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RESEARCH ARTICLE

Benthic Macroinvertebrates Diversity in the Tiemba River, North-West of Côte d'Ivoire

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Abstract

This study was carried to determine the diversity and structure of macroinvertebrates in the Tiemba river in north-west Côte d'Ivoire. Sampling of these macroinvertebrates was carried out at four different stations in the river using a Van Veen bucket and a haul net over an area of 1 m² (2 m * 0.5 m). The structure of benthic species was then studied using Shannon and Piélou indexes. Finally, a Canonical Correspondence Analysis (CCA) was carried to compare the relationship between the distribution of macroinvertebrate species and physicochemical variables. The results showed that a 253 macroinvertebrate species, divided into 04 classes, 09 orders and 20 families, were identified in the Tiemba river. This macrofauna is made up of 78% arthropods, 16% molluscs and 6% worms. The insect class was the best represented, with several orders including Hemiptera, Coleoptera, Diptera, Odonata and Hymenoptera. The most dominant orders in this river are Hemiptera, Coleoptera and Diptera, which are pollutant-resistant organisms, reflecting moderately polluted water. Analysis of the diversity indexes revealed that the macroinvertebrate groups in the Tiemba river are diverse and well organised. The distribution of macroinvertebrates was strongly influenced by temperature, conductivity, pH, nitrite, dissolved oxygen and depth. These results provide the foundations to all biomonitor action for the ecological quality of that river.

Keywords: Macoinvertebrates, Tiemba River, Diversity, Pollutants, Distribution.

1. Introduction

These days, water is at the heart of the world's major issues because of its scarcity and vulnerability. Water is used in many ways, all of which have a direct impact on its quality. Monitoring its quality appears to be an essential necessity in order to maintain its attributes and services to man and nature *[1]*. Côte d'Ivoire has a vast network of more or less permanent watercourses. As a result of the population explosion, agricultural intensification and economic development, the river Tiemba, like most of the country's watercourses, is subject to various disturbances *[2]*. The flow of anthropogenic pollutants has repercussions on the life of aquatic ecosystems, on the trophic chain and on human health. Under these conditions, it seems necessary to take an interest in the state of health of the Tiemba river to ensure its sustainable management. The conservation of ecosystems requires constant monitoring of their state of health *[3]* and the implementation of a monitoring system with effective bioindication tools. Macroinvertebrates are recognised as good indicators of the health of aquatic ecosystems because of their sedentary nature, varied life cycle, high diversity and variable tolerance to pollution and habitat degradation *[4]*. Given this importance, the benthic fauna is attracting particular attention and has already been the subject of several studies in several rivers in Côte d'Ivoire. However, our knowledge is still limited, as none of these previous studies have highlighted the benthic macroinvertebrate taxa of ecological interest in the River Tiemba. The aim of this study is to characterise the structure and diversity

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of benthic macroinvertebrates in the part of the River Tiemba located in the north of Côte d'Ivoire.

2. Materials and Methods

2.1 Study Environment

The Tiemba river is located in the north-west of Côte d'Ivoire, more precisely in the department of Odienné, between longitudes 950.000 UTM and 1.150.000 West and latitudes 600.000 UTM and 750.000 UTM North. It is a tributary of the Sassandra river and has its source in the department of Odienné.

2.1.1 Sampling Site

To select the stations, an exploratory visit was made from upstream to downstream on the Tiemba River in the Odienné department, resulting in the selection of 04 stations (S1, S2, S3 and S4) that were accessible in all seasons (Figure 1). These stations were chosen on the basis of the permanence of the water, accessibility in all seasons and the speed of the water current.

