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Parasitological loads of rivers crossing the city of Bukavu, Democratic Republic of Congo

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ABSTRACT: Assessing the parasite loads in rivers crossing cities is important for identifying the potential risks for humans and livestocks, and for selecting suitable risk reduction measures. The aim of this study was to determine parasite loads in four rivers (Bwindi, Kahwa, Tshula, and Wesha) crossing the city of Bukavu and flowing to the Lake Kivu. For each of the rivers data were collected at points located upstream of the lake embouchure during 2013-2014, and analysed through a modified Bailenger method. Our results showed that all the rivers were characterized by a rather high TDS content, an alkalinity above 7.7 and temperatures above 22°C, on average. Moreover, a diversity of parasites including nematodes, cestodes, protozoa and trematodes, was observed: *Entamoeba coli*, *Ascaris sp.*, *Hymenolepis diminuta*, *Taenia saginata*, *Giardia lamblia*, *Ankylostoma sp., Strongyloides stercoralis, Schistosoma mansoni*, *Entomoeba histolytica*, *Hymenolepis nana*, and *Trichuris trichura.* Nematodes represented the most common parasites in Kahwa, Tshula and Wesha rivers (57% to 71% of species recorded), while cestodes were predominant in Bwindi river (77% of species recorded). Additionally, high parasite loads were observed during the rainy season. The results highlight the health risks to people who use water from these rivers for various needs (bathing, irrigation, dishes, and laundry). The use of the modified method of Bailenger would be of great interest for the characterization of urban waste waters and the promotion of public health because of the simplicity of its implementation and its low cost.

KEYWORDS: Parasite, pollution, river, Bwindi, Kahwa, Tshula, Wesha.

1 INTRODUCTION

Sustainably managing the environment in urban ecosystem is of increasing interest worldwide, specifically in developing countries such as the Democratic Republic of Congo (DRC). In most DRC cities, including Bukavu, rivers play a key role in urban wastewaters discharges due to the lack of wastewaters treatment systems. Important quantities of wastewaters are thus poured into rivers without any treatments, leading to major public health concerns. Reference [7] reported that 90% of the produced raw sewage are discharged into rivers, lakes and coastlines in developing countries. Limited access to basic sanitation systems has important implications for the water resources and the public health in developing countries. Studies of parasitological pollutions (e.g. [6], [21], [9]) included urban wastewaters drained through collectors; a few relating to rivers crossing cities which are used in most cases as outlets of urban waste because of the deficiency of sanitation systems [12].

Bukavu is the capital city of the South-Kivu Province, eastern DRC, with a total population of circa is 800,574 inhabitants, that is 13,343 inhabitants per km^2 (Institut Provincial des Statistiques, 2012). According to the provincial census, 53.5% of the population do not have access to potable, drinkable water, and only 23% of households do use hygienic toilets. The city has faced several infrastructure damages over the years, namely because of landslidings and sudden gully development leading to frequent waterworks and sewerage systems disruptions [13]. Moreover, the potable water production and distribution company in Bukavu is no longer able to face the increasing population needs, and often supplies itself by acquiring water directly from lakes or rivers, despite the existing health risks that could be occurred.

The general aim of this study was to contribute to the health safety of populations in Bukavu, and to reduce the risks associated to the water consumption and use in this city. In this paper the parasite loads of four main rivers (i.e., Bwindi, Kahwa, Tshula, and Wesha) crossing the city of Bukavu and flowing to the Lake Kivu were assessed during the dry and wet seasons. To our knowledge, no study has been carried out to identify and to quantify the microbial parasites within these rivers. The results of such studies should help as a basis for policy decision makers, government health agencies, NGOs, to better tackle major health risks associated to the use/consumption of waters from these rivers in this region.

2 Materials And Methods

2.1 Study Area And Data Collection

The town of Bukavu is separated from Rwanda by the Lake Kivu (1,460 m above sea level) and the Ruzizi river that connects the Lake Kivu to the Lake Tanganyika [18], [19]. All the rivers that cross the town belong mainly to the Lake Kivu basin **(Fig. 1)**.

