

A comparison of the physical chemical limnology in the pelagic waters of Lake Tanganyika at Kigoma Bay (Nondwa point) and Kitwe point:

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Introduction

Fresh water ecosystems, including lakes, wetlands, rivers and streams, have been important to the establishment of civilizations throughout human history.

Deeper lakes such as Lake Tanganyika and Lake Baikal are usually stratified. When the surface water of these lakes warm up, heat takes a long time to penetrate to the bottom of the lake. These temperature differences between upper and lower layers cause differences in densities, thus resulting in stratification. Deeper lakes usually become stratified into three different identifiable layers, namely the epilimnion, metalimnion and hypolimnion.

Lake Tanganyika is one of the oldest tropical lakes found in the western branch of the East African Rift Valley (Coulter, 1994). It has an estimated age of 9-12Ma (Cohen, 1993). The lake is oligotrophic and permanently thermally stratified with an anoxic hypolimnion (O'Reilly, 2003). The upwelling events during the dry season (May to September) force the nutrient rich waters upwards, displacing warmer oxygenated waters and thus making the nutrients available to the biotic community.

In many lakes the amount of winds impinging is adequate to circulate the entire water column (Wetzel, 1983). For Lake Tanganyika, the southeast winds from May to September have an impact on a cycle of 26 to 33 days (Coulter, 1991). It has also been suggested that smaller movements (3 to 4 days) may occur within this cycle. Surface waters can be greatly impacted by changes in wind speed and air temperature, which induce convection currents that mix the upper layers of water column (Venburg et al., 1997).

The internal movement of thermocline can have an impact on the distribution of favorable nutrients towards the euphotic zone. Therefore, organisms in the water column (phytoplankton, zooplankton, and ultimately fish) could be influenced by a shorter period internal waves (Kimerei & Nahimana, Nyanza Report 1999).

This study aims at investigating the physical chemical character of the pelagic waters of Lake Tanganyika to study how the intensity of wind influences the rate of upwelling in the pelagic zone of Lake Tanganyika. The rate of upwelling at Nondwa point is expected to be smaller than that at Kitwe point because Nondwa point is protected from wind speed by a hilltop, while Kitwe point is in an open bay.

A study of physical and chemical parameters could detect internal movements, which can cause mixing (upwelling).

Methodology

In this study two sites were investigated, Kitwe Point (Site 1) and Nondwa Point (Site 2). Kitwe Point is in an exposed windward bay while Nondwa is in a protected bay.

The following parameters were measured: temperature, transparency (secchi disk depth), dissolved oxygen (DO), turbidity, alkalinity, pH, conductivity, iron concentration and chlorophyll a.

Sampling was done in the pelagic zone off Kigoma Bay and Mzungu Beach. Vertical sampling at an interval of 20 m was done for each location, and the locations were recorded using a GPS. The sampling dates were 24th, 26th, 28th July and 1st, 3rd, and 5th August at Kitwe (S04° 55.926, E029° 36.325) and Nondwa (S04° 51.856, E029° 35.658) between 09:00 and 13:00 hours.

A 20 cm diameter secchi disc was used to measure the transparency, where the average value of the two secchi depths observed by two observers was recorded. A Hydrolab Datasonde 4a was used to measure temperature, DO, and conductivity. The measurements were taken for each interval of sampling.

The pH was measured using a pH meter Thermo Orion model 250 probe and the reading was recorded for each column of water that was sampled.

Turbidity measurements (NTU) were made with a Hach turbidimeter model 2001A. Alkalinity was determined through a titration procedure by using an automatic titrator with a continuous magnetic stirrer.

Results

Temperature

The temperature was observed to fluctuate through the sampling period. The highest water temperature recorded at both sites was 26 °C. The highest temperature was observed at the surface except for Site 1 on 28th July, where a cool spot was observed. The thermocline was found to be between 55 m and 75 m at both sites (Fig. 1). The thermocline rose through the sampling period. However, there were fluctuations of the thermocline throughout the sampling period. The air temperature as recorded by the Tanzania meteorological agency weather station was found to average 27°C, while the wind speed was 110km/day for the June period. Generally the lake was stable for most of the sampling period.

