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Use of zooplankton to diagnose the ecological quality of the waters of the Banco River (South-East of Ivory Coast).

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Abstract

The aim of this study was to evaluate the ecological quality of the Banco River water through the zooplankton community. Sampling took place monthly from July 2020 to June 2021 at four defined points on the Banco River. The diversity of releases led to the selection of these sampling stations. The analysis of environmental parameters was conducted in accordance with ISO standards. A 20 µm void plankton net was used to collect the zooplankton. A total of 49 zooplankton species were recorded, including 36 rotifers, 8 cladocerans, and 5 copepods. Rotifers represented the most abundant group, accounting for 73.46% of the total abundance. Station B1 had the highest taxonomic richness with 46 taxa. Stations B2 and B3 were virtually identical, each with 42 taxa. Station B4 recorded the lowest taxonomic richness with 34 taxa. The Cladoceros/Rotifer index showed that station B4 is the least disturbed by human activities, while stations B1, B2, and B3 are heavily disturbed. Based on these results, water pollution control measures are a priority for the long-term protection of this aquatic ecosystem.

Keywords: Zooplankton, Banco River, Water Quality, Eutrophication, Côte D'Ivoire

INTRODUCTION

Rapid urbanization and industrialization in cities lead to a large production of solid and liquid waste. Domestic and industrial waste is discharged into aquatic ecosystems without prior treatment (Hounkpè et al., 2017) in most developing countries. The influx of effluents into aquatic environments exerts considerable pressure on these ecosystems. This pressure results in a degradation of water quality and the habitats upon which aquatic life depends. According to Owa (2013), these activities thus alter the composition of biological

communities present in waterways, generally by reducing the biological diversity of the aquatic ecosystem. For decades, zooplankton has constituted an important energy resource in aquatic environments for fish and other organisms at higher trophic levels (Aka et al., 2010). Furthermore, zooplankton organisms are also a good indicator of water quality in the global context of eutrophication of aquatic environments attributable to rapid urbanization and industrialization on the one hand, and the use of pesticides in agro-industrial operations on the other (Brito et al., 2011). Zooplankton therefore plays an important role in the functioning of aquatic ecosystems. Indeed, knowledge of the distribution and structure of zooplankton communities is important not only for monitoring the quality of watercourses but also for understanding energy transfer in aquatic ecosystems.

In Côte d'Ivoire, several studies on zooplankton have been carried out. These studies were conducted in various basins and watercourses, namely the agro-pastoral reservoirs in the Korhogo, Ferkessédougou and Ouangolo areas. (Aka et al., 2000), the Bia and Agnéby rivers (Ouattara et al., 2007), the Comoé river basin (Yao et al., 2015), the Bagoé river (N'da et al., 2015), the Ehania, Boulo 1 and 2 and Bodoua coastal rivers (Monney, 2017), the Hana River in Tai National Park (Diomandé et al., 2018) etc. However, our knowledge remains limited, as none of these previous studies conducted in Côte d'Ivoire have highlighted the dynamics of the zooplankton community in the Banco River. It is therefore important to inventory the zooplankton species in order to characterize the structure of their assemblage in such a context of high anthropogenic pressure, in order to assess the ecological status of this river. The objective of this study is to evaluate the water quality of the Banco River, located in the heart of Banco National Park, in the center of Abidjan.

METHODOLOGY

Description of sampling stations:

The Banco River is a waterway covering a basin of 56 km² (Mangoua et al., 2009). This river originates at the foot of a plateau on the northern edge of the park, flows for 9 km before emptying south into the Ebrié Lagoon at Banco Bay (Lauginie, 2007). Low water

levels caused by dry periods are almost nonexistent in this watercourse. Its flow rate always exceeds 1.35 m³/s, and significant flooding is frequently observed during the main rainy season (Kouamé, 2009). Cdi Park is located between 5°21' and 5°25' N, and 4°01' and 4°05' W in southern Côte d'Ivoire, specifically in the city of Abidjan. Its catchment area covers 3,474 hectares. The park is bordered to the northeast ¹ by the municipality of Abobo, to the southeast by the municipality of Adjamé, and to the west by the municipality of Yopougon. Taking into account accessibility, the upstream-downstream gradient, and the influence of human activities, four (4) sampling stations were selected (Fig 1).

