Scholars Academic Journal of Biosciences (SAJB)
Abbreviated Key Title: Sch. Acad. J. Biosci.

A Unit of Scholars Academic and Scientific Society, India
www.saspublishers.com

ISSN 2347-9515 (Print)
ISSN 2321-6883 (Online)

Biology

Assessment of Spatial and Seasonal Water Quality Variation in Nyabarongo River Using Physicochemical Parameters

Bagalwa M[1*], Iragibalya BR[2], Shamavu M[3]
[1]Centre de Recherche en Science Naturelles de Lwiro, Bukavu, D. R. Congo
[2]Institut Supérieur Pédagogique de Kalehe, D.R. Congo
[3]Département de Géochimie et Environnement, Observatoire Volcanologique de Goma (OVG), D. R. Congo

Original Research Article

***Corresponding author**
Bagalwa M

Article History
Received: 01.07.2018
Accepted: 06.07.2018
Published:30.08.2018

DOI:
10.36347/sajb.2018.v06i08.001

Abstract: This Paper present to study of the assessment of spatial and seasonal water quality of Nyabarongo using physicochemical parameters. Monthly variation in physicochemical such as water temperature, pH, dissolved oxygen, biological oxygen demand after 5 days incubation, chemical oxygen demand, total phosphorus, soluble reactive phosphorus, total nitrogen, ammonium and nitrate were analyzed for a periods of one year from 1st January 2015 to 31st December 2015 using standards method for water analysis. Low values are recorded at the site of Kabirikarhaba except for pH, DO and COD. All parameters were within the permissible limits for aquatic life. The results indicate that the variations are observed during the year and from site to site.

Keywords: Nyabarongo river; physico-chemical parameters, monthly variation.

INTRODUCTION

Rivers represent the major source of water used for human consumption, culture irrigation, and industrial purposes. Efficient management of these water resources requires information about the river water quality and its variability [1]. The deterioration of river water quality water can result from natural processes and more recently due to anthropogenic activities through the discharge of industrial and domestic wastewater as well as agricultural drainage to the rivers [2, 3]. The wide variety of anthropogenic waste generated in watersheds can make water unsuitable for drinking, cause siltation in rivers, reduce microhabitat diversity and associated biodiversity [4], increase the frequency of waterborne diseases, and diminish aesthetic and recreational values.

The quality of surface water within a region is governed by both natural processes (such as precipitation rate, weathering processes and soil erosion) and anthropogenic effects (such as urban, industrial and agricultural activities and the human exploitation of water resources) [3, 5, 6, 7]. Seasonal variations in both of these anthropogenic and natural processes, affect the quality of river water and lead to different attributes between seasons [8]. These environmental factors such as rainfall, temperature, weathering of rocks, anthropogenic activities plays crucial task in quality of rivers.

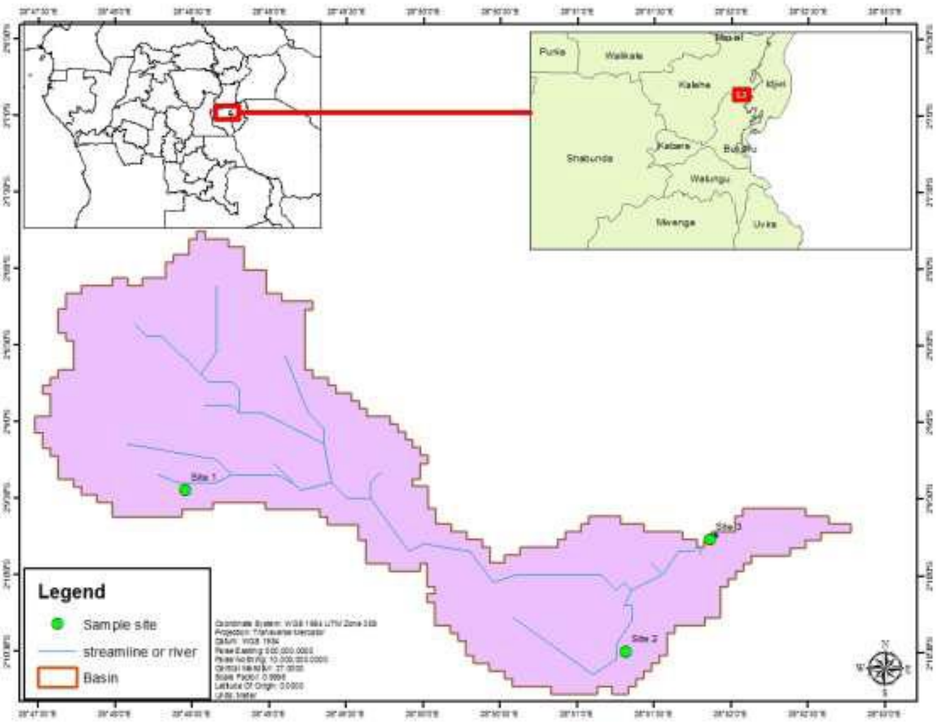
The quality of a river at any point reflects several major influences, including the lithology of the basin, atmospheric inputs, climatic conditions and anthropogenic inputs [9, 10]. The anthropogenic discharges constitute a constant polluting source, whereas surface runoff is a seasonal phenomenon, largely affected by climate within the basin [11-13].

