# GEOCHEMICAL INVESTIGATION OF THE LOWER CUYAHOGA RIVER, CLEVELAND, OHIO[1]

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*Abstract.* Fifty-four surface and near-bottom water samples from the lower Cuyahoga River were collected in the early spring of 1974. The distribution of K, Na, Ca, Mg and Zn with respect to water depth and location in the river was investigated. The average concentrations of K, Na, and Zn of the surface samples are slightly higher than those of the near-bottom samples. Correlation between element concentration and distance along the river indicates that Mg stays nearly constant and other elements fluctuate, particularly along the sections with local industries. The sharp drop of K and Na contents in near-bottom samples near the river's mouth could be caused by the intrusion of cooler lake water. pH values of water samples were slightly alkaline, ranging from 6.98 to 7.45. The average concentrations of K, Na, Ca, Mg, and Zn of the lower Cuyahoga River were 6.2, 60.8, 58.2, 15.0, and 0.020 ppm respectively. These values are considerably higher than those of the mid-lake water of Lake Erie.

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The Cuyahoga River has its headwater near the Geauga-Ashtabula county line and flows south to Akron. From Akron, it flows north to Cleveland, passing through the heavily industrialized regions, and then empties into Lake Erie.

Lamar and Schroeder (1951), in their investigation of the chemical characteristics of surface waters of Ohio, did analyze surface water samples of the Cuyahoga River stationed at the Center Street Bridge. However, a systematic sampling and more detailed geochemical investigation on the lower Cuyahoga River in Cleveland is lacking. We present data on the distribution of some elements, K, Na, Ca, Mg, and Zn, with respect to location and water depth, and examine the possible contribution of local industries to the concentration of certain elements.

## METHODS AND PROCEDURES

In the Spring of 1974, 54 water samples were collected from ten sites along the lower Cuyahoga River. All the water samples were collected from cross-sections of the river at one-mile intervals, beginning with section 1 at the river's mouth, next to the U.S. Coast Guard station, and finishing with section 10, nine miles up river (fig. 1). The cross-sections were subdivided into three areas: western bank (left bank downstream), middle of the river, and eastern bank (right bank downstream). Both surface and bottom samples were collected using a Kemerer bottle. Samples along the banks were taken not more than one yard away from the bank, and bottom samples were taken not more than one yard above the river bottom. The depth of each sample varies from zero (surface) to about nine yards. Bottom samples along both banks were not collected in sections eight, nine, and ten because of shallowness of the river. All samples were filtered using an extra high retention filter paper (Whatman, no. 42) and stored in polyethylene bottles and kept at 0°C until they were analyzed.

The samples were analyzed for K, Na, Ca, Mg, and Zn using an atomic absorption spectrophotometer (IL model 253), following the method described by Fishman and Downs (1966). The element concentrations were determined from calibration graphs of known standard concentrations, with detection limits in ppm: K: 0.003, Na: 0.0008, Ca: 0.002, Mg: 0.0003, and Zn: 0.001. A separate specimen of each sample was tested for pH value.

## RESULTS AND DISCUSSION

Thirty surface and twenty-four near-bottom water samples from the lower Cuyahoga River were analyzed for K, Na, Ca, Mg, and Zn. Average element contents are given in table 1. It was noted that average concentrations of K, Na,