Dissolved oxygen

Generally the highest amount of dissolved oxygen were found at the surface waters and decreased with increase in depth. The highest value of DO was found to be 8mg/l at Site 1 and 7mg/l at Site 2. The oxycline was between 50m and 78m at Site 1 and 58m and 78m at Site 2 (fig 2). The oxycline level rose at the end of the sampling period at both sites.

pH

pH generally was low in deeper waters and high in surface waters. The highest pH was 8.8 at both sites and the lowest pH was 7.2 at Site 1 and 7.6 at Site 2. At the end the sampling period, high pH was found in deeper water (Fig. 3). Below 100 m the pH is generally low for both sites.

Conductivity

The conductivity of the lake was generally very high and was found to increase with depth. The highest conductivity was 680 $\mu\text{S cm}^{-1}$ at both sites, and the lowest was 665 $\mu\text{S cm}^{-1}$ at both sites. The boundary between the low and high conductivity correlates with the thermocline and the oxycline (Fig. 4).

Alkalinity

The first date of the sampling period was characterized by low alkalinity at both sites. The maximum alkalinity for Site 1 was 310 mg/l CaCO_3 while at Site 2 it was 340mg/l CaCO_3 . The alkalinity at Site 1 was found to increase earlier than at Site 2 (Fig. 5). From 28th July the alkalinity at Site 1 was regular to the end of the sampling period, while at Site 2 the alkalinity is irregular with the point of maximum alkalinity found at the surface on 3rd August.

Turbidity

The highest turbidity of the water was found to be 0.4 NTU at Site 1 and 0.35 NTU at Site 2. Turbidity is generally high at the surface for both sites, however a patch of high turbidity was found 90 m to 100 m at Site 1 (Fig. 6).

Discussion

Temperature

The cool spot observed at the surface waters on 28th July at Site 1 could be due to strong winds in this area, which move the colder waters to the surface. This agrees with the hypothesis of this study that the rate of upwelling is strongly influenced by wind. This spot was not observed at Site 2. This could be because the local surge at Kitwe point is stronger than at Nondwa Point. The shallow depth at this area could also

influence mixing since the cold waters can reach the surface quite quickly. The thermocline at both sites was not linear throughout the sampling period, and reached the maximum amplitude at Site 1 on 28th July. This supports Coulter's (1991) suggestion that oscillations are accompanied by water movements that take a form of a large-amplitude progressive wave which gradually transforms into a standing wave. He suggested that such a surge could cause a "local mixing."

Generally, the whole sampling period was characterized by small amplitudes of upwelling. O'Reilly (2003) noted that the combined effect of increasing temperature and decreasing wind speed is to increase the stability of the lake and to reduce the mixing depths, hence diminishing deeper water nutrients input to the surface waters, and as a result causing a decline in primary productivity rates.

The differences in the nature of internal movements of the thermocline observed at the two sites can be used to explain patchiness in Lake Tanganyika. Patchiness has been observed in several studies on autotrophic (algae biomass) as well as heterotrophic organization (zooplankton) (Vuorinen & Kurki, 1994). The patchy distribution of the *Stolothrissa tanganyicae* has been reported by Collart (De Bont, 1972)

On a shorter time and geographic scale, random patchiness probably resulted from turbulence (Plisnier et al., 1999).

Dissolved oxygen

The highest value of DO at the surface observed at both sites is an indication of mixing of the waters. Site 1 had the highest value of DO, suggesting a higher rate of upwelling than at Site 2. According to Wetzel (1983), dynamics of oxygen distribution in lakes are governed by a balance between inputs from the atmosphere and photosynthesis and losses due to chemical and biotic oxidation. Therefore the highest amount of DO observed at Site 1 suggests a high rate of photosynthesis, implying a higher productivity of the lake at this time than at Site 2.

pH

The lower pH of deeper waters impacted the pH of the surface waters. Nutrient rich deep waters probably influenced the primary productivity when they were brought near the surface. Consumption of HCO_3 during photosynthesis results in high pH values (Plisnier et al., 1999).