Human activities are a major factor determining the quality of the surface and ground water through atmospheric pollution, effluent discharges, use of agricultural chemicals, eroded soils and land use [14]. These land use changes increase the amount of impervious surface resulting in storm runoff events that negatively affect stream ecosystems and water quality [15].

Several studies have been conducted on different rivers in the Lake Kivu watershed in DR Congo side based on the hydrology and geochemical variations [16, 18]. Nyabarongo River has received fewer studies on their physicochemical characteristics and is a major source of water in the Lake Kivu. Monitoring the river on seasonal basis provides valuable information on the ecohydrological conditions of a river basin [18]. This study evaluates the change in water quality during the year 2015 and the pollution state of the river Cirhanyobowa in an agricultural environment region.

MATERIALS AND METHODS

River Cirhanyobowa is located between Kahehe and Kabare sub-county constituent the admistrative limit of the two sub-counties. The river takes source in Kahuzi Biega National Park (PNKB) at 2000 m of altitude and passes through cultivted and deforested area of L wamisakule, Changulube, Lugohwa,Ntagalylwa, Karunvangoma, Cabwine-Mwami, Ceshero and flows in Lake Kivu in the bay of Kasheke-Irambo at 1465 m of altitude (Figure 1).



Nyabarongo River bank is populated and the water for the river is used by theses population for many anthropogenic activities such as agriculture using for irrigation of sugar cane plantation, water for drinking, washing by animal and human. The Nyabarongo micro-catchment is located in tropical humid climate region with two seasons; the dry season with 3 months (June, July and August) and the wet season with 9 months (September to Mai). The mean temperature varied between 19° and 20°C and with high precipitation of about 1500 mm/year [19].

Three sites were considered for sampling in the main river following the land use characteristics and accessibility during the year. These sites are Kabirikarhaba (02°09'26.6''S; 028°42'27.0''E at 1754 m above mean sea level (AMSL)), Cabwine-Mwami (02°10'29.7''S; 028°51'18.8''E at 1491 m AMSL) and Ceshero (02°09'45.6''S; 028°51'51,4''E at 1471 m AMSL). All the three sampling sites (Kabirikarhaba, Cabwine-Mwami and Ceshero) were sampling the same day from 7pm to 11pm.

Water samples were taken monthly and analyzed for the following parameters: NH_4^+ (µg/L), NO_3^- (µg/L), PO_4^{3-} (µg/L), TN (µg/L), TP (µg/L), Biological Oxygen Demand (BOD_5 mg/L) and Dissolved Oxygen (mg/L). The samples were collected in 1-liter polyethylene (PE) bottles, which were washed with deionized water before use. These sample bottles were sealed and placed in a dark environment at a constant temperature range of 4–10°C to avoid any contamination and the effects of light and temperature. All analyses were done in accordance with national standards [20, 21].

RESULTS AND DISCUSSION

The mean physico-chemical parameters of the three sites in Nyabarongo river is present in the table 1.

All the physico-chemical parameter varied from one site to another. Low values are recorded at the site of Kabirikarhaba except for pH, DO and COD. The high values of TP, SRP, TN, Nitrate and TSS were recorded at the site of Cabwine – Mwami were anthropogenic activities are frequents. But at the outlet at the site of Ceshero these parameters are decreased because of the wetland retained some of these parameters. This observation was also found by Bagalwa [17] in Lwiro river in the same region. Analysis of the data shown that the difference is significative between the three sites. Kabirikarhaba is significative different with the site of Cabwine-Mwami (p= 0,002) and Ceshero (p= 0.007) and also different between Ceshero and Cabwine –Mwami (P= 0.009).

