*Ascellus aquaticus*) are killed within 24 hours when placed in peat bog water. Low pH was probably the cause; however acidity was an indirect result of high concentrations of humic substances.

5. Geisler *et al*. (1971, Naturwissenshaften 58:303-311) found that Characidae and Cichlidae were highly sensitive to humic materials in bog waters, even though they were tolerant of high acidity.

6. Saponins washed from birch bark (a component of humic substances) can be responsible for heavy fish kills (Janzen, D.H. 1973. Biotropica 6: 69-103). The same author states that insect larvae are often adversely affected by phenolics in bog-derived waters.

7. Fish are "slow growing and stunted" in Wisconsin blackwater lakes fed from peat bogs, and fertilization does not completely eliminate the effect (Johnson and Hasler. 1954. J. Wildl. Mgmt. 18:113-134; Stross and Hasler. 1960. Limnol. Oceanogr. 5:265-272).

8. Humic acids in drinking water are supposed to cause endemic goiter in man (Galcenko. 1950. Priroda 39:73-74; Burkat. 1965. Gigiena i sanitarija 30:97-98). It has been recommended that humic substances in drinking water even in small amounts should be avoided (Prat. 1960. VII Congressus I.G.M. 26-31). However, goiterogenic actions of humic compounds could not be demonstrated in rats (though the response of rats may be different from that of humans and the "correct" humic substance may not have been used in these experiments; Janecek, J. and J. Chalupa. 1969. Arch. Hydrobiol. 65:515-522).

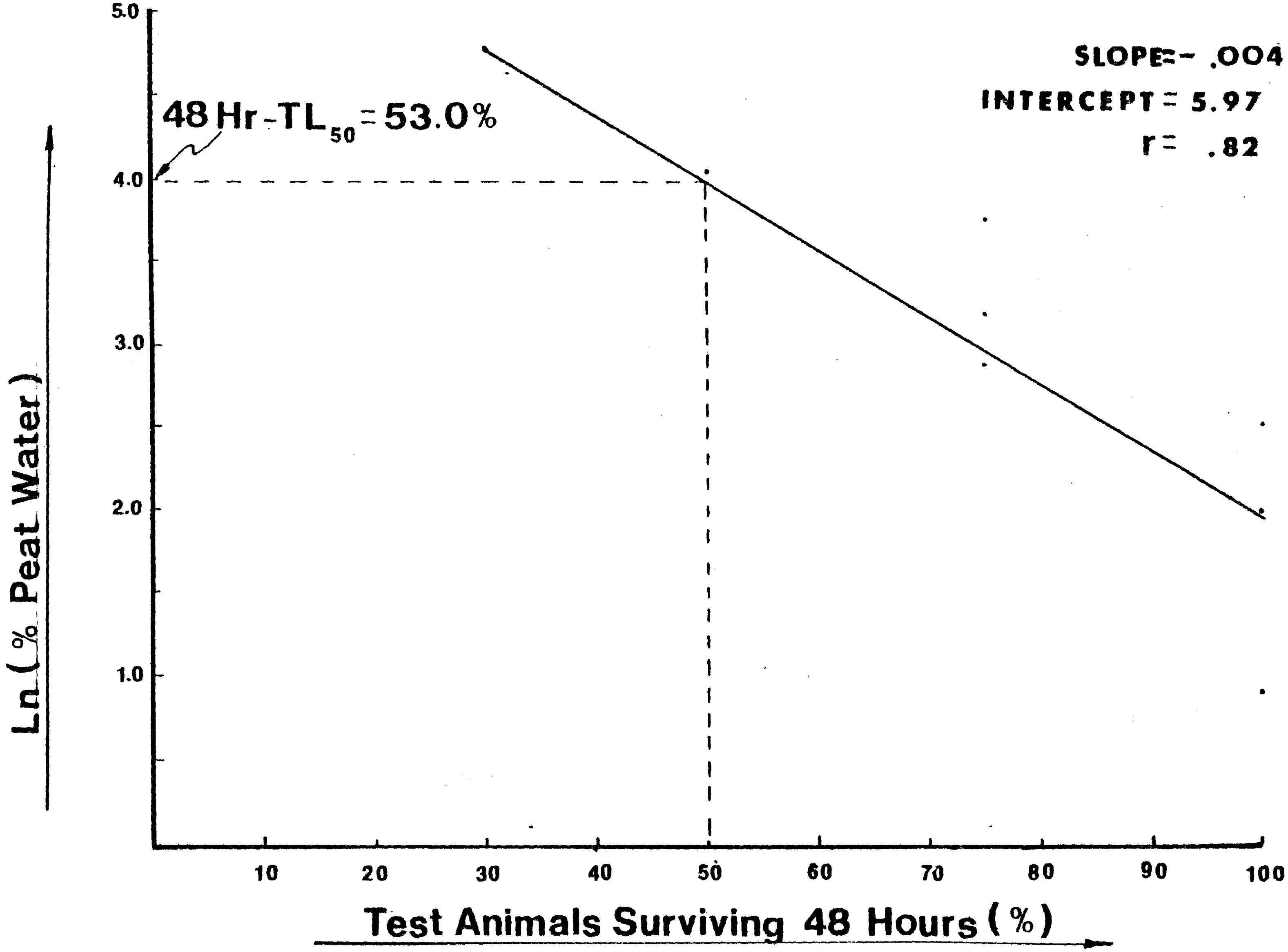
9. Trout (brook) did not colonize a stream that flowed from a peat bog until dilution raised the pH to > 4.0-4.75 (Dunson, W.A. and Martin, R.R. 1973. Ecology 54:1370-1376).

