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Analysis of Bottom Sediments in the Vicinity of a Proposed Submarine Cable

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Concern has been expressed about the potential effects on the aquatic environment of the placement of a proposed 230 kV submarine cable across Long Reach in the Bay of Quinte, Lake Ontario. Preliminary reports on the environmental effects of the proposed crossing recommended that the highly organic bottom sediments be tested in order to detect potential toxins or contaminants that may be released to the environment as a result of disturbance of the sediments (PALOHEIMO & REGIER 1976, SCOTT 1977).

This report presents the results of bulk sediment analysis, elutriate tests, bioassays and sedimentation tests that were conducted on the water and sediment of Long Reach in the vicinity of this proposed cable

MATERIAL AND METHODS

A Petersen dredge was used on Sept 19, 1977, to collect sediment samples from 10 locations across Long Reach (Figure 1). Each sample was placed in a 5-L plastic bottle, and samples from 3 of the locations were also collected in small sterilized glass jars to check for possible sample contamination due to the plastic containers. Three acid-washed, 25-L plastic bottles were used to collect a supply of surface water from the area between sample locations 2 and 4 (Figure 1).

Bulk sediment analysis was conducted for the parameters listed in Table 1. These parameters had been identified as being of potential concern and, therefore, warranted investigation. Pesticides and PCBs were analyzed by gas chromatography (INLAND WATERS DIRECTORATE 1974). After selective digestion or extraction, Hg was analyzed by flameless atomic absorption, As was determined colorimetrically and other metals were determined by flame atomic absorption. The bacteria *Pseudomonas aeruginosa*, was determined by the multiple tube technique using Drake's medium.

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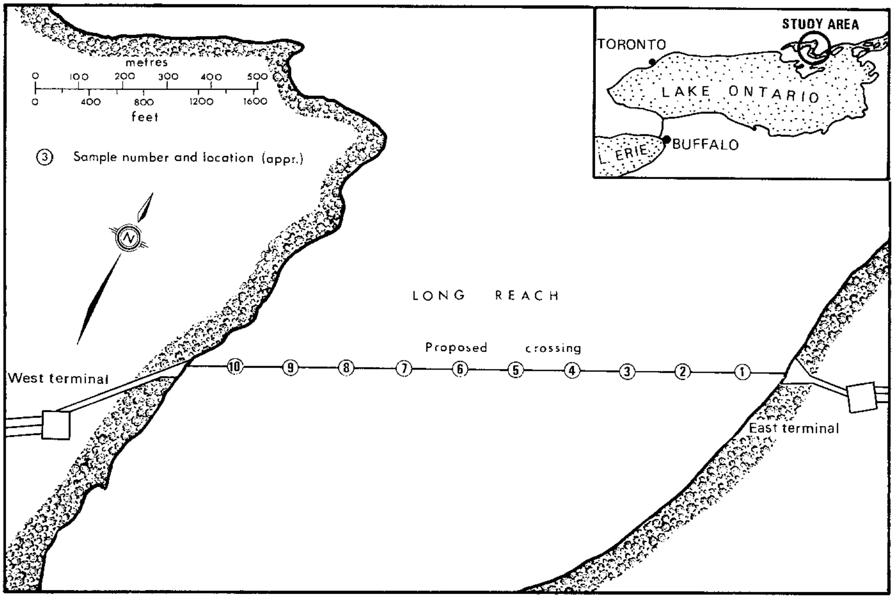

Figure 1: Location of the Long Reach Submarine Crossing

Elutriate tests were also conducted on the sediment samples using the test procedure outlined by LEE & PLUMB (1974) and by the US ARMY ENGINEER WATERWAYS EXPERIMENT STATION (1976).

Sedimentation tests were conducted on samples of sediment collected from locations 2, 5, 7 and 8, in order to determine the length of time for the sediment to settle after being disturbed. Ten mL of wet sediment were mixed with about one L of water in a graduated cylinder and allowed to settle. Turbidity of the top 100 mL was then measured at various time intervals over a 47 h period.