Fig 1: Location of the different sampling stations on the Banco River (B1 to B4)

Analysis of physicochemical parameters

Environmental parameters such as chemical oxygen demand (COD) and biochemical oxygen demand (BOD₅) were determined using APHA:1905 and AFNOR:1926 methods (Buhungu et al., 2018). Ammonium, nitrate, nitrite, and total phosphorus concentrations were assessed photometrically using the Palin Test DR 7500 photometer with pre-dosed reagents.

Sampling, observation and identification of the zooplankton population

The sampling strategy adopted in this study aimed to cover all climatic seasons in the Abidjan district. Eleven sampling campaigns were conducted between July 2020 and June 2021, from 9:00 AM to 2:00 PM, excluding October. Four 10-liter buckets (for a total volume of 40 liters) were collected from the upstream environment and filtered through a 20 µm mesh plankton net. The resulting concentrate was collected in a 120 ml vial.

Organisms were stained with Lugol's iodine and then fixed with 5% formaldehyde. In the laboratory, taxa were observed under a CARL ZEISS optical microscope (40x, 60x, and 100x objectives). Taxon identification was performed using various keys according to the different zooplankton groups. Thus, for Rotifers, the keys of Pontin (1978), Voigt & Koste (1978) and Pourriot (1980) were used. The keys of Rey & Saint-Jean (1980), Idris (1983) and Korinèk (1999) were used for the identification of Cladocera, while Copepods were

identified using the key of Dussart (1980).

Data analysis

The structure index, like the Shannon and Weaver species diversity index (H), was calculated using the Sanaa formula (2006) to determine the structure of the zooplankton community. The Cladoceran/Rotiferan (C/R) index (proposed by Viroux, 2002; Bouazzara et al., 2022; Bansode & Pawar, 2023; and Gavrilko et al., 2024) was used to assess the ecological status of the Banco River. This index is used in ecology to assess the trophic status of aquatic environments (El Batoul et al., 2023). The Cladoceran/Rotiferan (C/R) ratio is calculated using the following formula:

With N C: Total number of Cladocerans observed

N R: Total number of Rotifers observed

Zooplankton density (D), or the number of organisms per unit volume, was calculated using the formula used by Agadjihouede et al. (2010):

With n = number of individuals counted,

v 1 = volume of the filtrate taken (50 mL),

v 2 = volume of concentrated filtrate (100 mL),

v 3 = volume of filtered water (10 L).

The key of Dajoz (2000) was used to classify the species: constant species ($FO \geq 50\%$), accessory species ($25\% < FO < 50\%$) and accidental species ($FO \leq 25\%$).

Kruskal -Wallis and Mann-Whitney tests were used to assess the significance of the variations in the different parameters. These tests were chosen after verifying the normality tests by the test Shapiro normality. The Kruskal Wallis test was used to test the significance of the variation in parameters between different sampling stations and between different seasons. The significance of the results was assessed using the probability value p. When $p < 0.05$, the parameter being studied does not show

significant variation. If $p < 0.05$, there is a significant difference, and the analysis continues with the Mann-Whitney test to determine the extent of this difference.

The CANOCO program was used to establish the correlation between the distribution of taxa and the physicochemical parameters measured in each sampling site through a redundancy analysis (RDA).

These tests were performed using R software version 3.5.2.

RESULTS

Physical and chemical characteristics

Table 1 presents the spatial and seasonal variation of the physical and chemical parameters of the water measured in situ in the Banco River.

Recorded temperature values fluctuated from 24.93°C to 27.37°C at station B4 during the main rainy season (MRS) and at station B1 during the main dry season (MSS), respectively. Statistical analysis revealed no significant difference between the seasons and stations (Kruskal -Wallis test, $p > 0.05$).

