 0030-0950/84/0003-0094 $2.00/0

GEOCHEMICAL STUDY OF LAKE ERIE WATER NEAR CLEVELAND, OHIO[1]

HOWARD H. LO, Department of Geological Sciences, Cleveland State University, Cleveland, OH 44115

ABSTRACT. In August 1981, 88 surface, intermediate-depth, and near-bottom water samples from 30 locations near Cleveland, Ohio, were collected from Lake Erie. The distribution of K, Na, Ca, and Mg with respect to water depth and location was investigated. Surface water generally had higher K, Na, Ca, and Mg contents than near-bottom water. Elemental concentrations increased sharply near the mouths of the Cuyahoga and Rocky Rivers, and these higher levels are probably the result of cultural inputs from residential and industrial wastes. The average concentrations of K, Na, Ca, and Mg were 1.5, 12.0, 38.2, and 9.6 ppm, respectively, in Lake Erie water far from the river mouths. These values are comparable with those reported for mid-lake water of Lake Erie but are considerably lower than values found for water near the mouths of the Cuyahoga and Rocky Rivers.

OHIO J. SCI. 84 (3): 94-98, 1984

INTRODUCTION

Lake Erie is the shallowest and the second smallest lake of the Great Lakes. It is approximately 380 km long and 75 km wide. Cleveland, Ohio, is the largest port on the lake and is located approximately 145 km east of the western end of Lake Erie. In the vicinity of Cleveland, 3 main rivers flow into Lake Erie: the Chagrin River to the east of the city, the Rocky River to the west, and the Cuyahoga River which flows right through the industrial heart of Cleveland. The geochemistry of the lower Cuyahoga River was reported by Lo and Shong (1976), and the chemical composition of the Rocky River was reported by Lo and Soster (1981). As indicated by Weiler and Chawla (1968), the composition of lake water from Lake Erie is quite homogeneous, except for some

[1]Manuscript received 8 April 1983 and in revised form 21 October 1983 (#83-14).

areas close to the shores and in the western basin.

This study investigates the composition of Lake Erie water near the mouths of 2 rivers, the Cuyahoga and the Rocky Rivers, as well as the composition of lake water far from the mouths of these rivers, based upon systematic sampling. Presented is data on the concentrations and distribution of K, Na, Ca, Mg with respect to location and water depth, as well as an examination of the possible contribution of local stream flow to the composition of Lake Erie water.

METHODS AND MATERIALS

During August 1981, a period of relatively dry weather, 88 water samples were collected from Lake Erie at 30 locations, from areas near the mouths of the Cuyahoga and Rocky Rivers and at selected sites away from these river mouths. Locations of the sample sites are shown in fig. 1. Three water samples (representing the surface, an intermediate depth, and the bottom) were collected at each location using a Kemerer sampler, with the water samples dispensed into polyethylene bottles. Most of the sample sites had a water depth of between 9-15 m, except locations 20 and 21 where water samples of intermediate depth were not taken because of shallowness (approximately 3 m) of the sites. All samples were filtered to remove suspended particles using a high-retention filter paper (Whatman No. 40) and were stored in polyethylene bottles and kept in a freezer below 0 °C until analyzed.

The samples were analyzed for K, Na, Ca, Mg, using an atomic absorption spectrophotometer (IL Model 253) and following the methods described by Angino and Billings (1972) for fresh water. Calibration curves of known standards were used to determine elemental concentrations. Detection limits (in ppm) for the elements analyzed are: K: 0.003, Na: .0008, Ca: 0.002, and Mg: 0.003. The accuracy of analyses expressed as percent of error for the elements analyzed are: K: 4.0, Na: 2.5, Ca: 2.0, and Mg: 3.5.

