

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

3

4 **Abstract**

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

16 **Keywords:** Zooplankton, Banco River, Water Quality, Eutrophication, Côte d'Ivoire

17 **INTRODUCTION**

18 Rapid urbanization and industrialization in cities lead to a large production of solid and liquid waste. Domestic  
19 and industrial waste is discharged into aquatic ecosystems without prior treatment (**Houngpè et al., 2017**) in  
20 most developing countries. The influx of effluents into aquatic environments exerts considerable pressure on  
21 these ecosystems. This pressure results in a degradation of water quality and the habitats upon which aquatic life  
22 depends. According to **Owa (2013)**, these activities thus alter the composition of biological communities present  
23 in waterways, generally by reducing the biological diversity of the aquatic ecosystem. For decades, zooplankton  
24 has constituted an important energy resource in aquatic environments for fish and other organisms at higher  
25 trophic levels (**Aka et al., 2010**). Furthermore, zooplankton organisms are also a good indicator of water quality  
26 in the global context of eutrophication of aquatic environments attributable to rapid urbanization and  
27 industrialization on the one hand, and the use of pesticides in agro-industrial operations on the other (**Brito et al.,**  
28 **2011**). Zooplankton therefore plays an important role in the functioning of aquatic ecosystems. Indeed,  
29 knowledge of the distribution and structure of zooplankton communities is important not only for monitoring the  
30 quality of watercourses but also for understanding energy transfer in aquatic ecosystems.

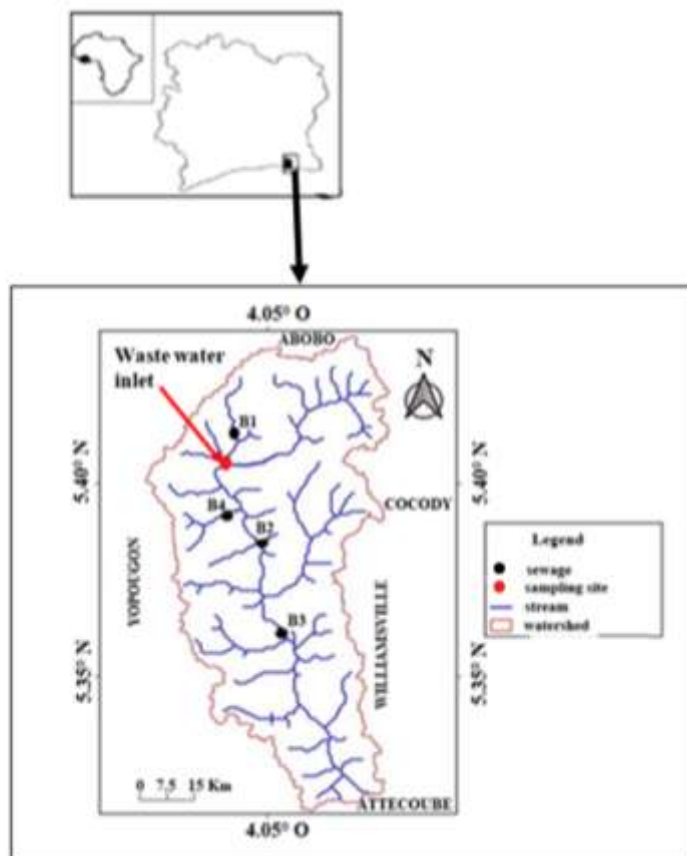
31 In Côte d'Ivoire, several studies on zooplankton have been carried out. These studies were conducted in various  
32 basins and watercourses, namely the agro-pastoral reservoirs in the Korhogo, Ferkessedougou and Ouangolo  
33 areas. (**Aka et al., 2000**), the Bia and Agnéby rivers (**Ouattara et al., 2007**), the Comoé river basin (**Yao et al.,**  
34 **2015**), the Bagoé river (**N'da et al., 2015**), the Ehania, Boulo 1 and 2 and Bodoua coastal rivers (**Monney,**  
35 **2017**), the Hana River in Tai National Park (**Diomandé et al., 2018**) etc. However, our knowledge remains  
36 limited, as none of these previous studies conducted in Côte d'Ivoire have highlighted the dynamics of the  
37 zooplankton community in the Banco River. It is therefore important to inventory the zooplankton species in

38 order to characterize the structure of their assemblage in such a context of high anthropogenic pressure, in order  
39 to assess the ecological status of this river. The objective of this study is to evaluate the water quality of the  
40 Banco River, located in the heart of Banco National Park, in the center of Abidjan.

