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Analysis of seasonal change effects on the major elements' concentrations and water level of South Lake Cyohoha, Rwanda

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This paper analyzed the effects of seasonal change on the quality and quantity of South Lake Cyohoha water, using primary data obtained from the analysis of water samples taken monthly at three different locations during the period 2009 – 2010. The spectroscopic technique was used to determine the concentration of the following major elements: Cr, Mn, Al, N, P, As, Ba, Ca, Cu, Fe, Mg, and K. The results showed that except calcium, iron and magnesium the concentrations of the remaining elements were high during the raining seasons and low during the dry seasons. The analysis of the change of water level in the Lake South Cyohoha during the same period revealed that water level increases proportionally with the increasing rainfall with correlation coefficient of 0.583 and decreases as temperature increases with the correlation coefficient of 0.708. Conductivity and pH also confirmed the seasonal change effects as conductivity was high during the raining seasons and low during the dry seasons while pH was high during the dry seasons and low during the raining seasons.

Key words: Seasonal change effects, major elements' concentrations, water level, South Lake Cyohoha.

INTRODUCTION

Water is an extraordinary substance that makes life on Earth possible Julian (2008). Water, used by all sectors of socio-economic life, plays a major role in the socioeconomic development of any given country. However, many parts of the world are facing the pollution and scarcity of fresh water (Lorber, 2002).The same problems have been found in South Lake Cyohoha. That lake is located in the East Province of Rwanda which is characterized by high temperature, less rainfall and lack of water compared with other parts of the country especially during the long dry season of June to September (Minitere, 2006; Okoola, 2001).

Precipitation patterns in East Africa where Rwanda is located are more variable and historical records indicate that there has been an increase in rainfall over the last century and under intermediate warming scenarios, parts of equatorial East Africa will likely experience 5~20% increased rainfall from December-February and 5~10% decreased rainfall from June-August by 2050 (Hulme et al., 2001; IPCC, 2001). This will have negative impacts on the availability of water resources, food, agricultural security, human health, tourism, coastal development

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Figure 1. Map of Rwanda with major lakes. This map is available online at this link: http://www.un.org/Depts/Cartographic/map/profile/rwanda.pdf.

and biodiversity (Boko et al., 2007). Therefore due to the increasing rainfall during the growing and raining seasons, Pesticides applied to farm fields and roadsides and homeowners' lawns run off into local streams and rivers or drain down into groundwater, contaminating the fresh water that is used for human consumption and also for the life sustenance of the fish living in the Lake Allen and Robert (2001), South Lake Cyohoha is experiencing this situation.

Also due to the population pressure, land degradation, soil erosion, pressure on natural resources, massive deforestation, overgrazing, sewage systems, high concentrations of manure which is stored in open lagoons and eventually sprayed on farmland and in most cases which is more than local fields can absorb, chemical fertilizers that contain "nutrients" such as nitrates, phosphates and potassium, deposition of atmospheric nitrogen (from nitrogen oxides), release of waste in the lake etc, not only facilitated the sedimentation, but also over-stimulated the growth of aquatic plants, such as water jacinth and algae in all parts of the lake and contributed to the pollution of water as well as to to the decrease of water level and the width of South Lake Cyohoha. For this reason a study to determine the concentrations of the following major elements Cr, Mn, Al, N, P, As, Ba, Ca, Cu, Fe, Mg, and K in South Lake Cyohoha, their relationship with seasonal change and that between water level, temperature and rainfall was carried out during the period 2009-2010, because in the surface water, over a certain concentration, some elements may be toxic to humans and other living organisms (Nor, 1987; Timmarmans, 1992; Silva et al., 2000).

MATERIALS AND METHODS

Site description

South Lake Cyohoha (also called Tshohoha South or Lac Cyohoha Sud) is situated 49 km south of the approximate center of Rwanda and 53 km south from the capital Kigali City. It has 100 km^2 areas around, with an approximate population of 1325697 and an average elevation of 1553 m above the sea. The main Rwandan part of that lake is in the district of Bugesera which is one of the seven Districts constituting the Eastern Province of Rwanda. The lake is shared by two neighbor countries Rwanda and Burundi with approximately 630 ha for the Rwandan part (Figures1 and 2). Note that Rwanda is located in the East of Central Africa between 1°04 and 2°51 latitude south, and between 28°45 and 31°15 longitude east, with a surface area of 26,338 km^2. Rwanda has a temperate continental tropical climate (Minitere, 2004).

