LEVELS OF NITRATE AND PHOSPHATE IN SOME SATELLITE LAKES WITHIN THE LAKE VICTORIA BASIN, TANZANIA

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ABSTRACT

Levels of nitrates (NO_3-N) and phosphates (PO_4-P) in some satellite lakes within the Lake Victoria basin were determined in Kagera (Lake Burigi), in Mara (River Mara) and in Mwanza region (Lake Malimbe) during August/September 2002 (dry season) and January/February 2003 (wet season). Water samples were collected using a van Dorn water sampler at chosen points from both deep and shallow areas of the water bodies. Results of the two surveys revealed that deep and shallow areas of the lakes had varying nutrient levels. In deep waters, PO_4-P values ranged between 0.171-0.225mg/l, 0.067-0.364mg/l, and 0.043-0.096 mg/l in Lake Malimbe, Burigi and Mara River, respectively. NO_3-N values ranged between 0.034-0.762mg/l, 0.019-1.367 and 0.034-1.54mg/l in Lake Malimbe, Lake Burigi and Mara River, respectively. In shallow areas, PO_4-P values ranged between 0.144-0.343 mg/l, 0.072-0.203mg/l and 0.025 –0.096 mg/l in Lakes Malimbe, Burigi and Mara River, respectively. NO_3-N values ranged between 0.035-0.932 mg/l, 0.017-0.622 mg/l and 0.028-0.912 mg/l in Lakes Malimbe, Burigi and Mara River, respectively. Generally, levels were higher during the dry than during the wet season. Appropriate pollution control measures should be taken though levels encountered are still within those recommended in the Tanzania Water Utilization (Control and Regulation) Amendment Act of 1981 for receiving waters.

INTRODUCTION

Lake Burigi (31^{O}15'E2^{o}01'S to 31^{o}20'E2^{o}15'S), Lake Malimbe (32^{o}53.5'E2^{o}37.5'S to 32^{o}54'E2^{o}37.8'S) and River Mara (33^{o}57'E1^{o}31'S to 33^{o}59'E1^{o}32'S) are satellite lakes found within the lake Victoria basin (Figure 1). These areas are surrounded by large expanse of lowland often used for agricultural activities (this is for the case of Mara River and Lake Malimbe since Lake Burigi is in a game reserve).

Population growth in the watershed has been the basic cause of aquatic impacts from primitive subsistence agriculture, intense animal husbandry and occupancy of riparian shoreline for access to fish and water. Consequently, due to deforestation, surface runoff has increased nutrient concentration causing spatial and temporal variation in the limnological characteristics in lakes, rivers and surrounding wetland areas. This has in turn influenced the ecological structure and functioning of these aquatic ecosystems (Chapman 1996, Nogueira et al. 1999).

Despite the paucity of information on satellite lakes, recent studies have ascertained that these important ecosystems (lakes, rivers, adjacent wetlands, ponds and dams) found within the Lake Victoria catchment are faunal reservoirs for endangered fish species (Kaufman and Ochumba 1993, Kaufman et al. 1997, Chapman et al. 1995). Unlike Lake Victoria whose scientific research dates as early as the 1920s (Talling 1957, Lowe McConnell 1997, Ogutu-Ohwayo 1990), research in satellite lakes is only recent, creating an urgent need for increased efforts in order to furnish information which will contribute to the effective conservation of biological diversity.