## 41 METHODOLOGY

### 42 Description of sampling stations:

43 The Banco River is a waterway covering a basin of 56 km<sup>2</sup> (Mangoua et al., 2009). This river originates at the  
44 foot of a plateau on the northern edge of the park, flows for 9 km before emptying south into the Ebrié Lagoon at  
45 Banco Bay (Lauginie, 2007). Low water levels caused by dry periods are almost nonexistent in this watercourse.  
46 Its flow rate always exceeds 1.35 m<sup>3</sup>/s, and significant flooding is frequently observed during the main rainy  
47 season (Kouamé, 2009). Cdi Park is located between 5°21' and 5°25' N, and 4°01' and 4°05' W in southern Côte  
48 d'Ivoire, specifically in the city of Abidjan. Its catchment area covers 3,474 hectares. The park is bordered to the  
49 northeast by the municipality of Abobo, to the southeast by the municipality of Adjamé, and to the west by the  
50 municipality of Yopougon. Taking into account accessibility, the upstream-downstream gradient, and the  
51 influence of human activities, four (4) sampling stations were selected (Fig 1).



52

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

54 **Analysis of physicochemical parameters**

55 Environmental parameters such as chemical oxygen demand (COD) and biochemical oxygen demand (BOD<sub>5</sub>)  
56 were determined using APHA:1905 and AFNOR:1926 methods (Buhungu et al., 2018). Ammonium, nitrate,  
57 nitrite, and total phosphorus concentrations were assessed photometrically using the Palin Test DR 7500  
58 photometer with pre-dosed reagents.

### 59 **Sampling, observation and identification of the zooplankton population**

60 The sampling strategy adopted in this study aimed to cover all climatic seasons in the Abidjan district. Eleven  
61 sampling campaigns were conducted between July 2020 and June 2021, from 9:00 AM to 2:00 PM, excluding  
62 October. Four 10-liter buckets (for a total volume of 40 liters) were collected from the upstream environment and  
63 filtered through a 20 µm mesh plankton net. The resulting concentrate was collected in a 120 ml vial. Organisms  
64 were stained with Lugol's iodine and then fixed with 5% formaldehyde. In the laboratory, taxa were observed  
65 under a CARL ZEISS optical microscope (40x, 60x, and 100x objectives). Taxon identification was performed  
66 using various keys according to the different zooplankton groups. Thus, for Rotifers, the keys of Pontin (1978),  
67 Voigt & Koste (1978) and Pourriot (1980) were used. The keys of Rey & Saint-Jean (1980), Idris (1983) and  
68 Korinèk (1999) were used for the identification of Cladocera, while Copepods were identified using the key of  
69 Dussart (1980).

### 70 **Data analysis**

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

$$C/R = \frac{N_C}{N_R}$$

77

78 With  $N_C$ : Total number of Cladocerans observed

79  $N_R$ : Total number of Rotifers observed

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

$$D = \frac{n}{v_1} \times \frac{v_2}{v_3}$$

82 With n = number of individuals counted,

83  $v_1$  = volume of the filtrate taken (50 mL),

84  $v_2$  = volume of concentrated filtrate (100 mL),

85  $v_3$  = volume of filtered water (10 L).

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

88 Kruskal -Wallis and Mann-Whitney tests were used to assess the significance of the variations in the different  
89 parameters. These tests were chosen after verifying the normality tests by the Shapiro normality. The  
90 KruskalWallis test was used to test the significance of the variation in parameters between different sampling  
91 stations and between different seasons. The significance of the results was assessed using the probability value p.  
92 When  $p < 0.05$ , the parameter being studied does not show significant variation. If  $p < 0.05$ , there is a  
93 significant difference, and the analysis continues with the Mann-Whitney test to determine the extent of this  
94 difference.

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

97 These tests were performed using R software version 3.5.2.

## 98 **RESULTS**

### 99 **Physical and chemical characteristics**

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

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

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

108 Minimum turbidity values ( $9.29 \text{ NTU}$ ) were observed at station B4 during the major rainy season (GSP), while  
109 maximum values ( $243.5 \text{ NTU}$ ) were recorded at station B1, also during the minor rainy season.

