Chemical Analysis of Water Samples from Selected Tributaries of the Wabash River

JOSEPH R. SIEFKER and OYETUNDE SALAKO
Department of Chemistry
Indiana State University, Terre Haute, Indiana 47809

Introduction

Since there were limited data on the seasonal surface water qualities of streams near coal fields, this study was undertaken to show seasonally, the trends and effect of coal mining on the quality of surface water near coal fields. Samples were collected biweekly from five different sites. Two sites were near new mines and three sites were near old mines. These samples were analyzed for the concentrations of calcium, iron, lead, magnesium, manganese, potassium, and sodium cations; chloride, nitrate, and sulfate anions; and for physical properties like acidity, alkalinity, dissolved oxygen, pH value, temperature, and turbidity. The cations were analyzed using a Jarrell-Ash Atomic Absorption Spectrophotometer, while the anions were analyzed by titrimetric or colorimetric methods.

Experimental

Small tributaries of the Wabash River were sampled in Vigo County, Indiana. The streams were Coal Creek, Sugar Creek, and three tributaries of Honey Creek. Water samples were collected about a mile from the confluence of Coal Creek with the Wabash River. Samples from Sugar Creek were collected about three miles from the confluence with the Wabash River. Samples from the Honey Creek tributaries were collected about twelve to sixteen miles from the confluence with the Wabash River. Samples were taken twice a month from June 1979 to June 1980. Two of the sampling sites on Honey Creek were near new mines, and the third site was near an old mine. The sampling sites on Coal Creek and Sugar Creek were near old mines.

The analysis procedures used to assay the samples were performed according to standard methods (1,2). An atomic absorption spectrophotometer was used to determine concentrations of various cations in the samples. Five ml of nitric acid was added to a liter of water from the atomic absorption determinations. Selected anion concentrations were determined by titrimetric and colorimetric methods. Acidity was determined by titration of the sample with a standard base until a pH of 8.3 was attained. Alkalinity was determined by titration with a standard acid until a pH of 4.5 was attained. Dissolved oxygen, pH, temperature, and turbidity were measured with appropriate meters.

Results and Discussion

The maximum acidity concentrations for the samples collected near new mines for summer, autumn, winter and spring were 93.8, 22.0, 20.0 and 36.0 mg/1, respectively; and for samples taken near derelict mines the concentrations were 111.0, 230.0, 144.0 and 98.0 mg/l, respectively. The minimum concentrations found near new mines were 3.3, 8.0, 8.0 and 6.0; and 8.0, 10.0, 16.0 and 16.0 for the samples taken near derelict mines for summer, autumn, winter and spring, respectively. On the average, the concentrations near the new mines were 19.1 in summer compared with 13.1 in autumn, 13.3 in winter and 17.4 mg/l in spring; and near the derelict mines the averages were 44.4, 54.3, 44.9 and 38.7 mg/l, respectively. The acidity was always greater in samples taken near abandoned mines than near new mines.

The maximum alkalinity concentrations for the samples collected near new mines were summer, 235.0; autumn, 206.0; winter, 226.0; and spring, 256.0 mg/l; while maximum concentrations for the samples taken near derelict mines were summer, 220.0; autumn, 196.0; winter, 190.0; and spring, 160.0 mg/l. The minimum concentrations found near new mines were summer, 45.0; compared with autumn, 56.0; winter, 44.0; and spring, 24.0 mg/l; while minimum concentrations in the samples taken near derelict mines were 16.0, 24.0, 48.0 and 50.0 mg/l for summer, autumn, winter and spring, respectively. For the samples taken near new mines the averages were summer, 121.1; autumn, 148.2; winter, 145.2; and spring, 150.1 mg/l; and average concentrations near derelict mines were 100.4, 102.7, 120.4 and 99.4 mg/l, respectively. The alkalinity was almost always greater in the samples taken near new mines than near abandoned mines, indicating that the acidity was more completely neutralized near the new mines.