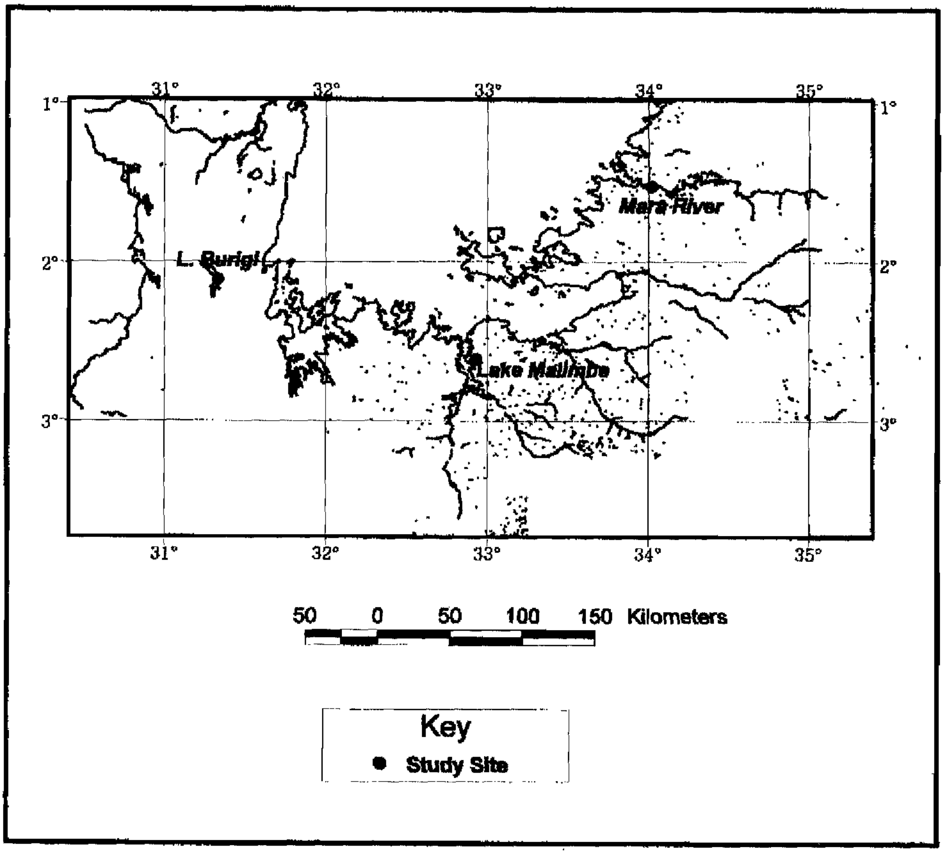


Figure 1: Lake Burigi, Lake Malimbe and River Mara within the Lake Victoria catchment

This paper gives the results of limnological studies aimed at investigating the levels of phosphate and nitrates in some satellite lakes within the Lake Victoria basin. Nitrogen and phosphorus levels were monitored since they are often identified as the nutrients limiting algal biomass or productivity in aquatic ecosystems (Hecky and Kilham 1988). Levels observed were compared to those in the Tanzania Water Utilization (Control and Regulation) Amendment act of 1981 for quality control purposes.

MATERIALS AND METHODS

Study sites

Samples were collected from Lake Burigi (Figure 2), River Mara (Figure 3) and Lake Malimbe (Figures 4). Lake Burigi, is the largest satellite lake in the Lake Victoria basin, and connects to River Kagera and Lake Victoria through the drainage by River Mwisa. River Mara has its origin on the slopes of mount Kenya. It drains with smaller and semi-permanent rivers through the dry Serengeti plains in the south-east and finally discharges into Lake Victoria. Lake Malimbe has no direct connection to the main lake. Its source of water is through seepage and rains. Characteristic to both River Mara and Lake Malimbe is that the two areas are surrounded by huge stands of papyrus (*Cyperus papyrus*). Along River Mara, pockets of small stands of water Hyacinth (*Eichornia crassipes*) do occur and occasionally high densities are found under the Kirumi bridge. Lake Burigi is fringed by savannah type of vegetation mainly characteristic of that found in game reserve areas.