In the course of the year, in Rwanda, temperatures vary between 16 and 17°C in the high altitude region, between 18 and 21°C in the Central Plateau, and between 20 and 24°C in the lowlands of the East and West. Annual rainfall varies between 700 and 1400 mm in the lowlands of the East and West, between 1200 and 1400 mm in

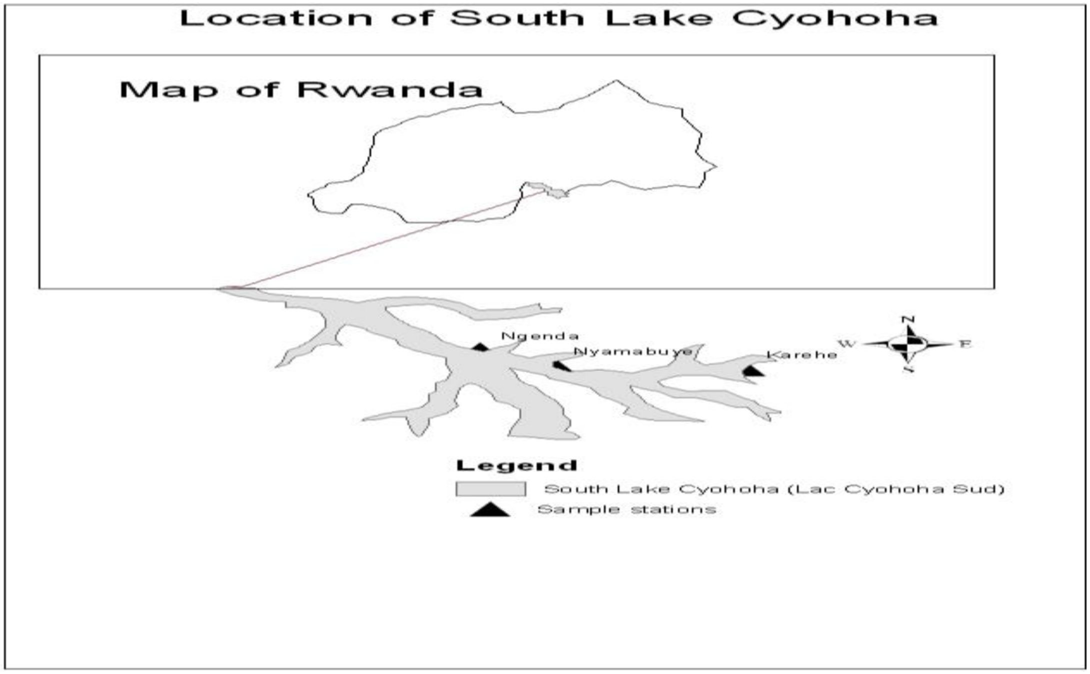

Figure 2. Location of South Lake Cyohoha in the map of Rwanda and sample stations.

the Central Plateau, and between 1400 and 2000 mm in the high altitude region (Minitere, 2002).

Data collection

Three sampling stations Ngenda, Nyamabuye and Karehe were established based on the accessibility, location, and activities carried out in the catchment area. Note that the main activities carried out near the lake are agriculture and fishing with few commercial activities and agricultural industries. Water samples were collected monthly from those stations mentioned above in the period of two years, from January 2009 to December 2010, every time four samples were taken, two at the lake shore and two at the distance of 5 to 10 m from the lake shore, the depth was about 60 cm from the surface water. After collection, water samples were kept in polyethylene bottles with tight sealing caps deemed suitable for collection and storage of samples. There have been much care to prevent cross contamination during sample collection and those bottles were rinsed with demonize-distilled water and sample water before taking the sample. Collected water samples were filtered though Millipore Ap-15 pre-filter and subsequently to 0.45 µm HA Millipore filters and finally they were analyzed through atomic mass spectroscopy (4000 Q TRAP LC/MS/MS, Applied Biosystems, Vernon Hills, Illinois, USA).

Atomic mass spectrometry consists of an ion source, a mass analyzer, and a detector. Atoms' identities are determined by their mass-to-charge ratio (via the mass analyzer) and their concentrations are determined by the number of ions detected (Sparkman, 2006; Jnrgen, 2006). The principle consists of ionizing chemical compounds to generate charged molecules or molecule fragments and measuring their mass-to-charge ratios. First a sample is loaded onto the mass spectrometry instrument, and undergoes vaporization, next the components of the sample are ionized by impacting them with an electron beam, which results in the formation of charged particles (ions), and then ions are separated according to their mass-to-charge ratio in an analyzer by electromagnetic fields. Ions are detected and ion signal is processed into mass spectra.This method has been used in many other studies such as Covey et al. (1986); Sparkman (2000); Harvey et al. (2000); Samecka and Kempers (2001); Filgueiras et al. (2002) and Smichowski et al. (2005).

