

## **Evaluation of pore water biogeochemistry at Kigoma bay, Lake Tanganyika.**

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### **Introduction**

Lake Tanganyika is located in the western branch of the East African Rift System. The lake contains a rich ecosystem that remains poorly studied. In particular, Tanganyika has high fisheries production that is controlled by the level of nutrients. The nutrients distributions are controlled by the hydrodynamics of the lake, since physical movement of water leads into translocation of dissolved nutrients (Hutchison, 1975)

In Lake Tanganyika, nutrients show variations in their concentrations with depth. These nutrients circulate between water and sediments depending on the efficiency of mixing processes such as bioturbation, diffusion, internal waves and thermal gradients. Sediments act as both sources and sinks for nutrients: they are sources when they deliver nutrients to water, and sinks for nutrients when nutrients are buried with sediments. Although nutrients, such as Si, P, and N, are ultimately buried in sediments, they can be heavily recycled prior to their burial through oxic and anoxic degradation of organic matter and other geochemical processes. The extent of this recycling helps to determine the degree of internal nutrient loading and productivity of Lake Tanganyika.

This study intends to make observations of nutrient concentrations in sediment- pore waters in order to infer the extent to which sediments may act as nutrient sources to Tanganyika, and to assess how mixing processes such as diffusion affect the concentration of nutrients. It is expected that the concentration of some nutrients such as ammonia will show a near sediment-water interface peak and a regular increase at deeper sediment level while some such as nitrate will decrease at deeper sediment level. The trends in nutrient concentrations with depth in the sediments will thus vary depending on the redox geochemistry of the nutrient and characteristics of the depositional environment.

### **Methods and materials.**

Field work:

A sediment core was collected using a benthos gravity corer with crane and winch from the boat *MV Echo* on July 19, 2005 in Kigoma Bay at a depth of 110m (04° 52.840' S, 29° 35.315' E). A Lowrance echo sounder and cable mounted meter were used to measure depth, and location was determined using a hand-held GPS (Global Positioning System) unit. The core was taken from an anoxic area with a gently sloping bottom, and the site chosen was located at a distance from the influence of river discharge to avoid complications from variable sediment inflow (Lewis, 2000). The 0.70 m-long sediment core was collected into a 2m long cylindrical polybutarate liner. The core was capped and held in a vertical position and transferred to Nyanza Project laboratory facilities at Kigoma TAFIRI.

### **Laboratory work:**

Water overlying the sediment – water interface was siphoned off into bottles for geochemical analysis.

The 0.70m sediment corer was sectioned in a vertical position in a nitrogen filled glove bag into 1cm thick slices for the top 40cm and then at an interval of 10cm. A piston inserted into the bottom of the core liner was used to force the sediments upward along a graduated wood bar. The 1cm thick slices were spooned into whirl packs in the glove bag

A low pressure mechanical squeezer (5ton hydraulic jack) supported by a wooden screw frame was used to force pore water through a 0.47 $\mu$ m bottom filter within a stainless steel pore water squeezer. The squeezed pore waters were collected in a disposable syringe with in-line 0.45  $\mu$ m Supor membrane filters mounted at the exit port at the bottom of the device. At least 45minutes were usually required to extract 2.5-3ml of pore water from each sample. Extracted pore water then stored in rinsed polyethylene bottles prior to analysis.

### **Chemical analysis.**

Water samples were diluted with deionised water to get enough water for analysis; each 1ml of pore water was diluted to 75-125ml.

Laboratory analysis was performed following standard spectrophotometric methods as described in the HACH Model DR/2400 manual.