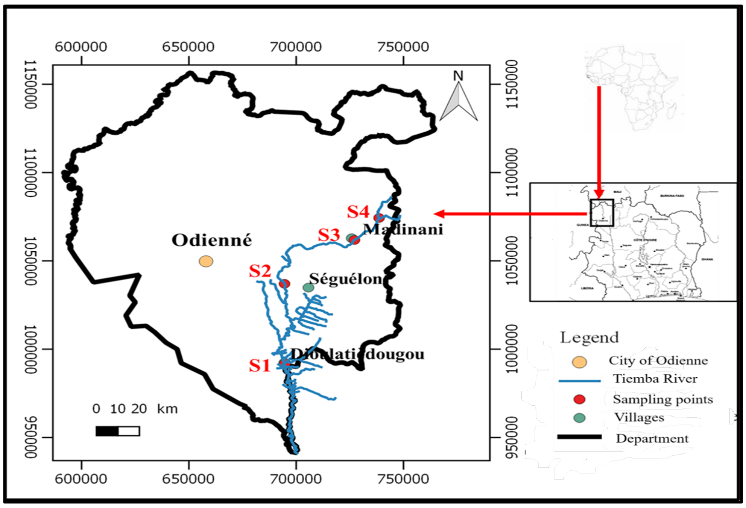


Figure 1. *Location of sampling sites in the study area*

2.2 Method

2.2.1 Measurement of Physico-Chemical Parameters of Water in the Tiemba River

At each station, the physico-chemical parameters were measured in situ between 6 a.m. and 8 a.m. and included temperature, depth, transparency, conductivity, dissolved oxygen and pH. For these measurements, we used a Secchi disc to measure water transparency (in cm) and depth (in cm) and a branded multiparameter AZOTA to measure conductivity (in µS/cm), temperature (in °C), dissolved oxygen (in mg/L) and pH. Water samples were also taken at the various stations in question in 500 ml polyethylene bottles. They were transported to the ENVAL laboratory in coolers containing ice packs, where they were kept refrigerated at 5°C before being analysed. These water samples were used to determine Nitrite (NO2-) and Nitrate (NO3-) ions and Total Phosphorus in accordance with the standardised protocols of the Association Française de Normalisation *[5]*.

2.2.2 Sampling of Macroinvertebrates

Benthic macroinvertebrates were sampled using a stainless steel Van Veen grab for sediment organisms and a dip net for submerged macroinvertebrates. For the benthos, at each site, three sediment samples corresponding to a total surface area of 0.15 m2 were taken at different depths. For submerged organisms, the turbid net (250 µm mesh) was used according to the SASS (South African Scoring System) method *[6]*. Samples were collected for 3 minutes by submerging the turbid net and dragging it through the water column over an area of 1 m² (2 m * 0.5 m). The net was also struck against the substrate to dislodge and collect organisms from the sediment. The collected organisms were fixed in 70% ethanol in labelled jars and transported to the laboratory.

2.2.3 Sample Sorting, Observation and Analysis

In the laboratory, each sediment sample, previously preserved in alcohol, was rinsed with tap water. The samples were then sieved, and the individuals collected sorted using a binocular magnifying glass to separate the fauna from the sedimentary debris and particles. The organisms thus collected were counted, photographed and identified to the lowest possible taxonomic level using the appropriate determination keys *[7] ; [8]* and preserved in 70% ethanol.

2.2.4 Data Analysis Methods

Biocenotic methods

Taxonomic richness, taxonomic group abundances, observation frequency, Shannon diversity and Piélou equitability indices were determined.

Taxonomic richness: was used to highlight the total number of species encountered at the sampling stations *[9]*.

Abundance of taxonomic groups : represents the ratio of the number of individuals of taxon (i) present to the total number of individuals at a sampling site *[9]*. Relative abundance is expressed as follows:

$$Pi=ni/N$$

where Pi represents the relative abundance of species (i), ni the number of individuals of species (i) and N the total number of individuals.

Frequency of observation : the frequency of occurrence provides information on the preference of a given species for a given type of habitat **[10].** The percentage of occurrence is calculated by counting the number of times species i appears in the samples. It is calculated as follows :

$$F = Fi \times 100 / Fi$$

where Fi is equal to the number of surveys containing species i and Ft = total number of surveys carried out. Depending on the value of F, three groups of species are distinguished according to Dajoz (2000) : constant species ($F > 50\%$), accessory species ($25\% < F < 50\%$) and accidental species ($F < 25\%$).

Shannon-Weaver diversity index : based on the number of species and the regularity of their distribution frequency. $H' = - \Sigma p i \log 2 pi$ where pi represents the relative abundance of species i in the sample ($p i = n i /N$). H' fluctuates between 0 and log S. A high Shannon index corresponds to favourable environmental conditions allowing many species to establish themselves. Generally, the value of H' is between 0.5 (very low diversity) and 4.5 or 5 (most diverse communities).

