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MICROBIOLOGICAL INDEX OF WATER POLLUTION IN LAKE KIVU, RWANDA.

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ABSTRACT

Investigation of the microbiological purity of lake kivu as index of water pollution was carried out in Gisenyi, Kibuye and Cyangugu over a period of 24 months.

Microbial load did not differ significantly with season and locations but Fecal Coliform (FC) had positive significant correlation ($r = 0.36$; $p<0.05$) with season. Mean Total Coliform (TC) (cfu/100ml) was highest 7.7×10^5 in Gisenyi and lowest 1.7×10^5 at Cyangugu. These values exceeded the 5000 colony forming units/100ml recommended by WHO for public surface water supplies. Total heterotrophic bacterial (THB), FC, TC and Fecal streptococcus (FS) were widespread with abnormally high values in the sampling locations signifying poor water quality. Microbial isolates from the water samples were of wide range of groups and their occurrence and distribution varied from location to location. Bacillus sp, E. coli, Citrobacter freundii, Klebsiella pneumonia and Proteus sp were the cosmopolitan microbial species in the lake water.

The microbial quality of the water was poor rendering it unsafe for domestic purposes without treatment and this was largely caused by direct contamination of the lake by animals and human domestic wastes.

***Keywords**:* Microbiological index, microbial isolates, Lake Kivu, water pollution, *Rwanda*

INTRODUCTION

Water quality problems have intensified through the ages in response to the increased growth and concentration of populations and industrial centres. Polluted water is an important vehicle for the spread of diseases. In developing countries, 1.8 million people mostly children die every year as a result of water related diseases (WHO, 2004). According to Okhawere (2003) transmission through contaminated water supply is by far the most serious source of infection and is responsible for the massive epidemic outbreak of the most serious enteric diseases (especially cholera and typhoid fever). Lake kivu supports very important fisheries that provide livelihood to hundreds of people and contribute significantly to food supply as a prime source of animal protein (Fishbase, 2003). An estimated 2 million people who live around the lake draw their drinking water from the lake without treatment. The major environmental concern in the lake area are erosion, siltation and pollution of the water through garbage, human wastes and excreta deposition; effluents from industries, restaurants, motor garages and mechanical shops. Agricultural activities also contribute to the pollution of the lake. Investigation conducted by Green vision (2004) at 24 sites around the lake revealed that latrine of houses are directed into the lake; mud caused by erosion creates a garbage in a big part of the littoral zones and at certain places the lake is used as dump site. Adama and Kolo (2006) noted

that the characteristic features of water bodies determine its quality and biological condition. According to Okhawere (2003) the physical and chemical properties and also bacteria and fungal loads are necessary parameters to ascertain a healthy ecosystem and sustenance of human race. Okhawere (2003) also reported that water bodies are reservoir for microorganisms and that contamination of water by sewage or excrement from human or animals is the greatest danger associated with water. Okafor (1985) reported that the purpose for examining water microbiologically is to help determine the sanitary quality and its suitability for general use. According to him, the water considered safe for human consumption should among others be free from microbial contamination and should meet the standard for taste, odour and appearance. It is therefore, necessary to regularly investigate the microbial load of water bodies as a means of protecting water bodies from non – degradable and biodegradable pollutants and other forms of wastes. This study was undertaken to investigate the microbiological properties of Lake Kivu as a means of evaluating its pollution status and thus providing base line data on its microbial properties.

MATERIALS AND METHODS

Lake Kivu is a mountain lake located between 1^0 84^i 38^{ii} and 22^0 30^is and 28^0 50^i and 29^0 23^i E. Its characteristics are a result of volcanic activity in the region. Its surface area is 2,370 km^2 of which about 1000km^2 (42%) belong to Rwanda and 58% to Democratic Republic of Congo. It is a deep (maximum 489m), meromictic lake, with oxic mixolimnion up to 70m and a deep monimolimnion rich in dissolved gases, particularly methane (Tietze, *et al*, 1980; Schmid, *et al*, 2005). Due to its great depth and very steep shores, the littoral area of Lake Kivu having access to oxygenated waters represented only 12% (Beadle, 1981). The average daily temperature in the lake area is 23^OC (73^OF); relative humidity range between 59 – 83% while the average yearly rainfall is 1300mm.

The lake was sampled bi- monthly for a period of 24 months at three major towns namely Gisenyi, Kibuye and Cyangugu. These towns were chosen based on anthropogenic activities in them.

Sub surface water samples for microbiological analysis were collected at a depth of 20 – 30cm into 500ml capacity sterilized sampling bottles. The samples were collected every two months and transported to the laboratory for analysis.

Indicator bacterial such as faecal coliforms and *E. coli* were collected by membrane filtration and plated on Levine eosine methyl blue agar while faecal streptococcus was plated on Slanets agar and enumerated on IMVIC and TSI test was conducted.