Towards the end of the sampling period at both sites the pH values decreased with increasing depth. The persistence of the high pH values down to 50 m for most of the sampling days indicates higher productivity at Site 1 than at Site 2.

Conductivity

Surface waters have lower conductivity compared to deep water. Presence of the higher conductivity in the shallow depth indicates movement of the deeper waters to the surface. Site 1 was characterized by a shooting up of the high conductivity on the surface water, which was not observed at Site 2. This could explain the effect of wind on upwelling, as already seen for the Temperature and DO curves.

Transparency.

The water was transparent for most of the sampling period as shown from the histograms. This is evidence of low suspended particle concentration and thus, limited upwelling during the sampling period.

Alkalinity

For the first days of the sampling period, alkalinity was low for both sites, except at Site 1 where a spot of high alkalinity was observed at the surface. This spot could be due to a prior upwelling event.

Deeper waters in some lakes have higher alkalinity than surface waters because the sediments are more reducing than the surrounding waters (Carigan, 1985). Hence the presence of higher alkalinity at shallower depth is evidence of upwelling.

Turbidity

High turbidity was observed at the surface on 26th July for both sites. Towards the end of the sampling period there was high turbidity. This may be due to an increase in primary productivity.

There is a slight difference in the timing and levels of turbidity for Sites 1 and 2. Site 1 indicates an earlier onset of high turbidity than Site 2. This could be because of upwelling introducing more nutrients and increasing primary productivity first at Site 1, similar to the reasons for the temperature and dissolved oxygen patterns.

Conclusion

Wind is an important parameter for the productivity of the lake. Changing climatic conditions mainly increasing heat and reducing wind speed seem to be altering the trends of upwelling in Lake Tanganyika. Small amplitudes of upwelling observed in this study are evidence of poor upwelling this year. This can be seen from the wind and temperature curve for the past ten years.

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Figure 1. Temperature (degrees C) at Sites 1 and 2.

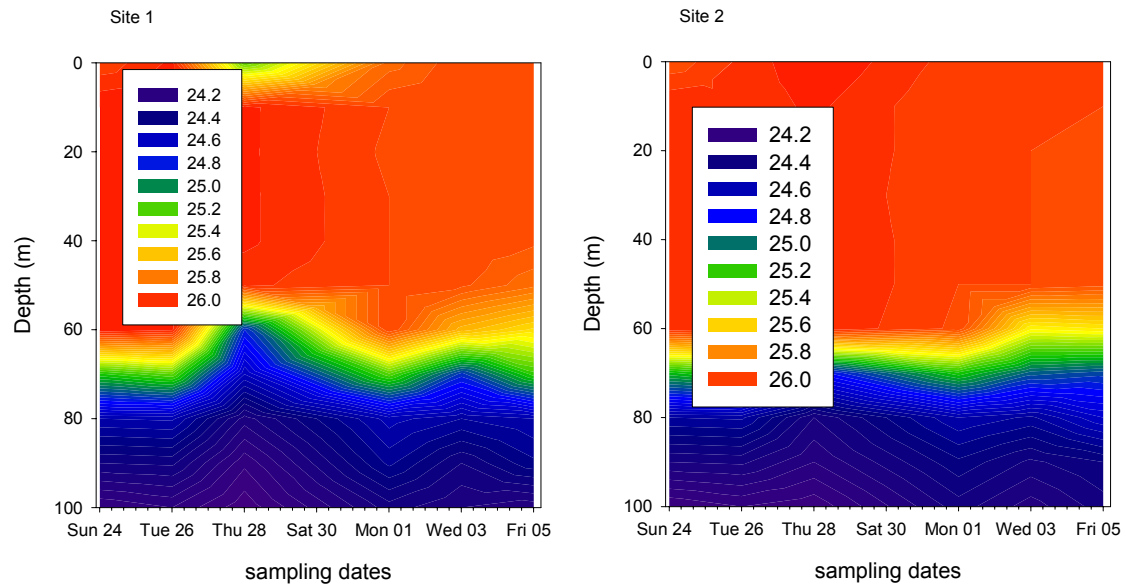


Figure 2. Dissolved oxygen (mg/l) at Sites 1 and 2.

