Seasonal Surficial Distribution of Water Quality Parameters at Lake Nyamagoma, Western Tanzania

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Abstract

This paper discusses the seasonal surficial distribution of water quality parameters at Lake Nyamagoma in Western Tanzania during dry and wet seasons. Standard methods and gears were used to determine levels of the water quality parameters such as turbidity, DO, PO_4^{3-}, NO_3^- and Cl^-. The study reveals that the water quality parameters vary significantly seasonally along the four sampling sites consequent to processes including nitrification, fixation, evaporation-crystallization, adsorption, photosynthesis, mixing and dilution effect. Higher surficial distribution data were recorded at Chagu compared to other sampling sites in both seasons. The data show elevated levels during the wet season compared to the dry season as shown by turbidity and PO_4^{3-} (5 - 13.28 NTU and 3 - 13.11 NTU along with 12 - 17.03 mg/L and 3 - 9.04 mg/L) in the wet and dry seasons respectively. These observations could be attributed to catchment anthropogenic activities disturbance such as agriculture using fertilizers along with cattle grazing and artisanal mining. The contour map clearly show the increasing trend of chloride from downstream to the upstream sites and has its sources in the Moyowosi River, whilst turbidity originates from Igombe River and near Mfumu landing site. The noted variation alters the water quality of the lake and in turn setting up health risks to the riparian community. However, most of these data are still within the WHO and TBS standards making it possible for use. The monitoring of the pollution influx from both point and diffused sources is recommendable by engaging both the riparian villagers and all the stakeholders of this precious and peculiar ecosystem.

Keywords: *Western Tanzania, Lake Nyamagoma, water quality parameters, processes, anthropogenic activities, seasonality effects*

1.0 Introduction

The Malagarasi-Muyovosi wetland is the Tanzania's first Ramsar Site and the world's 1024^{th} Ramsar Site since 2000. The wetland covers an area of 3,250,000 ha in Western Tanzania (Nkotagu and Athuman, 2008a, 2008b, 2004; Mtui and Nakamura, 2006). The core area of the wetland comprises the Lake Nyamagoma about 200 km from Lake Tanganyika. The lake has existed since 1930 s and 1940 s but has tended to shrink and expand over time depending on the rainfall regime in the area (Nkotagu and Athuman, 2008a).

However, in the last few decades, the Lake Nyamagoma has undergone large chemical and physical changes because of growing human interferences. Next to impacts from pollution, domestic and agricultural activities leading to deterioration of water quality, shallowing of the lake is increasing at a fast rate (Nkotagu and Ndaro, 2004). The lake is being plagued by an excessive growth of aquatic macrophytes. Hecky and Bugenyi (1992) pointed that, in any lakes such invasions presage early eutrophication and alteration of both quality and water body amenities. Despite the importance of this vast lake, no comprehensive studies have been undertaken in relation to the anthropogenic and seasonality impacts on current macrophyte invasion.

Several authors (For example, Enger and Smith, 2004, 2002; Fleishman *et al.* 2003; Samsunlu *et al.* 2002; Howard-Williams and Gaudet, 1995; Gaudet, 1979) pointed that, seasons of the year explain well the sources and hydrodynamics regime of the water quality parameters in a particular ecosystem and that, the ecological system of these parameters may change its chemical properties yearly, monthly, daily and even hourly.

This study therefore assessed the seasonal surficial distribution of water quality parameters at the Lake Nyamagoma during both dry and wet seasons.

The following basic questions were set to shade light on the research work; (i) How do the anthropogenic activities influence the quality of the lake waters? (ii) What are the processes influencing the chemical character of the lake? (iii) What are the seasonality effects on the water quality parameters?