The geomorphology of the city is characterized by the presence of geological faults due to its position at the intersection of Tanganyika and Albertine trends, giving a typical landscape with plateaus and rift valleys such as Mukukwe and Industrial [17].

The climate is tropical humid and characterized by two seasons, a rainy season from September to May, and a relatively short dry season, from June to August.

Four rivers, i.e. Bwindi, Tshula, Wesha and Kahwa, were selected for the sampling and data collection. For the purpose of the study (to determine the parasite loads that flow into the Lake Kivu) the sampling point at each of the four rivers was established at 100 m upstream the lake embouchure. It was assumed that such areas comprised valuable information on most of pollutants drained into the lake.

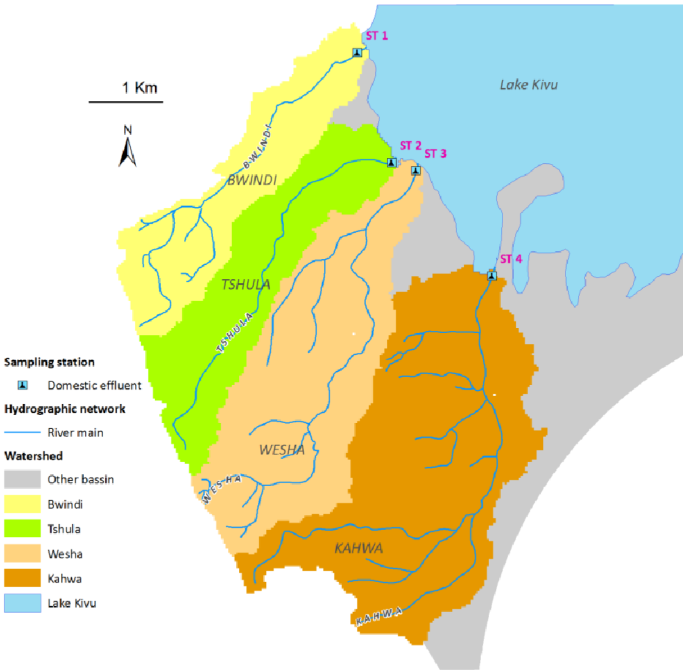


Fig.1. Watershed of the Lake Kivu including the rivers Bwindi, Tshula, Wesha and Kahwa.

The survey was carrying out fortnightly during June 2013 and March 2014 at each sampling point. Water temperatures, conductivity and pH were measured *in situ* before the sampling, using a multi-sensor system (HANNA). Sterile glass recipients (2 l of capacity) were used for collecting the water samples. Then, a formol 10% (2ml l^{-1}) was added and the glass recipients were conserved at 4°C in a thermos flask for laboratory analyses.

2.2 Determining Parasite Concentrations

Because of the wide dispersion of their eggs and/or larva in residual waters, the counting of parasites in water samples may be tedious. The determination of the concentration appears therefore as a suitable and safe way for the counting ([22], [14], [21]), although a "good" concentration depends on factors such as the hydrophilic-lipophilic equilibrium of the parasite and its relative density in comparison to the reagent solution [3], [4]. The Bailenger's technique, recommended by [14], is commonly used to determine the parasite concentration because of its reliability, reproducibility, cheapness, easiness to implement, and its high recovery.

A description of the Bailenger's technique can be summarized as follows: after a 24-hour settlement period, the residue of the collected sample was poured in another vase (or several vases if the residue is very important) and centrifuged for 15 minutes at 1,000 rpm. The new residue was then treated by a buffer aceto-acetic solution (pH 4.5), with an equal proportion volume added/volume of the residue. Then, an ether solution was added (volume proportion equals to the double of the buffer solution volume) and the mixture was agitated during few minutes using a stir plate of Vortex type. A second centrifugation (1,000 revolutions per min) was then performed with the mixture during six minutes. After this last centrifugation, the sample presents three distinct phases. Once the top floating elements were eliminated, the residue was put in suspension in a solution of zinc sulphate at 33% (density = 1.18) in order to allow existing parasites to adhere to the upper surface of the Mac Master slide and to facilitate the counting using a microscope [14].