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

112 Nitrate levels in the Banco River waters ranged from  $6.40$  to  $13.88 \text{ mg/l}$  at stations B4 and B1 respectively  
113 during the main rainy season (GSP). COD levels varied from  $4.03 \text{ mgO}_2 / \text{L}$  to  $27.21 \text{ mgO}_2 / \text{L}$ . The highest value  
114 was recorded at station B3 during the short rainy season (SRS), while the lowest value was recorded at station  
115 B1 during the long dry season (LDS). Regarding BOD5 values, they ranged from  $2.05 \text{ mgO}_2 / \text{L}$  to  $7.75 \text{ mgO}_2$   
116  $/\text{L}$ . The lowest values were recorded at station B4 during the long dry season (LDS), while the highest value was  
117 obtained at station B3 during the short rainy season (LDS).

118 Table

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

123

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

124

125 **Qualitative analysis of the zooplankton population:**

126 A total of 49 zooplankton taxa were recorded at the four stations along the Banco River. This community  
 127 comprises 36 rotifers, 8 cladocerans, and 5 copepods, belonging to 18 families and 21 genera (Table II). Rotifers,  
 128 with 36 taxa (73.46%), are the most diverse group in the community, followed by cladocerans with 8 taxa  
 129 (16.32%) and copepods with 5 taxa (10.20%). The rotifer group is the most diverse in this study, containing 10  
 130 families, including Asplanchnidae, Brachionidae, Euchlanidae, Hydrachnidae, Gastropodidae, Lecanidae,  
 131 Lepadellidae, Synchaetidae, Trichocercidae, and Trochosphaeridae. Among these families are the Brachionidae  
 132 families with 10 taxa (*Brachionus bidentatus*, *Brachionus patulus*, *Brachionus quadridentatus*, *Keratella*  
 133 *cochlearis*, *Keratella lenzi*, *Notholca labis*, *Notholca* sp.1, *Notholca* sp.2, *Notholca* sp.3, *Notholca* sp.4) are the  
 134 most diverse. Cladocerans are represented by four (4) families, including the Chydoridae, Daphniidae, Moinidae,  
 135 and Sididae families. Among these families, the Daphniidae are the most diverse with 3 taxa (*Simocephalus*  
 136 *npunctatus*, *Simocephalus serrulatus*, *Simocephalus* sp). As for the Copepod group, it consists of two families:  
 137 Cyclopidae and Diaptomidae. Station B4 has the lowest taxonomic richness with 34 taxa, while station B1 has  
 138 the highest with 46 taxa. Stations B2 and B3 have the same number of taxa, with 42 each.

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

Zooplankton taxa	Acronyms	Stations			
		B1	B2	B3	B4
<b>CLADOCERA</b>					
<b>Chydoridae</b>					
<i>Alona</i> sp.	Alsp		*	**	
<b>Daphniidae</b>					
<i>Simocephalus punctatus</i> (Orlova -Bienkowskaja)	Sipu		*	*	*
<i>Simocephalus serrulatus</i> (Koch)	Sise	***	*	*	*
<i>Simocephalus</i> sp.	Sisp	*		*	*
<b>Moinidae</b>					
<i>Moina macrocopa</i> (Straus)	Moma	*	*	*	
<i>Moina micrura</i> (Kurz)	Momi	*	**		
<b>Sididae</b>					
<i>Diaphanosoma excisum</i> (Sars)	Diex	**	**	*	
<i>Diaphanosoma</i> sp.	Disp	**	*	*	*
<b>COPEPODA</b>					
<b>Cyclopidae</b>					
Copepodites	Cope	*		*	*
<i>Mesocyclops</i> sp1.	Mes1	**	*	**	
<i>Mesocyclops</i> sp2.	Mes2	**	**	**	
Copepod <i>Nauplii</i>	Naco	*	**	*	
<b>Diaptomidae</b>					
<i>Aglaodiaptomus leptopus</i> (Light)	Agle	*	*		*
<b>ROTIFERA</b>					
<b>Asplanchnidae</b>					
<i>Asplanchna</i> sp.	Assp	*		*	*
<b>Brachionidae</b>					
<i>Brachionus bidentatus</i> (Anderson)	Brbi	*	*	*	*
<i>Brachionus patulus</i> (Müller)	Brpa	*	**	*	*
<i>Brachionus quadridentatus</i> (Hermann)	Brqu	**	*		*
<i>Keratella cochlearis</i> (Gosse)	Keco	**		**	
<i>Keratella lenzi</i> (Hauer)	Kele	**	**	*	*
<i>Notholca labis</i> (Gosse)	Nola	**	*	*	
<i>Notholca</i> sp.1	Nos1	**		*	*
<i>Notholca</i> sp.2	Nos2	**	**	*	**
<i>Notholca</i> sp.3	Our 3	**	*	*	*
<i>Notholca</i> sp.4	Nos4	*	**	*	*
<b>Euchlanidae</b>					
<i>Euchanis</i> sp.1	Eus1	**	*		*
<i>Euchanis</i> sp.2	Eus2	*	*	*	