Table-1: Mean physico-chemical parameters of the three sites in Nyabarongo river

Sites	Kabirikarhaba	Cabwine-Mwami	Ceshero
Temperature	16.13	18.15	19.68
pH	7.53	6.82	6.86
DO (mg/L)	4.78	3.19	2.52
BOD_5 (mg/L)	2.37	1.37	1.17
COD (mg/L)	5.44	3.19	3.29
TP (umol/L)	0.13	0.24	0.16
SRP (umol/L)	0.10	0.13	0.11
TN (umol/L)	2.59	3.67	1.17
NH_4^+ (umol/L)	1.00	0.95	1.31
NO_3^- (umol/L)	1.97	1.51	0.62
TSS (mg/L)	0.89	1.85	1.53
Discharge (m^3/s)	0.27	0.62	1.25

Table-1: Correlation between physic-chemical parameters in the three sites of Nyabarongo river

	Temp	pH	DO	BOD5	COD	TP	SRP	TN	NH4+	NO3-	TSS	Discharge
Temp	0											
pH	0.607*	0										
DO	0.805**	0.198	0									
BOD5	0.912***	0.305	0.107	0								
COD	0.778**	0.171	0.027	0.134	0							
TP	0.997***	0.390	0.191	0.085	0.218	0						
SRP	1***	0.393	0.195	0.088	0.222	0.004	0					
TN	0.865***	0.258	0.077	0.047	0.104	0.132	0.135	0				
NH4+	0.946***	0.339	0.141	0.039	0.167	0.051	0.054	0.086	0			
NO3-	0.927***	0.320	0.122	0.020	0.149	0.070	0.073	0.062	0.042	0		
TSS	0.927***	0.321	0.123	0.046	0.149	0.069	0.072	0.075	0.023	0.044	0	
Discharge	0.968***	0.361	0.163	0.059	0.190	0.029	0.032	0.106	0.022	0.063	0.040	0

Legend: *Significant; **Very significant; ***Very high significant

The table below shown that temperature is significant and very significant with others physicochemical parameters analyzed in this study. This is similarly to the results obtained in waste water effluents from textile industrial area of Tirupur, Tamil Nadu, India [22]. The annual results of physicochemical parameters of the three sites in the river Nyabarongo is present in different figures as follows.

Temperature

Temperature is an important ecological factor which influences the chemical, Biochemical and Biological characteristics of water body. The high temperature in the entire river was recorded in April in the site of Ceshero (20^{o}C) and the low temperature was recorded at the site of Kabirikarhaba (15.3^{o}C). The monthly variation of temperature in the three sites during the year 2016 is presented in the figure 2.

Similarly to the others river in the region [17, 19], temperature is low at high altitude near the Kahuzi-Biega National Park and high at the outlet near the Lake Kivu.

Overall observations shows, gradual increase in temperature recorded from the upstream to the downstream as observed by Bhave and Borse[23].

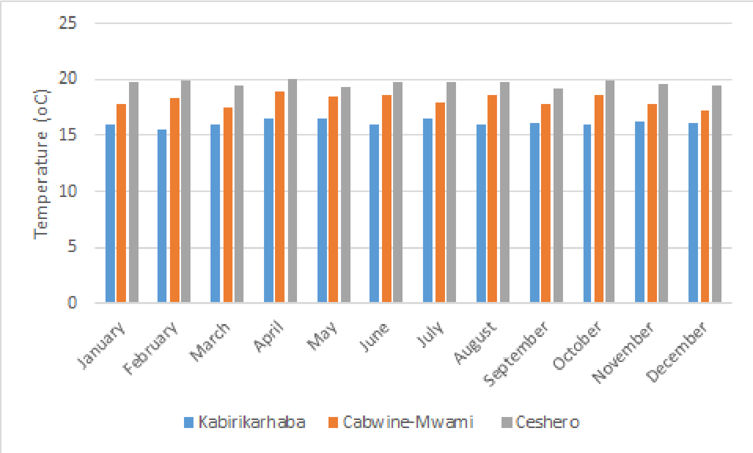


Fig-2: Variation of water temperature in the twee sites during the year in the river Nyabarongo

The figure shows also the same trend in this river. Water temperature controls the rate of all chemical reactions, and affects fish growth, reproduction and immunity. Drastic temperature changes can be fatal to fish.

Temperature also affects the concentration of dissolved oxygen and can influence the activity of bacteria in a water body as well as positively correlated with hardness and phosphate [22].

pH

Monthly fluctuation of pH is present in all three sites of river Nyabarongo during the sampling period in Figure 3.