2.3 Identification Of Existing Parasites

The observation and identification of existing parasites (eggs or free forms) were performed using a binocular microscope. In our study, when the species cannot be correctly identified the genus was kept. Based on the height, form, and content of eggs, a magnification of 10x and 40x was applied [10]. In order to determine the total number of parasite eggs per litre of water, the following formula was used:

$$N = \frac{A \times X}{P \times V}$$

where *N* is the number of eggs per liter of waste water used; *A* is the number of eggs counted on the blade Mac Master ; *X*(ml) refers to the volume of the final product; *P* is the capacity of the blade Mac Master (P = 0.3 ml); and *V* refers to the volume of the initial sample (2 liters in our case).

2.4 Data Analysis

2.4.1 Species Richness

The species richness is an ecological indicator related to the preference of a species for a given biotope or site [8]. It is expressed as the proportion between the number of samples (*Fi*) where the species *i* appears and the total number of samples (*Ft*) for a given biocenotic unity.

$$F = \frac{\left(F_i \times 100\right)}{F_t}$$

According to [8], a species is considered as constant species if it is present in more than 50% of samples (F > 50). It is an accessory species if F ranges from 25 to 50; and it is an accidental species if F< 25.

2.4.2 Sorensen Index

The Sorensen index is used to compare two river waters based on the presence or absence of specimens in their samples. It is expressed as follows:

$$C = \frac{2j}{a+b}$$

where *C* refers to the Sorensen index; *a* and *b* are the number of taxons at stations A and B, respectively; *j* refers to the number of common taxons in the two stations.

A Sorensen index of 0 means absence of similarity, while a value of 1 corresponds to identical sites.

3 Results

3.1 Physicochemical Properties Of The Selected Rivers

The physicochemical properties of the four rivers **(Table 1)** showed the alkaline character of waters (i.e., average pH greater than or equal to 7.7) during the dry season, and a neutral trend (pH = 7.0 on average) during the wet season. Some peaks of alkalinity (pH > 8.5) were however observed during the survey. The pH threshold indicated by WHO [23] for rivers being 8.5, these peaks are of major interest because the sustainability of the river ecosystem could be seriously threatened if such conditions persist. The results are consistent with those found by [11] who report that in dry season (Ivory Coast), the pH can rise locally, around 8 because of the abundance of phytoplankton and photosynthetic activities. Also, the trend of selected river waters would be selected due to intense human activities (mainly discharges from soap units scattered throughout the city) and the influence of basaltic soils of Bukavu.

The mean electrical conductivity ranged from 743.4 µS/cm (Bwindi) to 936.4 µS/cm (Kahwa), indicating a relatively high mineralization of river waters during the survey period. The electrical conductivity in river Kahwa was close to the limit threshold as indicated by [23] (i.e., 1000 µS/cm), which can be detrimental if persisting.

With regards to the temperatures, the average temperatures of river waters at Bukavu ranged from 20°C to and 25°C over the survey period, amply the threshold beyond which a danger can occur in the receiving environment [16].

Table 1. Mean physicochemical properties ± standard deviation of selected rivers in Bukavu

Parameters	Bwindi	Kahwa	Tshula	Wesha
pH (-)	7.7 ± 0.4	8.2 ± 0.4	7.9±0.5	8.0 ± 0.3
Temperature (°C)	21.7 ± 1.5	23.6 ± 0.9	23.3±1.3	22.9 ± 1.3
Conductivity (µS/cm)	743.4± 201.0	936.4±159.1	762.6±130.1	751.3±134.8

3.2 FAMILY AND SPECIES OF EXISTING PARASITES IN THE FOUR RIVERS

The percentage of positive river samples during the survey varied according to the river: 75% for Tshula and Wesha, 65% for Bwindi, and 60% for Kahwa. Likewise, did vary the species and species richness according to the river, the season and the month of survey **(Tables 2 and 3)**.