High (13.29 mg/L) and low (2.17 mg/L) dissolved oxygen values were observed at stations B1 and B4, respectively, during the short rainy season (SRS). Dissolved oxygen in the Banco River showed significant variations between seasons and between stations (Mann-Whitney test; $p < 0.05$).

Minimum turbidity values (9.29 NTU) were observed at station B4 during the major rainy season (GSP), while maximum values (243.5 NTU) were recorded at station B1, also during the minor rainy season.

These turbidity values show significant variations from one season to another and from one station to another (Mann-Whitney test; $p < 0.05$).

Nitrate levels in the Banco River waters ranged from 6.40 to 13.88 mg/l at stations B4 and B1 respectively during the main rainy season (GSP). COD levels varied from 4.03 mgO₂ / L to 27.21 mgO₂ / L. The highest value was recorded at station B3 during the short rainy season (SRS), while the lowest value was recorded at station B1 during the long dry season (LDS). Regarding BOD₅ values, they ranged from 2.05 mgO₂ / L to 7.75 mgO₂ /L.

The lowest values were recorded at station B4 during the long dry season (LDS), while the highest value was obtained at station B3 during the short rainy season (LDS).

Table

Table 1: Spatial and seasonal variations of the physical and chemical parameters of the Banco River waters. B1-B4: Sampling stations; T: temperature; O2: Dissolved Oxygen; Turb: turbidity; BOD5: 5-day Biochemical Oxygen Demand; COD: Chemical Oxygen Demand; GSS: major dry season; GSP: major rainy season; PSS: minor dry season; PSP: minor rainy season;

Stations

Seasons

T

(°C)

O2

(mg /L)

Turb

(NTU)

Nitra (mg/L)

BOD5

(mgO2 /L)

DCO

(mgO2 /L)

B1

GSS

27.37

3.34

48.40

5.35

2.65

5.11

GPS

26.40

3.69

154.10

13.88

5.22

10.98

PSS

25.74

7.06

50.60

8.80

3.70

5.55

PSP

26.63

13.29

243.50

6.25

2.55

4.03

B2

GSS

25.27

3.49

65.15

7.10

3.00

9.30

GPS

25.98

4.26

63.29

10.84

4.10

10.32

PSS

25.95

6.18

48.20

8.95

6.90

10.65

PSP

25.39

2.56

103.25

10.40

5.00

11.94

B3

GSS

25.68

3.14

62.15

14.10

4.75

15.15

GPS

25.69

3.64

40.32

10.22

4.54

12.26

PSS

25.81

7.46

41.20

16.30

7.65

8.95

PSP

25.58

2.58

84.65

12.35

7.75

27.21

B4

GSS

26.14

3.64

12.00

7.90

2.05

5.66

GPS

24.93

4.00

9.29

6.40

4.06

10.40

PSS

25.53

5.11

10.99

6.90

3.95

8.80

PSP

25.80

2.17

13.57

7.25

3.95

6.99

Qualitative analysis of the zooplankton population:

A total of 49 zooplankton taxa were recorded at the four stations along the Banco River. This community comprises 36 rotifers, 8 cladocerans, and 5 copepods, belonging to 18 families and 21 genera (Table II). Rotifers, with 36 taxa (73.46%), are the most diverse group in the community, followed by cladocerans with 8 taxa (16.32%) and copepods with 5 taxa (10.20%). The rotifer group is the most diverse in this study, containing 10 families, including Asplanchnidae, Brachionidae, Euchlanidae, Hydrachindiae, Gastropodidae, Lecanidae, Lepadellidae, Synchaetidae, Trichocercidae, and Trochosphaeridae. Among these families are the Brachionidae families with 10 taxa (*Brachionus* *bidentatus*, *Brachionus* *patulus*, *Brachionus* *quadridentatus*, *Keratella* *cochlearis*, *Keratella* *lenzi*, *Notholca* *labis*, *Notholca* *sp.1*, *Notholca* *sp.2*, *Notholca* *sp.3*, *Notholca* *sp.4*) are the most diverse. Cladocerans are represented by four (4) families, including the Chydoridae, Daphniidae, Moinidae, and Sididae families. Among these families, the Daphniidae are the most diverse with 3 taxa (*Simocephalus* *npunctatus*, *Simocephalus* *serrulatus*, *Simocephalus* *sp*). As for the Copepod group, it consists of two families: Cyclopidae and Diaptomidae. Station B4 has the lowest taxonomic richness with 34 taxa, while station B1 has the highest with 46 taxa. Stations B2 and B3 have the same number of taxa, with 42 each.