It was found that the maximum calcium ion concentrations for the samples taken near new mines were summer, 300.0; autumn, 320.0; winter, 350.0; and spring, 250.0 mg/l; and the maximum concentrations in samples near derelict mines were 260.0, 240.0, 160.0 and 170.0 mg/l, respectively. The minimums for samples collected near new mines were summer, 35.0; autumn, 113.0; winter, 50.0; and spring 66.0 mg/l; while the minimums for samples near derelict mines were 53.0, 65.0, 50.0 and 25.0 mg/l, respectively. The averages near new mines were summer, 169.0; autumn, 214.0; winter, 207.0; and spring, 183.0 mg/l; while averages near derelict

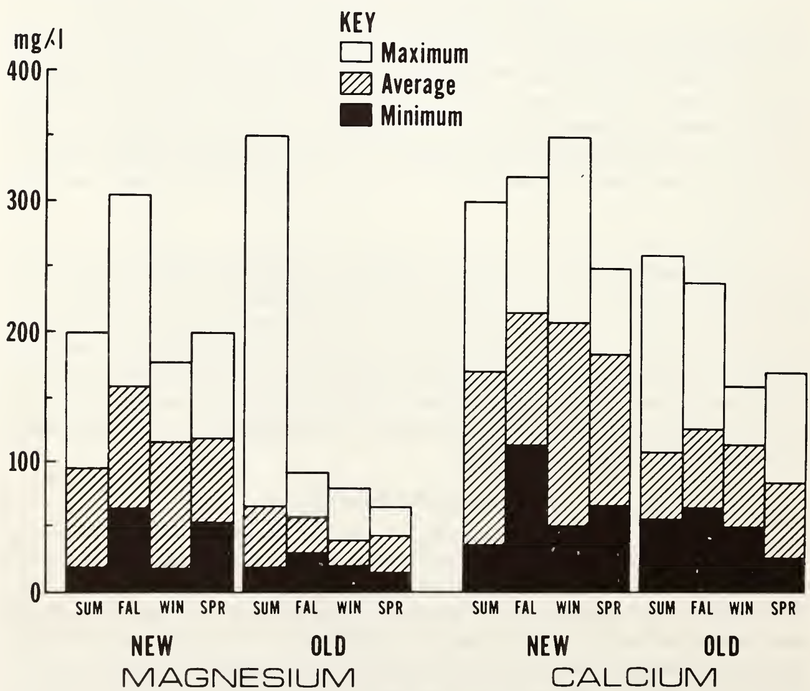

FIGURE 1. *Magnesium and calcium concentrations.*

mines were summer, 109.0; autumn, 127.0; winter, 113.0; and spring, 83.7 mg/l. The calcium ion concentrations were almost always higher in samples taken near new mines because the acidity was neutralized to a greater extent as was shown in the acidity and alkalinity sections.

The maximum chloride ion concentrations near new mines were 49.7, 63.9, 35.5 and 49.7 mg/l for summer, autumn, winter and spring respectively; while the maximum concentrations near derelict mines were 35.5, 63.9, 42.6 and 42.6 mg/l respectively. The minimum concentrations near new mines were 7.1 in summer, 14.1 in autumn, 14.2 in winter and 21.3 mg/l in spring; and the minimum concentrations near derelict mines were 7.1 for summer, 14.2 for autumn, 21.3 for winter and 28.4 mg/l for spring. Average concentrations near new mines were 20.6 in summer, 30.2 in autumn, 25.7 in winter and 32.5 mg/l in spring; while concentrations near derelict mines were 23.1, 40.5, 33.7 and 34.7 mg/l, respectively. For chloride ion concentrations, the results were basically comparable, although the averages tended to be somewhat higher near abandoned mines.

The maximum concentration of dissolved oxygen in streams near new mines was 10.2 in summer, 10.6 in autumn, 9.0 in winter and 7.2 mg/l in spring; while maximum oxygen concentration in streams near derelict mines was 10.6 in summer, 14.8 in autumn, 9.0 in winter and 9.2 mg/l in spring. The minimum concentration near new mines was 5.2 in summer, 5.0 in autumn, 5.8 in winter and 4.0 mg/l in spring; while minimum concentreations near derelict mines were 3.6, 6.2, 4.8 and 3.6 mg/l,