The main families of parasites recorded include protozoa, nematodes, cestodes, and trematodes. Those families were observed in all the rivers, except the river Bwindi **(Table 2)**. The rainy season was characterized as the period with the relatively highest parasite species observed in all the selected rivers, except the river Kahwa (high occurrence of parasites during the dry season). At least, a parasite species was observed during each of the survey months at all sites, except in November and February for the rivers Kahwa and Wesha (only in February) and in March for Bwindi. The richest river in terms of observed parasites was the river Wesha, where 11 taxons were recorded **(Table 3)**; *Ascaris sp*. was constant (F > 50%), while the other ten species were accidental (F < 25%). In the river Bwindi, four species were isolated**:** *Entamoeba coli, Ascaris sp., Hymenolepis diminuta,* and *Taenia saginata. Ascaris sp., Hymenolepis diminuta* and *Taenia saginata* were accessory species (Table 3), whereas *Entamoeba coli* was an accidental species (F < 25%). No constant species were found during the study period in this river.

Table 2. Occurrence of parasites in the selected rivers crossing Bukavu, Democratic Republic of Congo.

River	Taxa	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Occurrence
Bwindi	***Entamoeba coli***	+	-	-	-	-	-	-	-	-	-	10
	Ascaris sp.	-	-	+	-	+	+	-	-	-	-	30
	Hymenolepis diminuta	-	+	-	-	+	-	-	+	+	-	40
	Taenia saginata	+	-	-	+	-	+	+	-	-	-	40
	Total	***2***	***1***	***1***	***1***	***2***	***2***	***1***	***1***	***1***	***0***	
Kahwa	***Entamoeba coli***	+	-	-	-	-	-	-	-	-	-	10
	Giardia lamblia	-	-	+	-	-	-	-	-	-	-	10
	Ascaris sp.	+	+	+	-	+	-	+	+	-	-	60
	Ancylostoma sp.	-	+	-	-	-	-	-	-	-	-	10
	Strongyloides sp.	+	-	-	-	-	-	-	+	-	-	20
	Hymenolepis diminuta	-	-	+	-	-	-	-	-	-	-	10
	Taenia saginata	-	-	-	-	-	-	-	-	-	+	10
	Schistosoma mansoni	-	-	-	+	-	-	-	-	-	-	10
	Total	***3***	***2***	***3***	***1***	***1***	***0***	***1***	***2***	***0***	***1***	
Tshula	***Entamoeba coli***	-	-	+	-	-	-	-	-	-	-	10
	Entamoeba histolytica	+	-	-	-	-	-	-	-	-	-	10
	Giardia lamblia	-	+	-	-	-	-	-	-	-	-	10
	Ascaris sp.	-	+	+	+	+	+	-	+	+	-	70
	Ankylostoma sp.	-	-	-	-	-	-	+	-	-	-	10
	Strongyloides sp.	-	-	-	-	+	-	-	-	-	-	10
	Hymenolepis nana	-	-	-	+	-	-	-	-	-	-	10
	Taenia saginata	-	-	-	-	-	-	-	-	-	+	10
	Schistosoma mansoni	-	-	-	-	-	-	-	+	-	-	10
	Total	***1***	***2***	***2***	***2***	***2***	***1***	***1***	***2***	***1***	***1***	
Wesha	***Entamoeba coli***	-	-	-	-	-	+	-	-	-	-	10
	Entamoeba histolytica	+	-	-	-	-	-	-	-	-	-	10
	Giardia lamblia	-	-	-	-	+	-	-	-	-	-	10
	Ascaris sp.	+	+	+	-	-	+	+	+	-	-	60
	Ankylostoma sp.	-	-	-	-	-	-	+	-	-	-	10
	Strongyloides sp.	-	-	-	-	-	-	-	-	-	+	10
	Trichuris trichiura	-	+	-	-	-	-	-	-	-	-	10
	Hymenolepis diminuta	-	-	-	-	+	-	-	-	-	-	10
	Hymenolepis nana	-	-	-	+	-	-	-	-	-	-	10
	Taenia saginata	-	-	-	-	-	-	+	-	-	-	10
	Schistosoma mansoni	-	-	+	+	-	-	-	-	-	-	20
	Total	***2***	***2***	***2***	***2***	***2***	***2***	***3***	***1***	***0***	***1***	

The sign '+' ('-') refers to the presence (absence) of the given species.

Table 3: Specific richness of existing parasites in the four selected rivers crossing Bukavu, Democratic Republic of Congo.

