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Relationship of Per Cent Mortality of Four Species of Aquatic Biota from 96-Hour Sediment Bioassays of Five Lake Michigan Harbors and Elutriate Chemistry of the Sediments

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The increasing concern with toxic substances in aquatic ecosystems prompted the United States Congress to enact legislation in 1972 requiring the U.S. Environmental Protection Agency (EPA), in conjunction with the U.S. Army Corps of Engineers (COE), to develop guidelines regulating the disposal of dredged materials in the oceans (P.L. 92-532, Section 103) and inland waters (P.L. 92-500, Section 404). Guidance developed through these cooperative efforts has been published in the Federal Register (for P.L. 92-532, see Vol. 58, No. 198, 15 October 1973; for P.L. 92-500, see Vol. 40, No. 173, 5 September 1973 and Vol. 44, No. 182, 18 September 1979).

Traditional concerns relevant to the evaluation of the potential ecological effects of dredged material disposal have questioned the validity of the evaluation procedures used. Two principal methods have been utilized for the evaluation of dredged materials with each possessing unique strengths and weaknesses. The U.S. EPA, Regions V and IX, have used bulk chemical sediment analysis (FWPCA 1968, JENSEN 1971, BOWDEN 1977) for the evaluation of dredged materials while the U.S. COE has utilized the elutriate test (U.S. ARMY CORPS OF ENGINEERS 1977). The strengths and weaknesses of both methods have been previously discussed (LEE and PLUMB 1974, PRATER and ANDERSON 1977a, b).

As part of a continuing investigation examining these procedures and others as means of evaluating dredged materials and selecting disposal methods; sediment grab samples were collected from five Lake Michigan harbors and analyzed using the bulk and elutriate chemical procedures, as well as a 96-hour sediment bioassay procedure (PRATER and ANDERSON 1977a, b). The objective of the portion of the study discussed herein was the empirical correlation of the mortality data from the bioassays and the elutriate chemical data.

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MATERIALS AND METHODS

During the summer and fall of 1977, 40 sediment grab samples were collected from the following Lake Michigan harbors: Indiana Harbor, Indiana; Grand Haven Harbor, Michigan; New Buffalo Harbor, Michigan; Green Bay Harbor, Wisconsin; and Marinette-Menominee Harbor, Wisconsin-Michigan; using a standard Ponar dredge. Five liters of sediment were collected from each station. Four liters of sediment were used in the sediment bioassay tests and 0.5 liter was used in each of the chemical procedures. The following chemical parameters were analyzed in the elutriate procedure: NH_3, COD, TP, TKN, NO_3 + NO_2, Cl-, SO_4 =, As, Cd, Cu, Fe, Pb, Mn, Ni, and Zn. All chemical analyses were performed using EPA methodologies (U.S. EPA 1974).

The sediment bioassay tests were conducted using the procedure of PRATER and ANDERSON (1977a, b) and followed standard guidelines for bioassay tests (U.S. EPA 1978). Test organisms used in the bioassays were *Pimephales promelas* Rafinesque, *Hexagenia limbata* Walsh, *Lirceus fontinalis* Rafinesque, and *Daphnia magna* Straus. The *H. limbata*, *L. fontinalis*, and *D. magna* were early instar immatures, while the *P. promelas* were adults with the standard length of the smallest individual being no less than 0.5 that of the largest. *P. promelas* and *D. magna* were obtained from laboratory cultures while *L. fontinalis* and *H. limbata* were collected from natural populations occurring in relatively unperturbed environments.

Bivariate correlations of the per cent mortalities of the test species and the elutriate chemical data were performed using the SPSS subprogram SCATTERGRAM on an IBM Model 360 computer. Correlation coefficients $\geq$ 0.40, p = 0.05, N = 40, were considered *a priori* as having the most probable biological and ecological meaning in terms of the mortality of the test organisms.

RESULTS

A total of 60 bivariate correlation analyses of the mortality and elutriate chemical data were performed. Of these, four met the *a priori* criteria established to identify a meaningful correlation. The mortality of *P. promelas* was significantly correlated with the elutriate concentration of chloride (Fig. 1) and the mortality of *H. limbata* was significantly correlated with the elutriate concentrations of chloride, ammonia, and nickel (Fig. 2 - 4).