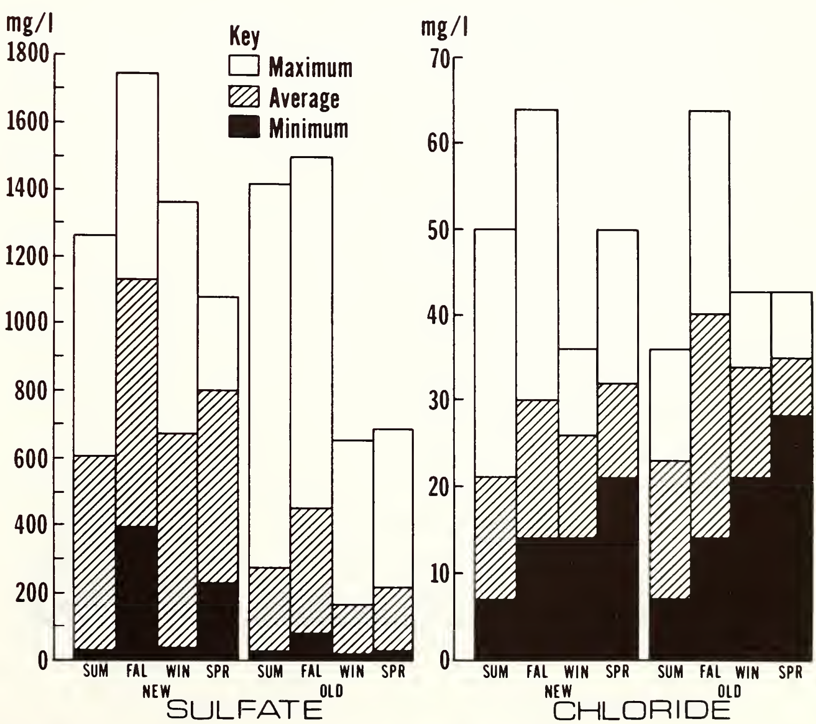

FIGURE 2. *Sulfate and chloride concentrations.*

respectively. The average concentrations near new mines were 7.7, 8.5, 7.4 and 5.8 mg/l; and average concentrations near derelict mines 6.7, 9.1, 6.6 and 5.4 mg/l, respectively, for the seasons under study. The concentrations of dissolved oxygen were relatively high in all measurements, and there was essentially no difference in amounts of oxygen dissolved in streams near new and abandoned mines.

The maximum concentrations of iron near new mines were 4.0 in summer, 9.0 in autumn, 5.0 in winter and 10.0 mg/l in spring; while the maximum concentrations near derelict mines were 43.0 in the summer, 70.0 in autumn, 55.0 in winter and 38.0 mg/l in spring. The minimum concentrations near new mines were 1.0 in summer, 0.5 in autumn, 0.5 in winter and 1.0 mg/l in spring; while the minimum concentrations near derelict mines were 1.0 in summer, 3.0 in autumn, 2.0 in winter and 7.0 mg/l in spring. The average concentrations near new mines were 2.1 in summer, 3.5 in autumn, 2.4 in winter and 3.4 mg/l in spring; while average concentrations near derelict mines were 14.7, 21.6, 20.6 and 14.0 mg/l, respectively, for the seasons under study. The higher concentrations of iron near abandoned mines was probably caused by the greater acidity of the water.

The lead ion maximum concentrations near new mines were 24.0 in summer, 21.0 in autumn, 10.0 in winter and 12.0 in spring. The minimum concentrations were 0.2, 0.1, 0.1 and 0.1 mg/l, respectively, for the seasons under study. The average concentrations near new mines were 8.4 in summer, 8.0 in autumn, 5.5 in winter and 4.2 mg/l in spring. Lead was not detected in samples taken near derelict mines, except in one sample which contained 5.0 mg/l during the summer. Most of