Piélou equitability: Equitability is defined on the basis of Shannon's diversity index. It is calculated as the ratio of actual specific diversity to maximum diversity. Equitability can be used to study the regularity of species distribution and to compare the diversity of two stands with different numbers of species *[10]*.

$$E = H \log2(S)$$

Where H is the Shannon diversity index for a sample and S is its species richness. Equitability varies from 0 to 1.

Statistical Methods

The Shapiro-Wilk normality test was used to test the normality of the various data. In this test, the p-value was used to analyse the results. The Kruskal-Wallis test was used to compare the various parameters measured at different sampling stations. These tests were carried out using Past 3.4 software.

Canonical correspondence analysis (CCA) was performed using Past 3.4 software *[11]*.to match biotic and abiotic data obtained during sampling.

3. Results

3.1 Physico-Chemical Quality of Tiemba River Water

Table 1 shows the average values of the nine physico-chemical water quality variables at the study stations. Analysis of the temperatures measured at the various stations reveals that station S1 has the highest temperature and station S3 has the lowest temperature value. All the water at the various stations was basic, but the most basic was at station S4.

The maximum value of transparency is observed at station S1 and the minimum value is recorded at station S2. The greatest depth (35 ± 2.08 cm) was obtained at station S4, while the lowest value (25 ± 2 cm) was obtained at station S1.

The highest conductivity (94.2 ± 0.64 µS/cm) was recorded at station S1 and the lowest (82.5 ± 1.15 µS/cm) at station S4. Dissolved oxygen shows a similar trend to that of conductivity. The highest dissolved oxygen value was recorded at station S1 and the lowest at station S4.

Table 1. *Physico-chemical characteristics of the Tiemba River*

Stations/Parameters	S1	S2	S3	S4
Temperature	28,4 ± 0,1	25,4 ± 0,95	25,2 ± 0,56	25,3 ± 0,61
pH	7,16 ± 0,16	7,06 ± 0,2	7,18±0,05	7,20±0,17
Transparency (cm)	20 ± 1,52	12 ±1,52	15±2	18±1,52
Depth (cm)	25 ± 2	30 ± 2	33±1	35 ± 2,08
Conductivity (µS/cm)	94,2 ± 0,64	84,3 ± 2,5	83,6 ± 1,01	82,5±1,15
Dissolved oxygen (mg/L)	5,8 ± 0,2	5,7 ± 0,2	5,5 ± 0,32	5,2 ± 0,25
Nitrate (N03-) (mg/L)	3,8 ± 0,32	5,534 ±0,76	4,5 ± 1,04	4,10 ±0,76
Nitrite (NO2-) (mg/L)	0,05 ± 0,01	0,06 ±0,01	0,04 ± 0,01	0,03 ±0,01
Total phosphorus (P) (mg/L)	0,03 ±0,01	0,09 ± 0,01	0,05 ± 0,01	0,06 ±0,01

The Nitrate values observed ranged from 3.8 ± 0.32 mg/L (S1) to 5.534 ±0.76 mg/L (S2). The highest Nitrite concentration (0.06 ±0.01mg/L) was recorded at station S2 and the lowest (0.03 ±0.01mg/L) at station S4.

The highest phosphorus concentration (0.09 ±0.01mg/L) was recorded at station S2 and the lowest (0.03 ±0.01mg/L) at station S1.

Generally speaking, the physico-chemical parameters of water quality subjected to the Kruskal-Wallis test revealed no significant difference between the stations ($p > 0.05$).

3.2 Composition and Occurrence of the Benthic Fauna of the Tiemba River

Table 2 presents the general list and spatial distribution of benthic macroinvertebrate taxa encountered at the sampling sites in the River Tiemba.