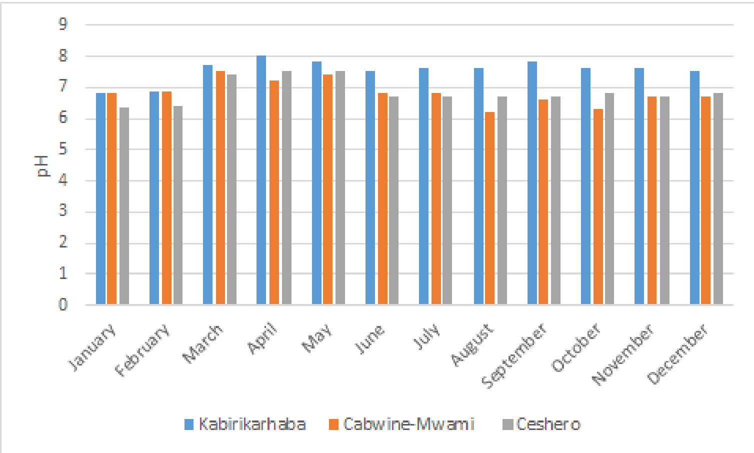


Fig-3: pH variation in tree sites in the river Nyabarongo during the year

Average values ranged between 7.11 and 7.35 (Table no.2). It was noted that pH of water at all sites varied within the same range (6.2 - 8.0) which is between the standard set by the WHO [24] and UNECE [25]. In general, pH values shows, slightly alkaline nature of river water at all the station except in January and February. It is within the limit of drinking purpose and for aquatic biodiversity. Drinking water with a pH between 6.5 to 8.5 is generally considered satisfactory. Mini *et al.* [26] showed similar results Vamanapuram river in India. The high value of pH is due to the deposition of sewage from house near the river and agriculture waste from different farmers. pH value is essential for the growth of aquatic flora [27]. Sirajudeen *et al*. [28]. Thus indicated that the measured pH values of the drinking water samples were within permissible value of WHO; which will not cause any harmful effect to the consumers.

Various factors bring about changes the pH of water. The higher pH values observed suggests that carbon dioxide, carbonate-bicarbonate equilibrium is affected more due to change in physico-chemical condition [29].

Dissolved Oxygen

The analysis of Dissolved Oxygen plays a very important role in water pollution control as well as waste water control. Aquatic ecosystem totally depends on DO, various biochemical changes and its effects affected the metabolic activities of microorganism. Adequate DO is necessary for good water quality, survival of aquatic organism and decomposition of waste by microorganism [30]. The variation of DO in the three sites of the river Nyabarongo is present in the figure 4.

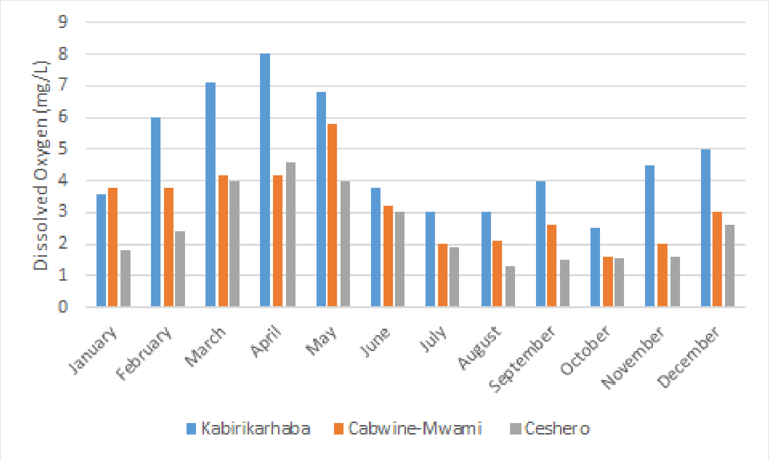


Fig-4: Variation of dissolved oxygen in the tree sites in the river Nyabarongo

High value of DO was recorded at the upstream in April (8 mg/L) and the lowest was recorded at the site downstream in August (1.3 mg/L). In generally, the lowest values of DO were recorded in dry season.

The lower DO indicates the use of various organic chemicals coming in waste water from different houses near the river bank and the residues of agricultural farmers. The decay of organic compounds consumes much oxygen and leads to the decrease in DO level at the downstream. This was also found by Bagalwa *et al*. [19] in Lwiro river. Reduced DO below 4 mg/L impact adversely on all aquatic life and put them under stress. In dry period, intense sunlight during the period seems to accelerate photosynthesis by phytoplankton, utilizing CO_2 and giving off oxygen [31].