10. Inhibition of plant growth by "bog toxins" has been demonstrated by numerous investigators (e.g. Dachnowski, A. 1908. Bot. Gaz. 46:130-143; Dachnowski, A. 1909. Bot. Gaz. 47:389-405). Livingston demonstrated such toxicity toward the alga *Stigeochlonium* (Livingston, B.E. 1905. Bot. Gaz. 39:348-355).

11. We have examined here at the Institute the question of bog water toxicity toward prey fish (fathead minnows).

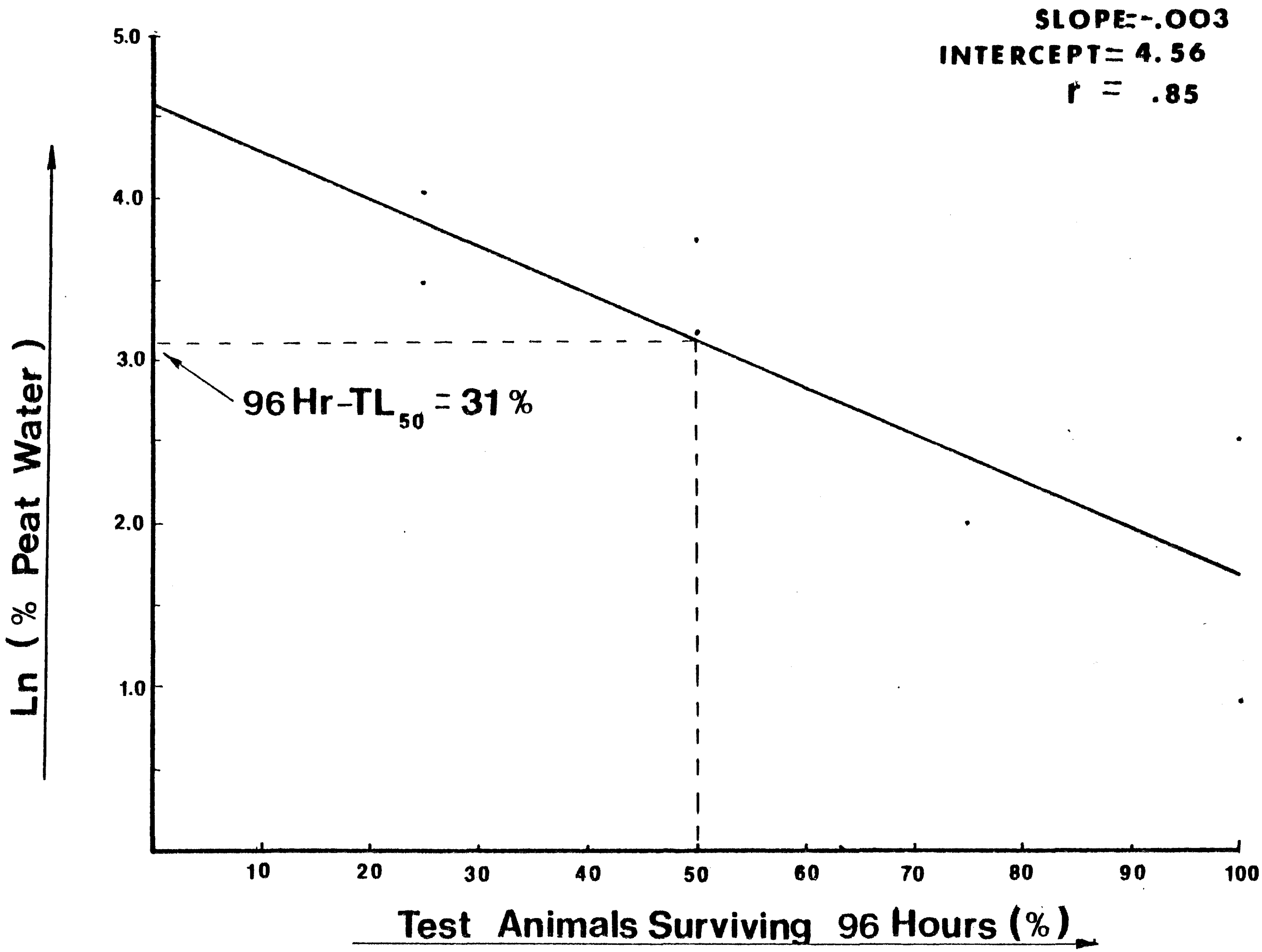
Fathead minnows were placed two per flask in 1 liter flasks containing the following mixtures of Lake of the Woods water and water from an acid (pH 5.5) sphagnum bog (expressed as Peat water volume/lake water volume): 0.56, 0.42, 0.32, 0.24, 0.18, 0.125, 0.075, 0.025, and 0.0. Survivorship was monitored to 48 hours and 96 hours. The 48 hour and 96 hour TL-50 values (50% survival tolerance limits) were estimated using least squares regression techniques. Results of these analyses are shown in Tables 3 and 4. Slopes of the two lines were not significantly different at CI 0.95. Y intercepts were significantly different at CI 0.95. At 96 hours 31% by volume peat bog water was required to produce TL-50 (Table 3), while at 48 hours the observed TL-50 was 53.0% peat bog water (Table 4). These data indicate that considerable volumes of bog water must enter watershed waters before toxicity to prey fish is observed. Toxicity effects probably follow pH effects, though toxicity of dissolved compounds in the bog water cannot yet be ruled out (see above).