2.0 Materials and Methods

2.1 Study area

This study was carried out at the Lake Nyamagoma (maximum depth *ca.* 2.5 m) with an estimated area of about 173 km^2 during the dry and wet seasons in September 2007 to January 2008 respectively (Figure 1). The lake lies within the Moyowosi National Parks and it is shallow and chocked with silt and mud and is surrounded by macrophytes along with swampy areas at the inflows and outflows. The core area of the lake is characterized by the continental type of climate with temperature ranging between 20 °C and 30 °C. The rain season extends from November to April. The rainfall drains the average swamp area of 10,000 km^2 during the rainy season. The available rainfall allows the growing of maize, beans, millets, groundnuts, cassava and tobacco within the catchment. The Lake Nyamagoma is drained by rivers; Igombe, Kigosi, Moyowosi and Malagarasi. During the dry season the lake empties its water into Malagarasi River direct to Lake Tanganyika, whilst during the wet season the Malagarasi River overflows into the lake. However, during heavy rains Lake Nyamagoma joins Lake Sagara through the Usinge point (See Figure 1).

2.2 Water Sampling and Storage

Sampling points were located using a hand-held field GPS following Crosby and Patel (1995) as shown in Figure 2. The lake was divided into four zones *viz* western zone at site 1 (Mfumu), southern zone at site 2 (Kigurwe), northern zone at site 3 (Mouth of Moyowosi River) and eastern zone at site 4 (Chagu) as shown in figure 2 depending on the accessibility and land-use activities. These sites had more-or-less equal maximum depth ranging from 2.0 to 2.5 m. Water samples were collected depth wise using a 2-litre water sampler, filtered using 0.45 µm filtered membrane and then kept into half-litre plastic bottles, cooled at 4 ºC and immediately taken in the laboratory for chemical analyses.

2.3 In situ measurements

Water turbidity and Dissolved Oxygen (DO) were measured *in situ* between 0900 and 1200hours using using a HACH turbidimeter 2100P model and a calibrated multi probe meter 340i model respectively.

2.4 Laboratory work

The laboratory analyses were performed at Southern and Eastern African Mineral Centre (SEAMIC). Nutrients including Nitrate (NO_3^-) and Phosphate (PO_4^{3-}) were determined from the filtered water samples using a HACH Spectrophotometer DR/2400 model as per HACH (2002). The concentration of Chloride (Cl^-) was determined titrimetically.

2.5 Data analysis and interpretation

The data from each depth at each site were averaged to obtain the surficial distribution results and then analyzed using Sigma Plot 8.0 package as per Kothari (2004) and Davis (1986). Standards for World Health Organization (WHO) and Tanzania Bureau of Standards (TBS) were also acquired to compare with the obtained water quality data.

3.0 Results

3.1 Seasonal surficial distribution data

The results for seasonal surficial distributions of water quality parameters across the dry and wet seasons are shown in figures 3 and 4. The distributions show higher amount of most of the pollutants in the wet season than the dry season. Higher values are recorded at Chagu compared to other sampling sites in both seasons. However, most of these data are still within the WHO and TBS standards making it possible for use (Table 1).

3.2 Seasonal contour maps for Chloride data

The seasonal contour maps demonstrate clearly the increasing trend of chloride values towards the upstream with higher values at Moyowosi River in both seasons (Figures 5 and 6).

3.3 Seasonal contour maps for turbidity data

The turbidity values increase towards upstream sites with higher values determined at Chagu and the Igombe River which are the upstream and the agricultural activities sites of the lake in both seasons as shown on the contour maps (Figures 7 and 8).

4.0 Discussion

The surficial distribution data of most water quality parameters were higher during the wet season as compared to the dry season consequent to seasonality effects on the water quality parameters. The inferred phenomenon could be attributed to anthropogenic activities such as tobacco agriculture using fertilizers along with cattle grazing and artisanal mining in the riparian catchment of the lake within the Malagarasi Wetland Ecosystem (Nkotagu and Athuman 2008a; 2008b; 2004). Higher levels were observed in macrophytes engulfed and agricultural practised areas such as Chagu and Mfumu probably consequent to the N-fixation by blue-green algae and macrophyte respirations along with the use of fertilizers in the tobacco farms as observed at Chagu landing site. This agrees with previous findings by Nkotagu and Athuman 2004 that the elevated levels of water quality parameters could trigger the well-being of the lake waters and in turn leading to health risks amongst the riparian community.