In addition to the laboratory analysis, there were other field's measurements such as water level change, temperature, pH and electro-conductivity. Electro-conductivity and temperature were measured using a YSI 85D oxygen/temperature/conductivity meter while pH was determined using a hand held pH meter. GIS (arcmap) has been used also to produce the study area map; SPSS and ORIGIN PRO 8.0 were used to determine the relationship between different parameters and to produce the required figures.

RESULTS

Figure 3 illustrates the relationship between water level change and temperature at Ngenda station during the period 2001 to 2010. While Figure 4, depicts the relationship between water level change and precipitation at the same station and the same period. Table 1, presents the concentrations in mg/L of Cr, Mn, Al, N, P, As, Ba, Ca, Cu, Fe, Mg and K at Ngenda station from January 2009 to December 2010. Table 2, presents the concentrations in mg/L of Cr, Mn, Al, N, P, As, Ba, Ca, Cu, Fe, Mg and K at Nyamabuye station from January 2009 to December 2010. Table 3, presents the concentrations in mg/L of Cr, Mn, Al, N, P, As, Ba, Ca, Cu, Fe, Mg and K at Karehe station from January 2009 to December 2010. Table 4, presents the results of water level changes in cm, pH, Electro-conductivity in μ

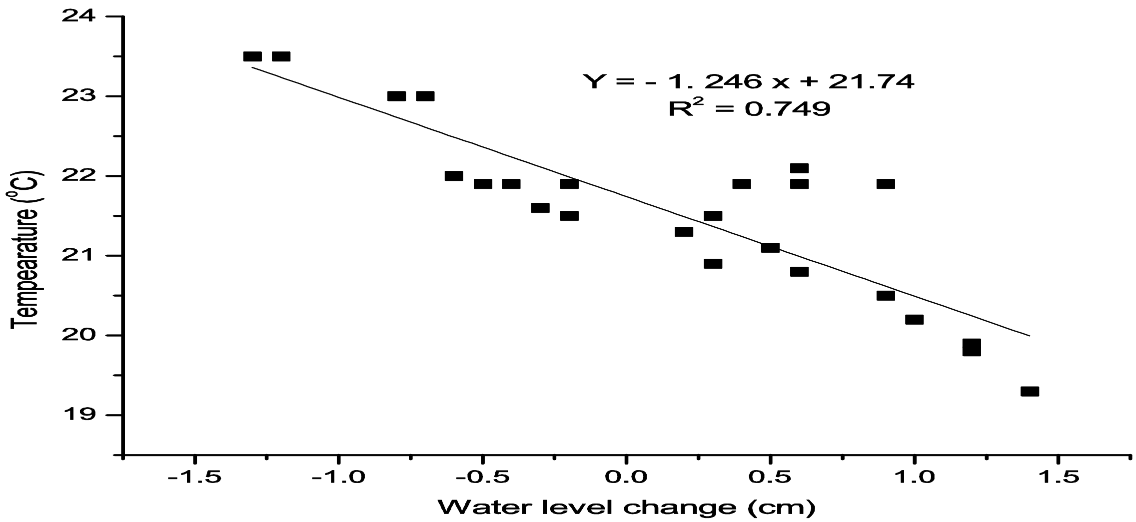

Figure 3. Correlation between water level change and temperature at Ngenda station during the period 2009 to 2010.