TABLE - 3



SLOPE = - .004
INTERCEPT = 5.97
r = .82
48 Hr-TL50 = 53.0%
5.0
4.0
3.0
2.0
1.0
Ln (% Peat Water)
10
20
30
40
50
60
70
80
90
100
Test Animals Surviving 48 Hours (%)

TABLE - 4



SLOPE=-.003
INTERCEPT= 4.56
r = .85
5.0
4.0
3.0
2.0
1.0
96 Hr-TL50 = 31 %
Ln (% Peat Water)
10
20
30
40
50
60
70
80
90
100
Test Animals Surviving 96 Hours (%)

12. Also in our laboratory, we have examined the buffering effect of lake water on the acidity of peat-bog water. Our general conclusions are that lake water (e.g. from Lake of the Woods) can receive at least an equal volume of bog water (e.g. pH 5.5 water from a sphagnum bog) before lowering of the lake water pH is observed, indicating a considerable buffering capacity by the lake water. Toxicity of mixtures of lake water plus bog water to fish (minnows) closely follows pH effects, with toxicity (LD_{50}) becoming apparent when pH of mixtures drops into the acidic range (see above).

Conclusions concerning toxicity of bog waters to the flora and fauna of receiving waters:

1. There is much scientific evidence attesting to the toxic properties of waters derived from peat bogs. Observed toxic effects are general, affecting plants, animals, and microorganisms.

2. Before large quantities of bog waters are allowed to enter Minnesota watersheds, it must be established that there will be sufficient dilution to avoid toxic effects on the flora and fauna of receiving waters. The dilution required remains to be firmly established.

C. The Ability of Peat to Adsorb Metals and Other Ionic Species

There is a large volume of scientific literature firmly establishing that peat has a tremendous capacity to adsorb metals and metal ions. The following are representative, literature examples.

1. "Chemical elements enter peat deposits in the form of true solution, colloidal systems, and mechanical suspensions of disintegrated rock, and minerals with feed waters (ground, sewage, precipitation) and ashy dust. Increased concentrations of Cu, Ni, Co, Va, and other elements is observed in peat deposits from areas where geological formations harbor oars of these minerals. Copper concentrations determined for peats include values from 3.3 - 33.7 mg/kg. Similarly zinc concentrations ranged from 7.2 - 30.2 mg/kg. (Largin, I.F. *et al*. 4th International Peat Congress, 1972: 77-85).

2. Mercury in waste water can be recovered quantitatively by treatment with peat. For example, waters containing 500 ppm of Hg were treated with peat in suspension yielding treated water containing 15 ppb of Hg. The Hg could be recovered by combustion of the adsorbent in the presence of limited air (Lalancette, J.M. and B. Coupal. 1972. Int. Peat Congress, #4, 213-217).

3. Pakarinen and Tolonen (Ambio 5:38-40) state that "peat mosses can be used to reveal regional distribution of heavy metal pollution, even on a global scale". They observed heavy metal concentrations in peats as high as the following: Pb = 17-40 ppm, Cd = 0.6 ppm, Hg = < 0.1 ppm, Fe = 770-1440 ppm, Zn = 50 ppm, Ni = 5 ppm, Cr = 18 ppm. They estimated the annual deposition rate for lead in a bog in the center of Finland to be 2.8 mg $Pb/m^2/yr$.

4. Szalay (1970, Int. Symp. Hydrogeochem. and Biogeochem., Tokyo 361-371) believes that accumulation of micronutrient metals (Mn, Cu, Fe, Zn) in peat depletes the subsoil water and renders these elements less accessible to plants (a desireable process with respect to Hg, Cd, etc.). Humic substances were thought to be the adsorptive agent in peat and bog waters.