Further, the high DO values recorded at Kigurwe and Chagu sampling sites in both seasons (Figure 3 and 4), may be attributed to increased photosynthetic activities of probably phytoplanktons at the water surface (Cohen, 2003; Wetzel, 2001; Carr and Whitton, 1973 and Fogg *et al.* 1973). The NO_3^- values were also high at Chagu in both seasons probably consequent to the nitrification process enhanced by higher oxygen values. However, the low DO values as recorded at the other sampling sites of the lake may be due to oxidation of organic matter (Werner, 1977). Generally, lower DO values were recorded during the wet season than in the dry season indicating inputs of organic matter into the lake from the catchement.

Again, the observed higher PO_4^{3-} values during the wet season than the dry season (Figs 3 and 4) could be attributed to sediment trap by adsorption process on to ferric hydroxide, $Fe(OH)_2$ particles as inorganic phosphate (Golterman, 1973; Mortimer, 1971). This is a consequence of increased mixing process. The observed high levels of PO_4^{3-} trend data indicate also high level of fertilizer application within the catchment area (Nkotagu and Athuman, 2008a, 2008b, 2004).The high concentration of PO_4^{3-} as observed at Chagu in both seasons confirms the presence of inputs from the agricultural and overgrazing activities.

Moreover, the chloride values for Lake Nyamagoma waters show a significant value in the dry season (Figure 3). This may be due to evaporation-crystallization process. However, in the wet season, the chloride values showed low values along the sampling sites (Figure 4). According to Wetzel (2001) and Eugster (1970), this observation could probably be due to dilution effects triggered by surface runoffs. However, the seasonal contour maps demonstrate clearly the increasing trend of chloride from downstream to the upstream sites thus indicating its sources from the Moyowosi River, whilst turbidity originates from Igombe River and near Mfumu landing site (Figures 5, 6, 7 and 8). These pollutants reach into the lake during the wet season through the inflowing rivers and the surface runoffs accelerated by the deforested catchment within the wetland (See also Figure 1).

5.0 Concluding Remarks

The study concludes that the water quality parameters vary significantly seasonally across the sampling sites consequent to processes including nitrification, fixation, evaporation-crystallization, adsorption, photosynthesis, mixing and dilution effect. The data show elevated levels during the wet season compared to the dry season. This could be attributed to catchment anthropogenic activities disturbance such as agriculture using fertilizers along with cattle grazing and artisanal mining especially at Chagu. The noted variation alters the water quality of the lake and thus setting up health risks to the riparian community. However, most of the data from this study are still within the WHO and TBS standards making it possible for use. Future work is recommended to focus on monitoring of the pollution influx from both point and diffused sources by engaging both the riparian villagers and all the stakeholders who benefit either directly or indirectly from this precious and peculiar lake in this part of the world.