Ammonia was measured with the salicylate method for high ammonia (program selected was 343N, Ammonia HR program TNT, 0.4-50mg/L). Silica was analyzed with the Heteropoly Blue Method for low range (651 Silica HR Program, 0.01-1.6mg/L). Soluble reactive Phosphorous (orthophosphate) was measured using the Phosver<sup>®</sup>3 Method (533 P React PV TNT, MR Program, 0.006-5mg/L or 0.02-1.6mg/L). Nitrate was analyzed using the Cadmium Reduction Method for medium range (351 N, Nitrate MR, 0.01-0.5mg/L). Ferrous iron was analyzed with the 1,10 Phenanthroline Method (255 Iron Ferrous program, 0.02-3.0mg/L) and alkalinity was measured using titration with sulphuric acid after addition of Phenolphthalein.

The results for ferrous iron and nitrate are reliable up to the depth of 22cm below which lack of reagents and delays precluded their analysis.

### **Results and Discussion.**

The mean concentrations of ammonia, silica, phosphate, ferrous iron, nitrate and alkalinity were 4.37, 1.63, 0.06, 1.52, 2.70 and 0.37 mM/L, respectively (Table 1). Statistical analysis (table 2) of the variations of pore water concentrations for these nutrients with respect to depth in the sediments (Figures 1-6) shows that there is a down core decrease in concentrations of ammonia, silica, phosphate, and nitrate with higher values in the upper 8-10cm. Alkalinity concentration decreases with depth and reaches a minimum at the depth of 8cm after which it rises. The concentration of ferrous iron generally increases with depth.

Ferrous iron in the pore waters comes from the dissolution of more crystalline iron hydroxides, or because of diffusion from the sediment-water interface causing a weak increase in the iron concentration as the core was collected at the depth of 110m (anoxic environment) where reduction is dominant (Spagnoli and Bergamini, 1997). Also ferrous iron may rise due to sheathed and stalked bacteria, algae, protozoan flagellates, and some bacteria, which precipitate ferric iron on their cells. The phosphate in pore waters comes from degraded organic material. Within the pore waters, phosphate may be bound by ferrous iron, creating a correlation between Fe and PO<sub>4</sub> concentration in pore water (Spagnoli and Bergamini, 1997). Our results show only a weak correlation between these nutrients (Table 2), illustrating that these processes are only of minor importance in Kigoma Bay pore waters.

Silica concentration decreases but attains its maximum value at the depth of 8cm. This maximum value may be attributed to high productivity in the lake at a particular time or may be due to high rates of dissolution of biogenic silica. The decrease may be associated with diatom productivity in the water column, or the precipitation of clays in the sediments.

Nitrate concentration shows large fluctuations for the first top 10cm with a general decreasing trend with depth. Ammonia concentrations showed higher values at top 10cm thereafter decreasing with depth. This may be a result of organic matter degradation in the sediments which releases ammonia into pore waters.

From the dendrogram (figure 7), data are grouped into two major clusters according to depth i.e. from the upper 10cm, and below that. The concentrations in the top 10cm are higher and reach a maximum at the depth of 8-10cm except for alkalinity, which reaches its minimum at 8cm. Such fluctuations and high concentrations in the top 10cm may be due to intense microbial activities, or perhaps anthropogenic activities that have resulted in high rates of nutrient loading to the sediments of Kigoma Bay. Future work could investigate this possibility by dating the sediments and examining compositional changes in the solid sediments themselves.

## **Conclusion.**

The sediment column can act as a source or sink of nutrients for the overlying water. When sediments absorb nutrients from water they act as sink and source when contributing to water column nutrient concentrations they act as a source. Data show high fluctuations of nutrients at the depths of 8-10cm; these may be attributed to anthropogenic nutrient loading in Lake Tanganyika.