	F (%)			
Taxa	**Bwindi**	**Kahwa**	**Tshula**	**Wesha**
Entamoeba coli	10	10	10	10
Entamoeba histolytica	0	0	10	10
Giardia lamblia	0	10	10	10
Ascaris sp.	30	60	70	60
Ankylostoma sp.	0	10	10	10
Strongyloides sp.	0	20	10	10
Trichuris trichiura	0	0	0	10
Hymenolepis diminuta	40	10	0	10
Hymenolepis nana	0	0	10	10
Taenia saginata	40	10	10	10
Schistosoma mansoni	0	10	10	20

Furthermore, the rivers Kahwa and Tshula showed similar trends: eight and nine species were recorded, respectively **(Tables 2 and 3)**, with *Ascaris sp*. being a constant species in both rivers, and the other species (i.e., *Entamoeba coli*, *Giardia lamblia*, *Ankylostoma sp*., *Strongyloides sp*., *Hymenolepis diminuta*, *Taenia saginata*, and*Schistosoma mansoni*) being accidental.

3.3 CONCENTRATIONS OF PARASITES IN THE SELECTED RIVERS

Overall, the number of parasite eggs collected during the survey period was 139.9, 292.9, 171.6, and 207.7 at Bwindi, Kahwa, Thsula and Wesha, respectively. The mean concentration of parasites for each of the four rivers and by parasite group is shown in **Table 4**. The nematodes eggs were predominant at Kahwa, Tshula and Wesha (percentage of eggs per liter greater than 57% on average), whereas the cestodes eggs were dominant at Bwindi (percentage of eggs per liter equals 77%). No trematodes eggs were observed at Bwindi.

Table 4: Mean parasite concentrations in the selected rivers at Bukavu during June 2013 to March 2014. The concentration was calculated on the basis of the total count over the study period (both rainy and dry seasons included).

		Bwindi	Kahwa	Tshula	Wesha
	Total eggs	***139.9***	***292.9***	***171.6***	***207.7***
	Species	**Eggs/liter**			
Protozoa	***Entamoeba coli***	0.42	0.55	0.38	0.54
	E. histolytica	-	-	0.5	0.42
	G. lamblia	-	0.42	0.34	0.63
	Percentage(%)	***5.9***	***6.6***	***14.1***	***15.2***
Nematodes	***Ascaris sp.***	1.21	7.81	3.88	3.88
	Ankylostoma sp.	-	0.79	0.79	0.92
	Strongyloides sp.	-	1.92	0.63	0.71
	T. trichiura	-	-	-	0.41
	Percentage (%)	***17.2***	***71.8***	***61.7***	***56.9***
Cestodes	***H. diminuta***	2.13	1.54	-	0.59
	H. nana	-	-	0.54	0.38
	T. saginata	3.25	0.84	0.88	0.71
	Percentage (%)	***76.9***	***16.2***	***16.5***	***16.0***
Trematodes	***S. mansoni***	-	0.79	0.67	1.21
	Percentage (%)	**-**	***5.4***	***7.8***	***11.7***

Not surprisingly, the mean higher concentration of parasite eggs occurred during the wet (rainy) season at all sites, except Kahwa **(Fig. 2)**.

