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CHEMICAL AND BIOLOGICAL STUDIES OF BABINE LAKE, B.C.

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INTRODUCTION

Because of the increasing industrial operations and rapidly growing human activities on the watershed of Babine Lake, there have been many multi-disciplinary studies carried out in this area to study their possible impacts on the water quality and fish production (Babine Watershed Committee Annual Report 1972). The major industries in this area are logging and mining. The two major mining companies currently extract nearly 9,000,000 tons of ore annually for copper and zinc. It has become the concern of the Babine Watershed Change Program Committee to conduct a study to further investigate the concentration and the chemical state of these metals and the metal binding capacity (complexing capacity) of the lake water. At the invitation of the Babine Watershed Change Committee, we conducted a short study (October 20-26, 1974) on the characteristics of several metals related to the mining activities, with a view to better understand the trace metal chemistry of the lake. Simultaneously some biological investigations were also carried out to assess the potential capacity of the water to support growth. It is hoped that the information obtained in these studies will complement results of other investigations.

METHODS

Surface water samples were collected in polyethylene bottles. Membrane (0.45μ) filtered water was used for chemical analyses. Unfiltered water was used for biological investigations. Sediment samples were collected by means of a hand-operated Ekman grab. The sampling locations are shown in Figure 1.

The pH and conductivity of water were measured on site immediately after collection. Labile metals were analyzed one day after the collection using an anodic stripping technique (Chau and Lum-Shue-Chan, 1974). Complexing capacity of water was measured by the method of Chau et al. (1974). The following analyses of water were carried out by the Water Quality Branch Ontario Region at C.C.I.W.: dissolved organic carbon, dissolved organic nitrogen, total alkalinity, and total phosphorus according to the methods described by Philbert and Traversy (1973). Total hardness of water and metals in sediment were analyzed by the methods outlined in the analytical methods manual of Water Quality Branch (1974).

The procedures of Strickland and Parsons (1972) were used for the chlorophyll a determination with some modifications. The glass filter was homogenized with a teflon pestle at room temperature for one to two minutes. The content in the centrifuge tube was extracted in complete darkness for 10 minutes before centrifugation.

Primary production of water was measured by the method of Malanchuk and Gruendling (1973).

Bacterial numbers of sediments were determined by weighing 10 gm of sediment and suspending it into 10 ml of the corresponding filtered and steriled lake water. It was mixed thoroughly with a vortex and aliquots in triplicate were plated onto tryptone-soya-agar plates (Oxoid). Colonies appearing on the agar plates were enumerated after incubating at 20°C for 6 days.

Respiration studies on the sediment and water samples were performed with a Gilson respirometer. Five gm of sediment (dry weight) and 1 ml of the corresponding water were placed in the reaction flask. In the center well, a piece of filter paper saturated with 0.2 ml of 20% potassium hydroxide was placed. Duplicate samples were done for each sediment sample. All flasks were equilibrated for 15 minutes at 20°C. After equilibration, 0.2 ml of

5% glucose in the side-arm was tipped into the reaction flask. Respiration readings were followed every 10 minutes for four hours.

RESULTS AND DISCUSSION

Chemical Studies

A summary of the hydrochemical data of Babine Lake is listed in Table 1. The pH of lake water is normal but conductivity is rather low in comparison with the Great Lakes waters. This suggests that Babine Lake water would be quite sensitive to the toxic effect of heavy metals because of its low hardness. On the other hand, the high complexing capacity reflects that the water has ample capacity to complex ionic copper or other heavy metals. Although complexing capacity is not an absolute quantitative measure of the capacity of water to mask the toxic effects of metals on algal growth (Chau et al., 1974), it does serve as an indication of the capacity of the medium to ameliorate toxicity (Stokes, 1974).

The high complexing capacity of the water is unequivocately due to the high dissolved organic matter as indicated by dissolved organic carbon and dissolved organic nitrogen. The dissolved organic carbon concentration is high in comparison to the average concentration of the Great Lakes. An explanation for the high concentration of dissolved organic materials and the high complexing capacity may be found at least partly, in the prevalence of humic materials in Babine Lake water (Stockner and Shortreed, 1974). The high complexing capacity of the water is not surprising since Babine Lake has a high fish carrying capacity. Both dissolved organic matter and complexing capacity are expected to become even higher in summer time when the degradation rates are higher.