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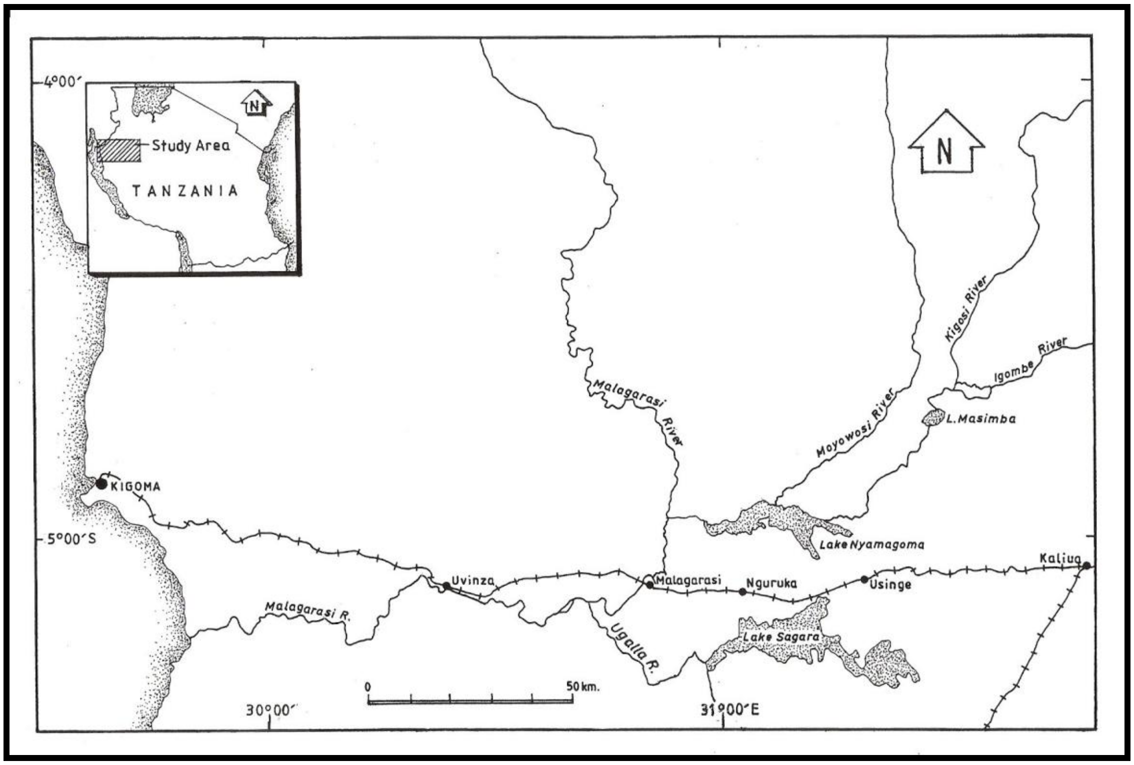