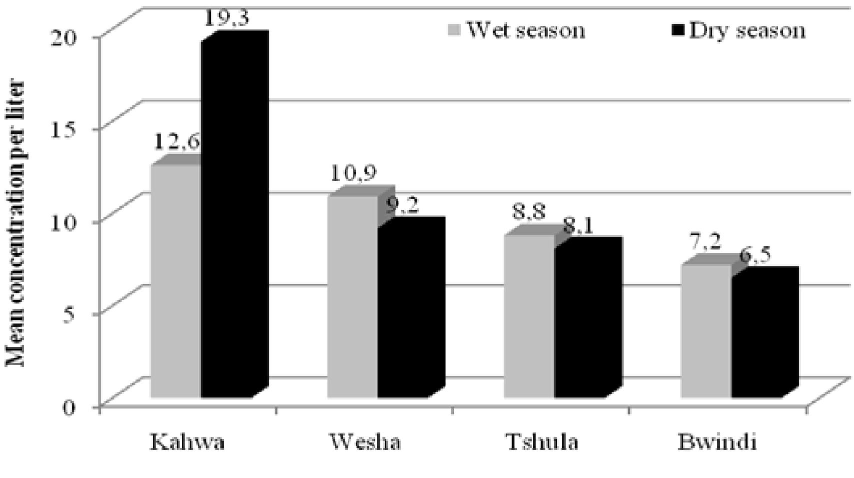
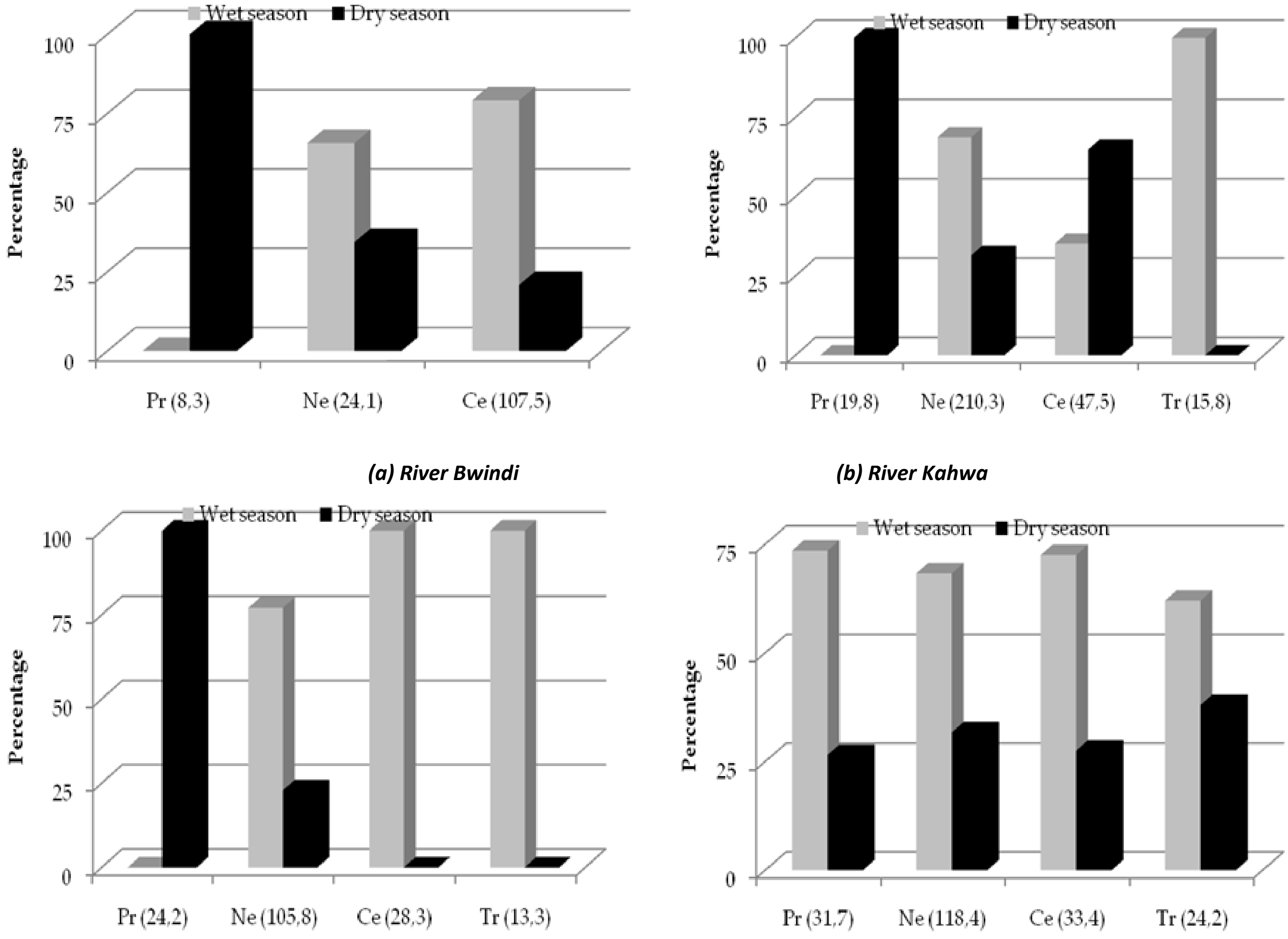


Fig. 2. Mean concentration in eggs per liter according to the season

The repartition according to the parasite group is depicted in **Figure 3**. Protozoa were found mainly during the dry season at Bwindi, Kahwa and Tshula.



