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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 34

TOXICITY OF SURFACE WATERS IN A PART OF SHUBENACADIE DRAINAGE SYSTEM, N.S.

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Introduction

Loss of quality in surface waters resulting from increase in acidity (decrease in pH) and amount of hydrous ferric compounds has curtailed activity of Department of Fisheries fish culture station near Wellington Station, Nova Scotia. Chemical pollution of the water has also been responsible for the death of fish in Shubenacadie River downstream from the fish culture station. Decrease in chemical quality of the water thus presents a two fold problem with respect to activities of Department of Fisheries: 1) unsatisfactory chemical quality of surface water supply for the fish culture station and 2) loss of fish life in Grand Lake and lower reaches of Shubenacadie River.

The following report is based on information contained in files of Department of Fisheries, Halifax and upon observations made in the field on August 15, 1961.

Chemical factors

Determinations of pH of Miller Lake drainage system were made by Department of Fisheries in May, 1961 with a Beckman portable pH meter. The results of these measurements, as shown on the accompanying map, indicate a general decrease in pH toward the headwaters of Miller Lake drainage basin. It was probable, therefore, that drainage from Miller Lake system into Lake Thomas and thence into the fish culture station at Wellington Station was responsible for decrease in pH of water at the fish culture station with a consequent loss of fish. In addition, hydrous iron compounds carried in suspension in the water were also responsible for killing fish by coating their gills and smothering fish eggs.

Measurements of pH made on August 15, 1961 also show a decrease in pH

toward headwaters of Miller Lake drainage system and a similar decrease in pH up-stream along Bennary Brook.

Chemical analysis of a sample of water with a pH of 2.8 from headwaters of Bennary Brook showed a total of 2384 ppm dissolved solids of which sulphate was 1497, R_2O_3,656, total iron 158, manganese 14.8, and no carbonate or bicarbonate. This analysis indicates a concentration of sulphate is primarily responsible for the low pH value. Along the headwaters of Bennary Brook and streams of Miller Lake system a precipitate of hydrous iron compounds was observed in the stream beds.

The toxicity problem therefore, apparently consists of two parts 1) low pH resulting from high sulphate concentration and 2) precipitation of hydrous iron compounds.

Geological factors

The source of the toxic compounds in the surface waters is undoubtedly the lower Cambrian slates which trend northeast in a belt 2 to 3 miles wide across the central part of map-area 11 D/13 East (see attached map). The slates, which occur in the headwater areas of both Bennary Brook and Miller Lake drainage systems are highly fractured, fissile rocks containing abundant pyrite disseminated throughout the rock and as nodular concentrations along bedding planes. Fracture planes in the rock are, where exposed to the atmosphere, coated with iron oxide and most samples of the rock display small pits resulting from complete oxidation and removal of pyrite.

Chemical weathering of pyrite is facilitated by acid waters draining from peat bogs located in the headwaters of the drainage system and probably also by bacterial action. Ferrous sulphate produced by atmospheric oxidation of pyrite may be further oxidized to ferric sulphate which, in solution, would undergo hydrolysis to ferric hydroxide thereby further reducing the pH of the solution (i.e. stream water).

Waters draining from the relatively inert quartzite areas (see map) should tend to dilute acid waters originating from the slates, however, the abundance of bogs and swamps throughout the drainage system would probably contribute acid waters of organic origin. Under conditions of an undisturbed drainage regimen containing pyritiferous slates and bogs, it would be logical to expect acid conditions in the downstream waters along with hydrous iron compounds in suspension. Values of pH from 4.6 to 5.6 in the southern part of Miller Lake drainage basin indicate more or less normal values of acidity for waters in the system and many wells throughout the general area contain appreciable quantities of iron.

Construction of the new provincial highway from Fall River to Enfield and construction of Halifax International Airport has exposed considerable areas of pyrite bearing slate. Pyrite in the freshly fractured rock is rapidly oxidized and thus contributes to increasing acidity of surface waters. This situation appears to be aggravated by unusually low summer precipitation both in 1960 and 1961 resulting in a minimum dilution effect. Periods of heavy run-off, according to Department of Fisheries flush out deposits of hydrous iron compounds accumulated in upper reaches of the drainage areas and carry them into Grand Lake and Shubenacadie River producing lethal consequences to fish and fish eggs.

Continued rainfall and run-off throughout the drainage system will probably restore the preexisting chemical character of waters of the drainage system but I do not know what period of time would be involved.

Conclusions

In order to effect a program of remedial measures to insure a surface supply of water of suitable chemical quality for the fish culture station and to maintain a chemical quality of water conducive to fish life in Shubenacadie drainage system the following steps are recommended based on the assumption that

treatment would be carried out at the outlet of Miller Lake and the mouth of Bennary Brook.

1. Water samples for complete chemical analysis be taken from the outlet of Miller Lake and Bennary Brook.

   The samples should be obtained in accordance with instructions from the agency performing the analyses, possibly Industrial Waters Section, Mines Branch, Department of Mines and Technical Surveys. It would be desirable to determine the change in chemical with seasonal variation in stream flow, thus monthly samples from the assigned locality for a period of a year are recommended.

2. Stream flow measurements be made at the mouths of Miller Lake and Bennary Brook to cover the sampling period. The outflow at the dam at Fall River could probably be easily obtained from Nova Scotia Power Commission. A measuring weir would be required at the mouth of Bennary Brook.

3. Investigation be made into a method for removing suspended iron compounds from waters of Bennary Brook and Miller Lake. Possibly a filter system at the mouths of these waterways would be the most feasible method.

4. Investigation be made for the treatment of water for reduction of acidity based on the findings of chemical analyses and stream flow. The location of the treatment facilities would probably be best downstream from the filter system.

5. The above recommendations could be applied to the flow of water at the fish culture station in order to solve the quality problem there but the Bennary Brook would appear to require treatment at its outlet in order to ensure quality of water in Shubenacadie River.

6. The use of ground water as an alternative source of water supply for the fish culture station is probably not economically feasible. A quantity of 2,000 gpm is required to operate the station. From a cursory field examination of the slates I consider it unlikely that these rocks would provide an aquifer sufficient to yield the required quantity of water from a system of wells in proximity to the station. A survey of existing wells in the area to determine quantities of water produced from these rocks would be required before a definite decision re the use of ground water could be reached.

August 17, 1961