The dissolved organic carbon concentration is quite uniform in the five sampling areas, whereas dissolved organic nitrogen varies considerably. At sampling station 1, in the southern basin of the lake, the highest DON was observed which may be related to the high productivity of the water in this area.

Of the four metals (Zn, Cd, Pb, Cu) studied, Zn was present mostly in labile state, whereas Pb and Cu were completely in bound forms. By lability, it is meant that the metal is either in free form (ionic), or is loosely bound to the organic and inorganic ligands. Zinc generally forms very weak complexes with the ligands in natural water, as compared to Pb, Cd and Cu; it is very often found in natural waters in labile form. The level of Zn in Babine Lake is not exceedingly high although there is mine extraction of Zn in the area.

Strongly bound metals include those bound to organics and strongly adsorbed by colloidal particles. The total concentrations of both Pb and Cu are relatively higher than that of the Great Lakes waters. At sampling station 2, which is at the downstream of the circulation, the concentrations of both metals are higher than that in the other parts of the lake. Similar higher concentrations of Zn and Pb are also reflected in the sediment collected at station 2. This could be the effect of the lake circulation. Cadmium was present in sediment in insoluble forms and was not detected in water. The findings of this investigation as far as water quality is concerned, indicate that there are no alarmingly high concentrations of these metals.

Biological Studies

In a comprehensive study of the phytoplankton succession and primary production in Babine Lake, Stockner and Shortreed (1974) ranked Babine Lake as one of the more productive large Canadian lakes. In terms of its annual production and humic stained waters, it was classed as mixotrophic. Narver (1967) compared the primary productivity of Babine Lake with those of 24 lakes in south-western Alaska. He found that the rate of carbon fixation on a per unit area basis was much lower in Babine Lake than in all but three Alaska lakes.

In this study, a chemically defined laboratory CHU-10 medium (1942) was used as a reference medium. The ability of this medium to support the primary productivity of *Ankistrodesmus falcatus* was compared with Babine Lake water. The use of a chemically defined medium as reference medium offers certain advantages such as known chemical composition, reproducible results and easy comparison with a variety of other unknown lake waters. As shown in Table 4, the productivity varied with the locations in the lake. Stations 1 and 4 supported more production than CHU-10, whereas stations 2, 5 and 6 were less productive. A separate study with lake waters from several lakes in Sudbury area and with CHU-10 as a reference medium had shown that stations 1 and 4 supported as much algal production as several organic-rich Sudbury lakes, suggesting that stations 1 and 5 were also rich in organic nutrients. It is interesting to note that the chlorophyll *a* concentrations (Table 1) and the complexing capacity (Table 2) were also higher in these stations. Stokes (personal communication) has found that high complexing capacity water exhibits a higher tolerance of metal toxicity. It is therefore not unreasonable to state that high complexing capacity in these locations provides a better medium for growth, although it may not be the only responsible factor. Stockner and Shortreed (1974) also observed a regional disparity in production, the northern part of the lake often exhibiting values less than one half of those found at stations to the south of Topley Landing. They hypothesized that such disparity in regional production was due to the lake physics and surface inflow disparity.

A general description of the surface sediment characteristics of Babine Lake has been made by Stockner and Smith (1974), however, no biological study of the sediment was reported. Results in Table 5 show that the bacterial number in sediment from station 4 was again the highest. The biological activity as indicated by the respiration was, however, slightly lower than that of station 6. Only slight stimulations of respiration were observed in all stations by the addition of glucose, suggesting that the organic nutrient in the sediment was already abundant. Unfortunately, no sediment sample was obtained for station 1, thus it was not possible to relate the characteristics of the sediment to the high productivity of the water.

No distinct relationship between heavy metal concentrations (Table 3) and biological activity (Table 5) were observed. However, the results of the biological investigation reveal that some inhibition effects have been recorded in certain parts of the lake particularly at stations 2 and 5, in spite of the relatively high complexing capacity of the water at these sites. It is inappropriate, however, to make any conclusion as to the causes of this growth inhibition, since data supporting these indications is limited and the matter requires further investigation.