5. Szalay and Szilagyi (1964, Adv. Org. Geochem., Proc. 1st Int. Meeting, Milan, 367-378) found that uranium is accumulated from very dilute solutions by the cation exchange properties of insoluble humic acids in peat. The accumulation can be characterized by a geochemical enrichment factor of 10,000:1. Vanadyl $[(VO)^{2+}]$ enrichments of > 50,000:1 were reported (Szalay and Szilagyi. 1967. Geochem. et Cosmochimica Acta 31:1-6). It was felt by these authors that retention and concentration of atmospherically transferred fission products (Y, Sr, Cs, Zr isotopes concentrated > 10,000:1) could be a significant problem in peat lands (Szalay and Szilagyi. 1961. Acta Physica 13:421-436).

6. There is a large volume of scientific literature firmly establishing that peat has a tremendous capacity to adsorb metals and metal ions (see above). Since much of Minnesota's peatlands is possibly subject to mercury-contaminated precipitation (downwind from coal burning industries and utilities), we felt it advisable to examine peat samples for the presence of mercury. We examined two peat and two sphagnum samples taken from bogs near Bemidji and Ely. The results of our metal analyses are shown in the following table:

Table 5: Levels of Hg, Be, and As in Peat and Sphagnum Samples from Northern Minnesota.

	Concentration, ppm		
Sample #	Hg	Be	As
1a	<1	<1	<1
1b	<1	<1	<1
2a	<1	<1	2
2b	<1	<1	<1
3a	<1	<1	1
3b	3	<1	<1
4a	<1	<1	1
4b	1	<1	<1

Analyses by Galbraith Laboratories, Inc., Knoxville, Tennessee.

1a = Air-dried sphagnum, Koochiching Co., site 1.
1b = Wet sphagnum, Koochiching Co., site 1.
2a = Air-dried sphagnum, Koochiching Co., site 2.
2b = Wet sphagnum, Koochiching Co., site 2.
3a = Air-dried peat, Koochiching Co., site 1.
3b = Wet peat, Koochiching Co., site 1.
4a = Air-dried peat, Koochiching Co., site 2.
4b = Wet peat, Koochiching Co., site 2.

Our metal analyses point to a couple of significant observations. Some peat samples have as much mercury (1 ppm) and some more mercury (3 ppm) than the average mercury concentration for coal (≃1 ppm). Since burning of coal is now a major source of mercury pollution, burning of peat may also be expected to be a significant source of atmospheric mercury pollution. Also, since our peat samples lost their mercury on air-drying (Table 5) simple drying of peat may result in release of mercury to the atmosphere, burning not being necessary. This latter observation indicates that mercury in peat may be in the form of elemental mercury (Hg°), or some other very volatile form of this metal. Mercury from harvested peat must ultimately end up in some other compartment of the biosphere.

Berylium is another volatile, toxic metal with pollution potentials similar to mercury. We found, in our limited survey, little evidence of Be contamination of peat. Also, levels of arsenic were relatively low, that found being probably of natural origin.

It must be emphasized that our data on these points is very preliminary, particularly concerning Hg contamination of peatlands. Many hundreds of samples from dozens of geographic locations must be examined for Hg before meaningful conclusions may be drawn. Our conclusions (above) are at this point highly speculatory. More analyses are a must.

Conclusions concerning accumulation of heavy metals in Minnesota peat lands:

1. There is ample reason to suspect that peat lands in Minnesota have acted and are presently acting as accumulators of atmospherically introduced (ash and/or precipitation) heavy metals, particularly mercury.

2. Data is insufficient to estimate the seriousness and extent of heavy metal accumulation.

3. Areas in Minnesota that have been subjected to atmospheric "fallout" from coal burning, smelting activities, and atmospheric nuclear testing are most likely to have accumulated toxic metals or other air-born substances.

4. Peat lands probably serve an environmentally useful function in removing heavy metals from potential concentration within food webs.

D. Stimulation of Algal Activity in Lake Water by Additions of Bog Water

Despite indications that bog waters are toxic toward plants, animals, and microorganisms (cf. above), when diluted into watersheds it is possible that bog waters may become stimulatory to lake phytoplankton. We have experimentally examined this possibility, as follows:

1. We have examined the effect of bog water (sphagnum bog, Itasca Co.) on algal growth and photosynthesis in lake water (Lake of the Woods). We find that bog water contains nutrients (NO_3^-, $PO_4^=$, and probably others) that are stimulatory to algae. Stimulation of algal growth and photosynthesis by bog water is proportional to the amount of bog water added to lake water. Increasing concentrations of bog water result in increased algal activity. Our preliminary conclusion is that - addition of bog water to nutrient poor northern Minnesota lakes may result in increased algal growth in those receiving waters. Thus the fate of the water removed from

peat lands must be considered in terms of its potential for increasing lake and stream eutrophication rates. Obviously, more research on this particular question is an absolute necessity.