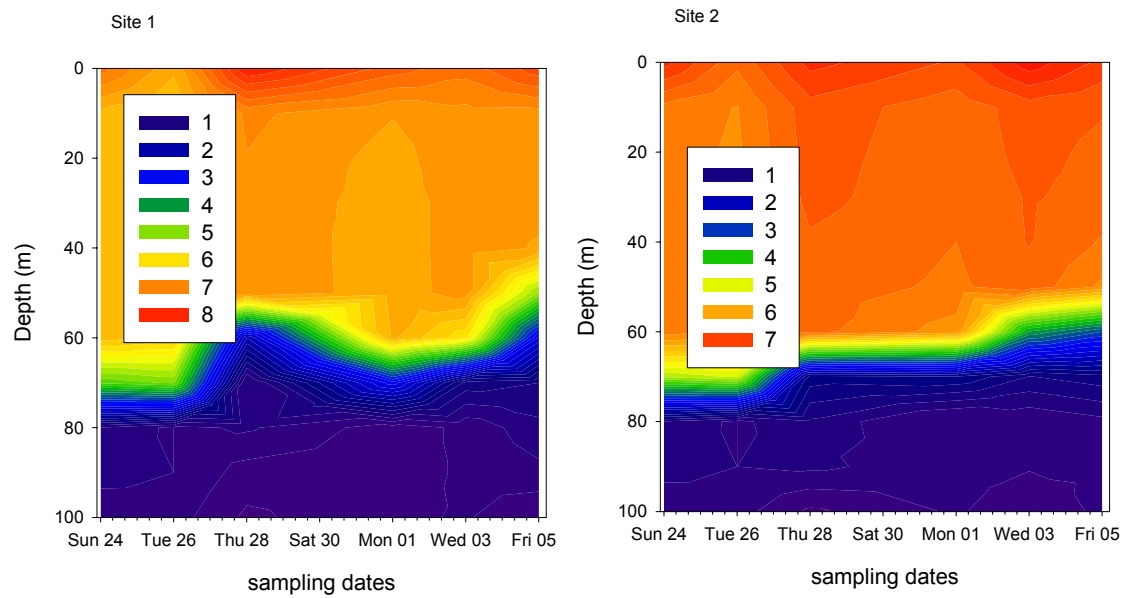


Figure 3. pH at Sites 1 and 2.