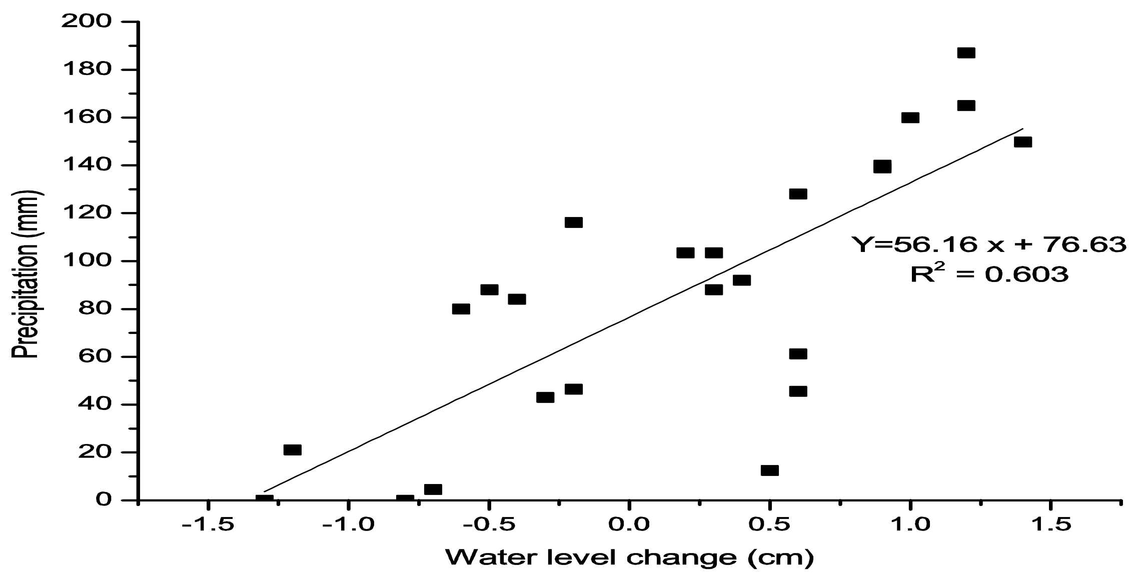

Figure 4. Correlation between water level change and Precipitation at Ngenda station during the period 2009 to 2010.

mho/cm and temperature in (°C), from January 2009 to December 2010 at all sample stations that is, Ngenda, Nyamabuye and Karehe, where WL represents water level change, EC is electro-conductivity and T stands for temperature. Note that for water level change measurement, the level of water on the 01/12/2008 was considered as the starting point or zero cm.

DISCUSSION

The results presented in the Tables 1 to 3 showed that the concentrations of nitrogen, phosphorous, potassium, arsenic Manganese, chromium, aluminum, barium and copper increased during the raining seasons and decreased during the dry seasons. Nitrogen concentration was high during the short raining season of September to October at all stations with the concentration in mg/L which varies between 7.8 and 9.5, while its lowest concentration of 3.7 was obtained at Nyamabuye station during the long dry season that is, August 2009. Phosphorous concentration was high during the two raining seasons April-May and September-October with the concentration in mg/L of 0.8 whereas its

Table 1. Concentrations of major elements at Ngenda station from January 2009 to December 2010.

Months	Cr	Mn	Al	N	P	As	Ba	Ca	Cu	Fe	Mg	K
January	0	0.6	0.3	5.2	0.7	0.04	0.7	50	1	0.8	8.3	5.6
February	0	1.2	0.5	5.4	0.5	0.04	0.8	53	1	0.8	9.1	6
March	0	1.8	0.6	5.7	0.7	0.06	0.7	59	1.2	0.8	10.2	5.9
April	0	2.1	0.6	5.4	0.8	0.07	0.8	43	1.1	0.8	10.2	6.1
May	0	0.8	0.6	5.9	0.8	0.07	0.8	46	1	0.7	10.8	6
June	0	0.8	0.3	5.2	0.6	0.06	0.7	40	1	0.8	11.7	6.2
July	0	0.6	0.2	5.2	0.6	0.06	0.6	38	1	0.7	11.7	6.6
August	0	0.5	0.4	5.7	0.5	0.05	0.6	38	0.7	0.5	9.9	5.5
September	0	1	0.4	9.5	0.8	0.08	0.6	30	0.8	0.5	10.3	9.1
October	0	0.8	0.4	9.5	0.8	0.08	0.6	42	0.8	0.6	11	9
November	0	0.9	0.4	5.2	0.7	0.06	0.7	47	0.9	0.6	11.3	6.3
December	0	0.5	0.3	5.7	0.5	0.05	0.7	45	0.7	0.5	9.1	5.3
January	0	0.7	0.3	5.1	0.5	0.05	0.6	47	0.9	0.6	8.7	5.5
February	0.01	1.1	0.4	5.9	0.7	0.05	0.7	48	1.1	0.6	9.9	6.9
March	0.02	1.5	0.4	5.9	0.7	0.07	0.7	51	1.8	0.6	10.8	7.8
April	0.02	1.9	0.6	5.8	0.8	0.08	0.7	51	1.3	0.7	10.8	7
May	0	1.8	0.6	5.5	0.8	0.08	0.7	50	1.4	0.7	10.9	7.9
June	0	1.4	0.5	5.4	0.7	0.06	0.7	48	1.1	0.7	10	8.1
July	0	1	0.4	5.3	0.6	0.06	0.6	46	1.2	0.7	10.2	6.5
August	0	0.5	0.3	5.4	0.6	0.04	0.6	46	1	0.5	10.1	6.4
September	0	0.9	0.4	8.9	0.8	0.07	0.6	50	1.2	0.5	9.8	8.6
October	0	0.9	0.4	9	0.8	0.07	0.7	50	1.3	0.6	8.9	8.3
November	0	1.3	0.4	5.3	0.5	0.05	0.6	45	0.9	0.6	8.7	6.2
December	0	1.4	0.3	5.2	0.4	0.06	0.6	46	0.7	0.5	8.5	5.2
Mean	0.002	1.1	0.4	6.1	0.7	0.06	0.7	46.2	1.0	0.6	10.0	6.8

Table 2. Concentrations of major elements at Nyamabuye station from January 2009 to December 2010.