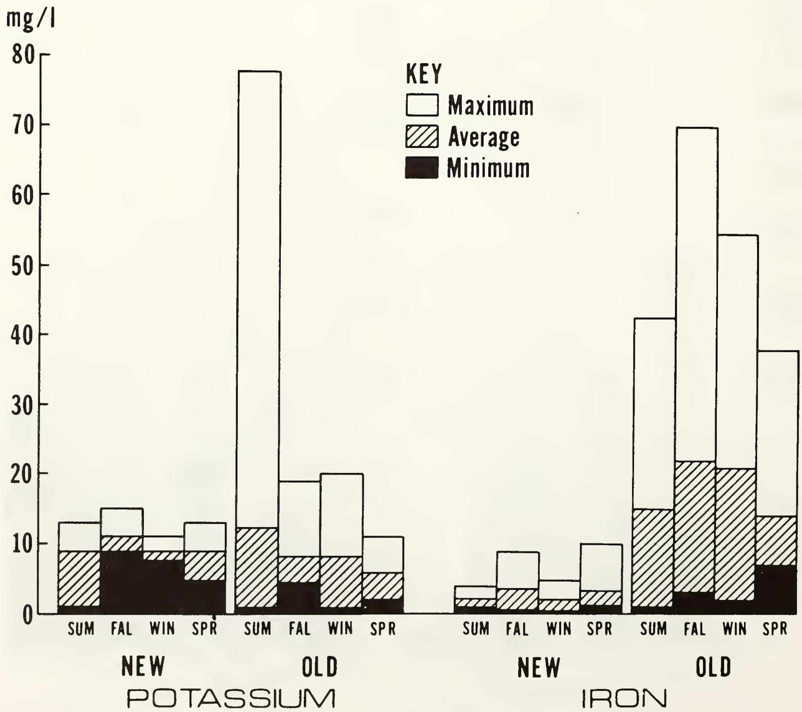

FIGURE 3. *Potassium and iron concentrations.*

the lead had apparently leached out of the areas near abandoned mines after long exposure to the elements.

The maximum concentrations for magnesium ion near new mines were 200.0 in summer, 304.0 in autumn, 175.0 in winter and 200.0 mg/l in spring; while the minimum concentrations were 17.0 in summer, 63.0 in autumn, 16.0 in winter and 52.5 mg/l in spring. The average concentrations near new mines were 96.4 in summer, 158.2 in autumn, 113.6 in winter and 117.8 mg/l in spring. The maximum concentration near derelict mines was 350.0 in summer, 92.0 in autumn, 80.0 in winter and 65.0 mg/l in spring; while the minimum concentrations were 17.0, 30.0, 18.0 and 15.0 mg/l, respectively, for the seasons under study. The average concentrations near derelict mines were 65.4, 56.4, 39.8 and 42.0 mg/l, for the seasons under study. The higher concentrations of magnesium in the samples taken near new mines probably resulted from the greater neutralization of acidity in these streams.

The maximum concentrations for manganese near new mines were 5.0 in summer, 3.0 in autumn, 3.0 in winter and 4.0 mg/l in spring; while the minimum concentrations were 2.5 in summer, 1.0 in autumn, 0.5 in winter and 1.0 mg/l in spring. The average concentrations for the seasons under study were 3.8, 1.8, 2.0 and 1.3 mg/l, respectively. The maximum concentration near derelict mines were 5.0 in summer, 3.0 in autumn, 1.5 in winter and 2.0 mg/l in spring; while the minimum concentrations near derelict mines were 2.3, 1.0, 0.6 and 0.0 mg/l, respectively; and the average concentrations were 3.7 in summer, 1.7 in autumn, 1.0 in winter and 0.0 mg/l in spring. The concentration of manganese was low in all samples. There was a negligible difference in the concentrations of manganese in samples collected near new mines and abandoned mines.