Figure 1: Location map of the study area

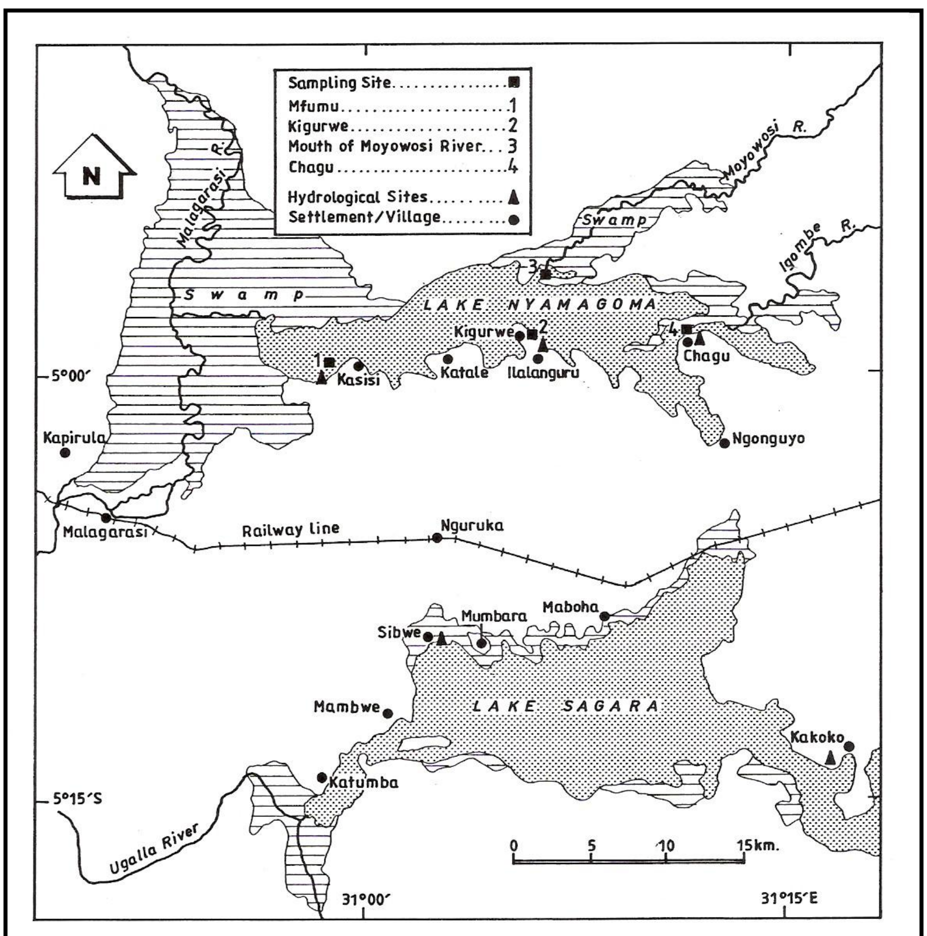

Figure2: Water sampling sites at the study area

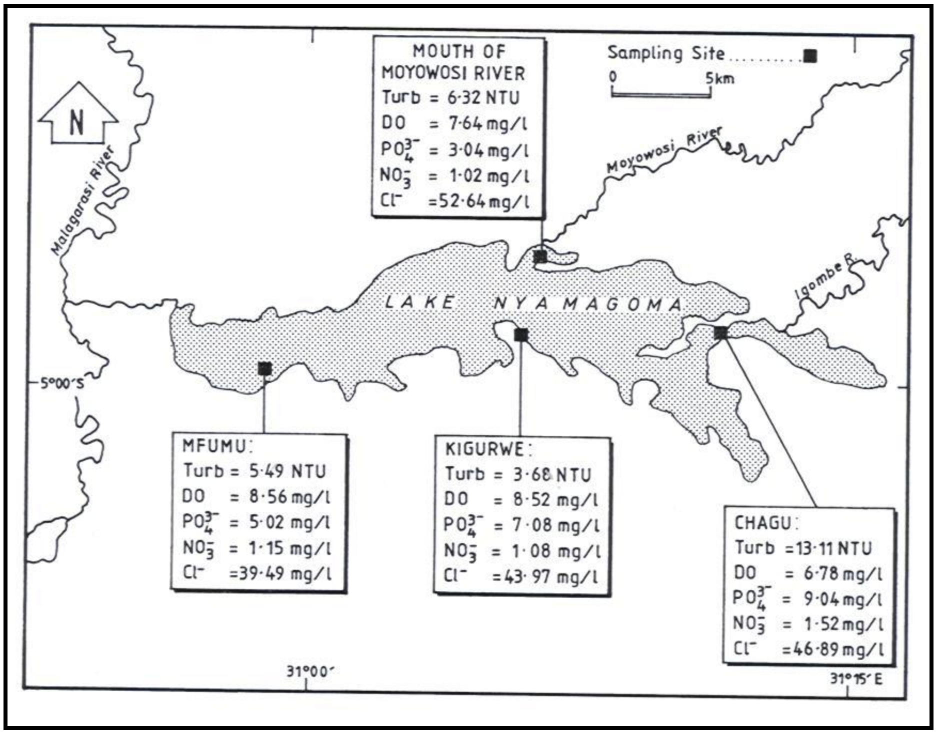

Figure 3: Surficial distribution data for water quality parameters in the dry season

