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Trends in organic pollutants in Lake Ontario sediments 1968–1987

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Key words: Pollutants, Lake Ontario, sediments, Mirex

Introduction

Samples of the uppermost 3 cm of sediment were taken on a grid of 232 points from Lake Ontario in 1968, 1977 and 1987. Samples were freeze,dried and retroactively analyzed for organic compounds. These compounds include Dieldrin, Chlordane, PCBs, DDT, metabolites, chlorobenzenes and Mirex. Mirex alone is used for illustrative purposes in this extended abstract.

Results and Discussion

Mirex is the trade name given to an insecticide formulated by Hooker Chemical at Niagara Falls, New York, USA on the Niagara River. It was used exclusively for the control of the fireant in the southern United States. It was first found in fish tissue from the bay of Quinte (Lake Ontario) by Kaiser (1974) who postulated an origin from atmospheric deposition.

Figure 1 presents the analysis of Mirex in bottom sediment samples taken from Lake Ontario in 1968, 1977 and 1987 illustrating changes in the distribution in the lake over a 20 year period. The distribution for 1968 is different than that given by Holdrinet et al. (1978) since samples at the mouth of the Niagara River were not included to provide conformity to the 1977 data for which these samples were missing. However, reference to the work of Holdrinet et al. (1978) clearly implicate the Niagara River as the major source of Mirex to the lake with a subsidiary source due to the remobilization of Mirex polluted sediment in the Oswego River. The manufacture of Mirex by Hooker Chemical stopped in 1976. The distribution of Mirex in 1977 should, therefore, represent the maximum pollution of the lake by this compound. This indeed is reflected for 1977 as shown in figure 1. Clearly, increases in the western basin (Niagara Basin) have occurred, agreeing with direct industrial loss from the Niagara River. The pollution of the central part of the lake (Mississauga Basin) has also increased from 1968 with a high spot indicating a possible source east of Wilson in New York State. Some indication of such a source can also be seen in the 1968 distribution. An increase can also be seen in the eastward transport of

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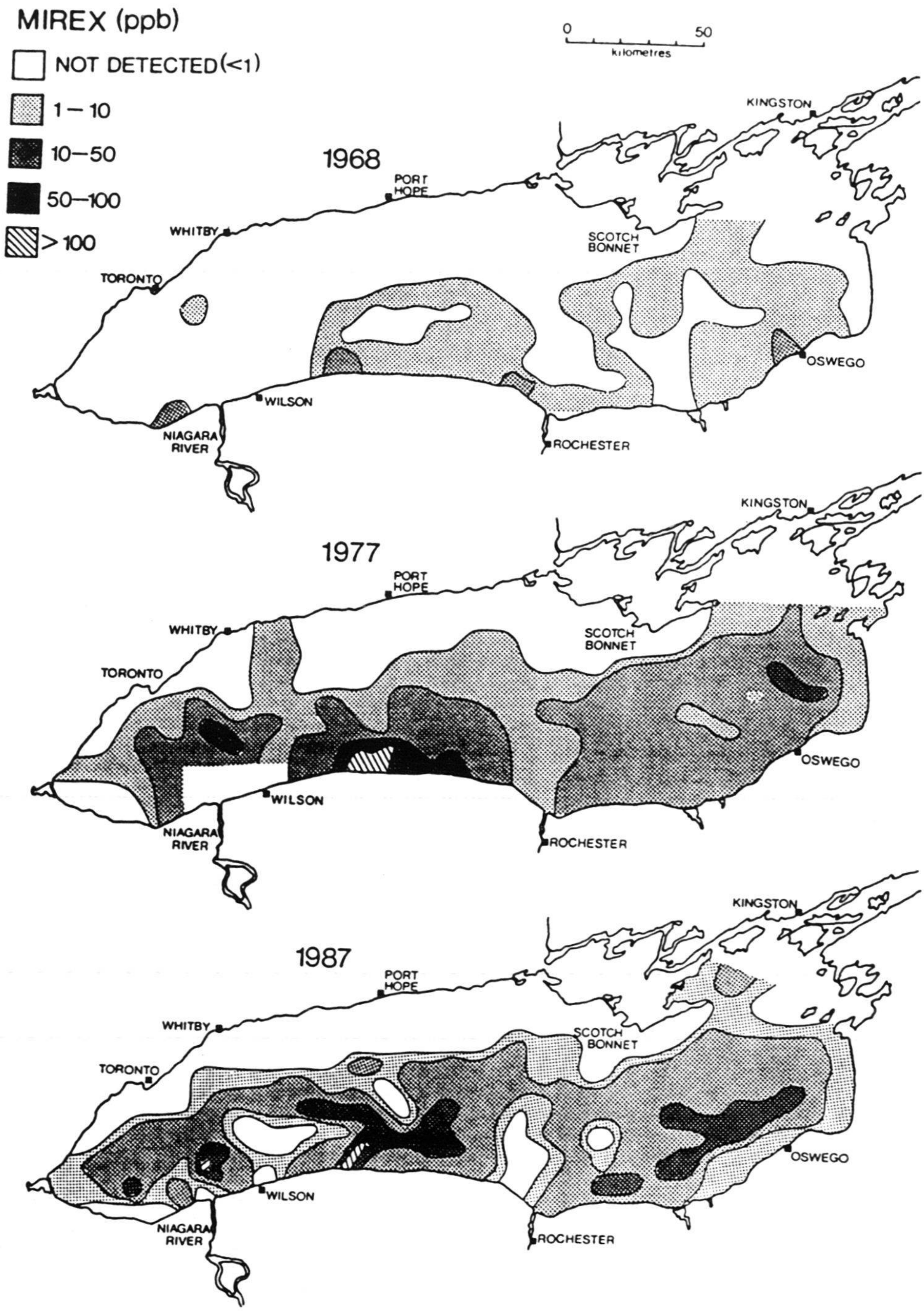