Biological Oxygen Demand (BOD_5)

Biochemical Oxygen Demand is important parameters of water. High BOD_5 is harmful to aquatic animals like fish and microorganisms [7]. It also causes bad taste to the drinking water. The variation of BOD_5 in the river Nyabarongo at different sites is present in the figure 5.

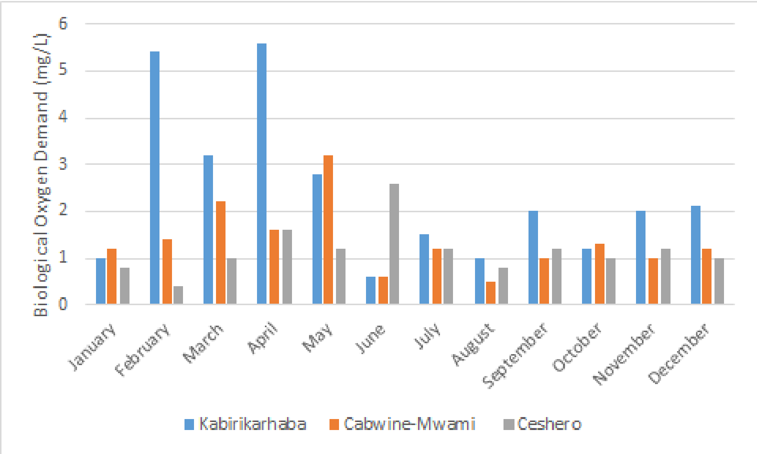


Fig-5: Variation of biological Oxygen demand after 5 days incubation in the 3 sites in river Nyabarongo

BOD_5 is generally low and less than the standard limit (50 mg/L) in all the sites in the river Nyabarongo. Comparatively to others rivers such as the textile effluent from Tirupur, Tamilnadu State, India with 472 mg/l of BOD_5. Low BOD_5 recorded all the year is suitable for fisheries production, recreation and irrigation as found also in Brahmaputra river [30]. If the BOD_5 level is too high, the water could be at risk for further contamination interfering with the treatment process and affecting the end product [32]. BOD_5 was found to be positively correlated to COD.

Chemical Oxygen Demand (COD)

The COD is used to measure pollution of domestic and industrial waste. COD for recorded in the three sites of Nyabarongo River are present in the figure 6.

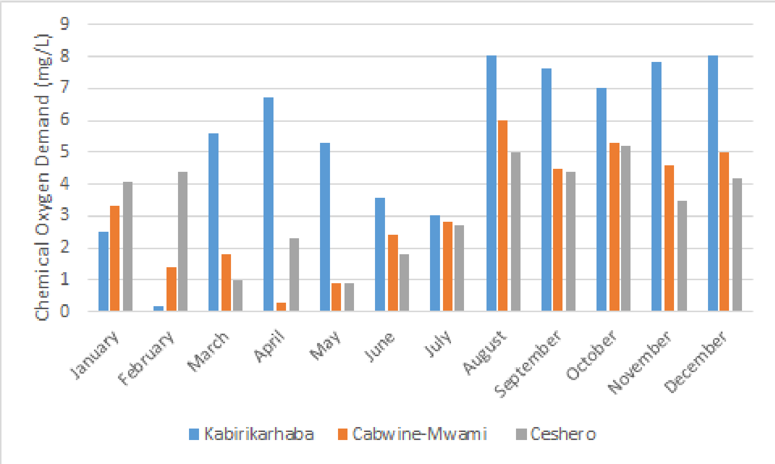


Fig-6: Variation of Chemical Oxygen Demand in the tree sites during the year in river Nyabarongo

The maximum COD in Nyabarongo River was 8 mg/L and the minimum was 0.2 mg/L. These COD values are less than the standard limit (250 mg/l). The higher COD concentration can cause a substantial damage to submersed plants. Like BOD, higher COD is also harmful to all aquatic life [25]. The high COD values compared to BOD_5 values and the non-correlation between them, indicate that the major part of organic material is not biodegradable. All of the above indicate that the COD could be related to the leaching and transport of natural, domestic sewage and agricultural [1].

Total Phosphorus (TP)

TP includes organic and inorganic phosphorus. In surface water, it content is less than 0.1 mg/l. The sources of TP in the water body are discharge of domestic and industrial water and the drainage of agricultural land fertilized. These sources contribute to increase the concentration of TP in the water. TP variation in the three sites in Nyabarongo River is present in the figure 7.