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**Table 1: Descriptive Statistics**

	N	Minimum	Maximum	Mean	Std. Deviation
DEPTH	44	1.00	43.00	22.4773	12.80714
NH3	43	.00	10.18	4.3682	1.95317
FE	21	.36	4.34	1.5171	.99512
NO3	43	.00	13.05	2.7040	3.30031
SI02	43	.60	7.54	1.6323	1.07245
PO4	43	.03	.18	0.0616	.03023
HCO3	43	.10	1.30	0.3674	.23271
A plan	21				
Valid N (listwise)					

**Table 2:Correlation Matrix**

Correlation	DEPTH	NH3	FE	NO3	SI02	PO4	HCO3
DEPTH	1.000						
NH3	-.358	1.000					
FE	.066	.035	1.000				
NO3	-.189	.259	.204	1.000			
SI02	-.293	.517	.400	.167	1.000		
PO4	-.071	.324	.406	.783	.434	1.000	
HCO3	-.252	-.434	.050	-.125	.058	-.076	1.000

Figure 1.

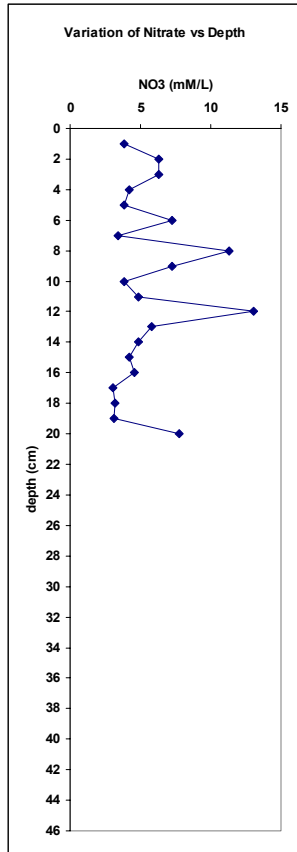


Figure 2

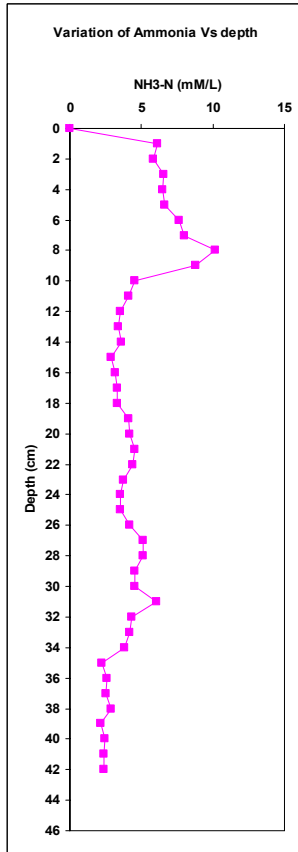
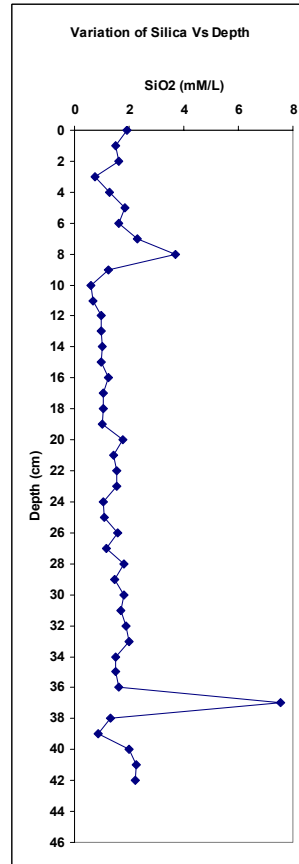
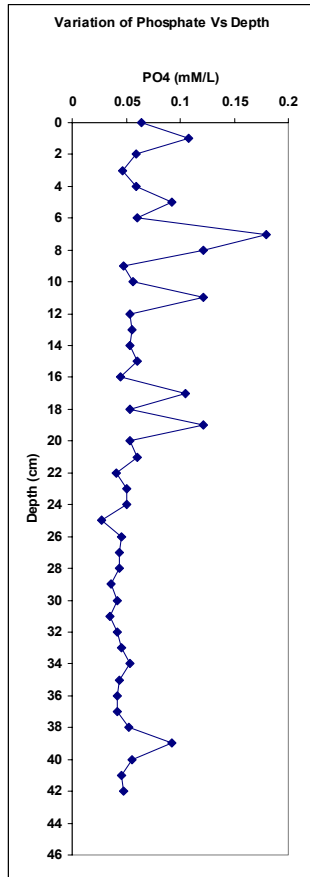