Fig. 1. Distribution of Mirex in the surface 3 cms of sediment in Lake Ontario for 1968, 1977 and 1987.

polluted sediment along the south shore of the lake with dispersal into the Rochester Basin. With the cessation of manufacture in 1976, the data for 1987 should be showing a decline in the concentration on the assumption that progressively less polluted sediment will be accumulating with time. That this is not the case is clearly manifested by the Mirex distribution of 1987. The Niagara River is having less influence than for 1977 and the Oswego river appears to be having no further effect. The distribution can be accounted for in part by movement of polluted sediment from the coastal region, with focusing into the deeper waters of the lake. However, levels continue to rise (see Table 1) and the source to the east of Wilson appears to be active and having a major impact on the sediments of the Mississauga Basin. This source will be discussed below since it may well have major significance to the future of this lake.

Evidence for the increase in Mirex can be clearly seen in the summary statistics given in Table 1. Inshore samples occur around the coastal region of the lake and on two cross lake sills which divide the lake into three separate basins (see the 1987 Mirex distribution diagram in figure 1). The inshore samples consist of sands and gravels overlying glacial deposits with no permanent accumulation of the fine modern sediment which provides the binding sites for the pollutants. From Table 1, it can be seen that the inshore samples increase from 1968 to 1977 but show little change to 1987. A slight decline may be seen though the change has no statistical significance. Basin sediments, however, show a dramatic increase from 1968 to 1977 by one order of magnitude and continue to rise to 1987, with an approximate 30% increase in concentration. This increase is seen for the sediments in the three individual basins.

Other compounds analyzed at the same time as the Mirex reveal identical trends, including anomalously high values in the coast region east of Wilson, New York. These compounds include Dieldrin, Chlordane, PCBs, and total DDT. These are not described further here.