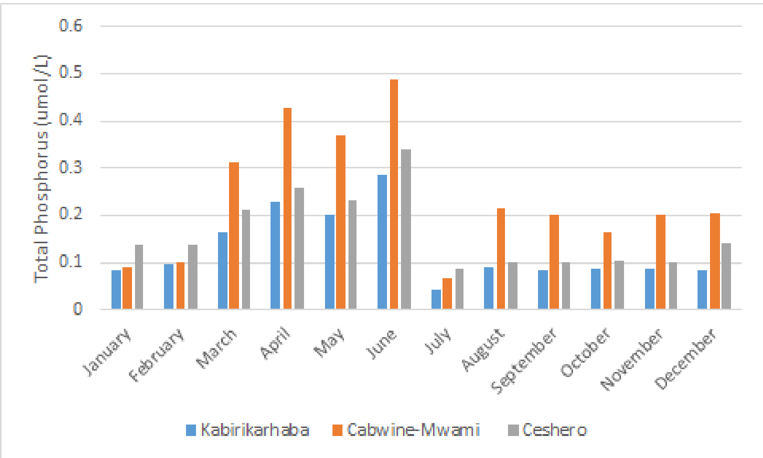


Fig-7: Variation of Total phosphorus in the three sites in river Nyabarongo

TP recorded in the water body of Nyabarongo river shows concentrations varied from 0.044 to 0.487 µmole/l. The high values of TP were recorded in the site of Cabwine-Mwami in March to June. These highest values were recorded in middle stream site. July is the month of low concentration of TP in all the sites in Nyabarongo river. Similar results reported by Arvindkumar [33].

Total Nitrogen (TN)

TN comes from the nitrogen-containing organic material and gas exchange between the water and the atmosphere [34]. It also comes from the biodegradation of waste and inputs from domestic and agricultural. Variation of TN in the different sites in Nyabarongo river is given in the figure 8.

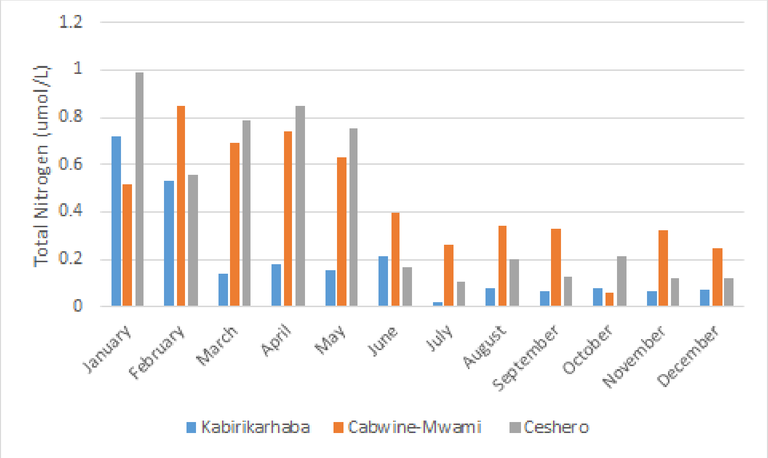


Fig-8: Variation of Total Nitrogen in the three sites in river Nyabarongo

The measured TN values vary between 0.06 and 22.848 µmole/l in the river. The high values were recorded in January in the site of Ceshero will the lowest value is July in the site of Kabirikarhaba.

Total Suspended Solids (TSS)

The sources of TSS can include erosion, industrial discharges, microorganisms, and eutrophication [35]. Erosion of soil remains a great problem for all rivers in DRCongo [17, 19]. Varation of TSS from the different sites in Nyambarongo river is presented in figure 9.

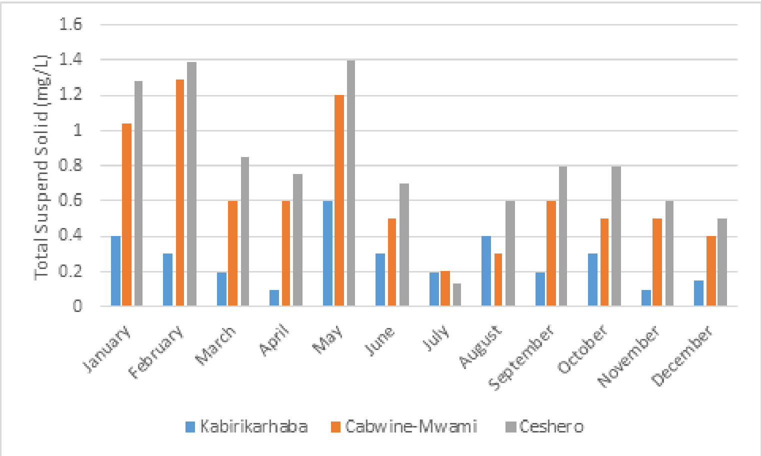


Fig-9: Variation of Total Suspend Solid in the three sites in river Nyabarongo

TSS ranged from 0.1 mg/L to 14 mg/L during the sampling period. The higher concentrations of TSS were observed at the site downstream at Ceshero during the rainy season in May. However, TSS values are under the standard limit of WHO [24] for drinking water and UNECE[25] for the quality of freshwaters for fish life [36].