2. Stimulation of algal activity in lake water by additions of bog water. Non-sterile water from Lake of the Woods (or sterile, defined algal growth medium) was mixed with water from a sphagnum bog (pH 5.5, dark brown) in the following proportions (volume bog water/lake water or culture medium): 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, and 0.8. These mixtures were inoculated with a culture of <u>Chlorococcus</u> sp. and incubated at room temperature for several weeks. The following parameters were monitored: O_2 production, respiration by bog water, gross production by volume, and specific gross production (Table 6). Results of these experiments are presented in Tables 7 and 8. A stimulation of algal photosynthesis and gross production was observed on addition of bog water to lake water or culture medium. Table 7 illustrates this stimulation of the relative rate of algal photosyntehsis. This linear plot appears to show a logarithmic response. A plot of log specific photosynthetic rate vs. proportion of bog water spike (Table 8) confirms that stimulation of algal photosynthesis by bog water does follow log kinetics.

These results are surprising and if confirmed by further experiments are of great significance. <u>Small</u> additions of bog waters to nutrient poor northern lakes may result in <u>large</u> increases in algal productivity. We are investigating this matter further (see below).

Table 6

Peat Culture	mg O_2/l 2.5 hr. incubation	Initial [O_2]	Δ O_2	Respiration by Peat	Gross Prod. by Volume	Specific Gross Prod.
0	8.52	8.35	+0.17	0	.17	.17
.1	8.34	8.18	+0.16	.25	.41	.46
.2	7.97	8.01	-0.04	.50	.46	.58
.3	7.72	7.85	-0.13	.75	.62	.89
.4	7.41	7.68	-0.27	1.0	.73	1.22
.5	7.04	7.51	-0.47	1.25	.78	1.56
.6	7.03	7.34	-0.31	1.50	1.19	2.98
.7	6.58	7.17	-0.59	1.75	1.03	3.43
.8	6.58	7.01	-0.43	2.0	1.57	7.85

Dark Bottle Culture	8.36
Dark Bottle Peat	4.17
Culture Initial	8.35
Peat Initial	6.67

Culture Respiration: 8.35 - 8.36 ≃ 0 Culture Algae: <u>Chlorococcus</u> sp.