	1968			1977			1987		
	N	Mean	s.d.	N	Mean	s.d.	N	Mean	s.d.
All samples	115	2.4	5.4	130	18.6	24.9	127	23.6	24.4
Inshore	48	2.3	7.3	66	5.7	10.7	66	5.3	9.7
Total basin	67	2.6	3.7	74	28.5	27.9	74	36.7	23.2
Niagara Basin	-	-	-	9	22.8	22.3	9	42.2	20.0
Mississauga Basin	26	2.4	3.5	29	29.9	36.8	29	35.4	28.0
Rochester Basin	33	3.3	3.9	36	28.7	19.4	36	36.4	19.2

Tab. 1. Means and standard deviations for Mirex in the surficial sediments of Lake Ontario for 1968, 1977, and 1987. Values in ng/g dry weight.

The source of organic compounds west of Wilson, New York is of considerable interest. It remains a possibility that they are derived from the Niagara River with transport along the south shore. The distribution data do not appear to support this origin and in all cases appears to indicate a source on the south shore of the lake. Sediment taken from small rivers along the south shore did not show high concentrations of the compounds and may be discounted as the source. An alternate hypothesis for their origin can be put forward as resulting from groundwater influx related to the tectonic setting and structure of the lake as discussed below.

Some debate remains over the origin of the Great Lakes Basin. Conventional thought still ascribes the lakes to ice scour with periodic earthquake activity resulting from readjustment of the crust by rebound, following the removal of the Pleistocene ice cover. This concept is currently being challenged by a hypothesis which proposed a tectonic origin for the Lower Great Lakes in a line of weakness defined by a Paleozoic rift (Thomas et al in press). The rift is an extension of the known St. Lawrence Rift, crossing Lakes Ontario and Erie at least to the State of Ohio, but probably continuing south-westwards to the