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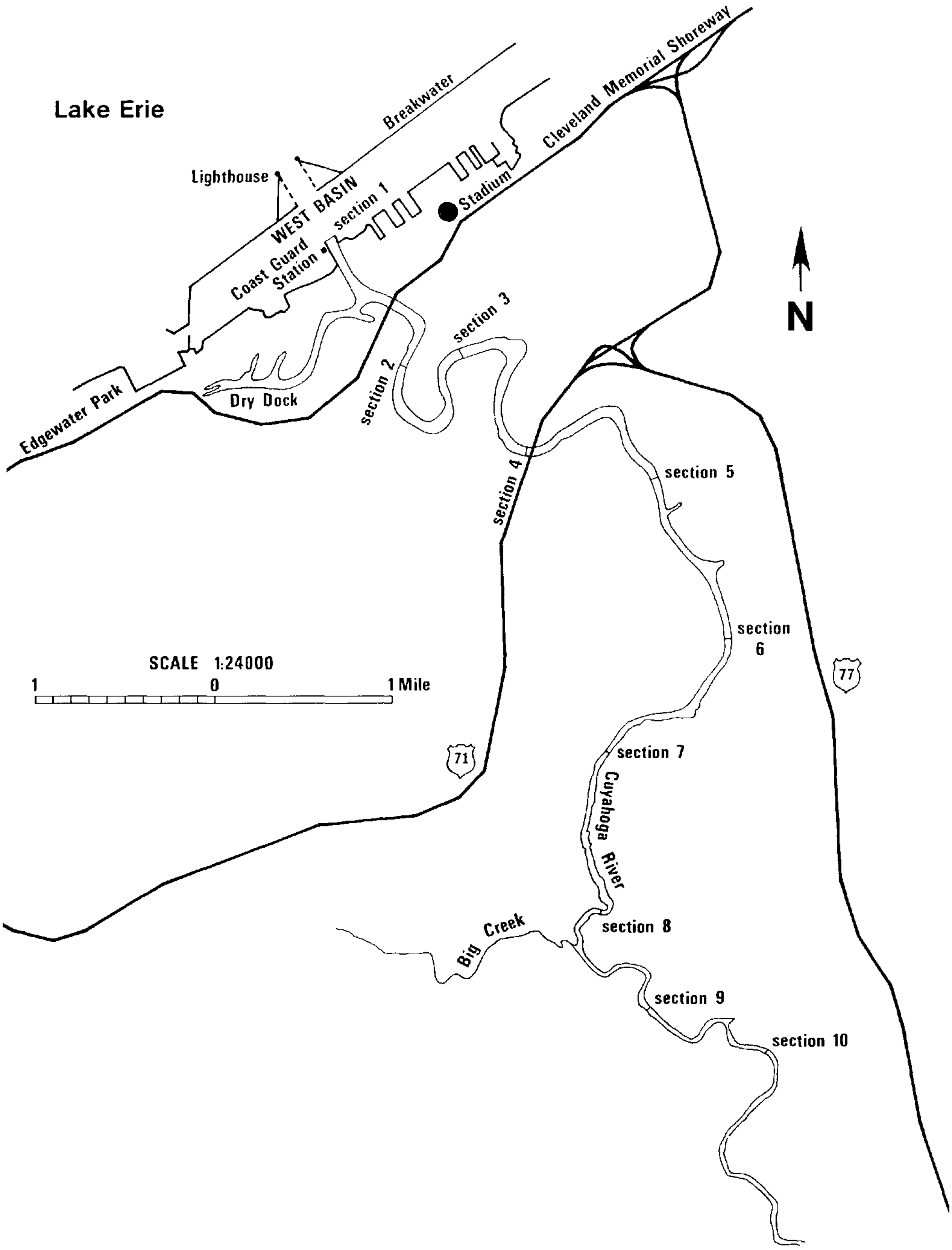


FIGURE 1. Map of lower Cuyahoga River area, showing ten (1–10) locations of sample collection sites.

Ca, and Zn of the surface samples were slightly higher than those of the near-bottom samples in the middle of river and western bank. Along the eastern bank, however, average concentrations of Na, Ca, and Mg of the surface samples were slightly lower than those of the near-bottom samples. Average concentrations of K, Na, and Mg were found to be the lowest in the middle of river, and Ca and Zn concentrations in the middle of river had values in between those of the eastern and western banks. Most samples were slightly alkaline with pH ranging from 6.98 to 7.45. The variation of pH of water sample to depth (zero to nine yards from river surface) and distance (zero to nine miles from the river's mouth) was tested, with no regular trend being found.

Concentrations of K, Na, Ca, Mg, and Zn versus distance from the river's mouth were plotted for both the surface and near-bottom samples as shown in figures 2 and 3. The concentration of K in the middle of river and eastern bank was nearly constant from nine to six miles, was highest at four miles, then gradually decreased toward the river's mouth. Na concentration in the surface and bottom samples remained fairly constant through the entire length of the river with only a few fluctuations. Ca concentration in the lower Cuyahoga River fluctuated considerably, especially for the samples taken along the middle of river. Mg concentration was nearly constant for both the surface and bottom samples along the entire length of the river (except one bottom sample in the middle of river), and Zn concentration fluctuated considerably.