SUMMARY

1. Babine Lake water contained high dissolved organic carbon and moderately high dissolved organic nitrogen in comparison to that of the Great Lakes water.

2. Concentrations of trace metals (Zn, Cd, Pb, Cu) were not exceedingly high. Zn was present in labile state whereas Pb and Cu were completely in bound forms.

3. Complexing capacity of the water was considered high, indicating that the water had a reasonable capacity to complex ionic copper and other heavy metals.

4. The capacity of lake water to support algal production varies with locations in the lake. Station 1 and 4 supported more production than CHU-10 medium, whereas stations 2, 5 and 6 were less productive. Direct relationship between algal production, chlorophyll a concentrations and the complexing capacity of lake was observed. However, no distinct relationship between heavy metal concentrations and biological activity was found.

5. Addition of glucose to sediment samples stimulated only a slight increase in bacterial respiration, suggesting that the sediment already contained enough organic nutrient.

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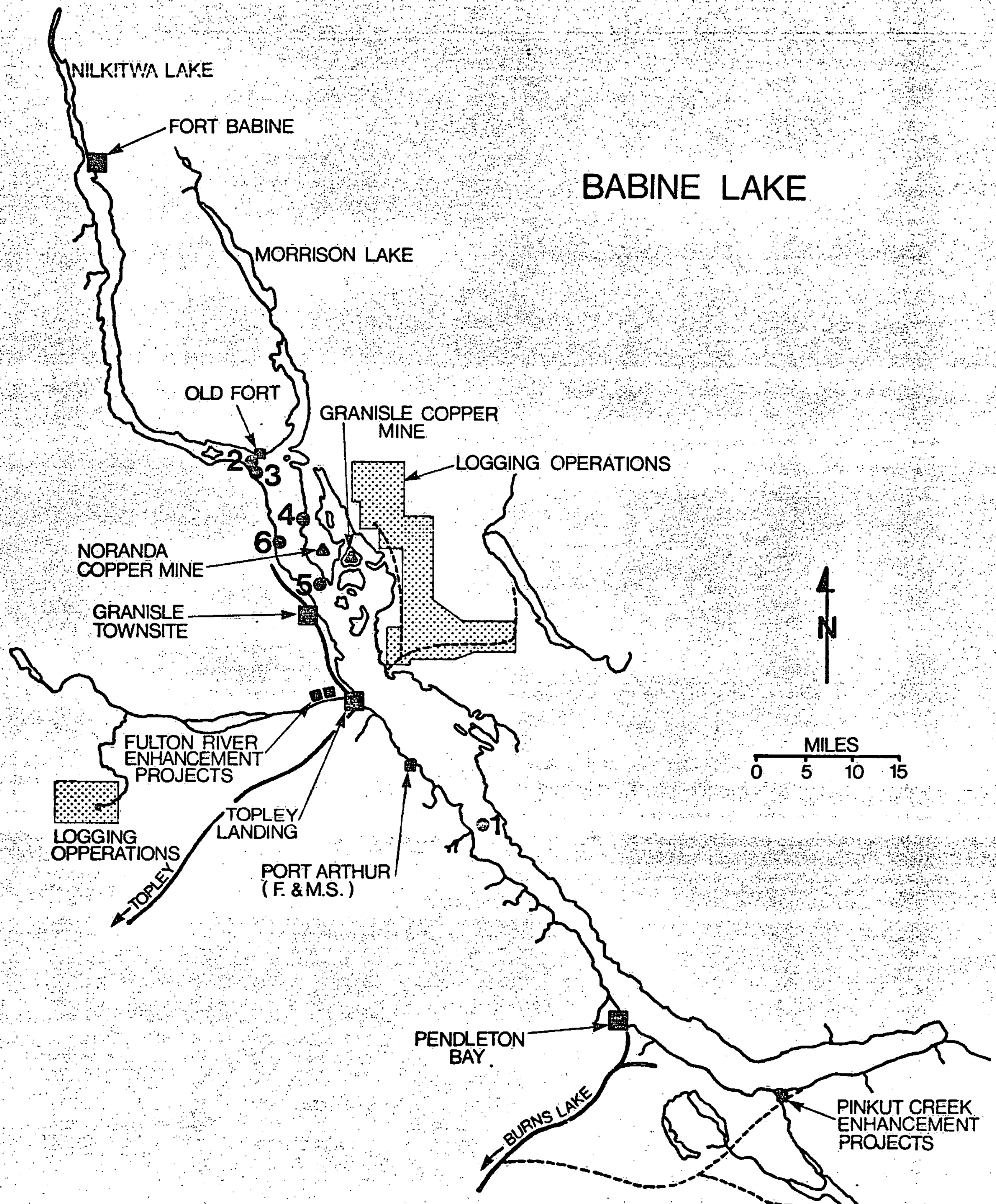
BABINE LAKE
NILKITWA LAKE
FORT BABINE
MORRISON LAKE
OLD FORT
GRANISLE COPPER MINE
LOGGING OPERATIONS
2
3
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5
1
NORANDA COPPER MINE
GRANISLE TOWNSITE
FULTON RIVER ENHANCEMENT PROJECTS
LOGGING OPPERATIONS
TOPLEY LANDING
TOPLEY
PORT ARTHUR (F. &M.S.)
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BURNS LAKE
PINKUT CREEK ENHANCEMENT PROJECTS