141 **Table 2:** Continued.

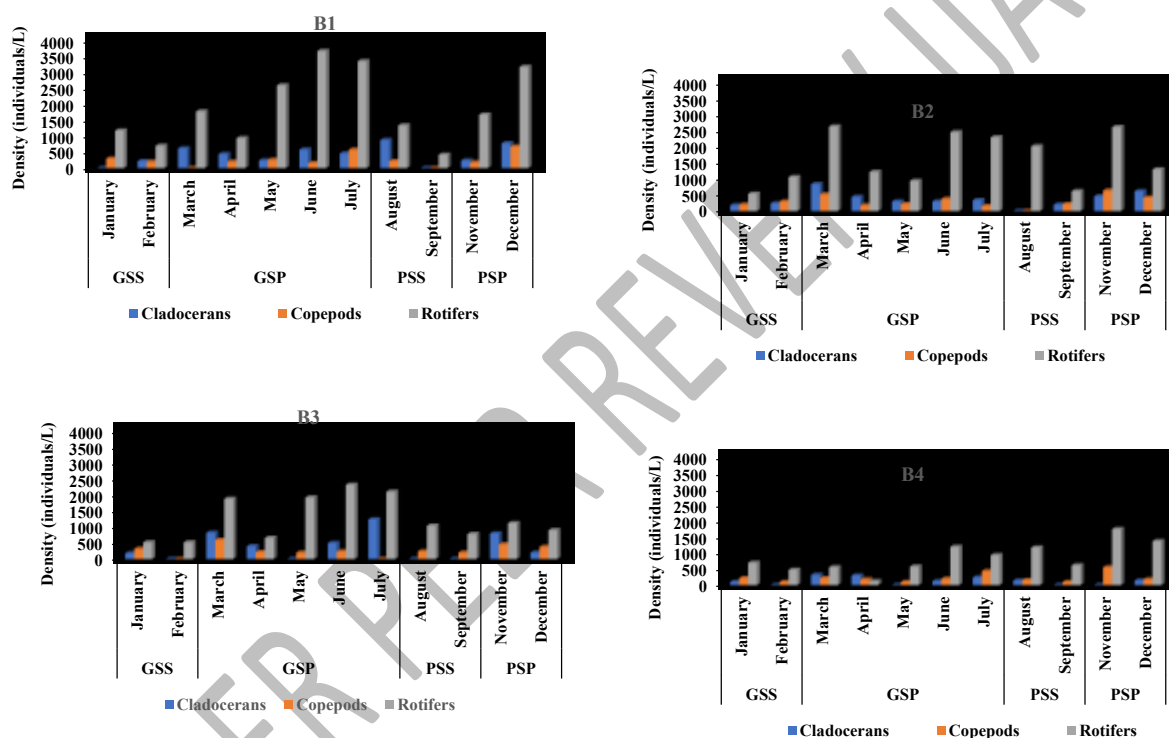
Zooplankton taxa	Acronyms	Stations			
		B1	B2	B3	B4
<b>ROTIFERS</b>					
<b>Hydrachindiae</b>					
<i>Hydracarina</i> sp.	Hysp		**	*	*
<b>Gastropodidae</b>					
<i>Gastropus stylis</i> (Imhof)	Gast	*	**	*	*
<b>Lecanidae</b>					
<i>Lecane bulla</i> (Gosse)	Lebu	**	*		*
<i>Lecane rothenburgi</i> (Lucks)	Lero	*	*	*	*
<i>Lecane sinuata</i> (Hauer)	Lesi	*	*	*	
<i>Lecane</i> sp.1	The 1	*	*	*	*
<i>Lecane</i> sp.2	The 2	*	*	*	
<i>Lecane</i> sp.3	The 3	**	*	*	**
<i>Lecane</i> sp.4	The 4	*		*	
<i>Lecane</i> sp.5	The 5	*	**		*
<i>Lecane</i> sp.6	The 6			**	*
<b>Lepadellidae</b>					
<i>Colurella obtusa</i> (Gosse)	Coob	*	*	*	*
<i>Colurella</i> sp	Cosp	*		*	*
<b>Synchaetidae</b>					
<i>Polyarthra Dolichoptera</i> (Idelson)	Podo	**	**	*	
<i>Polyarthra</i> sp.1	Pos1	*	**	*	*
<i>Polyarthra</i> sp.2	Pos2	**	*	*	*
<b>Trichocercidae</b>					
<i>Trichocerca flagellata</i> (Hauer)	Trfl		*	*	*
<i>Trichocerca marina</i> (Daday)	Trma	*	*	*	*
<i>Trichocerca porcellus</i> (Gosse)	Trpo	**	**	*	*
<i>Trichocerca</i> sp.	Trsp	*	*		*
<i>Trichocerca tenuior</i> (Gosse)	Trte	*	*		*
<b>Trochosphaeridae</b>					
<i>Filinia opoliensis</i> (Zacharias)	Fiop	*	*	*	*
<i>Filinia terminalis</i> (plate)	Fite	*	**	*	
<b>TOTAL</b>	<b>49</b>	<b>46</b>	<b>42</b>	<b>42</b>	<b>34</b>

