THE DISTRIBUTION OF NUTRIENTS IN THE SUBSURFACE SEDIMENTS IN THE KIGOMA BAY – LAKE TANGANYIKA

B. M. Musonda (Zambia)
Dr. K. Lezzar (Mentor)

INTRODUCTION

Location of Study Area

The Kigoma Bay is located in the N.E. part of Lake Tanganyika. It is bounded by longitudes 29° 35’ S / 29° 38’ S and latitudes 4° 51’ S / 4° 54’ S.

Selection of the study Area

The Kigoma Bay was selected on the basis of accessibility and its proximity to an urban area where the human activities are likely to have an impact on the sediment geochemistry.

Rationale for the study

Primary productivity in a fresh water lacustrine environment depends upon the availability of nutrients in the water column for phytoplankton development. Recycling of nutrients in the lake column plays an important role in the replenishment of nutrients that are assimilated by phytoplankton in the photic zone. Movement of nutrients from the sediment column to the water column is an important process whose significance depends upon the efficiency of the mixing mechanism. Bioturbation, diffusion, internal waves and thermal gradients can induce mixing.

Hypothesis

This study is testing the hypothesis that ‘the sediment column is a major sink for nutrients such as organic matter, phosphorous, nitrogen, silica and calcium.

OBJECTIVES OF THE STUDY

1) To establish the distribution of Nitrogen, phosphorous, silica, alkalinity, pH and conductivity in the subsurface sediment cores in the Kigoma Bay.
2) To establish the possible sources of these nutrients.
3) To make suggestions on the major factors which are controlling the distribution of these parameters.

Previous Work

Little data are available on the chemistry of the sediment column in Lake Tanganyika.

METHODS

Sampling and splitting of sediment cores

The three sediment cores used in this study were collected on the Kigoma transect. The geographical coordinates of coring sites are given in table 1 and figure 1. The sub-surface sediment cores were collected using motor and gravity coring equipment belonging to University of Arizona. The coring equipment was mounted on a boat and powered by a three phase diesel generator.

<table>
<thead>
<tr>
<th>CORE NUMBER</th>
<th>DEPTH OF WATER COLUMN</th>
<th>LENGTH OF CORE(cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPG2</td>
<td>105</td>
<td>87</td>
</tr>
<tr>
<td>NPG3</td>
<td>150</td>
<td>130</td>
</tr>
<tr>
<td>NPM1</td>
<td>100</td>
<td>34</td>
</tr>
</tbody>
</table>

The sediment cores were split into smaller fragments ranging in length from 2 cm to 5 cm. Each core segment was placed in a labeled sample bag. Two aliquots were taken from each core segment for extraction of pore fluids and determination of total organic carbon.
Preparation of Samples

A fraction of each segment of the core was placed in a vial and centrifuged at about 2500 rpm for 30 minutes in a centrifuge. The pore fluid was separated from the remaining sediment and placed in a sealed clean plastic bottle. The pore fluids from three to ten core segments were added together to form a composite sample which was stored in the refrigerator at 4° C prior to chemical analysis.

An aliquot of two to ten core segments was placed on a petri dish and dried in an oven at 50° C.

Analytical Measurements

The following types of measurements were carried out on the solid and liquid components of the sediment cores: pH, conductivity, total alkalinity, dissolved phosphorous, ammonia, nitrate-N, silica and total organic carbon. The pH of pore fluids was measured using a calibrated Hatch selective ion electrode while the conductivity was measured using a conductivity meter of the same model. The total alkalinity of the pore fluids was measured using a digital titrator and a standard solution of sulfuric acid and bromocresol methyl red as an indicator. The fluids were titrated to a violet pale gray color corresponding to a pH of about 4.8. Then the alkalinity was calculated following a standard procedure documented by the manufacturer of the Hatch titrator.

The total organic carbon of sediments was measured by placing samples dried in an oven at 50° C into the furnace and igniting them for two hours at 550° C and determining the relative loss in weight. The concentration of nitrate, phosphate, silica and ammonia in the pore fluids was determined by colorimetric methods using a UV/VIS Hatch 2032 spectrophotometer. The procedures which were used in these determinations are those which are prescribed by the manufacturer of the equipment.

RESULTS

The results are given in figures 2 to 8. It is clear that the pH varies from 8.0 to 8.6. The pH generally increases with depth though there are some slight variations. The total alkalinity generally varies from 250 to 300 m S/cm with a few exceptions. The conductivity varies from 620 to about 750 with a few exceptions. The high conductivity of some of the core segments in the upper part of core number NPG3 is a major deviation from the general trend. The total organic carbon content of cores varies from 12 to 21 %. The content of nitrate in the pore fluids decreases exponentially with increase in depth. The mean content of nitrate-N at the top of the sediment cores is about 0.11 mg/l. The content of ammonia increases with depth and varies from .1 to about 15 mg/l with the exception of two values, which are above 15 mg/l. The content of silica varies from 2 to about 50 mg/l and generally increases with depth. The content of phosphorous varies from about .1 to about 0.35 mg/l. The correlation between phosphorous content and depth is very weak.

CONCLUSIONS

The pH of the pore fluids is highly buffered and appears to be controlled by the precipitation and dissolution of carbonates as well as microorganisms mediated reactions such as those given below:

Aerobic oxidation

\[ \text{CH}_3\text{COO}^- + \text{O}_2 \rightarrow \text{HCO}_3^- + \text{H}_2\text{O} \quad (1) \]

Anaerobic Sulfate reduction

\[ \text{CH}_3\text{COO}^- + \text{SO}_4^{2-} \rightarrow 2\text{HCO}_3^- + \text{HS}^- \quad (2) \]
Methanogenesis

\[ \text{CH}_3\text{COO}^- + \text{H}_2\text{O} \rightarrow \text{CH}_4 + \text{HCO}_3^- \quad (3) \]

\[ \text{HCO}_3^- + 4\text{H}_2 + \text{H}^+ \rightarrow \text{CH}_4 + \text{H}_2\text{O} \quad (4) \]

Ammonia is the most dominant species of nitrogen because of the denitrification process for which the general reaction is given below.

\[ \text{CH}_2\text{O} + \text{NO}_3^- + \text{H}^+ \rightarrow \text{CO}_2 + 0.5\text{N}_2 \text{O} + 1.5\text{H}_2\text{O} \quad (5) \]

The salinity of the pore fluids is relatively low. The speciation of nitrogen is likely to be controlled by denitrification reactions and the pH. The increase in the silica content in pore fluids with depth suggests that the silica level is controlled by pH and the kinetics of the dissolution reactions involving siliceous bearing materials such as diatom fragments and minerals.

\[ \text{SiO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_4\text{SiO}_4 \]

The content of phosphorous is likely to be controlled by the dissolution and precipitation reactions involving P-bearing materials such as minerals and organic matter.

The sediment column is an important sink for nutrients and it is likely that during mixing across the sediment-water interface some nutrients may be transported from the sediment column to the overlying water column. The composition of the pore fluids depends upon the chemistry of the water column at the time of deposition of the sediments and the extent to which this is altered by the processes taking place in the sediment column. The high content of total organic carbon in the sediment column suggests that the relative rate of deposition of organic matter is high and that anoxic conditions are likely to have prevailed in the lake during the deposition of the investigated part of the sediment column.

FUTURE RESEARCH

Further research on geochemistry of sediments is required in order to address other aspects such as the ones outlined below:
- Distribution of heavy metals.
- Mineralogical composition
- C/N ratios for organic matter
- Stable isotopes of C and O.