CONCLUSION

This study addresses the spatial and seasonal variation of physicochemical parameters of Nyabarongo river and the results revealed that the most of the parameters were within the permissible limit of UNECE and WHO standard[37]. The site of Cabwine-mwami are used by population for their daily activities and can be the source of high concentration of some physicochemical parameters especially nutrient and causing various health problems and adversely affect the agriculture and aquatic life downstream.

However, others human activities along the banks of the river are also contribute to increase of pollutant in the river. Necessary initiatives, therefore, should be taken against river bank erosion to improve the overall quality of the water of Nyabarongo river for sustainable management. Moreover, further research and periodic monitoring of river water quality is of importance for the improvement or maintenance of the water of Nyabarongo river.

REFERENCES

1. Barakat A, El Baghdadi M, Rais J, Aghezzaf B, Slassi M. Assessment of spatial and seasonal water quality variation of Oum Er Rbia River (Morocco) using multivariate statistical techniques. International Soil and Water Conservation Research. 2016 Dec 1;4(4):284-92.
2. Carpenter SR, Caraco NF, Correll DL, Howarth RW, Sharpley AN, Smith VH. Nonpoint pollution of surface waters with phosphorus and nitrogen. Ecological applications. 1998 Aug 1;8(3):559-68.
3. Jarvie HP, Whitton BA, Neal C. Nitrogen and phosphorus in east coast British rivers: speciation, sources and biological significance. Science of the Total environment. 1998 Mar 24;210:79-109.
4. Callisto M, Goulart M, Medeiros A, Moreno P, Rosa C. Diversity assessment of benthic macroinvertebrates, yeasts, and microbiological indicators along a longitudinal gradient in Serra do Cipó, Brazil. Brazilian Journal of Biology. 2004 Nov;64(4):743-55.
5. Liao SW, Gau HS, Lai WL, Chen JJ, Lee CG. Identification of pollution of Tapeng Lagoon from neighbouring rivers using multivariate statistical method. Journal of Environmental Management. 2008 Jul 1;88(2):286-92.
6. Mahvi AH, Nouri J, Babaei AA, Nabizadeh R. Agricultural activities impact on groundwater nitrate pollution. International Journal of Environmental Science & Technology. 2005 Mar 1;2(1):41-7.
7. Nouri J, Karbassi AR, Mirkia S. Environmental management of coastal regions in the Caspian Sea. International Journal of Environmental Science & Technology. 2008 Dec 1;5(1):43-52.
8. Vega M, Pardo R, Barrado E, Debán L. Assessment of seasonal and polluting effects on the quality of river water by exploratory data analysis. Water research. 1998 Dec 1;32(12):3581-92.
9. Bricker OP, Jones BF. Main factors affecting the composition of natural waters. Trace elements in Natural Waters; Eds Salbu B. & Steinnes E. 1995:1-20.
10. Shrestha S, Kazama F. Assessment of surface water quality using multivariate statistical techniques: A case study of the Fuji river basin, Japan. Environmental Modelling & Software. 2007 Apr 1;22(4):464-75.
11. Karbassi AR, Nouri J, Ayaz GO. Flocculation of trace metals during mixing of Talar river water with Caspian Seawater. International Journal of Environmental Research. 2007 Jan 1;1(1):66-73.
12. Najafpour S, Alkarkhi AF, Kadir MO, Najafpour GD. Evaluation of Spatial and Temporal Variation in River Water Quality. International Journal of Environmental Research. 2008 Oct 1;2(4).
13. Singh KP, Malik A, Mohan D, Sinha S. Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India)—a case study. Water research. 2004 Nov 1;38(18):3980-92.
14. Niemi GJ, DeVore P, Detenbeck N, Taylor D, Lima A, Pastor J, Yount JD, Naiman RJ. Overview of case studies on recovery of aquatic systems from disturbance. Environmental management. 1990 Sep 1;14(5):571-87.
15. Paul M. J., Meyer J. L., 2001. Streams in the urban landscape. Annu. Rev. Ecol. Syst., 32, 1, 333 - 365.
16. Bagalwa M, Majaliwa JG, Kansiime F, Bashwira S, Tenywa M, Karume K. Sediment and nutrient loads into river Lwiro, in the Lake Kivu basin, Democratic Republic of Congo. International Journal of Biological and Chemical Sciences. 2015;9(3):1678-90.
17. Bagalwa M. The impact of land use on water quality of the Lwiro River, Democratic Republic of Congo, Central Africa. African Journal of Aquatic Science. 2006 Jan 1;31(1):137-43.
18. Kumarasamy P, James RA, Dahms HU, Byeon CW, Ramesh R. Multivariate water quality assessment from the Tamiraparani river basin, Southern India. Environmental earth sciences. 2014 Mar 1;71(5):2441-51.
19. Sayer CA, Máiz-Tomé L, Darwall WR. Freshwater biodiversity in the Lake Victoria Basin: Guidance for species conservation, site protection, climate resilience and sustainable livelihoods.
20. APHA. Standard methods for the examination of water and waste water. 21st edition, American Public Health Association, Washington, DC., USA. 2005.
21. Gotterman HL, Clymo RS, Ohnstad MA. IBP Handbook No. 8, Methods for Physical and Chemical Analysis of fresh waters. Black Well Scientific Publications. 1978.
22. Jayaseelan T, Damodaran R, Mani P. Analysis of physico-chemical properties of waste water effluents from textile industrial area of Tirupur, Tamil Nadu, India. Acta Biomedica Scientia. 2015. 2, 2, 84-89
23. Bhave SK, Borse PV. Seasonal Variation in Temperature, Dissolved Oxygen, pH and Salinity and their Influence on Planktons Inaner River Water, Jalgaon, Maharashtra. Pollution Research. 2001;20(1):79-82.
24. WHO. Guidelines for Drinking Water Quality. WHO: Geneva. 2003.
25. UNECE. Standard Statistical Classification of Surface Freshwater Quality for the Maintenance of Aquatic Life. In *Readings in International Environment Statistics.* United Nations Economic Commission for Europe: United Nations, New York and Geneva. 1994.
26. Mini I, Radhika CG, Devi TG. Hydrological Studies on a Lotic Ecosystem-Vamanapuram River, Thiruvananthapuram, Kerala, South India. Pollution Research. 2003;22(4):617-26.
27. Srinivas P, Huggi MS. Assessment of ground water quality characteristics and water quality index