RESULTS AND DISCUSSION

Thirty surface, 28 intermediate-depth, and 30 near-bottom water samples from

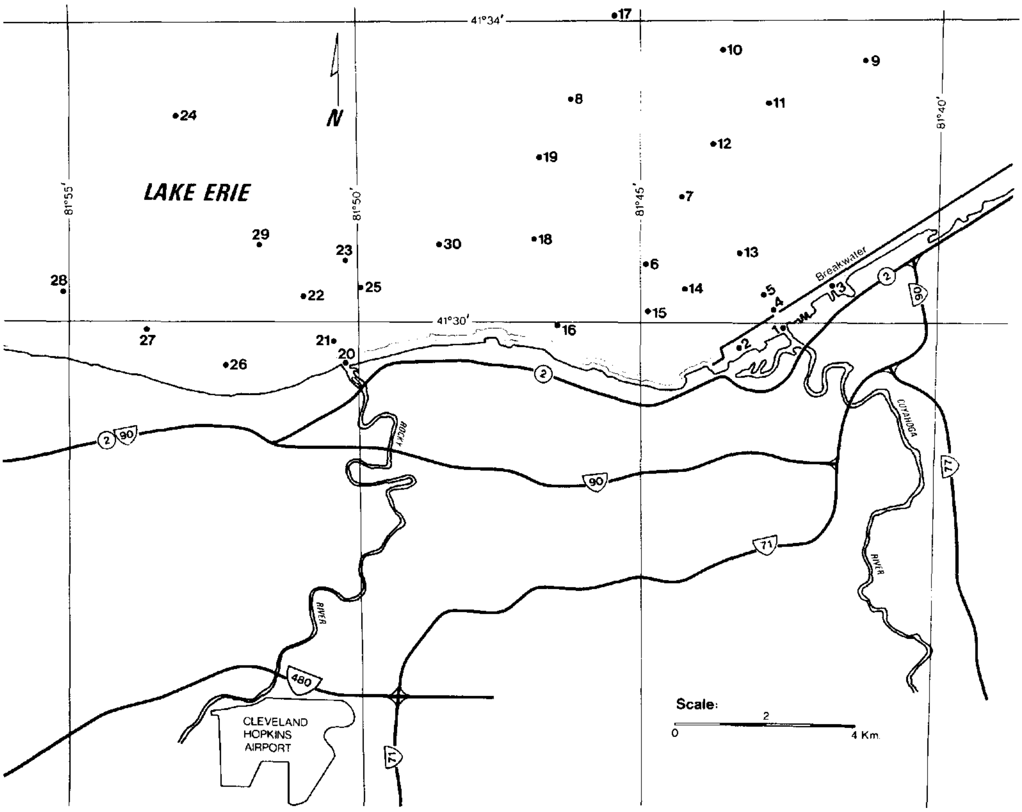

FIGURE 1. Map of Lake Erie shore at Cleveland, Ohio, showing locations of sample collection.

TABLE 1

Average concentrations of K, Na, Ca, and Mg (in ppm) in Lake Erie near Cleveland, and in the Cuyahoga River, the Rocky River, and mid-Lake Erie.

	K	Na	Ca	Mg
Near mouth of Cuyahoga River (6 sites)				
Surface	3.56	34.6	55.3	12.5
Interm. depth	3.23	25.6	54.0	11.4
Bottom	2.95	22.0	51.8	10.7
Average	3.25	27.4	53.7	11.5
Near mouth of Rocky River (5 sites)				
Surface	1.97	16.0	40.1	10.9
Bottom	1.84	13.4	38.6	10.4
Average	1.91	14.7	39.4	10.7
Near lake shore (6 sites)				
Surface	1.63	12.7	38.9	9.9
Interm. depth	1.54	12.2	39.2	9.7
Bottom	1.53	11.9	39.3	9.8
Average	1.57	12.3	39.1	9.8
Farther from lake shore (13 sites)				
Surface	1.58	12.1	38.8	9.6
Interm. depth	1.53	11.9	38.1	9.6
Bottom	1.51	11.8	37.8	9.4
Average	1.54	11.9	38.2	9.5
Lower Cuyahoga River*	6.2	60.8	58.2	15.0
Lower Rocky River**	7.4	62.0	59.0	—
Mid-Lake Erie***	1.3	11.8	38.7	8.0

*Lo and Shong (1976)
**Lo and Soster (1981)
***Weiler and Chawla (1968)

Lake Erie near Cleveland were analyzed for K, Na, Ca, and Mg. The locations of sample sites were divided into 4 groups: near the mouth of the Cuyahoga River (6 sites); near the mouth of the Rocky River (5 sites); near the lake shore (6 sites); and farther from the lake shore (13 sites). The average concentrations of K, Na, Ca, and Mg for the surface, intermediate-depth, and bottom waters in each of these groups are listed in table 1. It was found that surface water had the highest elemental concentrations, and bottom water had the lowest, as strongly indicated by the samples taken near the mouths of the Cuyahoga and Rocky Rivers. The values for elemental concentrations of intermediate-depth water were between those of the surface and bottom water values. Samples from areas far from the mouths of the 2 rivers showed little difference in the elemental concentrations of surface and bottom waters.The elemental concentrations varied greatly with respect to location on the lake, with the highest concentration in the area near the mouth of the Cuyahoga River and the lowest concentration in areas far from the lake shore.