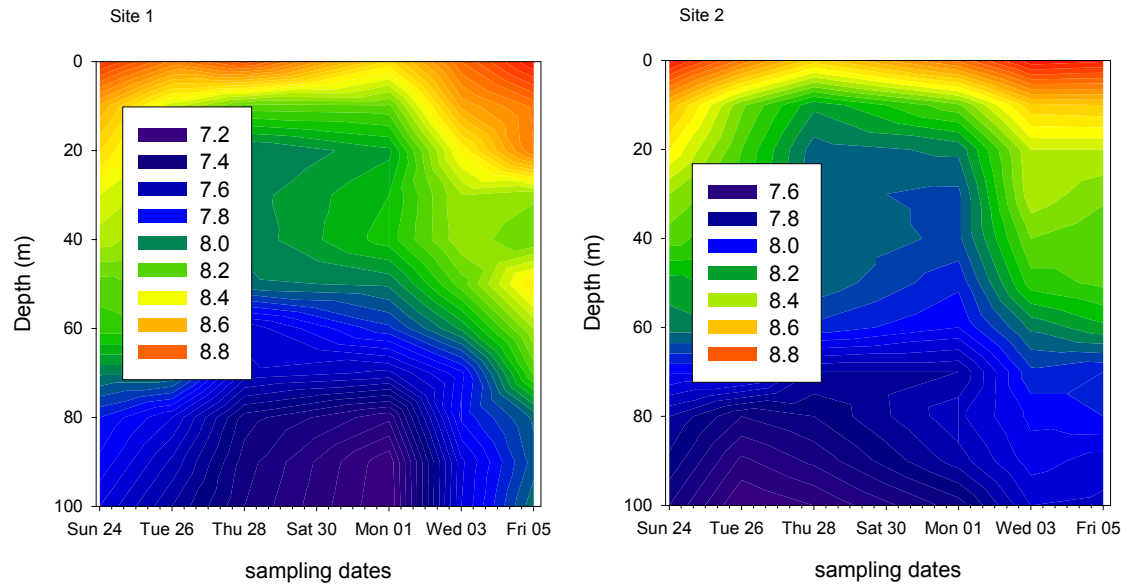


Figure 4. Conductivity at Sites 1 and 2.

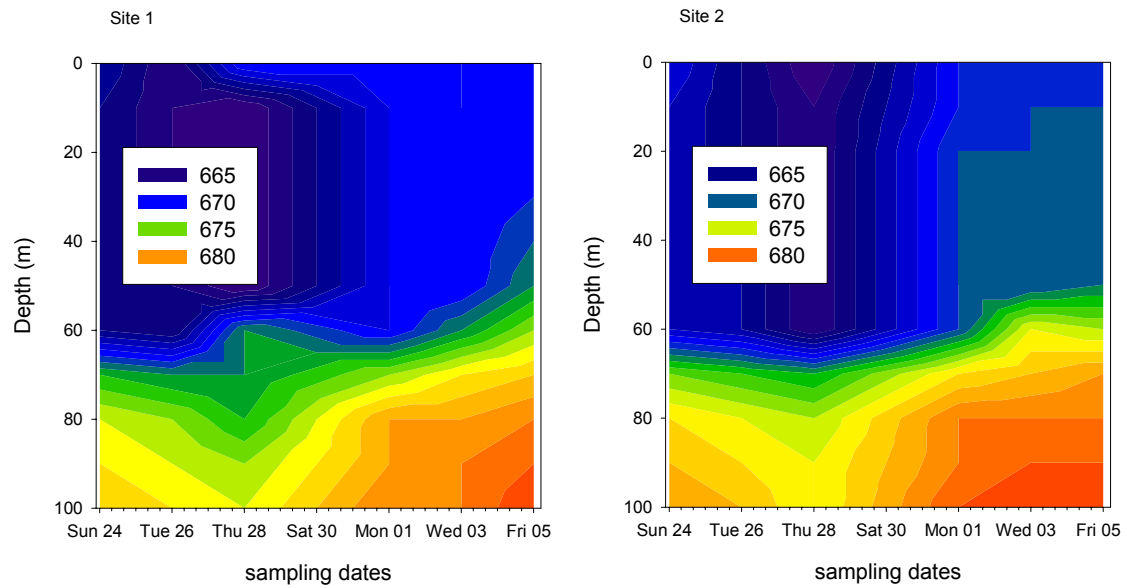


Figure 5. Alkalinity (mg/l CaCO₃) at Sites 1 and 2.