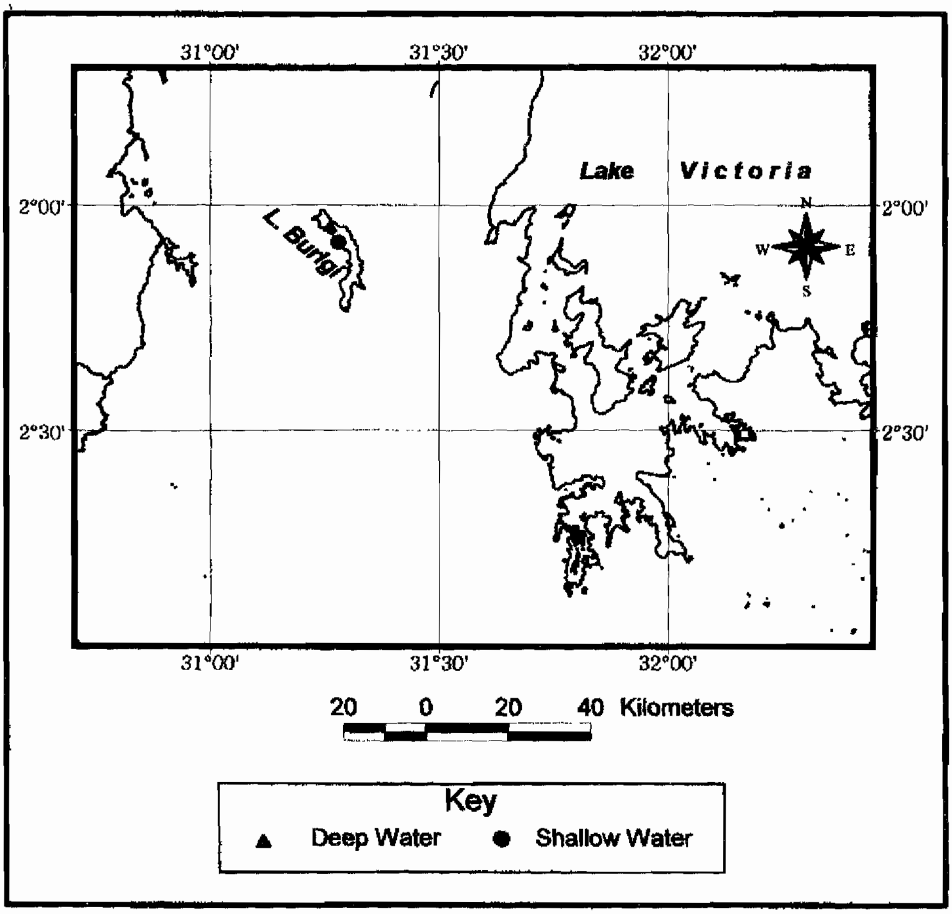


Figure 2: Lake Burigi showing sampling stations (Deep and shallow water)

Sampling and analysis of water

Water samples were collected using a van Dorn water sampler (1 litre capacity) from both deep and shallow areas. Deep water sampling involved collection of surface, mid and bottom water samples, whereas in shallow water, only surface and bottom samples were collected. Sampling bottles (250 ml) were initially soaked in 10 % HCl for 24 hrs and rinsed with distilled de-ionized water. Due to lack of refrigeration facilities, samples were preserved in concentrated H_2SO_4 (1 ml) and upon arrival at the laboratory they were kept in a deep freezer. Prior to analysis water samples were thawed, filtered using a Whatman GF/F filter and filtered used for nutrient analysis.

Soluble Reactive Phosphorous and nitrates were analyzed according to the Standard Methods for Examination of Water and Wastewater (ALPHA 1995). Water samples that were collected during the dry season were analyzed using a Shimadzu UV – Visible Spectrophotometer (model UV – 240) and for the wet season by a Hitachi Spectrophotometer (model U – 2001).

Statistical analysis
Data were analyzed using INSTAT statistical software. Friedman's Non-parametric Repeated Measures Analysis of Variance was used to check whether there were significant differences in nutrient levels among the study sites.