Table I: List of zooplankton taxa collected at the different sampling stations of the Banco River; Acro: Acronyms. B1-B4 = sampling stations; * = rare taxa; ** = occasional taxa; *** = common taxa.

Stations

Zooplankton taxa

Acronyms

B1

B2

B3

B4

CLADOCERA

Chydoridae

Alona sp.

Alsp

*

**

Daphniidae

Simocephalus punctatus (Orlova -Bienkowskaja)

Sipu

- *
- *
- *

Simocephalus serrulatus (Koch)

Sise

- ***
- *
- *
- *

Simocephalus sp.

Sisp

- *
- *
- *

Moinidae

Moina macrocopa (Straus)

Moma

*

*

*

Moina micrura (Kurz)

Momi

*

**

Sididae

Diaphanosoma excisum (Sars)

Diex

**

**

*

Diaphanosoma sp.

Disp

**

*

*

*

COPEPODA

Cyclopidae

Copepodites

Cope

*

*

*

Mesocyclops sp1.

Mes1

**

*

**

Mesocyclops sp2.

Mes2

**

**

**

Copepod Nauplii

Naco

*

**

*

Diaptomidae

Aglaodiaptomus leptopus (Light)

Agle

*

*

*

ROTIFERA

Asplanchnidae

Asplanchna sp.

Assp

*

*

*

Brachionidae

Brachionus bidentatus (Anderson)

Brbi

*

*

*

*

Brachionus patulus (Müller)

Brpa

*

**

*

*

Brachionus quadridentatus (Hermann)

Brqu

**

*

*

Keratella cochlearis (Gosse)

Keco

**

**

Keratella lenzi (Hauer)

Kele

**

**

*

*

Notholca labis (Gosse)

Nola

**

*

*

Notholca sp.1

Nos1

**

*

*

Notholca sp.2

Nos2

**

**

*

**

Notholca sp.3

Our 3

**

*

*

*

Notholca sp.4

Nos4

*

**

*

*

Euchlanidae

Euchanis sp.1

Eus1

**

*

*

Euchanis sp.2

Eus2

*

*

*

Table 2: Continued.

Stations

Zooplankton taxa

Acronyms

B1

B2

B3

B4

ROTIFERS

Hydrachindiae

Hydracarina sp.

Hysp

**

*

*

Gastropodidae

Gastropus stylist (Imhof)

Gast

*

**

*

*

Lecanidae

Lecane bulla (Gosse)

Lebu

**

*

*

Lecane rottenburgi (Lucks)

Lero

*

*

*

*

Lecane sinuata (Hauer)

Lesi

- *
- *
- *

Lecane sp.1

The 1

- *
- *
- *
- *

Lecane sp.2

The 2

- *
- *
- *

Lecane sp.3

The 3

- **
- *
- *
- **

Lecane sp.4

The 4

*

*

Lecane sp.5

The 5

*

**

*

Lecane sp.6

The 6

**

*

Lepadellidae

Colurella obtusa (Gosse)

Coob

*

*

*

*

Colurella sp

Cosp

*

*

*

Synchaetidae

Polyarthra Dolichoptera (Idelson)

Podo

**

**

*

Polyarthra sp.1

Pos1

*

**

*

*

Polyarthra sp.2

Pos2

**

*

*

*

Trichocercidae

Trichocerca flagellata (Hauer)

Trfl

*

*

*

Trichocerca marina (Daday)

Trma

- *
- *
- *
- *

Trichocerca porcellus (Gosse)

Trpo

- **
- **
- *
- *

Trichocerca sp.