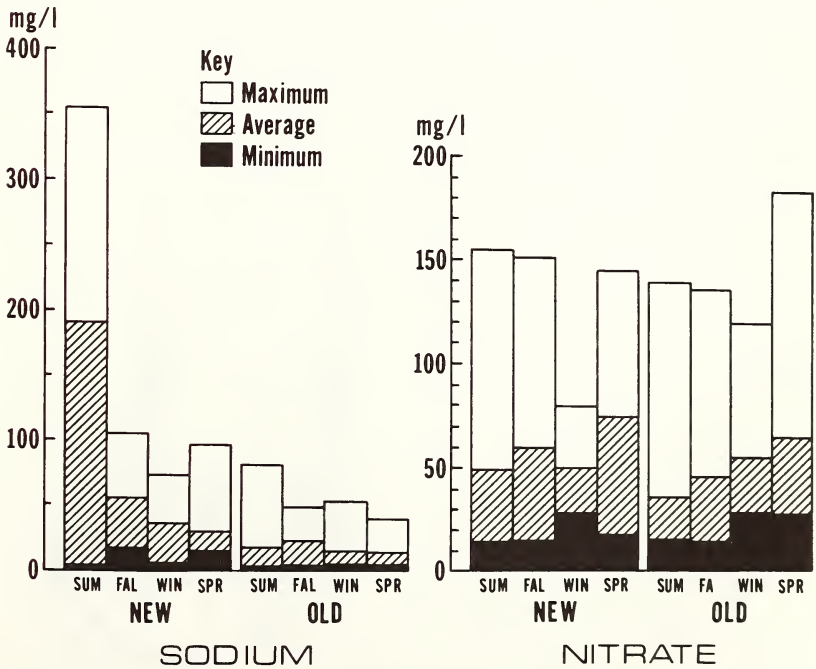

Figure 4. *Sodium and nitrate concentrations.*

The nitrate concentrations given in the following discussion are expressed as mg of nitrogen per liter. Maximum concentrations near new mines were 155.0 in summer, 150.6 in autumn, 79.7 in winter and 145.3 mg/l in spring. The minimum concentrations were 14.4 in summer, 14.6 in autumn, 28.4 in winter and 18.4 mg/l in spring. Average concentrations were 48.7 in summer, 59.6 in autumn, 49.8 in winter and 75.1 mg/l in spring. The maximum concentration near derelict mines was 139.1 in summer, 136.4 in autumn, 120.5 in winter and 173.7 mg/l in spring. The minimum concentration was 15.5 in summer, 13.7 in autumn, 28.4 in winter and 26.6 mg/l in spring. Average concentrations were 36.4 in summer, 45.8 in autumn, 55.0 in winter and 65.1 mg/l in spring. The nitrate concentrations were nearly the same near new mines and old mines. In some seasons, the nitrate concentrations were higher near new mines, and in other seasons the nitrate concentrations were higher near old mines.

The maximum pH near new mines was 8.7 in summer, 7.9 in autumn, 7.7 in winter and 7.9 in spring; while the minimum was 7.0 in summer, 6.7 in autumn, 6.7 in winter and 6.3 in spring. The average pH was 7.6 in summer, 7.3 in autumn, 7.3 in winter and 7.4 in spring. The maximums near derelict mines were 8.6, 7.0, 7.0 and 7.3, respectively, for the seasons under study; while the minimums were 6.2 in summer, 6.0 in autumn, 6.1 in winter and 5.8 in spring. The average pH near derelict mines was 7.0 in summer, 6.6 in autumn, 6.6 in winter and 6.6 in spring. The pH generally measured higher near new mines which agrees with the earlier discussion which indicated that acid was further neutralized near new mines than near old mines.

The maximum potassium ion concentrations near new mines were 13.0 in summer, 15.0 in autumn, 11.0 in winter and 13.0 mg/l in spring; while the minimums

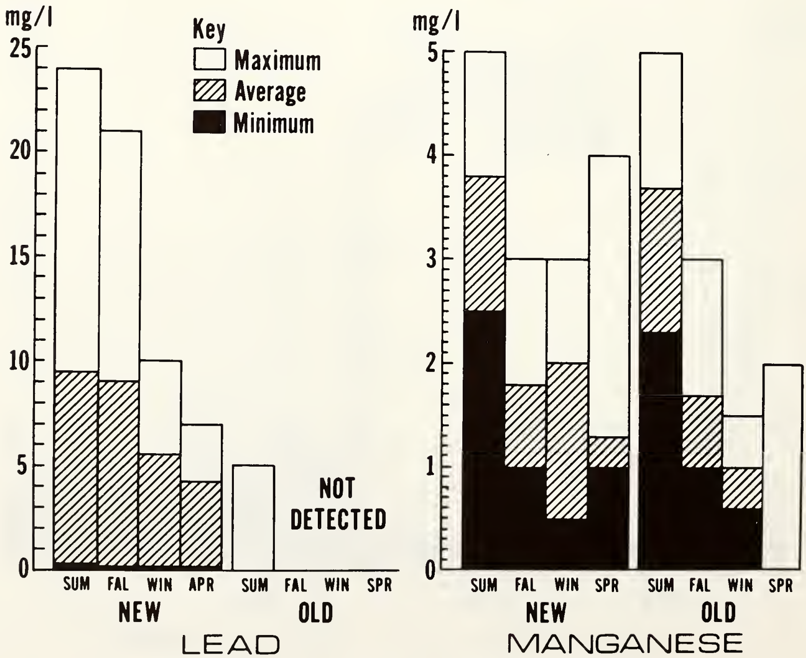

FIGURE 5. *Lead and manganese concentrations.*

were 1.0 in summer, 9.0 in autumn, 7.5 in winter and 5.0 mg/l in spring. The averages were 9.3 in summer, 11.4 in autumn, 9.2 in winter and 8.9 mg/l in spring. The maximums near derelict mines were 78.0 in summer, 19.0 in autumn, 20.0 in winter and 11.0 mg/l in spring; while minimums were 1.0, 4.0, 1.0 and 2.0 mg/l, respectively, for the seasons under study. The average concentration was 11.7 in summer, 8.4 in autumn, 7.5 in winter and 5.6 mg/l in spring. The potassium concentration was sometimes higher near new mines and sometimes higher near old mines. The overall average was about the same near new and old mines.