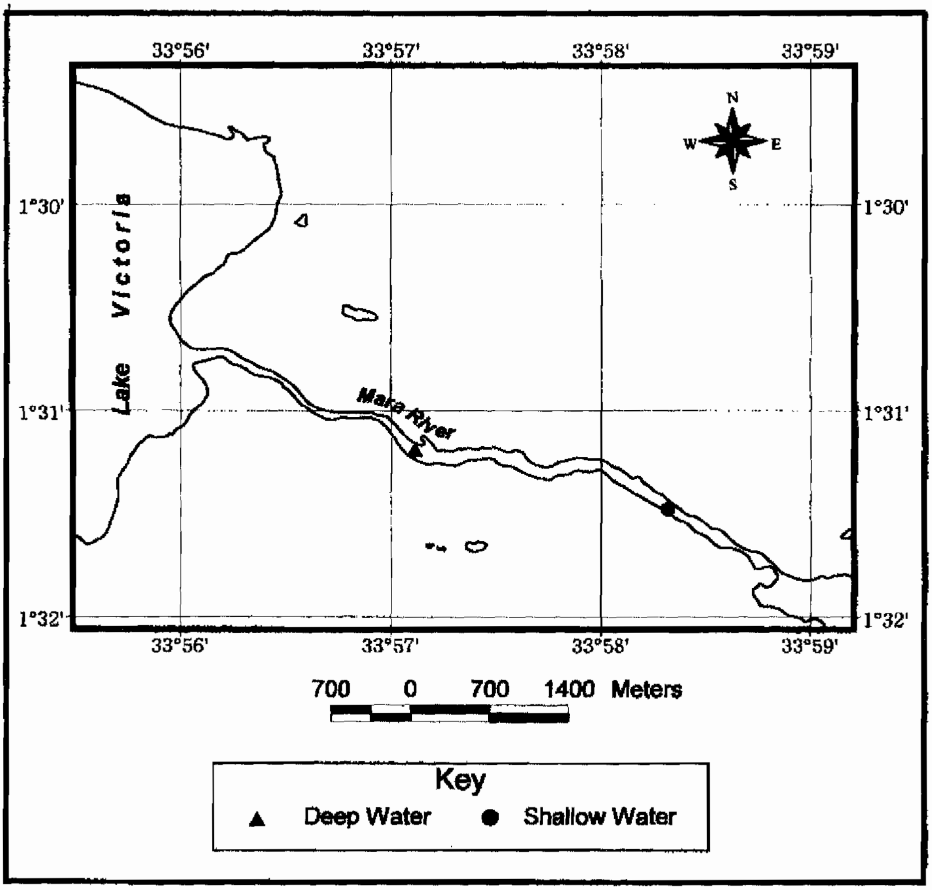


Figure 3: River Mara showing sampling stations (Deeep and shallow water)