Pathogenic bacteria e.g salmonella and shigella were collected by broth enrichment (APHA, 1998) and incubated on brilliant green agar (BGA) and xylose lysine desoxycholate (XLD) agars. Total heterotrophic bacteria were enumerated by plating technique (Jones, 1979). Vibrio cholerae was inoculated on thioglucolate and TCBS media.

DATA ANALYSIS

Results obtained from the study were analysed using mean, standard deviations, graphs and correlation coefficients.

RESULTS

The mean and standard deviation of THB, TC, FC and FS obtained from the different sampling locations are presented in Table 1. The correlation matrix of indicator bacteria examined is presented in Table 2. FC correlates positively and significantly ($r = 0.36^*$) with season of sampling. THB, FC, TC and FS were wide spread with very high values. THB, FC, TC and FS however, were not significantly different with months, seasons and locations. Salmonella, shigella and *Vibrio cholerae* were not detected in the ambient water. Bacteria isolates from the water samples

cut across diverse groups such as enteric gram – negative and pyogenic cocci. Their occurrence and distribution vary from location to location (Figures 1 – 3).
Bacillus sp and E. coli were present in all the locations. *Bacillus sp*, *Citrobacter freundii*, *Klebsiella pneumonia* and *Proteus sp* showed the most relative percentage abundance while enterobacter were least occurring in Cyangugu (2%).

DISCUSSION

The results of the bacteria analysis obtained for the three sampling locations (Gisenyi, Kibuye and Cyangugu) suggests that the general sanitary qualities of the water as indicated by the total coliforms count were unacceptable while the faecal coliforms results imply that the water poses a serious health risk to consumers of the water. According to WHO (1987) for a fresh water to be considered as posing no risk to human health, the faecal coliforms count per 100ml should be zero. The poor microbial quality of the lake might be due to contamination caused by human activities and livestock. It is a common practice for people living along the lake catchments to discharge their domestic and agricultural wastes as well as human excreta into the lake. In addition to using the lake as a source of drinking water people use the lake for bathing, washing of clothes and for recreational purposes such as swimming thus contaminating the lake. Daubner (1969) noted that many factors could affect stream bacteria numbers including temperature, BOD and flow rate. *Bacillus coli* and the Coliforms groups as a whole are most commonly used as indicators of sewage pollution. The presence of such bacteria in water is a valid evidence of contamination by faeces. Since the disease spreading organisms belong to Coliforms group of bacteria, their presence in any water body clearly indicates that it is unhygienic; presence of *streptococcus faecalis* also confirms the pollution of faecal origin (Daubner, 1969).

The sources of effluents in lake Kivu include herbicides and pesticides application by farmers around and near the lake; human and animal faeces, sewage, bathing, laundry, effluent from industries and mines majority of which are concentrated in the Democratic Republic of Congo; Oil and Metallic wastes from Mechanic Workshops (Car washing) and mineral releases from volcanic rocks. Cholera, typhoid fever and diarrhoea are the prevalent diseases in the three locations. The occurrence of these diseases had in the past reached an epidemic state. The results agreed with the findings of Adama and Kolo (2006) in Gurara River. It also agreed with the findings of Ampofo (1997) in his survey of microbial pollution of rural domestic water supply in Ghana, who said that inadequate availability of water will hamper people's efforts to practice personal hygiene and that frequent fetching, washing and bathing in the river will expose the river to pollution and users to infections.

The study has provided information about the water quality status of Lake Kivu as indicated by its microbiological characteristic. The microbial status of the lake is very poor and thus water from the locations sampled is not suitable for domestic use without treatment; and also for agricultural purposes, there is possibility of contamination from vegetables and crops eaten in their raw state.

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Table 1: Means of bacterial density measured at sampling locations (cfu/100ml)

Parameters	Gisenyi	Kibuye	Cyangugu
Total Heterotrophic Bacteria	168930.0	82060	75710
Total coliforms	76950	60115	66780
Faecal Coliforms	12360	24893	12798
Faecal streptococcus	532.3	6.30	122.2

Table 2: Correlation Matrix of X-Values of Mean data of Bacteria at the lake locations (P<0.05)

Parameters	Months	Season	THB	TC	FC	FS
Months	1.00					
Season	0.22					
THB	-0.10	-0.10				
TC	0.16	0.13	0.05			
FC	0.19	0.36*	-0.24	0.30		
FS	-0.05	0.27	-0.05	0.08	-0.03	1.00