Additional water and sediment samples were collected on Nov 9, 1977, from locations 3, 6 and 9 in order to conduct 96 h static bioassays. Each sample of sediment was mixed with 4 times its volume of water, agitated for 30 min and allowed to settle for 1 h. The resulting elutriate water was then divided into two portions, with one portion used as is for the bioassays, and the other portion filtered through a 0.45 u cellulose acetate membrane before being used for the bioassay. By using waters from before and after filtration, it was hoped that toxicity tests would distinguish between the probable effects of suspended particles and soluble substances.

Bioassays were conducted in wide-mouth glass jars, containing 10 L of water prepared as described above and 5 fish. The fish species used was rainbow trout

(*Salmo gairdneri* Richardson) which is a species commonly used in standard bioassay procedures and is known to be sensitive to toxicants. The fish were juvenile, ranging in weight between 1.2 and 2.0 g. Each prepared water sample was tested at its full strength as well as after being diluted to 50% concentration using clean dechlorinated laboratory water. Each concentration was tested in duplicate using a total of 10 fish.

Tests were conducted in an environmentally controlled room at 15°C. Lighting in this room was adjusted to simulate natural photoperiods. The fish used in these experiments were acclimated to the above mentioned test conditions.

The pH of each test solution was measured before introducing the fish into the test vessels, and it ranged between 6.9 and 7.7. This range is considered optimum for the fish species tested and, therefore, no pH adjustment was required. Biochemical Oxygen Demand (BOD) was also determined for the unfiltered samples.

Each test vessel was gently aerated during the test to ensure a dissolved oxygen level above 8 ppm. The period of exposure was originally 96 h, however, it was extended to ten days to monitor delayed effects. Temperature, dissolved oxygen and pH as well as fish survival were monitored daily in each test vessel.

RESULTS AND DISCUSSION

Bulk Sediment Analysis. It appears that many potential contaminants are being stored in the bottom sediments of Long Reach (Table 1). The mean levels of Loss on Ignition, Chemical Oxygen Demand, Total Kjeldahl Nitrogen, Total Phosphorus, Oil and Grease, Total Hg, Pb and Zn are all greater than stated guidelines for open-water disposal of dredged materials (INTERNATIONAL WORKING GROUP 1975). In addition, a number of other contaminants were present in the sediments.

Elutriate Tests. Elutriate test is designed to detect the release of chemical contaminants from dredged sediment suspended in a water column. It will not detect biological problems due to the physical presence of dredged material in the water column, effects of solids deposition on aquatic organisms, or the effect of chemical contaminants in dredged sediment on benthic fauna. Proper interpretation of elutriate test results requires consideration of existing concentrations of the contaminants of interest at the disposal site, potential concentration increases at the disposal site, and the critical concentrations of each

TABLE 1

Bulk Sediment Analysis

Parameter	Range	Mean Value
Loss on ignition (%)	21 - 28	26
COD (mg/g)	278 - 382	349
Total Kjeldahl Nitrogen (mg/g)	9 - 15	11
Total Phosphorus (mg/g)	0.96 - 1.06	1.02
Oil and Grease (mg/g)	1.2 - 2.5	1.8
Total Mercury (ug/g)	0.28 - 0.44	0.40
Lead (ug/g)	68 - 102	92
Zinc (ug/g)	218 - 242	230
Arsenic (ug/g)	10 - 20	14
PCBs (ng/g)	200 - 620	385
Mirex (ng/g)	<5*	<5*
DDD (ng/g)	<5*	<5*
DDE (ng/g)	<25*	<25*
Copper (ug/g)	29 - 42	39
Chromium (ug/g)	39 - 51	46
Nickel (ug/g)	38 - 58	48
Pseudomonas aeruginosa (counts/g)	43 - 1100	380

* detection limit

parameter for aquatic life rather than a concentration increase percentage under laboratory conditions (LEE & PLUMB 1974).