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143 **Quantitative analysis of the zooplankton population:**

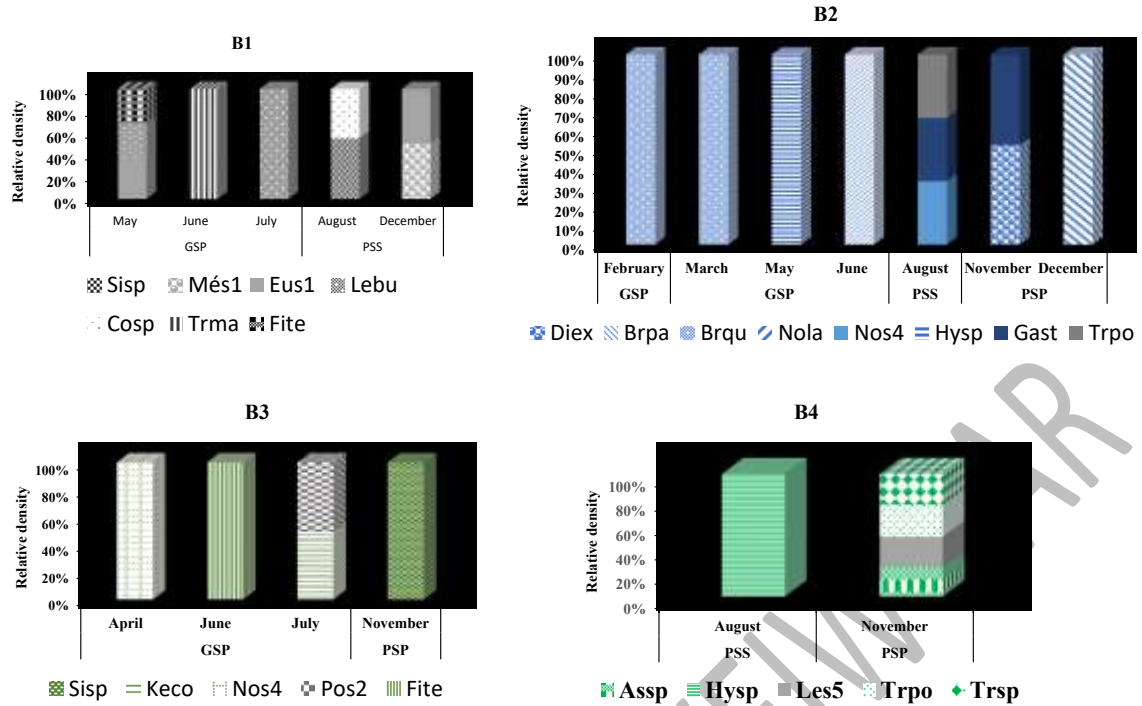
144 **Spatial and seasonal variations in zooplankton abundance**