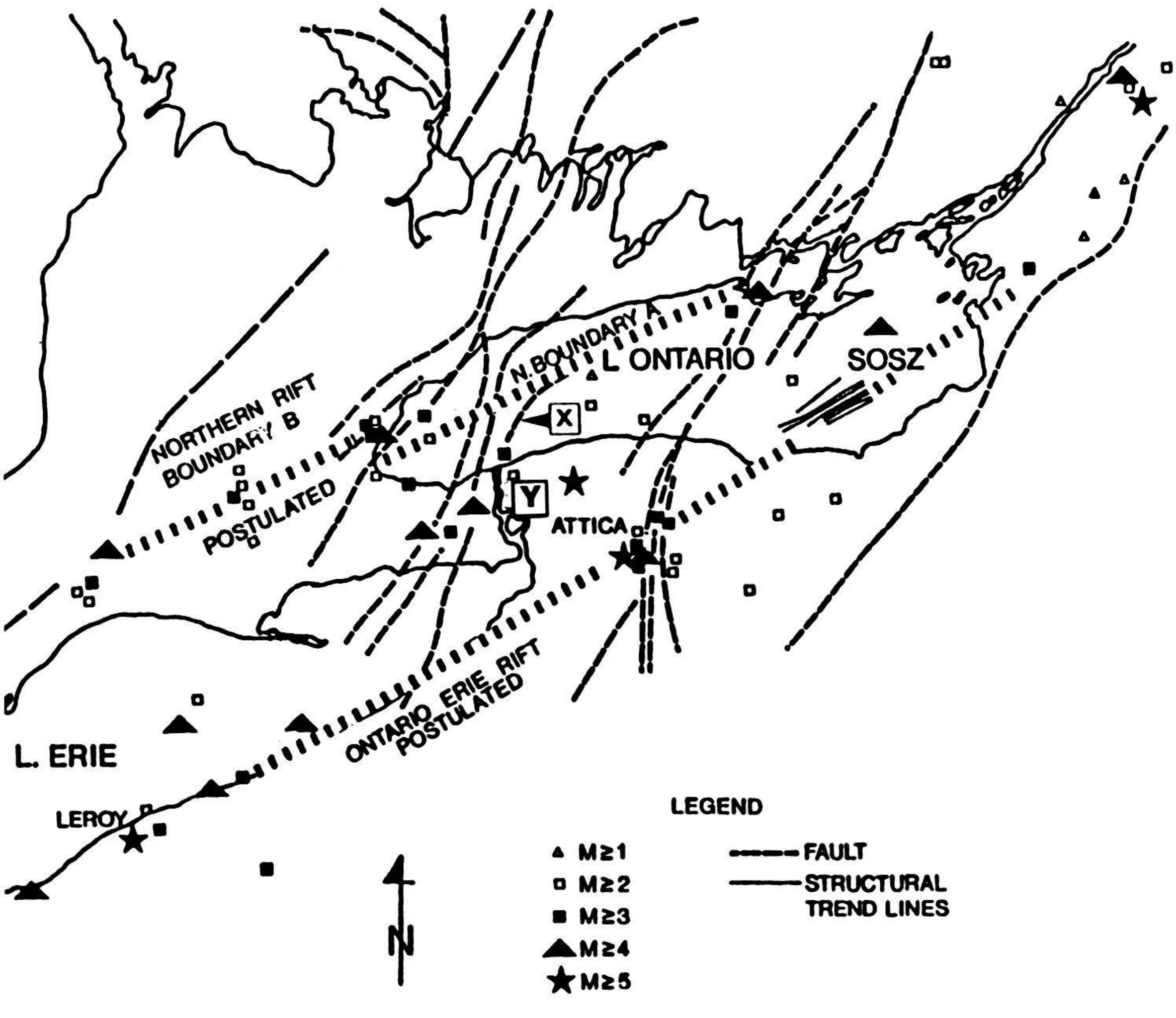

Fig. 2. Tectonic setting of Lake Ontario, Wilson-Port Hope magnetic lineament designated X. Y denotes Hyde Park chemical waste site.

Mississippi Valley. Current continental stress fields have resulted in reactivation of the preexisting fault system.

Figure 2 provides a reconstruction of the tectonic setting of the Lower Great Lakes. The southern rift margin has been determined by structural elements in Lake Ontario and extended along the south shore of Lake Erie. The northern margin is speculative at this time with the possibility of two boundaries designated A and B in figure 2. On the basis of aeromagnetic mapping, within lake structure observed by acoustic and other techniques and extension to known onland features, a number of conjugate faults crossing the lake are indicated. These are known as the Burlington-Toronto structural zone, the Niagara-Pickering Lineament, the Wilson-Port Hope fault line and Clarendon-Linden fault. The Wilson-Port Hope structure is of particular interest since its south western extension passes through the Niagara Frontier region of New York State close to the Hyde Park Toxic Waste Disposal Site (Y in Fig. 2) as well as many other old waste disposal sites in this region. It does not require much imagination to speculate that the movement of polluted groundwater along this major line of weakness may be the origin of the high concentrations of pollutants observed in Lake Ontario sediments just to the west of Wilson. Much current research is being directed to investigate this hypothesis.

Conclusions

Prohibiton or limitation of manufacture and use of many of the persistent organics were carried out between 1970 and 1976. Clearly, these compounds which include Mirex, PCBs, Chlordane and Dieldrin would be expected to decline in Lake Ontario. Sediment data show that this is not the case and these compounds are rising. The distribution of Mirex shows a source to the west of Wilson on the south shore of the lake. No known source is located in this region. It is speculated that the input may be related to polluted groundwater infiltrating along a line of structural weakness known as the Wilson-Port Hope magnetic lineament. This hypothesis supports the general concept of residual pollution from materials previously manufactured and disposed in the environment. It indicates that past usage and waste disposal practices continue to pollute natural systems and unless action is taken will continue into the foreseeable future.

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REFERENCES

HOLDRINET, M., FRANK, R., THOMAS, R. L., HETLING, L. J. 1978. Mirex in the sediments of Lake Ontario. J. Great Lakes Research 4, 69–74.

KAISER, K. L. E. 1974. Mirex: An unrecognized contaminant of fishes from Lake Ontario. Science 185, 523–525.

THOMAS, R. L., MCMILLAN, R. K., BOWLBY, J. R., FRAPE, S. K., KEYES, D., MOHAJER, A. A. in press: Tectonic implications of deformation in the bottom sediments of western and southeastern Lake Ontario. Geographie, Physique et Quaternaire (in press).