Trsp

- *
- *

- *

Trichocerca tenuior (Gosse)

Trte

- *
- *

- *

Trochosphaeridae

Filinia opoliensis (Zacharias)

Fiop

*

*

*

*

Filinia terminalis (plate)

Fite

*

**

*

TOTAL

49

46

42

42

34

Quantitative analysis of the zooplankton population:

Spatial and seasonal variations in zooplankton abundance

Figures 2 and 3 show the spatial and seasonal variations in the absolute and relative abundances (with relative densities greater than 4% at the Banco River stations) of the main zooplankton groups in the Banco River. However, no significant differences were observed between stations or between seasons (Kruskal -Wallis test; $p > 0.05$). The highest zooplankton density (3680 Ind/L) was recorded at station B1 during the major rainy season (MWS), while the lowest density (100 Ind/L) was noted at station B4 during the major dry season (MWS). At all sampling stations, a clear predominance of the Rotifers group was recorded. Rotifers represent the most dominant group with a total of 20,860 Ind/L, or 74.23%. The taxa that contribute to this increase in abundance are: *Filinia terminalis*, *Trichocerca marina*, *Colurella* sp, *Lecane bulla*, *Eucharis* sp., *Brachionus patulus*, *Brachionus quadridentatus*, *Notholca labis*, *Notholca* sp.4, *Hydracarina* sp, *Gastropus stylis*, *Trichocerca porcellus*, *Keratella cochlearis*, *Polyarthra* sp.2, *Asplanchna* sp., *Lecane* sp.5, *Trichocerca* sp.

Fig 2: Absolute abundance of Zooplankton communities collected in the Banco River from July 2020 to June 2021. B1-B4: Sampling stations, GSS = Great Dry Season; GSP = Great Rainy Season; PSS = Short Dry Season; PSP = Short Rainy Season.

Fig 3: Relative abundance of zooplankton communities collected in the Banco River from July 2020 to June 2021. B1-B4: Sampling stations; GSS = major dry season; GSP = major rainy season; PSS = minor dry season; PSP = minor rainy season.

Diversity Index

Figure 4 shows the spatial and seasonal variations of the Shannon diversity index and the

evenness index of zooplankton communities in the Banco River. These two indices were not significantly different between sampling sites and seasons (Kruskal -Wallis, $p > 0.05$). The highest Shannon index value (3.07 bits/ cell) was recorded at station B1 during the main rainy season, and the lowest (0.68 bits/ cell) at station B3 during the main dry season.

The maximum (0.95) and minimum (0.48) values of the fairness index were observed at station B1 during the major rainy season and the minor dry season respectively.

Fig 4: Spatial and seasonal variations of Shannon-Weaver (H) diversity and zooplankton community evenness indices collected in the Banco River from July 2020 to June 2021. B1-B4: Sampling stations; GSS = Great Dry Season; GSP = Great Rainy Season; PSS = Short Dry Season; SSP = Short Rainy Season.

Influence of environmental variables on population distribution:

Correlations between dominant taxa (those with a relative abundance greater than 4% in Banco River stations) and environmental variables, as determined by Canonical Redundancy Analysis (RDA), are shown in Figure 5. The first two axes (axis 1 and axis 2) accounted for 65.5% of the total variance. Axis 1, which accounted for 37.7% of the total variance, is positively correlated with ammonium, dissolved oxygen, and conductivity.

These parameters are weakly and positively correlated with *Filinia terminalis* (Fite), *Asplanchna* sp. (Assp.) at station B3 during the main rainy season (GSP). This axis is negatively correlated with COD, phosphorus, and turbidity. These parameters are negatively correlated with *Gastropus stylifer* (Gast), *Trichocerca* sp. (Trsp), *Diaphanosoma excisum* (Diex), *Keratella cochlearis* (Keco) at station B3 during the long rainy season (LWS) and the long dry season (LWS). The second axis represents 25.8% of the total inertia and is strongly and positively correlated with nitrate and BOD5. These are associated with the species *Lecane* sp.5 (Les5) at station B4 during the short rainy season. This same axis is negatively and weakly correlated with temperature and the species

Trichocerca marina (Trma) at station B1 during the long dry season (LWS).