Months	Cr	Mn	Al	N	P	As	Ba	Ca	Cu	Fe	Mg	K
January	0	0.5	0.2	5.4	0.5	0.03	0.6	49	1.1	0.5	7.2	5.7
February	0	1.1	0.4	5.2	0.5	0.03	0.9	52	1.1	0.5	8	7.1
March	0	1.7	0.5	5.2	0.7	0.07	0.9	52	1.2	0.5	10.1	8
April	0	2	0.6	5.9	0.7	0.07	0.9	42	1.1	0.6	10.1	8
May	0	0.7	0.5	5.9	0.7	0.06	0.8	45	1.2	0.7	10.7	8
June	0	0.7	0.2	6.2	0.6	0.06	0.8	40	1.1	0.6	11.6	8
July	0	0.6	0.1	5.2	0.6	0.06	0.5	39	1.1	0.7	10.6	7
August	0	0.4	0.1	3.7	0.5	0.04	0.5	36	0.8	0.5	8.9	7
September	0	0.9	0.3	8.9	0.8	0.07	0.6	30	0.9	0.5	11.2	9.2
October	0	0.7	0.2	8.8	0.8	0.07	0.7	42	0.9	0.5	11.9	9
November	0	0.8	0.3	5.9	0.7	0.06	0.8	47	1.1	0.5	10.2	6.4
December	0	0.4	0.1	5.7	0.5	0.04	0.6	44	0.8	0.4	8.9	5.4
January	0	0.8	0.3	5.1	0.5	0.04	0.7	46	1	0.5	7.7	5.7
February	0.02	1.2	0.5	5.9	0.7	0.05	0.8	48	1.2	0.5	8.9	7
March	0.02	1.6	0.6	5.9	0.7	0.06	0.8	51	1.2	0.5	10.7	7.9
April	0.03	2	0.8	6.8	0.8	0.07	0.9	51	1.1	0.6	10.7	8
May	0	1.9	0.9	6.3	0.8	0.07	0.9	50	1.1	0.6	10.5	8
June	0	1.5	0.8	5.1	0.7	0.06	0.8	48	1.2	0.5	10	8.2
July	0	1.1	0.8	5.2	0.6	0.06	0.7	46	1.3	0.6	11.1	6.6
August	0	0.6	0.7	5.1	0.6	0.03	0.5	45	1.1	0.4	9.9	5.5
September	0	1	0.8	8	0.8	0.07	0.5	50	1.3	0.4	8.9	9

Table 2. Contd.

October	0	1	0.7	7.8	0.8	0.07	0.8	50	1.4	0.6	7.8	9
November	0	1.4	0.3	6	0.5	0.04	0.7	44	1	0.6	7.6	6.3
December	0	1.5	0.2	5.2	0.4	0.05	0.5	45	0.8	0.5	7.4	5.3
Mean	0.003	1.1	0.5	6.1	0.7	0.055	0.7	45.4	1.1	0.5	9.6	7.3

Table 3. Concentrations of major elements at Karehe station from January 2009 to December 2010.