It is generally known that chemicals in rivers and lakes come from 2 major sources: one is the natural contribution of constituents derived from chemical weathering of rocks, minerals and soils; the other is the cultural contribution which includes industrial and agricultural wastes that are washed and discharged into rivers and lakes. The higher average concentrations of K, Na, Ca, and Mg that are found in areas near the mouths of the Cuyahoga and Rocky Rivers probably can be attributed to the increased input of cultural wastes from the residential and industrial areas located along these rivers. Elemental concentrations in water far from the mouths of the rivers are lower and nearly constant, indicating that the influence of stream flow to the composition of the lake water is almost nonexistent for areas far from the mouths of the rivers.

In fig. 2, concentrations in surface and bottom waters versus distance from the mouth of the Cuyahoga River (sample numbers are also indicated) are plotted for each of the 4 elements. All elements show a sharp rise in concentration near the mouth and remain nearly constant at distances far from the mouth of the river. For each element analyzed, the distribution patterns of surface and bottom waters are quite similar, showing either a parallel or

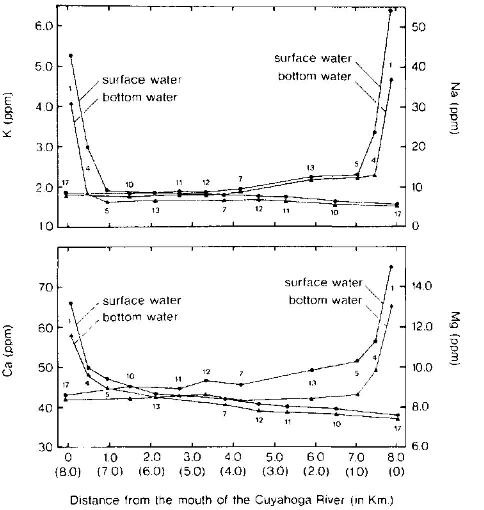

FIGURE 2. K, Na, Ca, and Mg in Lake Erie water plotted as a function of distance from the mouth of the Cuyahoga River. (Numbers in the figure are sampling sites.)

subparallel relationship, and with elemental concentrations higher in surface water than in bottom water. Similar distribution patterns and relationship are also observed in lake water near the mouth of the Rocky River.

The mixing of river water with the less concentrated lake water apparently causes the sharp increase of elemental concentrations near the mouths of the rivers, as strongly indicated in fig. 2. The same figure shows that the surface water is consistently higher in K, Na, Ca, and Mg contents than the bottom water. These concentration differences are particularly pronounced near the mouth of the river and could be caused by thermal stratification of the upper river water from the colder lake water. As pointed out by Schroeder and Collier (1966), water containing a large volume of industrial wastes and municipal sewage is warmer and tends to overlie the cooler, less mineralized water in Lake Erie. The difference in elemental concentration in surface and bottom waters decreases rapidly lakeward and even diminishes in locations far away from the shore. This would be a result of the disappearance of thermal stratification as the lake water far from the shore is more thoroughly mixed and circulated. These findings seem to be consistent with the report made by Varga and Kolodzie (1974) who found that, in the western basin of Lake Erie, concentrations of soluble Ca, Mg, Fe, etc., did not fluctuate much with respect to water depth.

In table 1, the concentrations of K, Na, Ca, and Mg in Lake Erie near Cleveland are compared with those found in the Lower Cuyahoga River (Lo and Shong 1976), the Lower Rocky River (Lo and Soster 1981) and mid-lake water of Lake Erie (Weiler and Chawla 1968). Elemental concentrations in lake water near the mouth of the Cuyahoga River are much lower than concentrations in the Lower Cuyahoga River, and the K, Na, and Ca contents in lake water near the mouth of the Rocky River are significantly less than in the Lower Rocky River. Elemental concentrations of lake water from areas far from the mouths of the rivers and in areas farther from the lake shore, are comparable with values for mid-lake water of Lake Erie. This finding appears to be consistent with those of Weiler and Chawla (1968) who reported that the composition of lake water in Lake Erie was quite homogeneous, except for some areas near the shore and the mouths of rivers. The much higher concentrations of K, Na, Ca, and Mg found in lake water near the mouths of the Cuyahoga River and the Rocky River indicate that these rivers apparently have made a significant contribution of these elements to Lake Erie.

ACKNOWLEDGMENTS. I thank James Smith for collecting the lake water samples, David Hogue for completing the chemical analyses, and Marilyn Entenok for help in improving the manuscript.

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