The maximum sodium ion concentrations near new mines were 352.0 in summer, 103.0 in autumn, 72.0 in winter and 96.0 mg/l in spring; while the minimums were 4.4 in summer, 16.0 in autumn, 7.0 in winter and 15.0 mg/l in spring. The average was 189.8 in summer, 53.7 in autumn, 37.0 in winter and 30.3 mg/l in spring. The maximum concentrations near derelict mines were 81.0 in summer, 48.0 in autumn, 52.0 in winter and 40.0 mg/l in spring; while the minimums were 5.0, 6.0, 7.0 and 6.0 respectively, for the seasons under study. The average was 19.3 in summer, 22.3 in autumn, 15.4 in winter and 13.9 mg/l in spring. The concentration of sodium usually was much higher near new mines. Again, this may have been from the greater extent of neutralization of the acid in the water near the new mines.

The maximum sulfate ion concentrations near new mines were 1260.0 in summer, 1750.0 in autumn, 1370.0 in winter and 1080.0 mg/l in spring; while the minimum concentrations were 36.0 in summer, 390.0 in autumn, 40.0 in winter and 235.0 mg/l in spring. The average concentration was 602.0 in summer, 1135.0 in autumn, 675.5 in winter and 799.2 mg/l in spring. The maximums near derelict mines were 1420.0 in summer, 1500.0 in autumn, 660.0 in winter and 685.0 mg/l in spring; while the minimums were 30.0, 75.0, 20.0 and 25.0 mg/l, respectively, for the seasons under study. The average concentrations were 273.3 in summer, 451.5 in autumn, 168.6 in winter and 214.1 mg/l in spring. The average sulfate concentrations were higher near the new mines, indicating again that more acid was neutralized near the new mines.

The maximum water temperatures near new mines were 27.0 in summer, 19.0 in autumn, 4.0 in winter and 18.0°C in spring. The minimums were 17.0 in summer, 1.0 in autumn, 0.0 in winter and 7.0°C in spring; while the averages were 23.6, 11.1, 1.8 and 12.9°C, respectively, for the seasons under study. The maximum water temperatures near derelict mines were 27.0 in summer, 18.5 in autumn, 6.0 in winter and 18.0°C in spring; while the minimums were 16.0 in summer, 2.0 in autumn, 0.0 in winter and 7.0 in spring. Average temperatures near derelict mines were 22.1 in summer, 10.7 in autumn, 2.7 in winter and 12.7°C in spring. There was no detectable differences in the temperatures of the water in the streams near new and old mines.

The maximum turbidity in the water near new mines was 112.0 in summer, 53.0 in autumn, 58.0 in winter and 85.0 in spring; while the minimums were 1.0 in summer, 2.0 in autumn, 3.0 in winter and 4.0 in spring. The average was 23.8 in summer, 11.2 in autumn, 27.2 in winter and 15.6 in spring. The maximums near derelict mines were 300.0 in summer, 345.0 in autumn, 345.0 in winter and 300.0 in spring. The minimums were 37.0 in summer, 55.0 in autumn, 43.0 in winter and 37.0 in spring; while the averages were 163.0 in summer, 164.1 in autumn, 128.9 in winter and 128.5 in spring. A great quantity of rusty-red iron-containing particles were present in the water near abandoned mines, explaining the high turbidity in the water in the streams near old mines.

Acknowledgment

The authors wish to thank the Indiana State University Research Committee for a grant for partial support of this research.

Literature Cited

1. American Public Health Association. 1975. Standard methods for the examination of water and wastewater, 14th edition. Washington, D.C. 1193 p.
2. Environmental Protection Agency. 1971. Methods for chemical analysis of water and wastes. Water Quality Office, Analytical Quality Control Lab., Cincinnati, O. 312 p.