Months	Cr	Mn	Al	N	P	As	Ba	Ca	Cu	Fe	Mg	K
January	0	0.7	0.4	5.1	0.7	0.05	0.5	47	1.2	0.6	7.2	5.8
February	0	1.2	0.6	5.9	0.5	0.04	0.7	47	1.3	0.5	7.8	7.4
March	0	1.8	0.7	5.9	0.7	0.05	0.8	47	1.2	0.5	9.9	7
April	0	2.2	0.8	5.6	0.7	0.07	0.8	40	1.1	0.6	10.2	7
May	0	0.9	0.7	5.7	0.7	0.07	0.8	43	1.3	0.6	10.6	7
June	0	0.9	0.2	6.2	0.7	0.06	0.8	38	1.2	0.7	10.5	7.1
July	0	0.8	0.1	5	0.6	0.06	0.5	37	1.2	0.6	9.5	6.7
August	0	0.6	0.1	5.7	0.5	0.04	0.6	35	0.9	0.4	9.8	6.4
September	0	1.1	0.3	8.9	0.8	0.07	0.6	35	0.9	0.5	10.1	9
October	0	0.9	0.2	8.7	0.8	0.07	0.7	40	0.9	0.6	10.8	9
November	0	1	0.3	5.9	0.7	0.06	0.8	45	1.2	0.6	9.2	6.4
December	0.01	0.6	0.1	5.7	0.4	0.05	0.6	42	0.9	0.5	9.8	5.4
January	0.01	1	0.3	5.1	0.5	0.04	0.7	44	1	0.5	9.6	5.7
February	0.02	1.4	0.5	6.9	0.6	0.05	0.7	46	1.3	0.5	9.8	7
March	0.02	1.8	0.6	5.9	0.7	0.06	0.7	49	1.2	0.6	9.9	7.2
April	0.03	2.2	0.6	5.8	0.7	0.07	0.8	49	1.5	0.5	10.8	7
May	0.03	2.1	0.6	5.3	0.8	0.07	0.8	48	1.2	0.6	10.4	7
June	0	1.5	0.6	6.5	0.6	0.06	0.8	46	1.3	0.6	10.1	7
July	0	1.3	0.4	6.2	0.6	0.06	0.7	44	1.4	0.6	10.2	6.5
August	0	0.8	0.3	5.1	0.6	0.03	0.5	42	1.2	0.4	8.7	6
September	0	1.2	0.8	8.7	0.8	0.07	0.9	48	1.4	0.4	7.9	7.7
October	0	1.2	0.3	8.9	0.8	0.07	0.7	48	1.5	0.5	7.9	7.4
November	0	1.6	0.2	5.1	0.5	0.04	0.7	43	1	0.6	8.6	6.3
December	0	1.7	0.2	5	0.4	0.04	0.5	42	0.9	0.5	8.3	5.2
Mean	0.005	1.3	0.4	6.2	0.6	0.056	0.7	43.4	1.2	0.5	9.5	6.8

lowest concentration of 0.4 was found during the short dry season in December. Potassium followed the same pattern as phosphorous but with different concentrations with the lowest concentration in mg/L which vary between 5.2 and 5.4 during the short dry season in December while the highest concentration was between 7.4 and 9.2 during the short raining season of September-October. For arsenic the highest concentration was found during the two raining seasons March-may and September-October with the concentration in mg/L between0.07 to 0.08 while the lowest value of 0.04 was found during the two dry seasons January-February and August. For manganese, the highest concentration in mg/L was between 2 and 2.2 and was obtained during the period April-may whereas its lowest concentration was between 0.4 and 0.5 and was noticed in the period of December-January and August. Aluminum concentration followed the same shape as manganese with high concentration in mg/L of 0.9 during the raining season of May and lowest concentration of 0.1 during the dry seasons of July-August and December. Chromium was almost zero in the lake but even the found little concentration of 0.003 mg/L was obtained during the raining period of April-May. For barium the highest concentration in mg/l of 0.9 was obtained during the long raining season of April-May while the lowest concentration of 0.5 was obtained in both dry seasons that is, June-July and December-January. The highest concentration of copper in mg/L of 1.8 was obtained during the raining season while its lowest concentration was found during the dry seasons in August and December.

Calcium, iron and magnesium showed the opposite or lack of correlation with seasonal change. The highest concentration of calcium in mg/L of 59 was found in

Table 4. The measurements of Water level changes, pH, Electro-conductivity and temperature from January 2009 to December 2010 at Ngenda, Nyamabuye and Karehe stations.