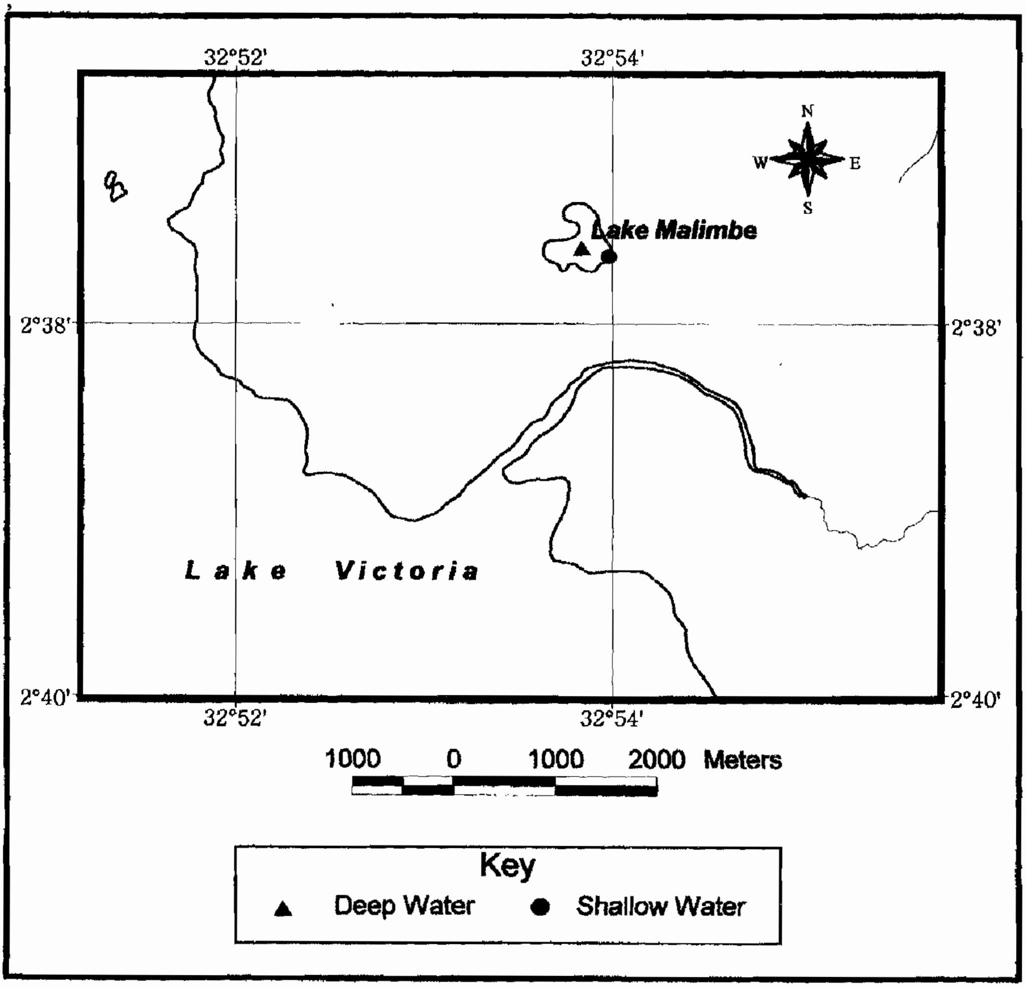


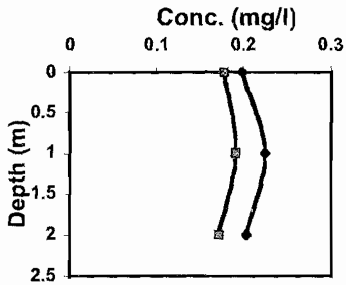
Figure 4: Lake Malimbe showing sampling stations (Deeepand shallow water)

RESULTS

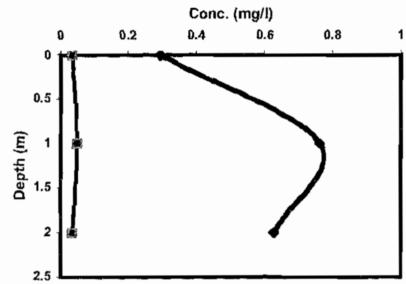
Vertical and seasonal distribution of nutrients

Fig. 5a-5f shows variation of PO_4-P and NO_3-N in deep waters of Lake Malimbe, Burigi and Mara River during the dry (August/September2002) and wet (January/February 2003) seasons. In Lake Malimbe (Figure 5a) the vertical distribution of phosphate during the dry and wet season followed the same pattern, with highest values (0.23 mg/l) in mid water. Similarly, nitrates were highest in mid-water in Lake Malimbe (0.76 mg/l) during the dry season as shown in Figure 5b. Phosphate levels in Lake Burigi increased with depth from 0.10 mg/l at the surface to 0.36 mg/l in deep water (5 m). However, during the wet season, phosphate levels were more or less uniform 0.07 mg/l with depth (Figure 5c). Nitrate levels were highest in mid-water in Lake Burigi (1.37 mg/l) during the dry season and more or less uniform (0.07 mg/l) during the wet season (Figure 5d). In Mara River phosphate concentration decreased with depth from 0.10 at the surface to 0.06 mg/l at 6.0 m during the wet weather and during the dry weather highest concentration