(a) River Bwindi ***(b) River Kahwa***

(c) River Tshula ***(d) River Wesha***

Fig. 3. Repartition (%) of parasite eggs concentrations according to the parasite group and the seasons at the selected rivers, Bukavu. Pr: protozoa; Ne: nematodes; Ce: cestodes; Tr: trematodes.

Although nematodes, cestodes and trematodes eggs were observed both in dry and wet seasons at all sites (no trematodes eggs observed at Bwindi), a predominance of eggs from the two latter groups was noted during the wet season at Tshula (percentage of eggs > 75%, **Fig. 3c**). The river Kahwa was, however, characterized by the dominance of trematodes eggs during this wet season.

3.4 Inter-Comparison Of The Selected Rivers

The degree of similarity between two rivers was assessed through the Sorensen index. The similarity was very strong between Kahwa, Tshula and Wesha (C greater than or equal to 0.8), moderately strong between Bwindi and Kahwa (0.66), relatively poor between Bwindi and Wesha (0.53) and poor between Bwindi and Tshula **(Table 5)**.That might be explained by the surrounding environment of the rivers: Kahwa, Tshula and Wesha are affected by domestic wastewaters discharges, while Bwindi is affected by livestock production systems.

Table 5. Similarity (Sorensen index) between selected rivers

	Bwindi	Kahwa	Tshula	Wesha
Bwindi	1			
Kahwa	0.66	1		
Tshula	0.46	0.82	1	
Wesha	0.53	0.84	0.80	1

4 DISCUSSION

The characterization of parasitological contents is crucial for several reasons including the increasing public awareness concerning environmental pollution (water quality, ecosystem sustainability, climate change impacts, etc.), health risks associated to such pollutions, and the availability of reliable data for planification purposes. In our study, a survey was performed at selected rivers (i.e., Bwindi, Kahwa, Tshula and Wesha) crossing the city of Bukavu, DRC, during the 2013-2014 period in order to determine the parasitological loads. Four parasite groups were observed in the rivers, with nematodes being predominant in rivers Kahwa, Tshula and Wesha waters, and cestodes in river Bwindi waters. This repartition was related to the nature of waters discharged in those rivers while crossing the city. Indeed, waters that are discharged in Kahwa, Tshula and Wesha are notably influenced by the living conditions of populations around (i.e., high population density leading to high volumes of domestic wastewaters). Whereas the main sources of discharged waters in river Bwindi are from agricultural activities (low residual domestic waters discharged, extensive livestock production systems in neighbouring places). Among the four parasite groups, nematodes eggs are the most resistant against unstable and sometimes hostile physicochemical environments ([2], [4], [20], [21]). They also have a direct transmission mode. The culinary habits in the region of Bukavu, which are based on the consumption of well-cooked meals and a few fresh (uncooked) foods, might explain the low percentages of other parasite groups, namely the cestodes, in rivers Kahwa, Wesha and Tshula. However, the diversity of species found in the two latter rivers (Wesha and Tshula) can be associated to the high density of households in drained areas, and thereby the diversity of domestic wastewaters produced. Human activities such gravel extraction for building purposes or industry-related wastewaters (soap factory, printing houses, etc.) may also impact the diversity and lead to a weak diversity of species. This is true for rivers Kahwa and Bwindi, where a low diversity was recorded.

A comparison with the number of taxons reported in studies involving some sites located in North- and Sub-Sahara African countries ([3], [15], [21]) reveals that the number recorder during our survey at Bukavu. References [15] and [21] reported seven and 10 taxons, respectively, in waters collected in the basin of Sebou, Kenitra, and at SidiYahia of Gharb, Morocco. Reference [6] reported 10 taxons in their study in Ivory Coast. This diversity of parasites may lead to different human diseases through direct or indirect transmission of parasites (e.g. ascaridiasis, helminthiasis, etc.), and threatens therefore a sustainable development of affected populations if efficient policies and measures to reduce the parasite loads are not undertaken.