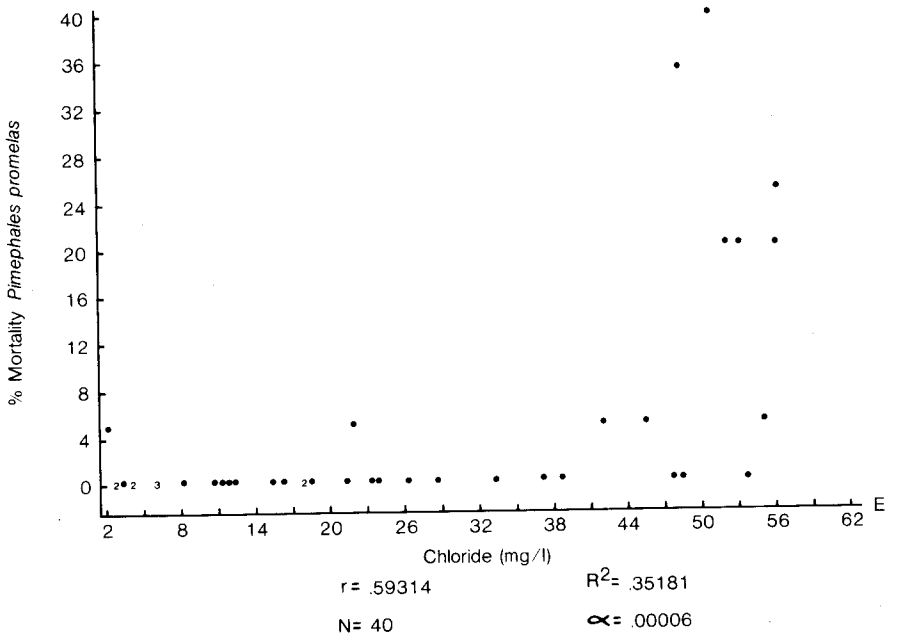

Figure 1. Plot of % mortality of Pimephales promelas versus elutriate concentration of chloride.

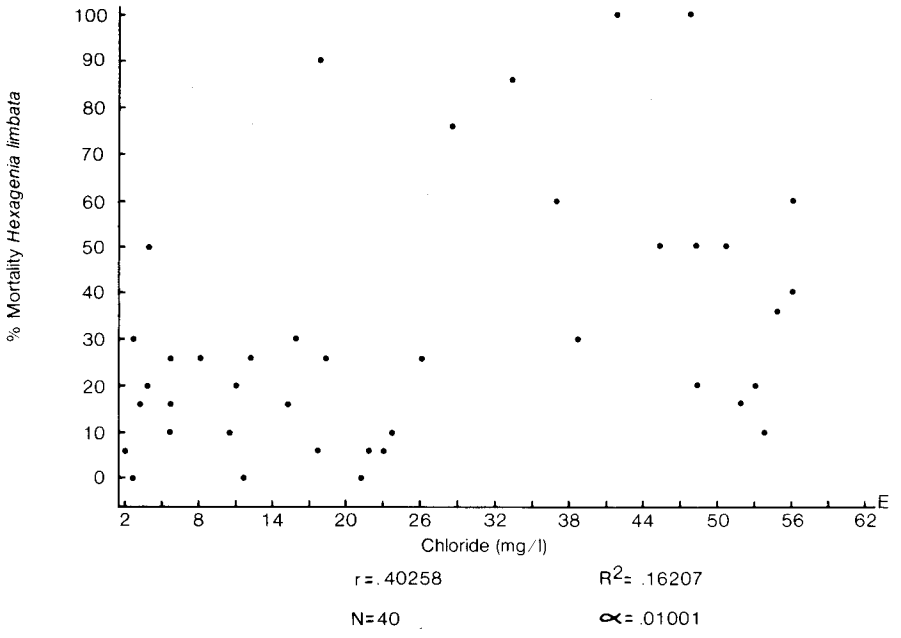

Figure 2. Plot of % mortality of Hexagenia limbata versus elutriate concentration of chloride.