The standard elutriate test procedure requires that if the concentration of selected contaminants in the elutriate exceed 1.5 times the ambient concentration in the disposal site water, then special conditions must govern the disposal of the material. The 1.5 factor is not intended to be a critical concentration increase indicating significant environmental damage, but should be used to indicate that release of contaminants does occur and, therefore, deserves further consideration.

Examination of the elutriate test results (Table 2) indicates that the concentrations of a number of parameters increased more than 1.5 times the ambient levels while only oil and grease decreased in concentration. Of the examined parameters that had detectable concentrations, only the concentration of dissolved solids increased less than 1.5 times.

TABLE 2

Elutriate Test Results

Parameter	Raw Water	Elutriate Range	Elutriate Mean
Dissolved Solids (mg/L)	161	163 - 205	188
Dissolved Solids Ash (mg/L)	138	151 - 182	167
COD (mg/L)	13	13 - 47	30
Total Kjeldahl Nitrogen (mg/L)	0.66	1.2 - 4.3	2.2
Total Phosphorus (mg/L)	0.06	0.3 - 2.2	1.3
Oil and Grease (mg/L)	9	<1 - 9	<3
Total Mercury (ug/L)	0.02*	0.16 - 2.2	0.65
Lead (ug/L	2	2 - 4	3.6
Zinc (ug/L)	7	4 - 30	13
Arsenic (ug/L)	<10*	<10 - 10	<10*
PCBs (ug/L)	<0.5	<0.5*	<0.5*
Mirex (ug/L)	<0.5*	<0.5*	<0.5*
DDD (ug/L)	<0.5*	<0.5*	<0.5*
DDE (ug/L)	<0.5*	<0.5*	<0.5*
Copper (ug/L)	<1.0*	1.0 - 6.0	3.5
Chromium (ug/L)	<2.0*	<2.0 - 2.0	<2.0*
Nickel (ug/L)	<1.0*	<1.0 - 4.0	<2.0

* detection limit

Of particular concern is the behaviour of mercury. The US ENVIRONMENTAL PROTECTION AGENCY (1973) suggested that total Hg concentrations should not exceed 0.2 mg/L at any time or place in natural waters and that the average concentrations should not exceed 0.05 ug/L in order to protect selected species of fish and aquatic organisms. These recommendations, however, are based on laboratory experiments investigating the lethal effects of acute doses, because insufficient data is available on the effects of chronic exposure to Hg. The real danger of Hg pollution results from biological magnification within the food chain. Aquatic organisms can accumulate Hg in their bodies to levels that are as much as 10,000 times the concentration in the water, and this degree of magnification can occur at each step along the food chain (HANNERZ 1968 as cited in USEPA 1973).

The results of the elutriate test (Table 2) indicate that Hg in the sediment will likely be released in relatively large quantities to the water column as a result of sediment disturbance during construction activities. The actual quantity released will depend on the quantity of sediment dredged or disturbed, and the length of time that the sediment remains suspended in the water column, whereas the actual concentration increase that will occur in the water column depends on the amount of mixing and dilution that would occur within the water body.

Other parameters such as phosphorus and nitrogen will likely also be released to the water column in significant amounts, with the quantity and concentration actually occurring as a result of cable placement depending on the same factors outlined above for mercury.

Sedimentation Tests. The results of the sedimentation tests indicate that the major portion of the sediment settled rapidly during the first few hours, and that by the end of the second day the turbidity of the samples had almost returned to the back ground level of about 20 NTU (Figure 2). Although the major portion of the sediment settled out rapidly, some of the fine matter remained suspended during the full two-day period. The best clarification during the test period was down to a turbidity level of 21 NTU which was approximately the same as background levels. This degree of clarification, however, is not likely to be achieved during a similar period of time under natural conditions where the waters will be subject to the effects of winds and currents. Increased turbidities not only affect the respiration of aquatic organisms, but can reduce feeding in fish by diminishing prey visibility. It must be remembered, however, that fish can avoid localized areas of high turbidity. The extent of this effect will depend on the degree of disturbance or amount of sediments that are suspended and the duration of the activities.