Peat Respiration: 6.67 - 4.17 = 2.5 Temperature: 22°C

TABLE - 7

Linear Plot of Log Fit Model

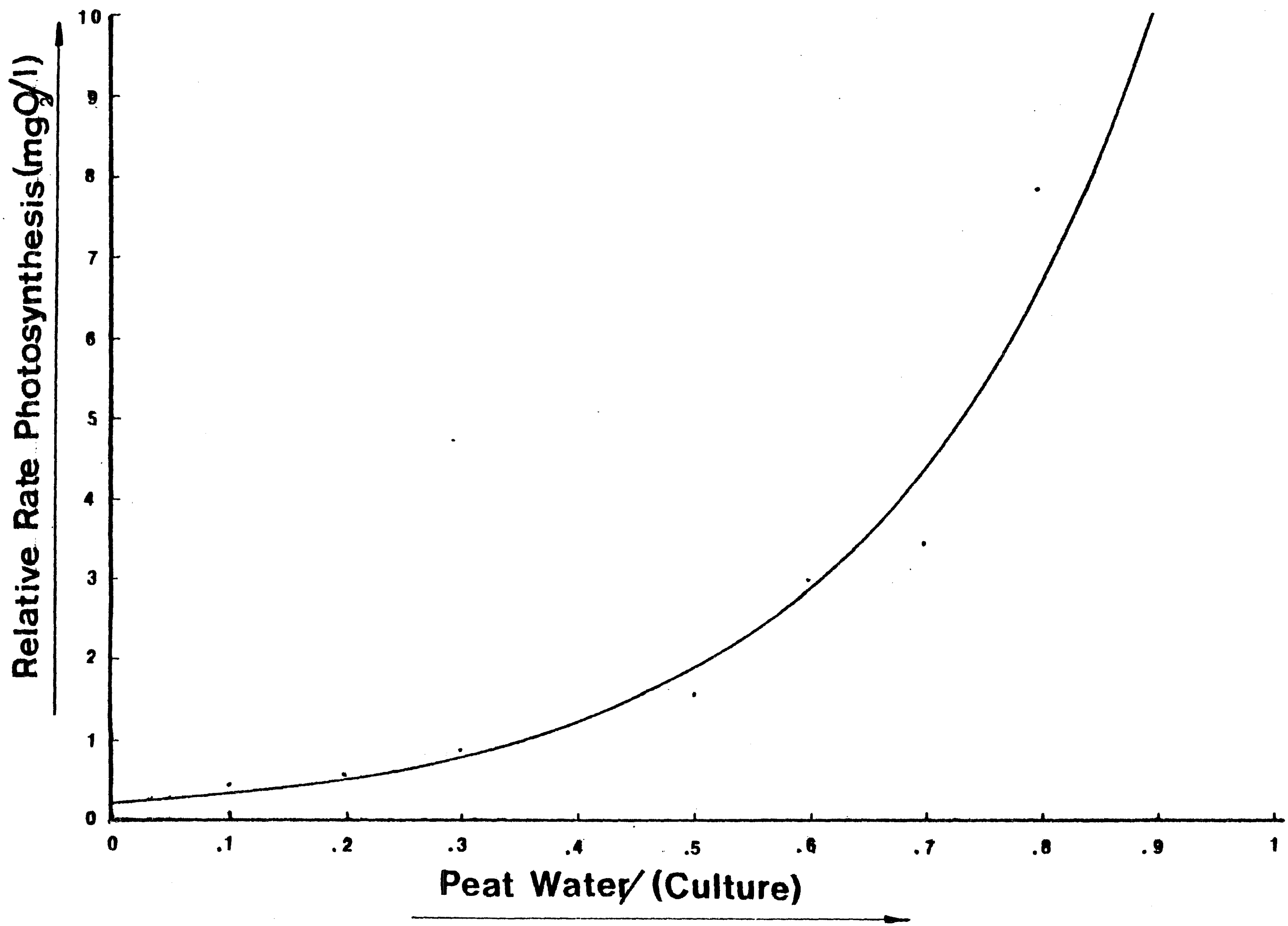
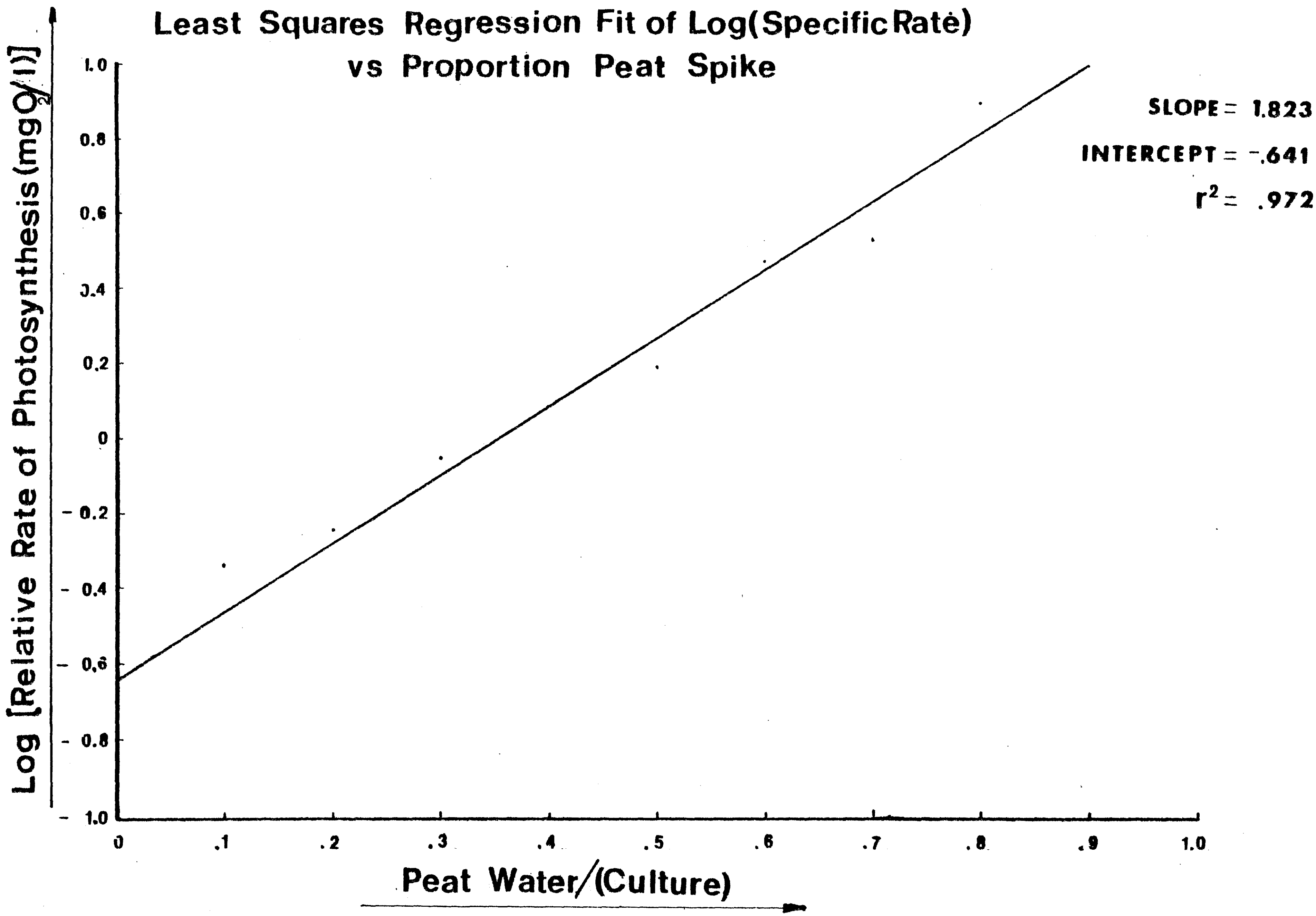