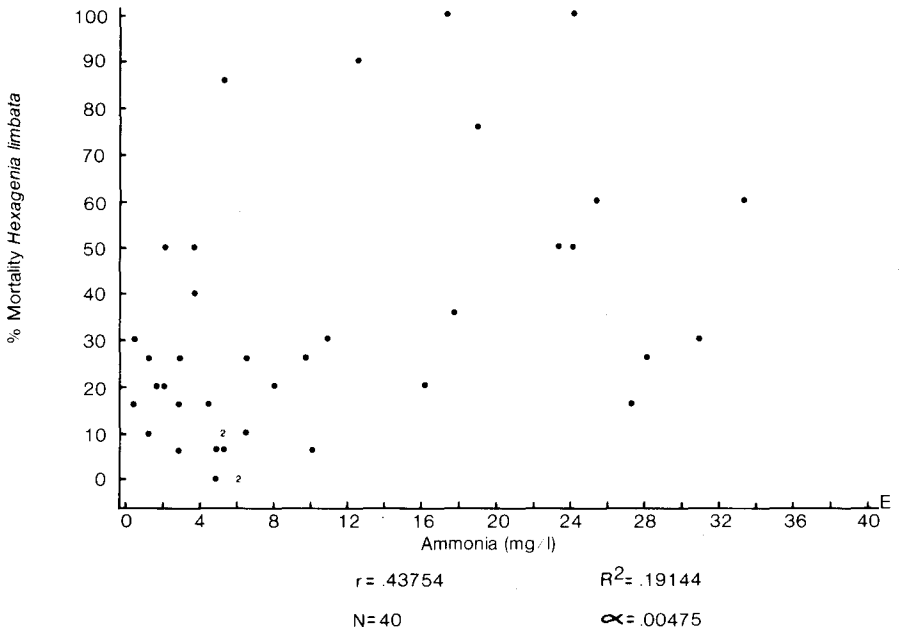

Figure 3. Plot of % mortality of Hexagenia limbata versus elutriate concentration of ammonia.

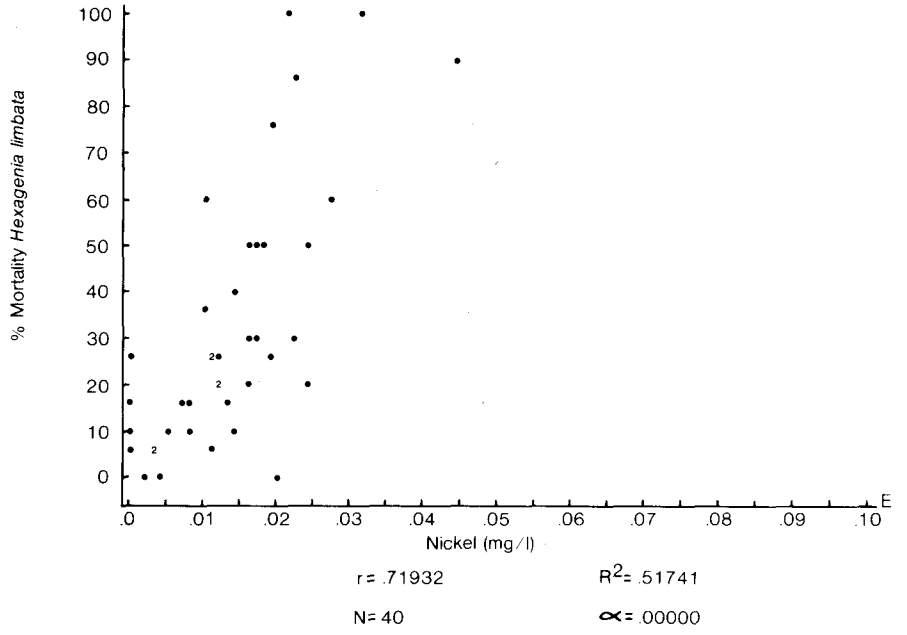

Figure 4. Plot of % mortality of Hexagenia limbata versus elutriate concentration of nickel.

DISCUSSION

The correlation of the mortalities of the test organisms from the sediment bioassays and the elutriate chemistry of the sediments conducted in this portion of the investigation was an empirical exercise because the test organisms were not exposed to the actual elutriate (leachate) portion of the sediments. However, there are data (PRATER and HOKE 1979d) which suggest strong similarities between the leachate from the elutriate test and the difference chemistry leachate (posttest water minus pretest water) from the sediment bioassays. Therefore, the empirical correlation of mortality and elutriate chemistry may actually reflect the correlation of mortality with the release of chemical constituents of the sediments as measured by the difference chemistry.

The small number of significant correlations (4) found between the mortality and elutriate chemistry data was slightly greater than the five per cent attributable to random chance. A greater number of significant correlations have been found between mortality of the test organisms and bulk chemistry of the sediments. Twenty-five of the 88 analyses correlating mortality and bulk chemistry were found to be significant using the previously mentioned a priori criteria (PRATER and HOKE 1979d).

Thus the utility of the elutriate test for the evaluation of the possible ecological effects of dredged material disposal on benthic fauna is suspect. The elutriate test only simulates the immediate impact of disposal events on the water column. The use of bulk sediment chemistry and sediment bioassays may more readily address the impact of disposal events on benthic communities.

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