Months	Stations											
	Ngenda				Nyamabuye				Karehe			
	WL	pH	EC	T	WL	pH	EC	T	WL	pH	EC	T
January	-0.5	7	2255	21.9	-0.4	7.3	2260	21.8	-0.5	7.3	2250	21.7
February	-0.2	6.5	2300	21.5	-0.1	6.8	2310	21.5	-0.1	6.7	2310	21.5
March	0.3	6	2380	20.9	0.2	6.4	2390	20.9	0.3	6.6	2390	20.9
April	1.4	5.6	2430	19.3	1.5	5.9	2440	19.3	1.6	5.9	2440	19.5
May	1.2	5.8	2390	19.9	1.1	6.2	2400	20	1.2	6.4	2400	19.8
June	0.5	7	2305	21.1	0.6	7.3	2305	21.1	0.7	7.3	2305	21.1
July	-0.7	7.2	2210	23	-0.8	7.7	2210	23	-0.5	7.7	2210	22.7
August	-1.2	8.4	2200	23.5	-1	8.5	2200	23	-1.3	8.4	2200	22.9
September	0.6	7	2270	21.9	0.8	7.3	2270	21.9	0.9	7.5	2270	21.9
October	0.9	6.4	2290	20.5	1.1	6.6	2300	20.5	1.2	6.6	2320	20.5
November	0.6	6.6	2260	20.8	0.5	6.6	2260	20.8	0.4	6.8	2265	20.8
December	-0.2	6.8	2255	21.9	-0.1	6.8	2258	21.5	-0.2	6.8	2260	21.5
January	-0.6	7.1	2250	22	-0.5	7.3	2250	22	-0.6	7.3	2250	22
February	-0.4	6.7	2356	21.9	-0.3	6.7	2360	21.9	-0.3	6.7	2360	21.9
March	0.2	6.6	2380	21.3	0.2	6.6	2380	21.3	0.2	6.6	2380	21.3
April	1.2	5.9	2425	19.8	1.3	6	2430	20.1	1.4	6.3	2430	20
May	1	6	2390	20.2	0.9	6.3	2390	20.2	0.9	6.3	2390	20.1
June	0.3	7.1	2300	21.5	0.4	7.4	2300	21.5	0.3	7.4	2300	21.5
July	-0.8	7.5	2210	23	-0.8	7.7	2220	23	-0.7	7.7	2220	22.8
August	-1.3	8.5	2205	23.5	-1.2	8.5	2205	23.2	-1.4	8.5	2205	22.9
September	0.6	7.3	2260	22.1	0.7	7.4	2280	22.1	0.7	7.6	2280	21.9
October	0.9	6.6	2280	21.9	1	6.8	2280	21.7	1	6.8	2270	21.7
November	0.4	6.7	2250	21.9	0.4	6.9	2250	21.9	0.5	6.9	2250	21.6
December	-0.3	6.8	2250	21.6	-0.2	7	2255	21.4	-0.3	7.2	2255	21.5
Average	0.16	6.8	2295.9	21.5	0.22	7.0	2300.1	21.5	0.23	7.1	2300.4	21.4

March while its lowest concentration of 30 was obtained in September. Therefore both highest and lowest concentrations were found during the raining seasons. For iron the highest concentration in mg/L of 0.8 was found in both raining and dry seasons that is, January-April and June, the lowest concentration of 0.4 was also found during the raining season and dry season that is, August-September and December. The highest concentration of magnesium was between 11.7 and 11.9 and was obtained during the dry season of June – July and during the raining season in October.

After analyzing and observing the study area, we found that the variations of the concentrations of Nitrogen, phosphorous, potassium, arsenic, manganese, chromium, aluminum, barium and copper are connected with the change of seasons and they increase during the raining seasons and decrease during the dry seasons. The reasons could be the increasing use of fertilizers and pesticides especially in the rice fields near the lake, and other anthropogenic activities such as fishing, grazing with its associated manure, solid wastes, and wastewater or spilling chemical wastes from the dwelling houses and increasing small outlets along the lake etc. Therefore those fertilizers and wastes are carried into the lake by raining water through soil erosion or agricultural runoff. Calcium, iron and magnesium showed the inverse or lack of correlation with seasonal change. The variability of them may be due to natural causes such as the origin of water as South Lake Cyohoha has a large catchment area and gets water from various rivers which means that water has more contact with soil before reaching the lake, physical geology of the lake which is located in the African lift valley, the death of living organisms and other daily human activities etc.

The results of conductivity and pH in all stations presented in the Table 4 also showed the seasonal change effects as the lowest number of pH of 5.6 was obtained during the raining period while the highest of 8.5 was found during the dry season in August. It was the same for conductivity with the highest number in μ mho/cm, of 2430 during the raining season in April and the lowest of 2205 during the dry season in August.

The level of water is also affected by seasonal change as shown by the results presented in the Table 4 and

Figures 3 and 4. Water level increased during the raining seasons with the highest increase in cm of 1.6 observed in April and decreased during the dry seasons with the highest decrease of -1.4 noticed in August. The analysis of correlations revealed that Water level in South Lake Cyohoha increases with the increasing precipitation with the correlation coefficients of 0.603 at Ngenda station, 0.591 at Nyamabuye station and 0.556 at Karehe station; while it decreases as temperature increases with the correlation coefficients of 0.749 at Ngenda station, 0.696 at Nyamabuye station and 0.68 at Karehe station.