TABLE - 8



Least Squares Regression Fit of Log(Specific Rate)
vs Proportion Peat Spike
SLOPE = 1.823
INTERCEPT = -.641
r^2 = .972
Log [Relative Rate of Photosynthesis (mgO_2/l)]
1.0
0.8
0.6
0.4
0.2
0
- 0.2
- 0.4
- 0.6
- 0.8
- 1.0
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Peat Water/(Culture)

3. We attempted to repeat the experiments described directly above, using a different combination of lake water (Spring Park Bay, Minnetonka) and bog water (Begonia Bog, Baker Park Preserve, Hennepin Co.). The results of this experiment are as follows:

Bioassay experiments were conducted to determine if peat water additions to lake water had an effect on algal growth. Batch cultures of Chlorococcum sp. were grown in various ratios of peat and lake water. Results are expressed as percent of the maximum growth attained during the experiment. As Table 10 shows algal growth was highest in the 100% peat water treatment that had been neutralized prior to inoculation with Chlorococcum. The second highest growth was attained in the non-neutralized 100% peat water treatment. Growth was not significantly different from the control for all treatments that had peat water as 16% or less of the total volume. While the maximum growth was obtained in the 100% peat water treatments, the initial rate of increase was less than the other treatments. This could have been the result of lower light intensities reaching the cells in these highly colored waters. The pH and percent peat water of the different treatments are shown in Table 9.

A second bioassay was conducted using Anabaena sp. 7119 from the University of Texas culture collection. In this experiment the peat water was run through a continuous flow centrifuge in addition to the normal filtration steps. Centrifugation removed additional detritus and bacteria. No stimulation of growth was found for any concentration of peat water used. This result is as expected if the nutrients associated with the peat additions in the first bioassay were in particulate form. In the second bioassay these particles were removed by centrifugation. In addition, bacteria were also removed hence nutrients in dissolved organic form would be less available for the algae. An alternative explanation is that nutrient requirements of Anabaena sp. 7119 are substantially higher than those of Chlorococcum.

The effect of peat water additions on the specific photosynthetic rate of Anabaena sp. 7119 was also investigated. Specific photosynthetic rate depends on the intracellular concentrations of phosphorus when phosphorus is the limiting nutrient (Senft, 1977). Batch cultures of Anabaena sp. 7119 were grown in lake water with different amounts of peat water added. To these mixtures sufficient nutrients were added to ensure adequate growth. The nutrient enrichment was done such that phosphorus would be the limiting nutrient. Specific photosynthetic rates at saturating light were not significantly lower (at the .05 level) in the 50% peat water treatment (.273 ± .032 μmoles O_2 μg $chl^{-1}hr^{-1}$) than in the control (.310 ± .008 μmoles O_2 μg $chl^{-1}hr^{-1}$). Further experiments are necessary to confirm this result since these values are in borderline region of acceptance or rejection.

Table 9

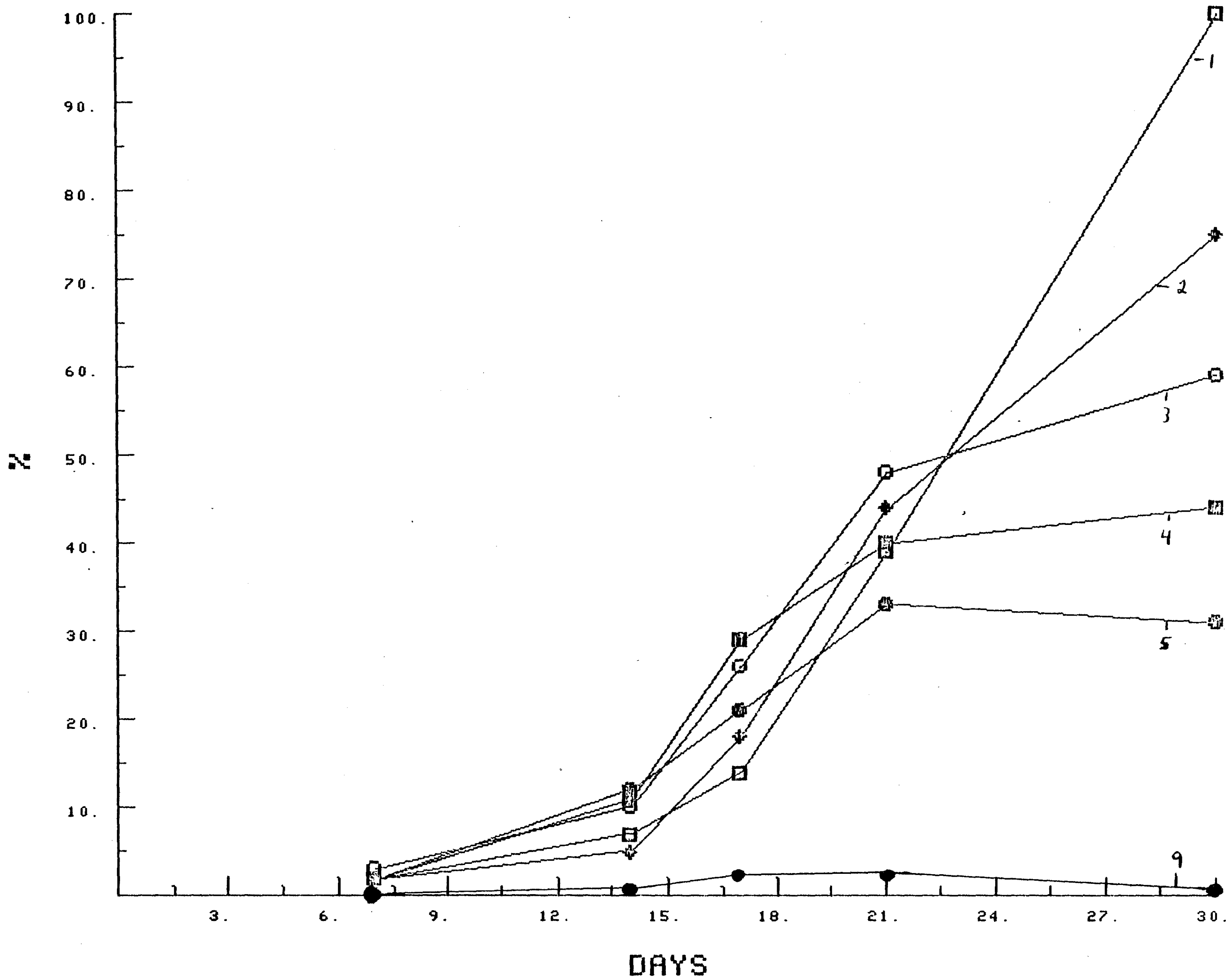
Treatment	% peat water	pH
1	100	7.00*
2	100	5.61
3	67	6.90
4	50	7.25
5	33	7.41
6	16	7.58
7	10	7.62
8	1	7.64
9	0	7.64