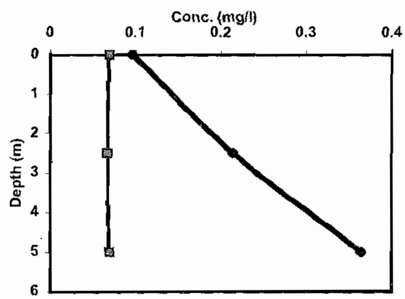
(0.09 mg/l) was observed in mid-waters (3 m) as shown in Figure 5e. Nitrates in Mara River were uniform (0.04 mg/l) with depth during the rain season. During the dry season the level decreased from 1.54 mg/l at the surface to 0.21 mg/l in mid water, then increased to 1.04 mg/l in deep water (Figure 5f).



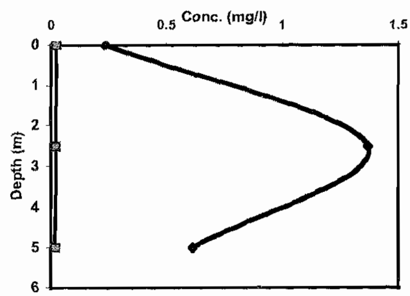
a) Variation of PO_4-P in deep waters of L. Malimbe



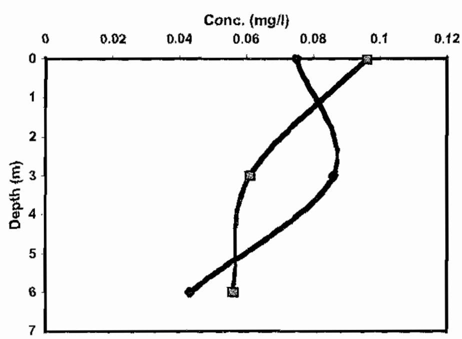
b) Variation of NO_3-N in deep waters of L. Malimbe



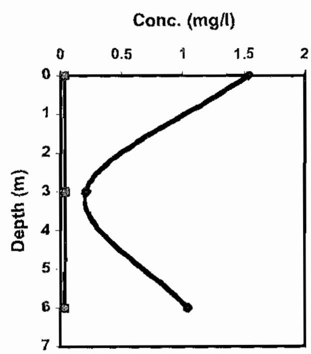
c) Variation of PO_4-P in deep waters of L. Burigi



d) Variation of NO_3-N in deep waters of L. Burigi



e) Variation of PO_4-P in deep waters of Mara River



f) Variation of NO_3-N in deep waters of Mara River

Dry season — wet season

Figure 5a-f: Nutrients profiles (concentrations vs depth) for Lake Burigi, Lake Malimbe and Mara River for deep water stations during the dry and wet seasons.