Table 1. Chemical Analyses of Babine Lake Water

Stations	pH	Conductivity µM	DOC mg/l	DON µg/l	Total Phosphorus mg/l	Total Alkalinity mg/l $CaCO_3$	Total Hardness mg/l $CaCO_3$	Chlorophyll *a* mg/m^3
1	--	58	7.0	271	0.012	37.1	36.7	2.58
2	8.1	58	6.6	194	0.007	36.1	36.2	1.55
4	7.9	57	7.0	208	0.008	36.2	36.3	2.18
5	7.8	57	7.4	167	0.014	35.5	36.2	1.41
6	7.8	61.5	7.4	248	0.005	35.8	36.1	1.56

DOC - dissolved organic carbon; DON - dissolved organic nitrogen

Table 2. Complexing capacity and heavy metals of Babine Lake Water.

Metals: labile and total (in brackets) μg/l

Stations	Zn	Cd	Pb	Cu	Complexing Capacity μm/l Cu
1	21.2(26.0)	0 (0)	0 (10.6)	0 (43.8)	1.78
2	21.8(21.0)	0 (0)	0 (15.3)	0 (37.4)	1.62
4	12.0(20.0)	0 (0)	0 (5.8)	0 (26.8)	1.93
5	3.9(21.6)	0 (0)	0 (4.5)	0 (16.6)	1.34
6	5.7(19.4)	0 (0)	0 (4.6)	0 (16.4)	1.54

Table 3. Concentrations of heavy metals in Babine Lake sediments (μg/g dry sediment)

Station	Zn	Cd	Pb	Cu	moisture loss %
2	73.0	27.4	146	18.2	38.5
4	104.0	26.1	43.4	26.3	59.8
5	65.5	18.7	93.6	9.4	50.0
6	67.4	19.3	48.2	9.6	62.3

Table 4. Comparison of Babine Lake water and CHU-10 medium in supporting primary production of *Ankistrodesmus falcatus*

Station	Primary Production ($mgC.m^{-3}hr^{-1}$)
1	104.5 (129)
2	19.2 (24)
4	96.0 (119)
5	31.8 (39)
6	64.1 (79)
CHU-10	80.8 (100%)

Numbers within brackets are expressed as percentage of CHU-10

Table 5. Bacterial number and respiration in Babine Lake sediments

Station	Bacterial number per gm sediment	Respiration (μl O_2/hr/gm dry sediment) No glucose	Glucose added*
2	3.2×10^3	95.9	113.8
4	4.8×10^3	223.9	273.6
5	1.0×10^3	18.0	10.0
6	3.2×10^3	271.5	302.3

* glucose was added to give final concentration of 2 mg per gm dry weight sediment.