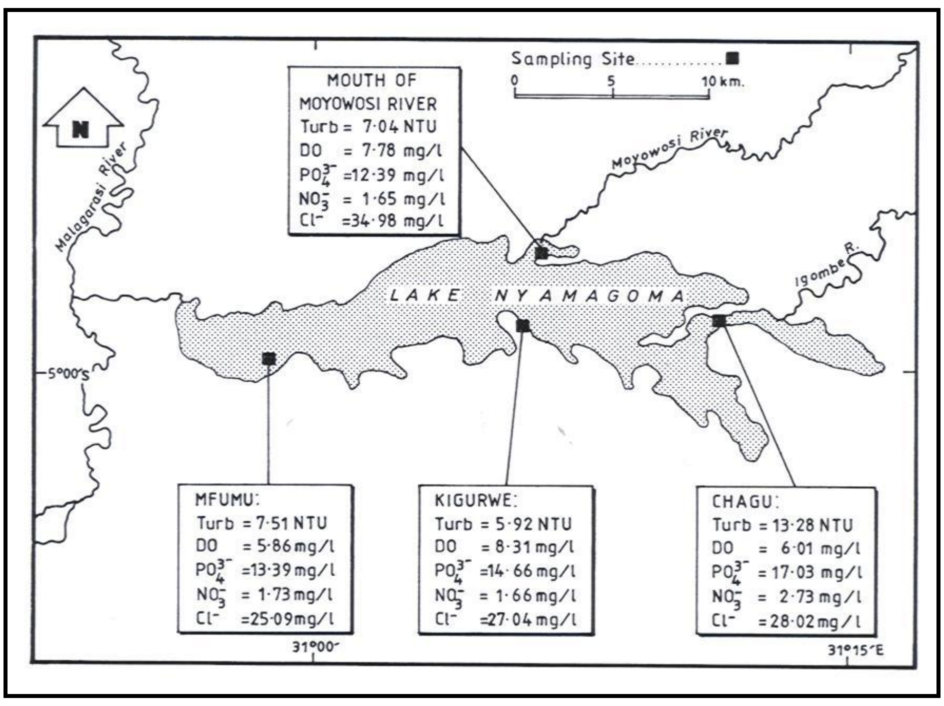

Figure 4: Surficial distribution data for water quality parameters in the wet season