The mean concentrations of parasites (in eggs/l) were 7 (Bwindi), 14.6 (kahwa), 8.6 (Tshula) and 10.4 (Wesha). Reference [21] had found mean concentrations of 22.11 eggs/l and 36.05 eggs/l respectively in two collectors in Moroco. We think that this difference is due to the dilution for our studies have been concerning the water of the rivers mixt with domestic waters whereas the studies of [21] have been based directly on residual urban waters poured in collectors.

The parasite concentration in the selected rivers at Bukavu depended upon the crossing direction of rivers. The highest parasite concentration was observed in river Kahwa waters. This river crosses the most densely populated places of the city and its suburbs, and drains therefore more volume of residual waters, compared to the other rivers. References [4] and [21] noted similar trends in their respective studies. High parasite concentrations in urban wastewaters are related to the demographic factor. Despite the constant presence of parasite eggs during the survey, parasite concentrations did vary according to the season. In fact, the rainy season showed higher concentrations than in the dry season: 7.2 against 6.5 eggs/l (Bwindi), 8.8 against 8.1 eggs/l (Tshula) and 10.9 against 9.2 eggs/l (Wesha), whereas Kahwa river had 12.6 against 19.3 eggs/l.

Given climate conditions in equatorial regions (e.g., relatively constant air temperatures above 22°C, high relative humidity, good oxygenation conditions) seem optimal for the growth of parasites throughout the whole year, the predominance of parasite concentrations in river waters during the rainy season might rely on the presence of small basins of black water retention (and regularly fed in this period) in many households in our study region. However, the river flow during the rainy season may negatively impact the parasite concentration. This was the case of Kahwa where the average parasite concentration in dry season was 19.3 eggs/l, compared to 12.6 eggs/l in rainy season. Within the other rivers, small changes were observed for the average parasite concentration during the two seasons (Figure 1). This trend support the conclusions of Kouam (2013) who found large concentrations of parasites in dry season (26.5 eggs/l) compared with that of the wet season in the river Abiergue, Cameroon.

In our study, the peak values of parasite concentrations (i.e., 58.3, 28.3, 17.5 and 20.8 eggs/l in rivers Kahwa, Wesha, Tshula and Bwindi, respectively) preceded the end-of-the-year period and/or associated social events and parties (Christmas, New year's day). This was also true for the Easter period. Indeed in periods preceding such events, people are keen to carry out short-term jobs in order to make money. The favouring weather conditions (readily available water due to the rainy seasons) lead thus to many sewage disposals, as well as the discharges of different kind of wastes into the rivers that cross the city. Jobs in the building sector also gain in popularity during these periods.

5 CONCLUSION

A survey was performed during the 2013-2014 period at Bukavu, Democratic Republic of the Congo, in order to assess the parasitological loads in four selected rivers crossing the city. Our analysis shows that 11 species, including *Entamoeba coli*, *Ascaris sp*., *Hymenolepis diminuta*, *Taenia saginata*, *Giardia lamblia*, *Ankylostoma sp., Strongyloides stercoralis, Schistosoma mansoni*, *Entomoeba histolytica*, *Hymenolepis nana*, and *Trichuris trichura*, and belonging to four main parasite groups (cestodes, nematodes, protozoa and trematodes) were found. The parasitological loads reveal that nematodes were dominant within the rivers Kahwa, Wesha and Tshula, while cestodes were dominant within the river Bwindi. Although the parasites were prolific during all seasons in all the selected river waters, most of the protozoa were found during the dry season. The average parasitological loads of each the four rivers represent a major risk for the river side populations (noticeable parasitological and chemical contamination, and thereby not indicated for human consumption) and may alter the water quality in Lake Kivu as they all flow into this lake. On-site domestic and/or a regional sanitation network systems need to be developed in order to lessen and avoid the health and ecological risks associated with the discharges of untreated wastewaters in rivers.

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