145 Figures 2 and 3 show the spatial and seasonal variations in the absolute and relative abundances (with relative  
 146 densities greater than 4% at the Banco River stations) of the main zooplankton groups in the Banco River.  
 147 However, no significant differences were observed between stations or between seasons (Kruskal -Wallis test;  $p$   
 148  $> 0.05$ ). The highest zooplankton density (3680 Ind/L) was recorded at station B1 during the major rainy season  
 149 (MWS), while the lowest density (100 Ind/L) was noted at station B4 during the major dry season (MWS). At all  
 150 sampling stations, a clear predominance of the Rotifers group was recorded. Rotifers represent the most  
 151 dominant group with a total of 20,860 Ind/L, or 74.23%. The taxa that contribute to this increase in abundance  
 152 are: *Filinia terminalis*, *Trichocerca marina*, *Colurella* sp., *Lecane bulla*, *Eucharis* sp., *Brachionus*  
 153 *patulus*, *Brachionus quadridentatus*, *Notholca labis*, *Notholca* sp.4, *Hydracarina* sp., *Gastropus stylis*, *Trichocerca*  
 154 *porcellus*, *Keratella cochlearis*, *Polyarthra* sp.2, *Asplanchna* sp., *Lecane* sp.5, *Trichocerca* sp.



155  
 156 **Fig 2:** Absolute abundance of Zooplankton communities collected in the Banco River from July 2020 to June  
 157 2021. B1-B4: Sampling stations, GSS = Great Dry Season; GSP = Great Rainy Season; PSS = Short Dry Season;  
 158 PSP = Short Rainy Season.

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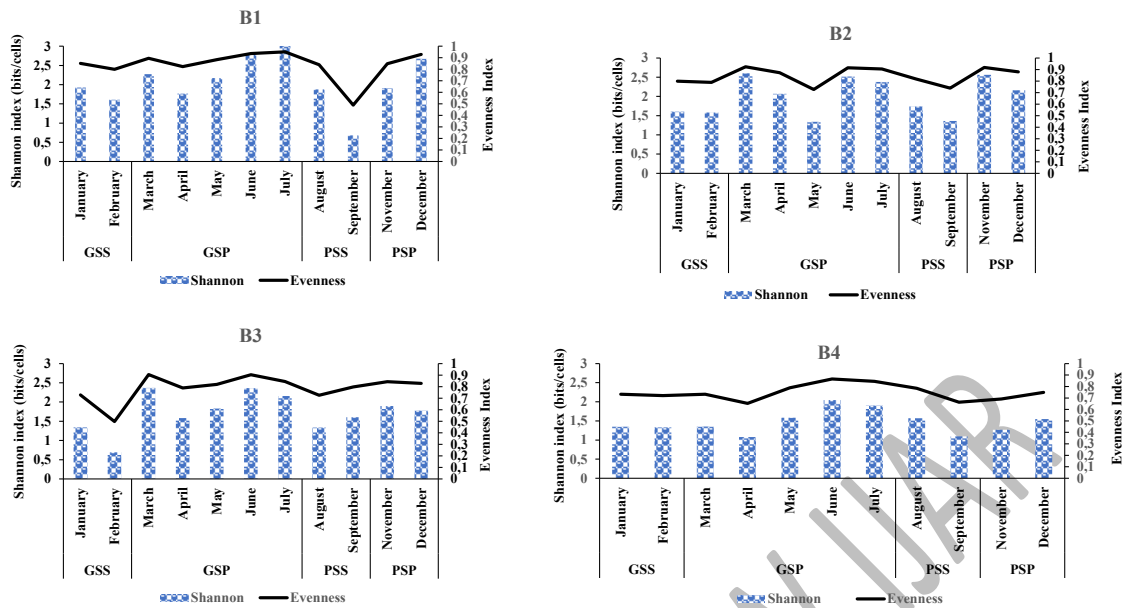
161 **Fig 3:** Relative abundance of zooplankton communities collected in the Banco River from July 2020 to June  
 162 2021. B1-B4: Sampling stations; GSS = major dry season; GSP = major rainy season; PSS = minor dry season;  
 163 PSP = minor rainy season.