Bioassays. The BOD's of the unfiltered elutriate waters of the three samples tested were 7, 10 and 14 mg/L for sites 3, 6 and 9 respectively. These are considered normal values and should not have any adverse effects on aquatic organisms.

In the bioassays, all the fish survived in all of the test vessels during the ten days of exposure. At the end of the exposure period, the fish looked healthy and no visible signs of stress were observed. The results, therefore, indicate that the presence of both dissolved substances and suspended colloidal matter released from the sediments did not seem to have any short-term impairing effects on the fish tested.

The results of the bioassays indicate that rainbow trout (and, therefore, less sensitive species common to

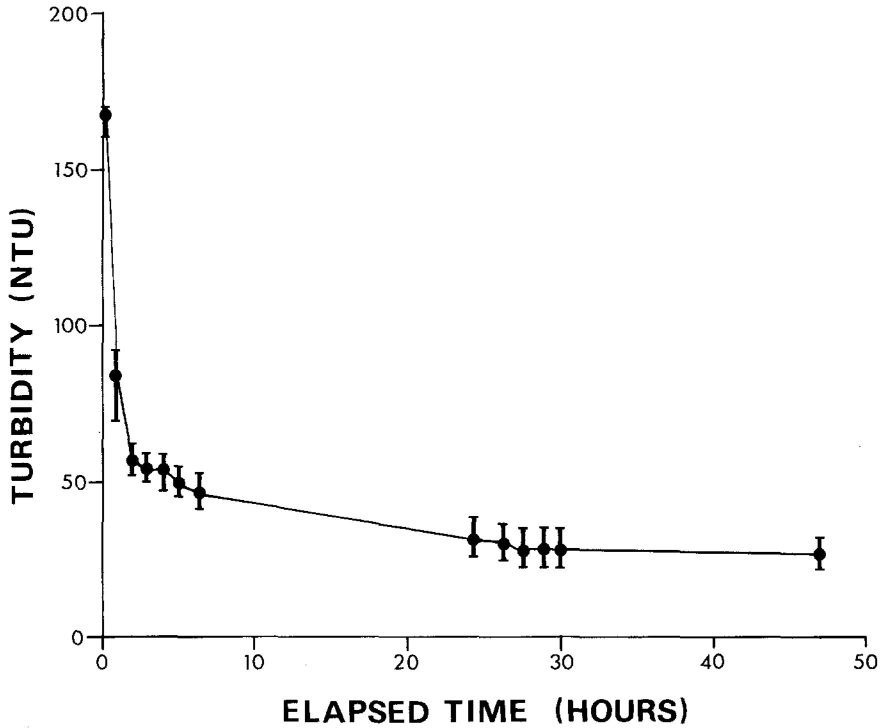

Figure 2: Variation in turbidity with elapsed time during sedimentation test. Mean values are plotted, with range represented by vertical lines.

Long Reach) can withstand the concentrations of contaminants that were released to the water column in the laboratory procedure used in this study. In reality, the concentrations of contaminants in the water column as a result of release from the sediments will depend on the length of time that the sediments remain suspended and the amount of dilution that occurs. Data from the sedimentation tests indicate that the material settles fairly quickly and, therefore, actual contaminant concentrations would probably not differ from the bioassay levels.

In conclusion, the results indicate that the sediments are highly contaminated and exceed stated guidelines for open-water disposal. Significant quantities of contaminants could be released to the water column as a result of sediment disturbance, but this would be a short-term effect since the sediments would rapidly settle and the released contaminants would quickly be diluted. Bioassays indicated that fish species inhabiting Long Reach would probably not be affected.

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