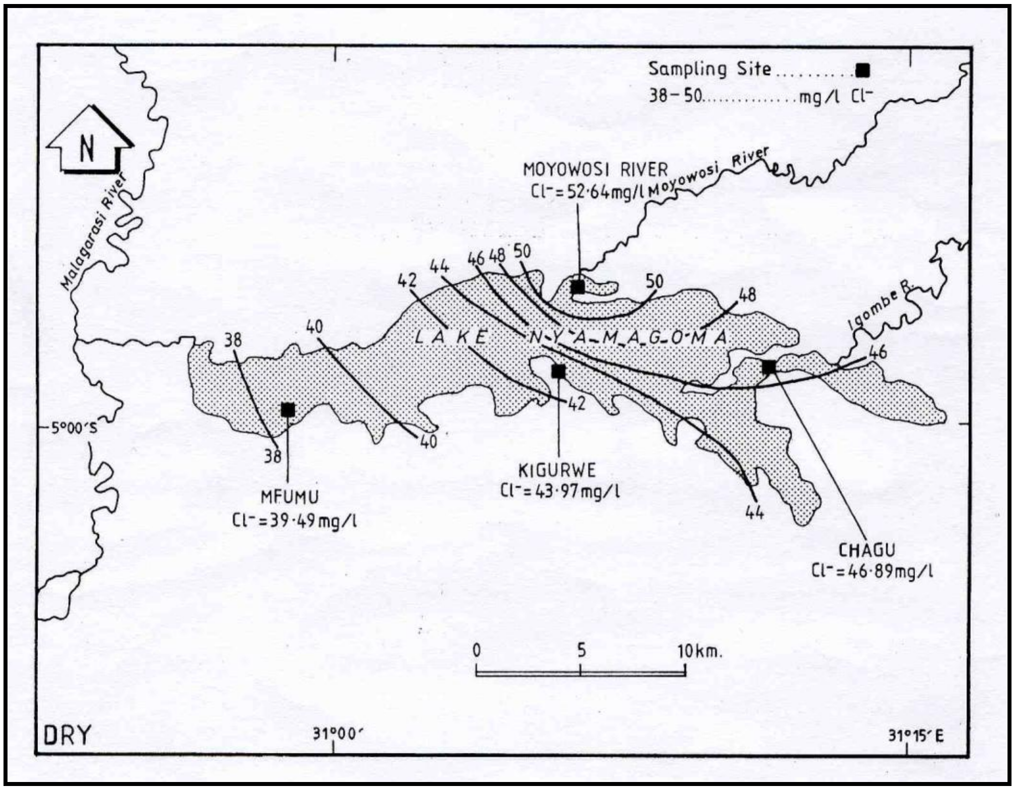

Figure 5: Contour map for Chloride values in the dry season

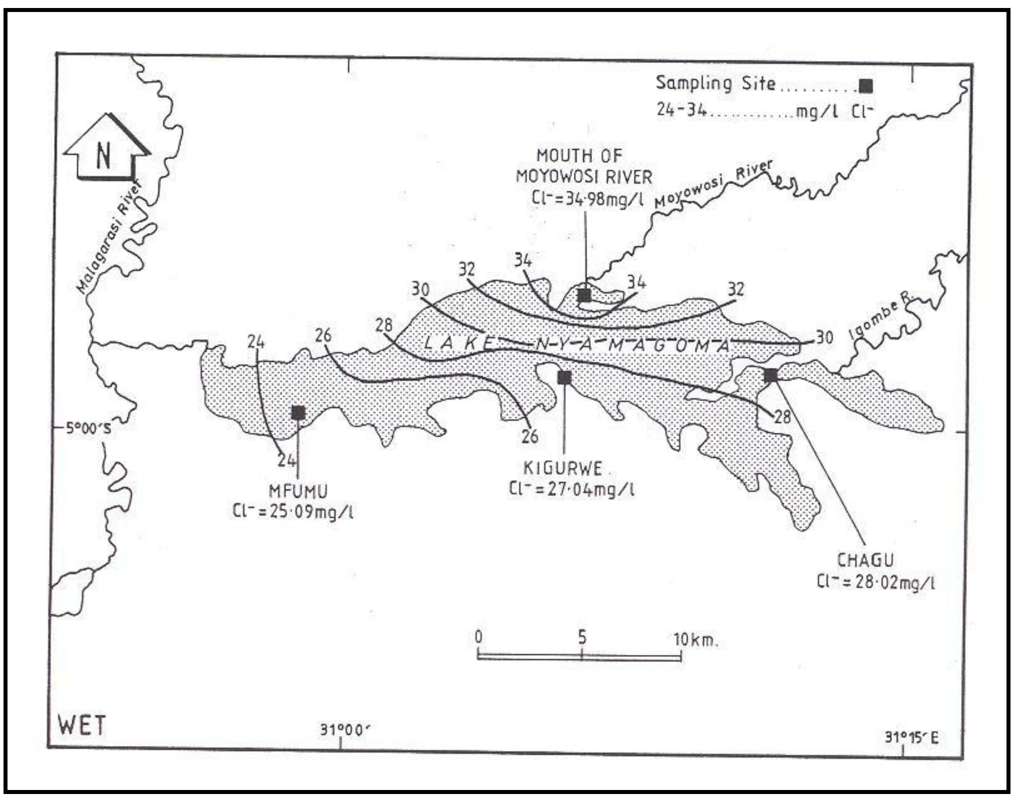

Figure 6: Contour map for chloride values in the wet season

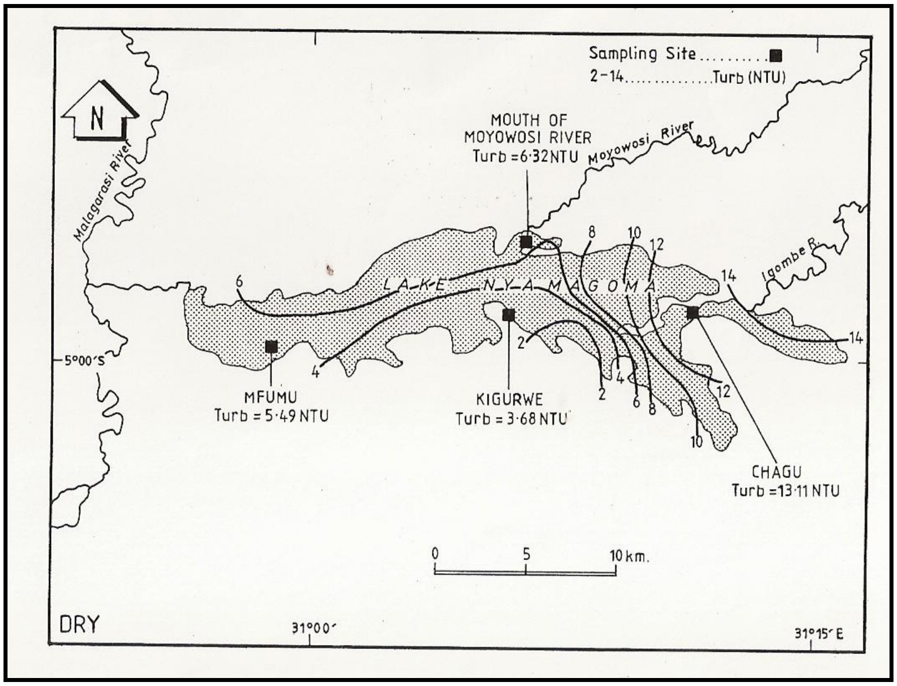

Figure 7: Contour map for turbidity values in the dry season

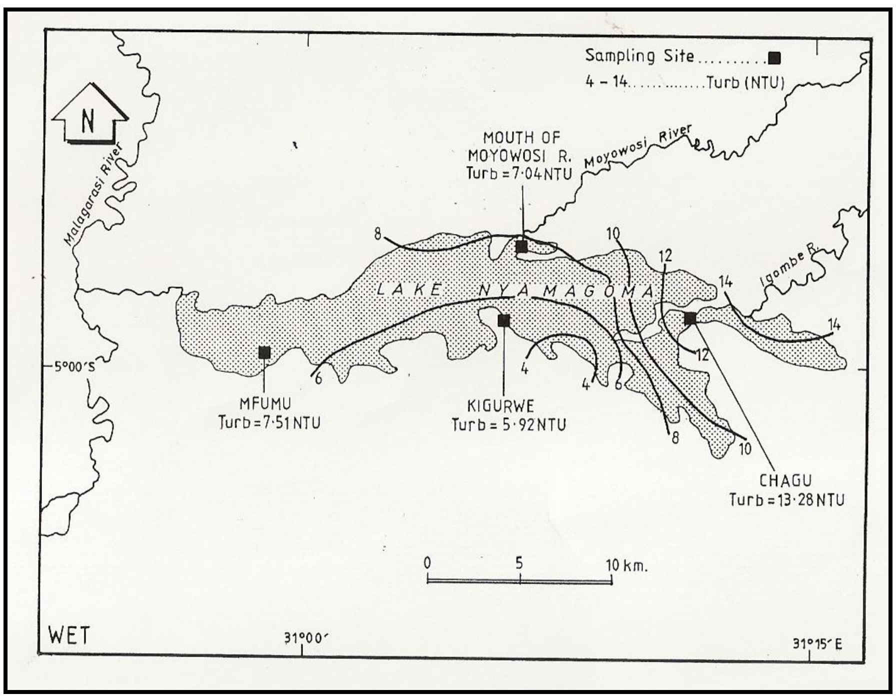

Figure 8: Contour map for turbidity values in the wet season

Table1: Selected WHO and TBS standards for drinking water

Water Quality Parameter	Minimum Recommended Level (WHO)	Maximum Recommended Level (WHO)	Recommended Level (TBS)
Turbidity (NTU)	5	50	30
DO (mg/L)	5	-	-
NO_3^- (mg/L)	-	45	100
SRP (mg/L)	0.3	2	-
Cl^- (mg/L)	200	600	-

(**Source:** WHO 1993; TZS 573: 1997)