Fig 5: Ordering in RDA of dominant zooplankton taxa and physical and chemical parameters of the Banco River waters. B1-B4: sampling stations; (Acronyms: see Table II); Temp: temperature; pH: potential of hydrogen; Cnd : conductivity; O2: dissolved oxygen; Turb: turbidity; Amm: ammonium; Phosp: orthophosphates; BOD5: 5-day biochemical oxygen demand; COD: chemical oxygen demand; GSS: major dry season; GSP: major rainy season; PSS: minor dry season; minor rainy season;

Assessment of the ecological quality of the waters of the Banco River

The Cladoceros/Rotifer (C/R) index

Table III presents the spatial and seasonal variations of the Cladoceran/Rotifer (C/R) ratio in the Banco River. The analysis highlights dominant eutrophication in the majority of stations (B1, B2, B3) with generally low C/R ratio values (0 to 0.5). Across all stations (B1, B2, and B3), the C/R ratio values indicate a eutrophic ecological state regardless of the season. In contrast to station B4, the values indicate oligotrophic variation during the dry season (1.09) and mesotrophic variation during the rainy season (0.97).

Table II: Spatial and seasonal variation of the C/R ratio of the Banco River

Sites

Seasons

Report C/R

Ecological state

B1

GSS

0.234

Eutrophe

GPS

0.171

Eutrophe

PSS

0.5

Eutrophe

PSP

0.209

Eutrophe

B2

GSS

0.262

Eutrophe

GPS

0.232

Eutrophe

PSS

0.007

Eutrophe

PSP

0.275

Eutrophe

B3

GSS

0.17

Eutrophe

GPS

0.333

Eutrophe

PSS

0

Eutrophe

PSP

0.495

Eutrophe

B4

GSS

1.104

Oligotrophic

GPS

0.99

Mesotroph

PSS

1.077

Oligotrophic

PSP

0.95

Mesotrophe

DISCUSSION

The physical and chemical parameters of the Banco River waters varied from station to station and over time. The high temperature during the dry season can be explained by the fact that during this season, the air temperature due to solar radiation is at its maximum. Indeed, during the dry season, the air is dry and hot, the water velocity is zero, and the canopy cover is zero, especially at station B1. This result is similar to those of Soro et al., 2020, for the Upper Bandama basin.

High BOD₅ and COD values were recorded during the rainy season. These high BOD₅ and COD values during the rainy season can be explained by runoff. Indeed, rainwater causes significant runoff, which carries organic matter, animal waste, and sediments into waterways. This organic matter increases the amount of substrate available for microorganisms. This result is consistent with those of Buhungu et al., 2018, on the Kinyankonge River in Burundi.

During this study in the Banco River, 50 zooplankton species were recorded and divided into three main groups: 36 Rotifers, 6 Copepods, and 8 Cladocera. The dominance of Rotifers can be explained by their low predation pressure (Lampert and Sommer, 2001; Kuczyńska-Kippen and Basińska, 2008), their life cycle, reproductive mode, and tolerance to a variety of environmental factors (Bennett and Borass, 1989; Badi et al., 2010). Indeed, the opportunistic nature of Rotifers allows them to better withstand variations in environmental conditions (Matsumuratundisi et al., 1990). Furthermore, their high competitiveness, due to their dietary plasticity with respect to available resources and their small size, makes them less vulnerable to predation pressure (Dumont, 1994). These results are also similar to several studies conducted on the Bandama River. The species richness obtained is very close to that reported by De Ridder and Pourriot (1984) with 53 species in the Bandama in Côte d'Ivoire. However, it remains much higher than the species richness reported in the Ogba and Iyiwu Rivers in Nigeria, which contain 25 and 27 species respectively by Anyanwu et al. (2021) and Anyanwu et al. (2022); in the Agnéby and Bagoé Rivers in Côte d'Ivoire with 30 and 38 species respectively by Ouattara et al.