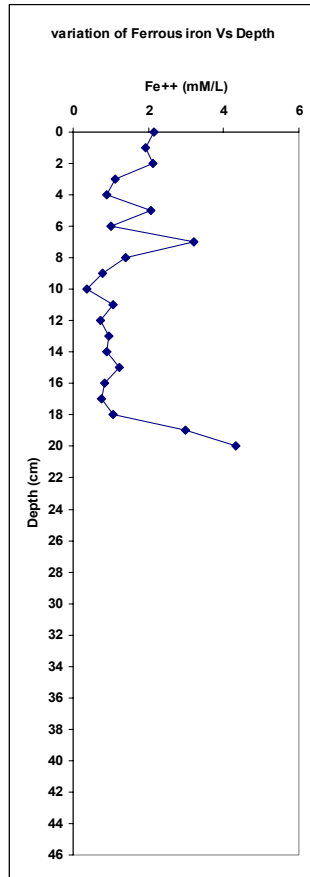
Figure 3



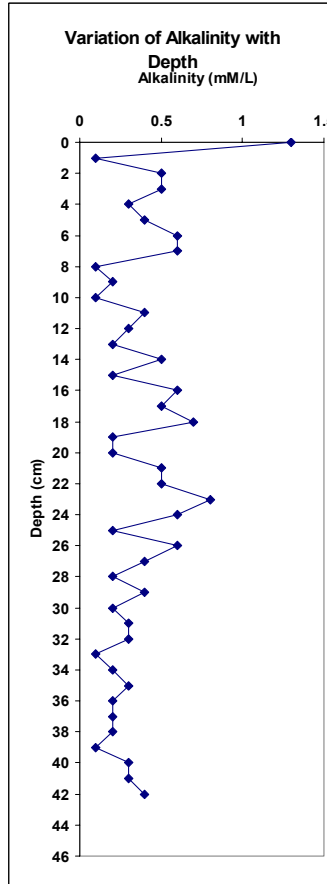
**Figure 4.**



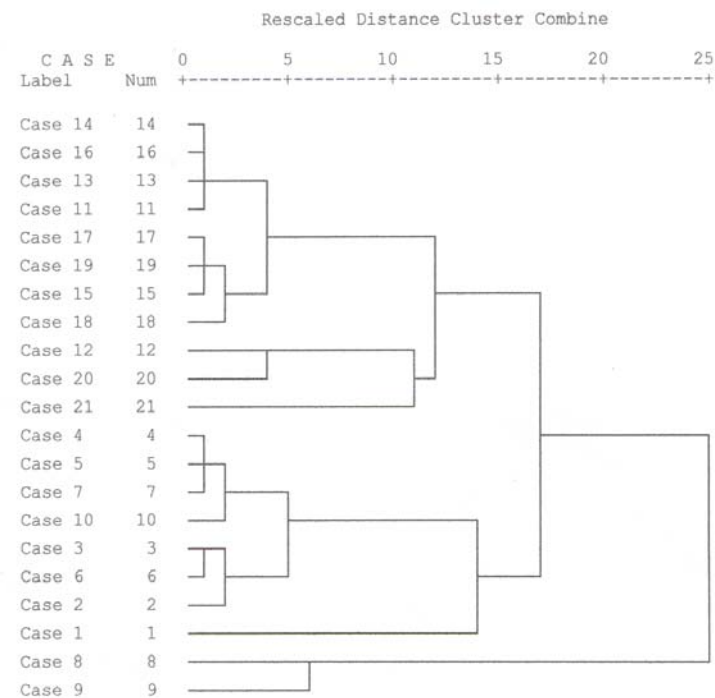
**Figure 5.**



**Figure 6**



Dendrogram using Ward Method



**Figure 7: Dendrogram**