164 **Diversity Index**

165 Figure 4 shows the spatial and seasonal variations of the Shannon diversity index and the evenness  
 166 index of zooplankton communities in the Banco River. These two indices were not significantly different  
 167 between sampling sites and seasons (Kruskal -Wallis,  $p > 0.05$ ). The highest Shannon index value (3.07 bits/  
 168 cell) was recorded at station B1 during the main rainy season, and the lowest (0.68 bits/ cell) at station B3 during  
 169 the main dry season.

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

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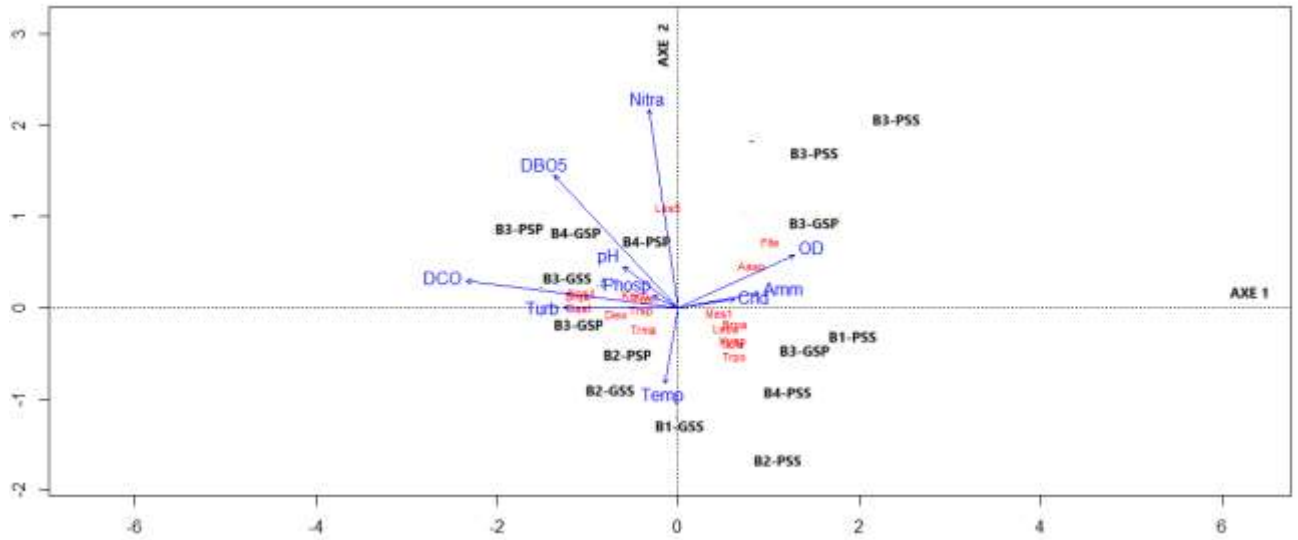


173  
 174 **Fig 4:** Spatial and seasonal variations of Shannon-Weaver (H) diversity and zooplankton community evenness  
 175 indices collected in the Banco River from July 2020 to June 2021. B1-B4: Sampling stations; GSS = Great Dry  
 176 Season; GSP = Great Rainy Season; PSS = Short Dry Season; SSP = Short Rainy Season.

177 **Influence of environmental variables on population distribution:**

178 Correlations between dominant taxa (those with a relative abundance greater than 4% in Banco River stations)  
 179 and environmental variables, as determined by Canonical Redundancy Analysis (RDA), are shown in Figure 5.  
 180 The first two axes (axis 1 and axis 2) accounted for 65.5% of the total variance. Axis 1, which accounted for  
 181 37.7% of the total variance, is positively correlated with ammonium, dissolved oxygen, and conductivity. These  
 182 parameters are weakly and positively correlated with *Filinia species. terminalis* (Fite), *Asplanchna sp.* (Assp.) at  
 183 station B3 during the main rainy season (GSP). This axis is negatively correlated with COD, phosphorus, and  
 184 turbidity. These parameters are negatively correlated with *Gastropus species. styliifer* (Gast), *Trichocerca sp.*  
 185 (*Trsp*), *Diaphanosoma excisum* (Diex), *Keratella cochlearis* (Keco) at station B3 during the long rainy season  
 186 (LWS) and the long dry season (LWS). The second axis represents 25.8% of the total inertia and is strongly and  
 187 positively correlated with nitrate and BOD5. These are associated with the species *Lecane sp.5* (Les5) at station  
 188 B4 during the short rainy season. This same axis is negatively and weakly correlated with temperature and the  
 189 species *Trichocerca marina* (Trma) at station B1 during the long dry season (LWS).