(WQI) of Bidar city and its industrial area, Karnataka state, India.

28. Sirajudeen J, Manikandan SA, Manivel V. Water quality index of ground water around Ampikapuram area near Uyyakondan channel Tiruchirappalli District, Tamil Nadu, India. Archives of Applied Science Research. 2013;5(3):21-6.
29. Karanth KR. Ground water assessment: development and management. Tata McGraw-Hill Education; 1987.
30. Islam MS, Meghla NT. Investigation on water quality in the Ashulia beel, Dhaka. Bangladesh Journal of Fisheries Research. 2010;14(1-2):55-64.
31. Ahmed M, Krishnamurthy R. Hydrobiological studies of Wohar Reservoir Aurangabad(Maharashtra state) India. Journal of Environmental Biology. 1990;11(3):335-43.
32. Manivasakam N. Physico-chemical examination of water, sewage and industrial effluents. Pragati Prakashan; 1984.
33. Arvindkumar. Some Immunological Aspects of the Fresh water Tropical Wetland of Santhal. Pargana (Bihar) India, J. Envi. Poll. 1995; 2, 3, 137 - 141.
34. Chapman DV, World Health Organization. Water quality assessments: a guide to the use of biota, sediments and water in environmental monitoring. 1996.
35. Bellingham K. Physicochemical parameters of natural waters. Stevens Water Monitoring Systems. Inc.(http 4). 2012.
36. Miho A, Çullaj A, Hasko A, Lazo P, Kupe L, Schanz F, Brandl H, Bachofen R, Baraj B. Environmental state of some rivers of Albanian Adriatic Lowland. Gjendja mjedisore e disa lumenjve të Ultësirës Adriatike Shqiptare. 2005.
37. World Health Organization. Guidelines for drinking-water quality: recommendations. World Health Organization; 2004.
38. Islam MS, Datta T, Ema IJ, Kabir MH, Meghla NT. Investigation of water quality from the Brahmaputra river in Sherpur district. Bangladesh Journal of Scientific Research. 2015 Jun;28(1):35-41.