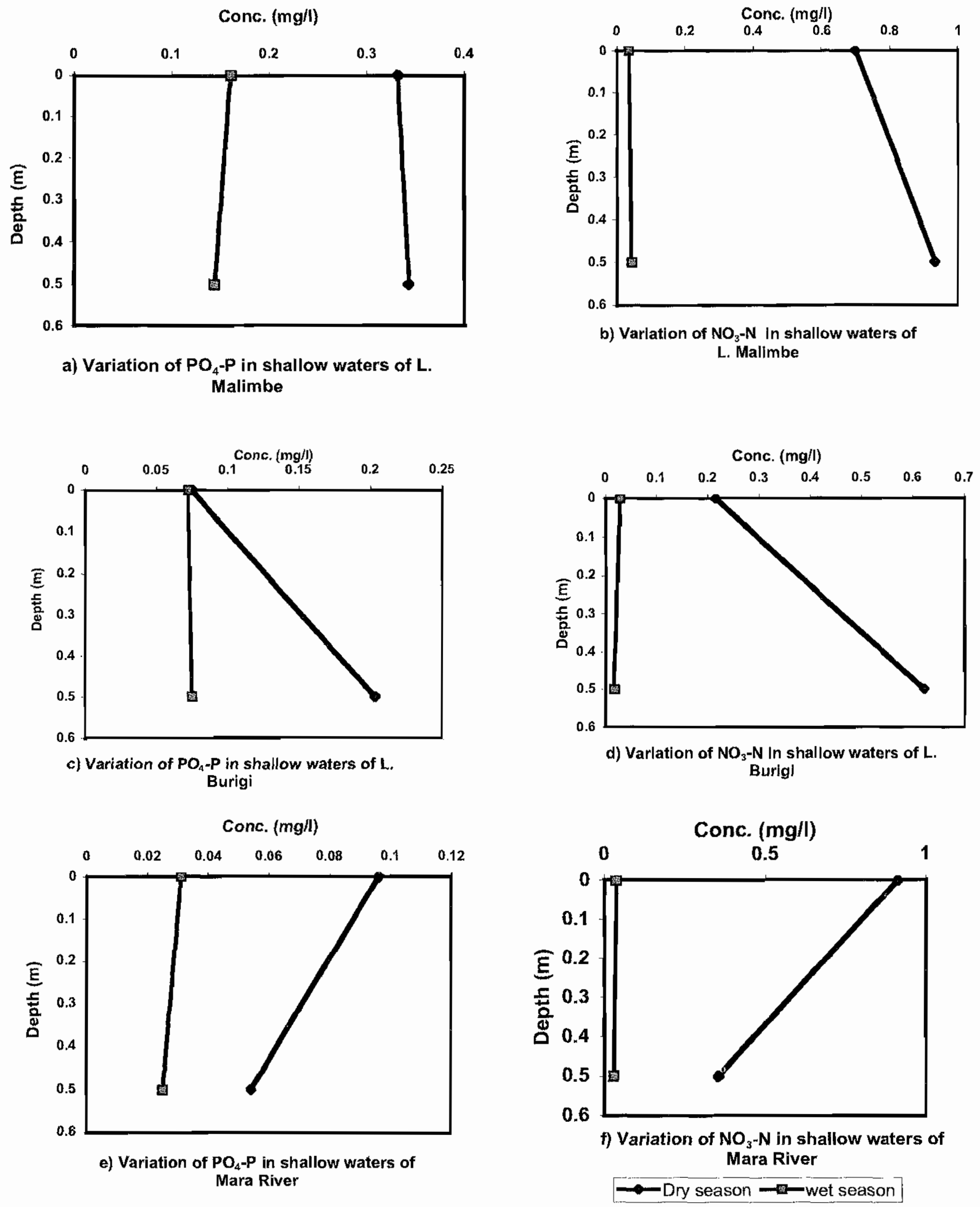


Figure 6a-f: Nutrients profiles (concentrations vs depth) for Lake Burigi, Lake Malimbe and Mara River for shallow water stations during the dry and wet seasons.

In the shallow areas of the satellite lakes, the concentration of nutrients was generally higher than in their respective deeper parts. Figure 6a-6f shows variation in PO_4-P and NO_3-N with depth in the shallow areas of Lake Malimbe, Burigi and Mara River. Nutrients were uniformly distributed in the entire water column in the shallow areas of the three water bodies during the rain season. In Lake Malimbe, PO_4-P was 0.15 mg/l and NO_3-N was 0.04 mg/l from surface to bottom (0.5m depth) in the water column (Figure 6a and 6b). In Lake Burigi PO_4-P was 0.07 mg/l while NO_3-N were 0.02 mg/l (Figure 6c and 6d). During the dry season PO_4-P and NO_3-N concentration in Lake Burigi and Malimbe was lowest in surface water and increased with depth. For instance in Lake Malimbe, PO_4-P was 0.33 mg/l at the surface and increased to 0.34 mg/l at the bottom (0.5m) and NO_3-N, increased from 0.70 mg/l at the surface to 0.93 mg/l at the bottom of the lake. In Lake Burigi PO_4-P increased from 0.08 mg/l at the surface to 0.20 mg/l at the bottom (Figure 6a, 6b, and 6c, respectively). In Mara River, nutrient profiles in the shallow areas were a bit reversed. Highest PO_4-P and NO_3-N concentration were observed at the surface (0.10 mg/l and 0.91 mg/l respectively), and decreased to 0.05 mg/l and 0.35 mg/l, respectively, at the bottom (0.5m) – Figure 6e and 6f.