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191

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

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

198 **The Cladoceros/Rotifer (C/R) index**

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

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

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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

214

## 215 DISCUSSION

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

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

226 During this study in the Banco River, 50 zooplankton species were recorded and divided into three main groups:  
 227 36 Rotifers, 6 Copepods, and 8 Cladocera. The dominance of Rotifers can be explained by their low predation  
 228 pressure (**Lampert and Sommer, 2001; Kuczyńska-Kippen and Basińska, 2008**), their life cycle, reproductive  
 229 mode, and tolerance to a variety of environmental factors (**Bennett and Borass , 1989; Badsı et al., 2010**).  
 230 Indeed, the opportunistic nature of Rotifers allows them to better withstand variations in environmental

231 conditions (**Matsumuratundisi et al., 1990**). Furthermore, their high competitiveness, due to their dietary  
232 plasticity with respect to available resources and their small size, makes them less vulnerable to predation  
233 pressure (**Dumont, 1994**). These results are also similar to several studies conducted on the Bandama River. The  
234 species richness obtained is very close to that reported by De **Ridder and Pourriot (1984)** with 53 species in the  
235 Bandama in Côte d'Ivoire. However, it remains much higher than the species richness reported in the Ogba and  
236 Iyiakwu Rivers in Nigeria, which contain 25 and 27 species respectively by **Anyanwu et al. (2021)** and  
237 **Anyanwu et al. (2022)**; in the Agnéby and Bagoé Rivers in Côte d'Ivoire with 30 and 38 species respectively by  
238 **Ouattara et al. (2007)** and **N'Da et al. (2015)**; and for the Comoé River, also in Côte d'Ivoire, with 20 taxa by  
239 **Yao et al. (2015)**. But this taxonomic richness is lower than that recorded by **Arimoro and Oganah (2010)** and  
240 **Houssou et al. (2017)** on the Orogodo River in Nigeria and in the Ouémé River basin in Benin, respectively 79  
241 species and 102 species; by **Gouton et al., 2024** in the Okpara River in Benin with 68 taxa; and by **Ouattara et**  
242 **al., 2007** in the Bia River basin in Côte d'Ivoire with 64 taxa. Indeed, these differences in the taxonomic richness  
243 of the zooplankton community could be related to sampling effort.

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

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

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

259 Diversity indices revealed that the zooplankton species found at station B3 tolerate heavily polluted waters and  
260 could be considered as bioindicators of pollution.

261 Redundancy Analysis revealed a seasonal discrimination of samples based on zooplankton biomass. Rainy  
262 seasons are characterized by a dominance of rotifers, while dry seasons are distinguished by a dominance of  
263 copepods and cladocerans. The rotifer dominance observed during the rainy season can be explained by the fact  
264 that rainfall at this time of year leads to soil leaching, increasing the organic matter and nutrient load, which  
265 promotes the growth of microalgae and bacteriamajor food sources for rotifers.

266 The eutrophic state observed at stations B1, B2, and B3 indicates pollution in this river. This situation could be  
267 explained by the fact that these stations are located on the main watercourse, which is subject to numerous  
268 human activities (urbanization, domestic wastewater, agricultural activities, etc.), and runoff from various  
269 municipalities of Abidjan contributes to nutrient enrichment of the water at these stations. The oligotrophic state

270 recorded at station B4 during the dry season is likely due to the fact that this station is located on a tributary of  
271 the river and is free from any human disturbance. These results are consistent with those observed for the Muha  
272 River flowing through the city of Bujumbura (Mpawenayo & Niyondiko, 2013).

### 273 **Conclusion**

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

### 281 **Acknowledgements**

282 Authors wish to thank National authorities of Department of Aquaculture and Fisheries Dr. Shep Helguile, Mrs.  
283 Hema Catherine and M. Allou Jacques Aka for their administrative assistance.

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

### 285 **Funding**

286 Not applicable

### 287 **Declaration of competing interests**

288 The authors report no declarations of interests

289

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