Near the mouth of the Cuyahoga River, the concentrations of K and Na (fig. 2) in the near-bottom samples showed a relatively sharp drop. This could have been caused by thermal stratification of the upper river water from the colder lake water. Schroeder and Collier (1966) pointed out that water containing large volumes of industrial and municipal wastes overlies the cooler and less mineralized water from Lake Erie. Unusually high concentrations of some elements were found at seven miles (K, Na, and Zn of surface samples in the western bank) and four miles (Na, Ca, Mg of bottom samples in the middle of river) from the mouth of the river. These anomalous concentrations of K, Na, Ca, Mg, and Zn (in samples from certain localities) were probably caused by the wastes and dumps of industries locating along the lower Cuyahoga River.

TABLE 1

*Average* element concentrations in ppm of surface and bottom samples from the lower Cuyahoga River, Cleveland, Ohio*

| | K | Na | Ca | Mg | Zn |
|---|---|---|---|---|---|
| Mid River | | | | | |
| Surface | 6.1 | 60.8 | 58.8 | 14.3 | .021 |
| Bottom | 5.7 | 58.4 | 57.8 | 15.0 | .018 |
| Avg. | 5.9 | 59.6 | 58.3 | 14.6 | .020 |
| Western Bank | | | | | |
| Surface** | 6.8 | 63.5 | 58.7 | 15.6 | .025 |
| Bottom | 6.2 | 57.0 | 55.9 | 14.2 | .021 |
| Avg. | 6.5 | 60.5 | 57.3 | 14.9 | .023 |
| Eastern Bank | | | | | |
| Surface** | 6.5 | 61.9 | 57.1 | 15.2 | .018 |
| Bottom | 6.2 | 62.8 | 61.1 | 15.7 | .017 |
| Avg. | 6.3 | 62.3 | 59.1 | 15.4 | .018 |

*A few unusually high concentrations are not included in the average.
**Average of the seven sites where the bottom samples were also collected.

Suface water samples of the Cuyahoga River at the Center Street Bridge (near our section 2 in fig. 1) were analyzed by Lamar and Schroeder (1951) for K, Na,