* = neutralized peat water

Table 10

Percent of the maximum growth attained versus days. Line 1 - open square - neutralized 100% peat water; Line 2 - solid diamond - 100% peat water; Line 3 - open square with open corners - 67% peat water; Line 4 - solid square - 50% peat water; Line 5 - solid square with open corners - 33% peat water; Line 9 - solid circle - control. Treatments 6,7 and 8 not significantly different from the control.

(cf. following figure)



100.
90.
80.
70.
60.
50.
40.
30.
20.
10.
%
3.
6.
9.
12.
15.
18.
21.
24.
27.
30.
DAYS
1
2
3
4
5
9

II. Recommendations

1. Concentrations of P and N in bog waters from proposed mine-lease areas should be determined experimentally, using proper ecological and statistical techniques. This data may then be used to predict the amounts of nutrient P and N that might potentially enter local watersheds. I seriously doubt that water drained from large areas of peat can be prevented from entering local watersheds.

2. Experiments should be designed to ascertain the potential toxic effects of bog humic substances on plants, animals, and microorganisms in watersheds of proposed peat-mining tracts. There are potential problems with bog toxins.

3. Precise hydrologic data must be collected so that dilution factors for bog water entering streams and lakes can be calculated. This will allow predictions of potential problems with bog acidity, bog toxins, and bog nutrient additions to receiving waters.

4. Concentrations and distributions of heavy metals in peat throughout northern Minnesota should be systematically determined. In particular, concentrations of the following should be examined: Hg, Be, Ni, Cu.

5. Experiments should be designed to discover what factors are responsible for our observed stimulation of algal growth by peat bog waters when they are diluted into lake waters. Optimally, mathematical predictions should be developed to estimate eutrophication increases produced in lakes and streams receiving known volumes of bog waters.

6. The State should insist that industries that propose to utilize peat as an energy provide detailed plans for waste treatment facilities. For example, peat gasification will produce noxious byproducts such as phenol, benzene (a carcinogen), and polynuclear aromatics (e.g. benzopyrene). Much of these byproducts can be recovered; however, significant amounts will unavoidably escape recovery and enter the environment. What will be the fate of these escaped substances? Plans I have seen for peat gasification processes (Minnegasco) do not adequately detail planned wastewater treatment procedures. Proposed treatment processes should be reviewed by competent, outside scientific experts.

7. The potential for alteration of the phytoplankton populations of lakes and streams upon addition of bog waters should be determined experimentally. For example, will addition of bog-derived water to a lake result in selection of undesireable blue-green algae over the more desireable green algae? Such questions have apparently never been asked and certainly not answered.

8. No State lands should be mined extensively until questions raised herein are adequately answered. The potentials for environmental harm are too large. There is presently insufficient data on which to base decisions concerning leasing of land for peat mining. There are a number of serious, unresolved questions concerning effects of peat mining on Minnesota's water quality. It would be a serious mistake to commence mining operations unless these questions receive satisfactory answers.