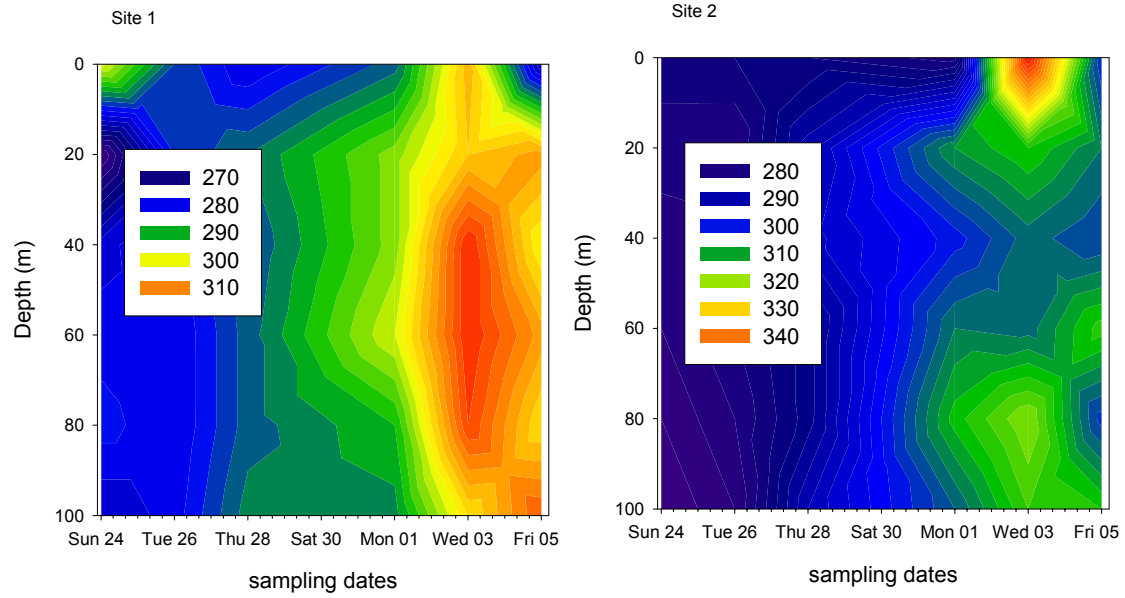


Figure 6. Turbidity (NTU) at Sites 1 and 2.

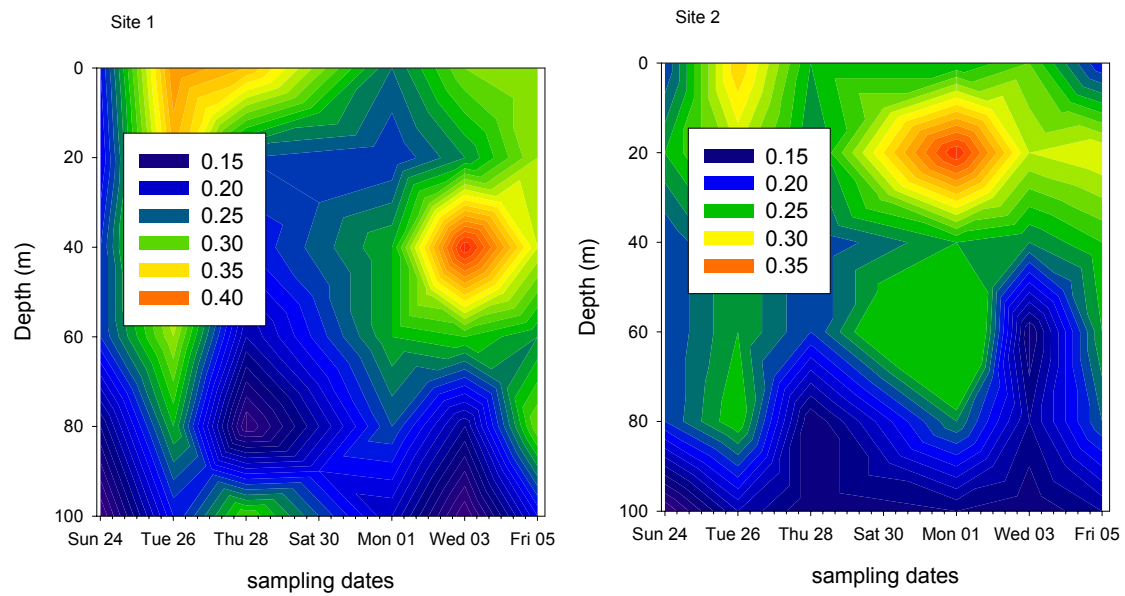


Fig. Variation of wind speed with years.