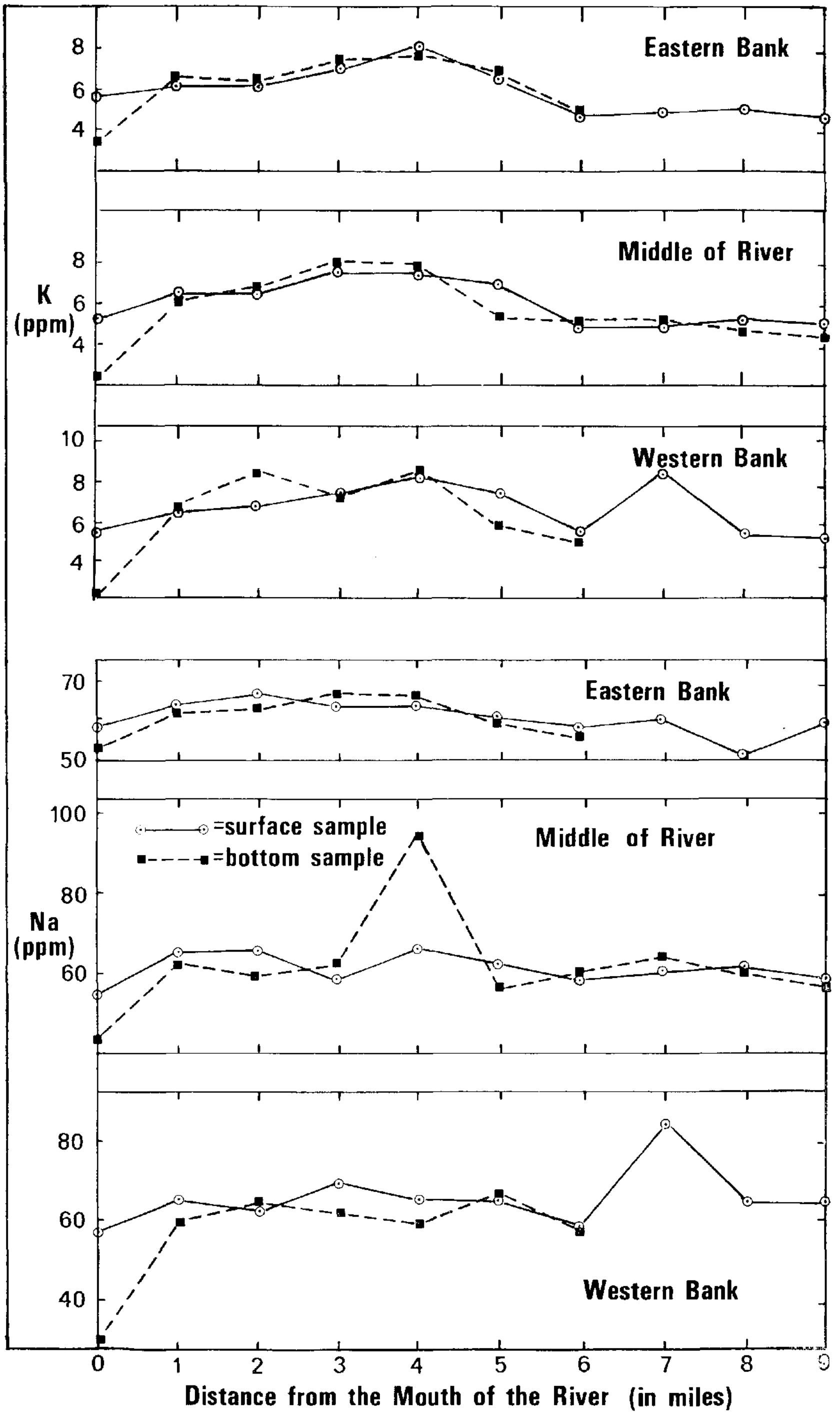


FIGURE 2. K and Na in lower Cuyahoga River as a function of distance from the mouth of the river.