THB= Total Heterotrophic Bacteria

TC = Total Coliforms

FC = Faecal Coliforms

FS = Faecal Streptococcus

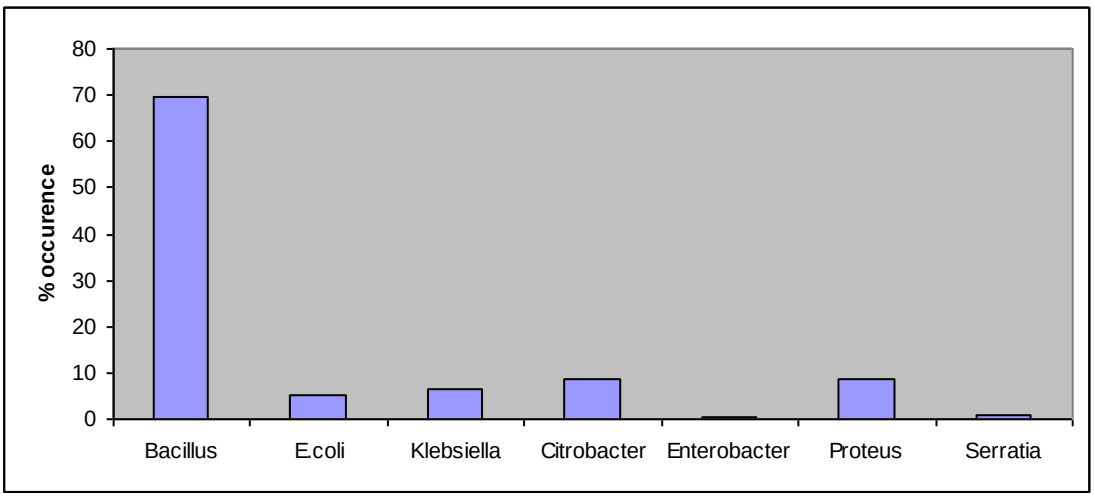

Figure 1: Microbial isolates in Gisenyi, Lake Kivu.

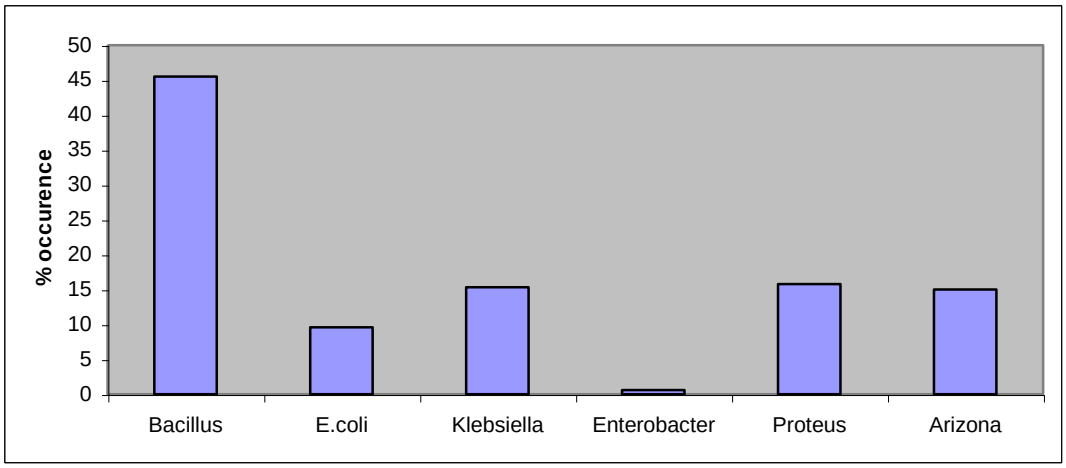

Figure 2: Microbial isolates in Kibuye, Lake Kivu

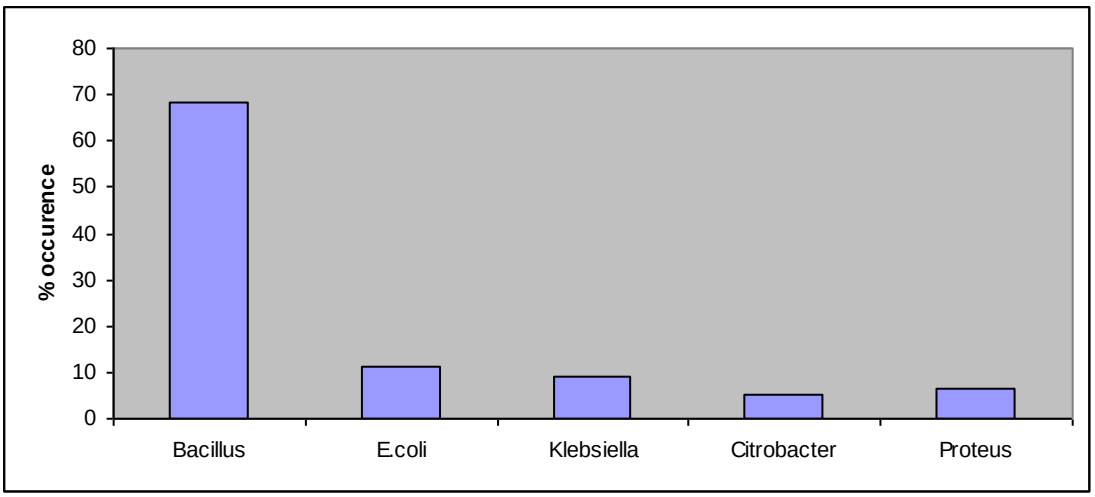

Figure 3: Microbial isolates in Cyangugu, Lake Kivu.