DISCUSSION:

Results of the two surveys i.e August/September 2002 (dry) and January/February 2003 (wet) seasons showed that there was variability in the nutrient concentrations in the surveyed sites. Friedman's Nonparametric Repeated Measures Analysis of Variance (Zar 1984) indicated that during the dry season PO_4-P concentrations were significantly different ($Fr = 6.400$, $P = 0.0394$) as opposed to NO_3-N concentrations which were not significantly different ($Fr = 1.200$, $P = 0.6914$). During the wet season both PO_4-P and NO_3-N were significantly different ($Fr = 8.400$, $P = 0.0085$; $Fr = 9.294$, $P = 0.0008$) respectively. However, levels of phosphates during the study period had decreased compared to levels that were obtained in the previous surveys by Kulekana (2003). Nutrients of anthropogenic origin and natural sources both contributed to the observed levels. Low nutrient levels in Mara River were due to the flushing effect of the river and also a number of associated wetland areas which have buffering effects (Kansiime et al. 1994). The dilution effect during the rain period reduced concentrations to very low levels at all sites.

Values obtained in the present surveys are comparable to those obtained in the waters of northern Lake Victoria by Bugenyi and Magumba (1990). Holtzman and Lehman (1998) attributes modern changes in land use practices and other natural influences such as rainfall as being factors which have accelerated erosion of Phosphate-rich soils into Lake Victoria and other historically Phosphate-rich lakes in East Africa. In most natural surface waters, phosphate ranges from 0.005-0.020 mg/l PO_4-P (Chapman 1996). From these surveys, some of the values obtained exceeded the range suggested by Chapman (1996) suggesting influence of human activity on these water bodies. Activities carried out by communities surrounding these lakes such as agricultural, household, animal husbandry etc. could have had a significant contribution to the observed values.

Nitrates showed an increasing trend especially during the dry season when there is low flow of water into these water bodies. Vandelannoote et al. (1996) also observed higher levels of nutrients in Nlahangwa River during the dry season. High temperatures experienced during the dry season in association with the increased rate of decomposition of organic matter (Battle and Mihuc 2000, Hecky and Bootsma 1993) in these water bodies could play a significant role in increasing NO_3-N levels.

In the present survey, blooms of cyanobacteria (Sekadende pers. com.) which were observed in Lake Malimbe and Burigi imparted a greenish colour to the water. Blooming of phytoplankton has been related to enrichment of nutrients in water bodies (Linnik and Zubenko 2000, Kleeberg et al. 2000).

Levels obtained from the present survey are below 50 mg/l which is the Tanzania's maximum permissible concentration of nitrates for receiving waters (Water Utilization Control and Regulation Amendment Act 1981). Also, the recorded values are lower than those reported by Petr (1975) in Nyumba ya Mungu dam (10 mg/l) and Ruvu River (8 mg/l). Values almost similar to those from the two previous surveys were also recorded in Lake Kossou in Ivory-coast (Entz 1984), Mwadingusha resevoir in Zaire (Vanden Bossche and Bernascek 1990) and Jabel Aulia resevoir in Sudan (Vanden Bossche and Bernascek 1991).

Since the results suggest eutrophication in some satellite lakes, efforts should be made to reduce discharges of nutrients generating wastes in these water bodies. Routine monitoring will help in the management of these vulnerable water bodies.

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