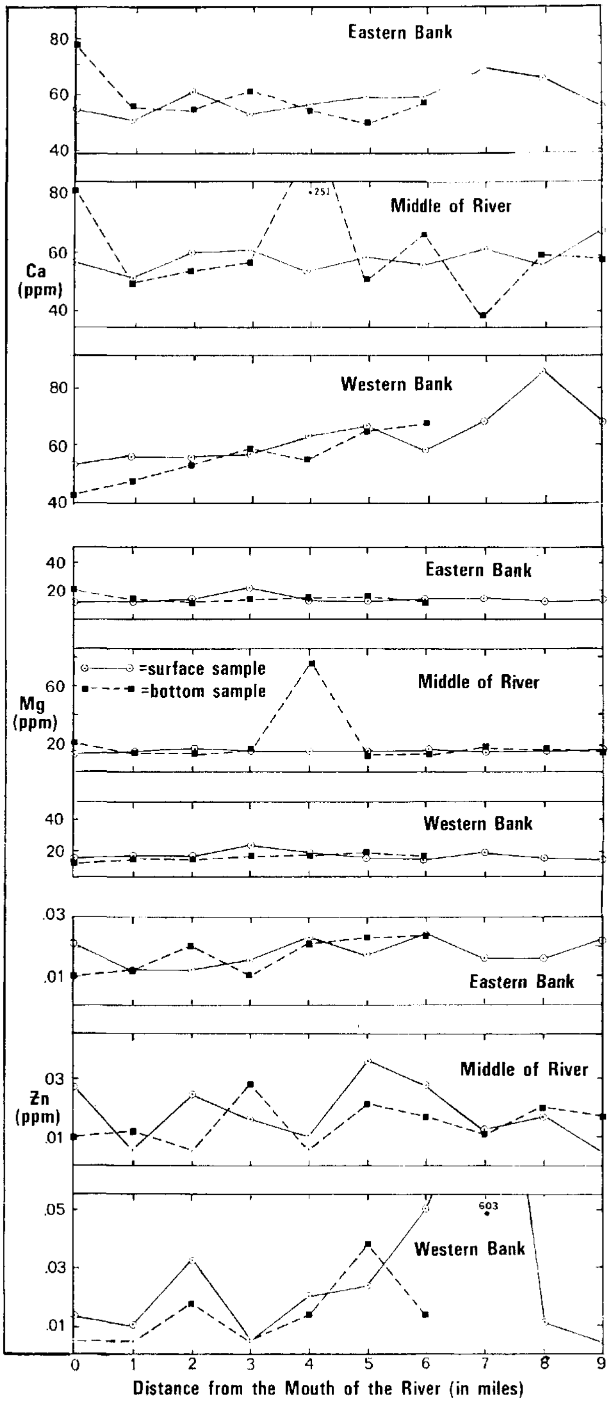


FIGURE 3. Ca, Mg, and Zn in lower Cuyahoga River as a function of distance from the mouth of the river.

Ca, and Mg. Their results were compared with the average values of our analyses in table 2. We found that the lower Cuyahoga River had a higher Mg and K–Na combination concentration and a lower Ca concentration in our present study. This may be related to fluctuations in streamflow and in natural and industrial input over the past 24 years.

The natural input of K, Na, Ca, and Mg also may be related to the concentrations of these elements in the riverbed. The lower Cuyahoga River flows through upper Devonian and lower Mississippian shale formations (Ohio Dept. Nat. Res., Div. Water, 1952). The Devonian, Chagrin Shale Formation contains blue to dark gray silty shales scattered with iron carbonate concretions and thin calcareous sandstone layers; the Cleveland Shale, a member of Devonian Ohio Shale, is black bituminous shale; and the Mississippian Bedford Shale Formation contains a soft blue-gray shale and calcareous lenses of sandstone. An analysis of the Bedford Shale at Cleveland (Lamborn *et al.*, 1939) showed that this shale contained 0.65% CaO, 1.62% MgO, 0.35% $Na_2O$, and 2.60% $K_2O$. It is apparent that the easily-weathered shales and the calcareous sandstones of these formations are important sources of K, Na, Ca and Mg in the lower Cuyahoga River.

Table 2 shows average concentrations of several elements in the lower Cuyahoga River and Lake Erie. It is noted that the average concentration of K, Na, and Zn are slightly higher in the surface samples than those found in the near-bottom samples. The average concentrations of K, Na, Ca, Mg, and Zn in the lower Cuyahoga River are compared with those found in the mid-lake water of Lake Erie by Weiler and Chawla (1968). The data from Weiler and Chawla represent average analyses obtained from their two mid-lake stations. They reported that Lake Erie is quite homogeneous except for some areas close to the shore and the western basin. The concentrations of K and Na in the river water were about five times greater than those in the lake, and the river's concentrations of Ca, Mg, and Zn were about one and one half to two times greater than the Lake Erie concentrations. The lower Cuyahoga River apparently has contributed and probably is still contributing much K, Na, Ca, Mg, and Zn to Lake Erie.

TABLE 2

*Average concentrations in ppm of K, Na, Ca, Mg, and Zn in the lower Cuyahoga River and Lake Erie.*

| Element | Lower Cuyahoga River | | | Cuyahoga River* (Center St. Bridge) | Lake Erie** |
|---|---|---|---|---|---|
| | Surface | Bottom | Avg. | | |
| K | 6.4 | 6.0 | 6.2 | 58.0*† | 1.3 |
| Na | 62.1 | 59.4 | 60.8 | | 11.8 |
| Ca | 58.2 | 58.2 | 58.2 | 68.0 | 38.7 |
| Mg | 15.0 | 15.0 | 15.0 | 14.0 | 8.0 |
| Zn | 0.021 | 0.019 | 0.020 | | 0.010 |

*Data from Lamar and Schroeder (1951).
**Data from Weiler and Chawla (1968).
†Combination of K and Na.

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