CONCLUSION AND RECOMMENDATIONS

This study showed that seasonal change has impact on the concentration variation of aluminum, nitrogen, potassium, arsenic, phosphorous, manganese, chromium, barium and copper in the South Lake Cyohoha. This is mainly due to the anthropogenic activities carried out in the catchment areas of the lake such as farming, grazing, fishing and few but increasing business and industrial activities which cause water pollution through uncontrolled soil erosion and agriculture runoff, by increasing use of fertilizers and pesticides in the fields near the lake, improper disposal of solid wastes, wastewater and spilling chemical wastes which are finally taken into the lake by raining water. Also this study revealed that Calcium, iron and magnesium concentrations vary independently with seasonal change and the reasons could be more physical and geological than anthropogenic. Conductivity and pH confirmed the seasonal effects on the quality of water in the South Lake Cyohoha since the highest number of conductivity was found during the raining season while the smallest was observed during the dry season, for pH the highest number was noticed during the dry season and the lowest during the raining season. The results of water level change also confirmed the seasonal change effects as water level in South Lake Cyohoha increased during the raining seasons and decreased during the dry seasons and the analysis of correlations showed a positive correlation between water level change and precipitation with the mean correlation coefficient of 0.583 and a negative correlation between water level change and temperature with the mean correlation coefficient of 0.708.

There is a requirement to carry out more studies on the causes of the concentration variation of Calcium, iron and magnesium. It is again suggested to study the concentration variation of major elements for a long period and finally we recommend future researchers to study the impact of land use change on the quality and quantity of South Lake Cyohoha and a continuous monitoring of that water as the population and economic activities are increasing in the catchment area.

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REFERENCES

Allen Burton JR, Robert Pitt (2001). Storm water effect handbook: A Toolbox for watershed, scientists and engineers, Lewis Publisher, Washington D.C. USA, P. 15.

Boko MI, Niang A, Nyong C, Vogel A, Githeko M, Medany B, Osman Elasha R, Tabo Yanda P (2007). Climate Change, Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge UK, pp. 433-467.

Covey TR, Lee ED, Henion JD (1986). Mass Spectrometry for the Determination of Drugs in Biological Samples, Anal. Chem. 58(12):2453– \2460, doi: 10.1021/ac00125a022.PMID3789400.

Filgueiras AV, Lavilla I, Bendicho C (2002). Chemical sequential extraction for metal partitioning in environmental solid samples. J. Environ. Monitoring. 4:823-857.

Harvey D, Dwek RA, Rudd PM (2000). Determining the Structure of Glycan Moieties by Mass Spectrometry, Current Protocol in Protein Science Chapter 12:12.7–12.7. 15.doi:10.1002/0471140864.ps1207s43.

Hulme M, Doherty R, Ngara T, New M, Lister D (2001). African climate change: 1900 – 2100. Climate Rese. 17:145-168.

Intergovernmental Panel on Climate Change (2001): Synthesis report. Cambridge University Press, Cambridge, UK.

Jnrgen HG (2006). A textbook of Mass Spectrometry, Springer-Verlag, Berlin Germany. ISBN 3-540-40739-1.

Julian C (2008). Water, the causes, costs, and future of global crisis, ISBN: 9780753517352 Version 1.0, The Random House Group Limited, UK.

Lorber M (2002). A pharmacokinetic model for estimating exposure of Americans to dioxin- like compounds in the past, present, and future. Sci Total Environ 288:81–95.

MINITERE (2002). National Environmental policy, Kigali，Rwanda.

MINITERE (2004). Sectorial policy on water and sanitation, Kigali, Rwanda.

MINITERE (2006). National adaptation programmes of action to climate change, Kigali, Rwanda.

Nor YM (1987). Ecotoxicity of copper to aquatic biota. Environ.res. 43:274-282.

Okoola R (2001). Synoptic systems affecting Eastern Africa, 1999; Marcel Leroux, meteorology and climate of tropical Africa.

Samecka CA, Kempers AJ (2001). Concentration of heavy metals and plant nutrients in water, sediments and aquatic macrophytes of antropogenic lakes (former, open cut brown coal mines) differing in stages of acidification. Total Environ 28:87-98.

Silva EM, Danavarro MFT, Barros AF, Mota MFV, Chastinet CBA (2000). Metals in the sediments of Jaua Lake, Brazil following an episode of industrial Contamination, Aquat. Ecosys. Health manage 3:509-514.

Sparkman OD (2000). Mass spectrometry desk reference. Pittsburgh Global view pub. ISBN 0-9660813-2-3.

Sparkman OD (2006). Mass Spectrometry Desk Reference. Pittsburgh Global View Pub. ISBN 0-9660813-9-0.

Timmarmans KR (1992). Ecotoxicity of trace metals for chironomids, Nethlands, J. Aquat. Ecol. 26:2-4.