(2007) and N'Da et al. (2015); and for the Comoé River, also in Côte d'Ivoire, with 20 taxa by Yao et al. (2015). But this taxonomic richness is lower than that recorded by Arimoro and Oganah (2010) and Houssou et al. (2017) on the Orogodo River in Nigeria and in the Ouémé River basin in Benin, respectively 79 species and 102 species; by Gouton et al., 2024 in the Okpara River in Benin with 68 taxa; and by Ouattara et al., 2007 in the Bia River basin in Côte d'Ivoire with 64 taxa. Indeed, these differences in the taxonomic richness of the zooplankton community could be related to sampling effort.

Zooplankton density varied from 100 Id/L at station B4 (the dry season) to 3680 Id/L at station B1 (the rainy season). The increase in zooplankton density during the rainy season in the Banco River could be linked to the influx of rainwater laden with various nutrients. Indeed, warm, nutrient-rich waters provide a rich environment for the development of microalgae and zooplankton (Makaoui et al., 2005; Somoue et al., 2013). Furthermore, the highest zooplankton abundance at station B1 could be related to the abundance of microalgae at this station. This result corroborates those of Ouattara et al. (2007) in the Bia River in Côte d'Ivoire.

The highest value of the Shannon index (3.07 bits/ cells) was recorded (3.07) at station B1 during the major rainy season and the lowest (0.68 bits/ cells) at station B3 (0.68 bits/ cells) during the major dry season.

The low Shannon-Weaver index values recorded at station B3 indicate the presence of predominant species such as *Brachionus. quadridentatus* and *Filina*. The Shannon-Weaver diversity index can be used to assess the pollution of a river's waters. According to Simboura & Zenetos (2002), if this index is between 0.5 and 3, the water is in poor ecological condition and is classified as heavily polluted; if the index is greater than 3, the waters are moderately polluted and promote zooplankton development and diversity. According to these authors, station B3 is heavily polluted and station B1 is moderately polluted. These results corroborate those reported by Buhungu et al. (2017; 2018) on the Kinyankonge River.

Diversity indices revealed that the zooplankton species found at station B3 tolerate heavily

polluted waters and could be considered as bioindicators of pollution.

Redundancy Analysis revealed a seasonal discrimination of samples based on zooplankton biomass. Rainy seasons are characterized by a dominance of rotifers, while dry seasons are distinguished by a dominance of copepods and cladocerans. The rotifer dominance observed during the rainy season can be explained by the fact that rainfall at this time of year leads to soil leaching, increasing the organic matter and nutrient load, which promotes the growth of microalgae and bacteria major food sources for rotifers. The eutrophic state observed at stations B1, B2, and B3 indicates pollution in this river. This situation could be explained by the fact that these stations are located on the main watercourse, which is subject to numerous human activities (urbanization, domestic wastewater, agricultural activities, etc.), and runoff from various municipalities of Abidjan contributes to nutrient enrichment of the water at these stations. The oligotrophic state recorded at station B4 during the dry season is likely due to the fact that this station is located on a tributary of the river and is free from any human disturbance. These results are consistent with those observed for the Muha River flowing through the city of Bujumbura (Mpawenayo & Niyondiko, 2013).

Conclusion

Physical and chemical analyses conducted on the Banco River revealed organic pollution from domestic wastewater discharges from homes located along its banks. The taxonomic composition of the zooplankton shows that species that thrive in environments polluted by organic matter are the ones that proliferate abundantly in this river. However, dissolved oxygen and turbidity are the environmental variables that significantly influence the diversity and abundance of zooplankton communities in the Banco River. Based on the results, measures to control water pollution are a priority for the long-term protection of this aquatic ecosystem. Raising awareness among the local population is essential for the preservation of the waterway.

Acknowledgements

Authors wish to thank National authorities of Department of Aquaculture and Fisheries Dr.

ShepHelguile, Mrs. Hema Catherine and M. Allou Jacques Aka for their administrative assistance.

Reviewers are also thanked for the time dedicated and their comments.

Funding

Not applicable

Declaration of competing interests

The authors report no declarations of interests

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