Across all the sampling sites, 26 taxa belonging to 20 families and 9 orders were recorded. The macroinvertebrates collected came from 03 phyla: Molluscs, Annelids and Arthropods. These species are grouped into 04 classes : Insects, Gastropods, Clitellates and Malacostracans. The insect class is the most represented, with 19 taxa. Next come the Gastropods with 05 taxa. Clitlates and Malacostracae are each represented by one taxon. Insects are represented by the orders Coleoptera (03 families), Diptera (02 families), Hemiptera (05 families), Hymenoptera (01family) and Odonata (02families). Gastropods are represented by the order Caenogasteropoda with 04 families (Planorbidae, Tomichiidae, Ampullariidae and Hydrobiidae) and the order Basommatophores with the family Physidae.

Table 2. *Composition and occurrence of benthic fauna in the River Tiemba*

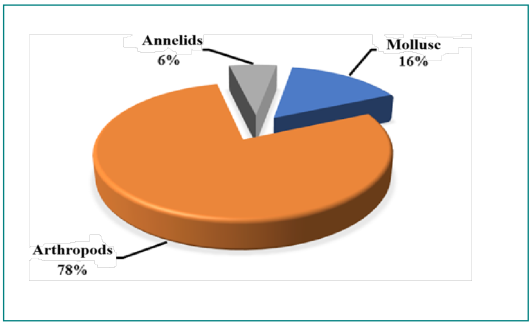
	Branch	Classes	Orders	Families	Species	Code	S1	S2	S3	S4	Occurrences (in%)
	Mollusc	**Gastropods**	**Basommatophores**	Physidae	*Aplexa waterloti*	*Apl*	+	-	-	+	50
			Caenogastropods	Planorbidae	*Révoir la Police*	*Afr*	+	-	-	+	50
				Tomichiidae	*Tomichia sp.*	*Tom*	+	-	-	+	50
				Ampullariidae	*Lanistes ciliatus*	*Lan*	+	+	-	-	50
				Hydrobiidae	*Uniformisez la Police*	*Lob*	-	-	+	-	25
	Arthropods	**Insects**	**Coleoptera**	Dytiscidae	*Heterhydrus sp.*	*Het*	-	-	+	-	25
					Hydroglyphus sp.	*Hyd*	-	-	+	-	25
					Lacc police philus luctuosus	*Lac*	-	-	-	+	25
				Gyrinidae	*Dineutus* sp.	*Din*	-	-	-	+	25
				Hydrophilidae	*Enochrus* sp.	*Eno*	+	+	-	-	25
			Diptera	Chironomidae	*Polypedilum fuscipenne*	*Pol*	+	+	-	-	50
				Culicidae	*Anopheles coustani*	*Ano*	+	+	-	-	50
			Hemiptera	Belostomatidae	*Appasus* sp.	*App*	+	+	+	+	**100**
					Diplonychus sp.	*Dip*	+	+	-	-	50
				Gerridae	*Limnogonus luctuosus*	*Lim*	+	+	-	-	50
				Nepidae	*Laccotrephes ater*	*Lac*	+	+	-	-	50
					Ranatra sp.	*Ran*	+	+	+	-	**75**
				Notonectidae	*Anisops* sp.	*Ani*	+	+	+	+	**100**
				Veliidae	*Microvelia* sp.	*Mic*	+	+	-	+	**75**
					Rhagovelia reitteri	*Rha*	+	-	-	-	25
			Hymenoptera	Formicidae	*Solenopsis* sp.	*Sol*	-	-	+	-	25
			Odonata	Coenagrionidae	*Coenagriocnemis reuniense*	*Coe*	-	+	-	+	**50**
					Pseudagrion punctum	*Pse*	+	+	-	-	50
				Libellulidae	*Zygomix torridus*	*Zyg*	+	+	-	-	50
		Malacostraca	**Decapods**	Atyidae	*Caridina nilotica*	*Car*	+	-	-	-	25
	Annelids	**Clitellata**	**Haplotaxida**	Tubificidae	*Tubifex* sp.	*Tub*	+	+	-	+	**75**
Totals	**3**	**4**	**9**	**20**	**26**						

In terms of abundance, a total of 253 macroinvertebrate individuals were collected at all the sampling sites. The macroinvertebrate communities in the study area were dominated by the insect class, with 197 individuals collected. The Hemiptera order was the most diverse in the study area, with 98 individuals and the 08 taxa *Appasus* sp., *Diplonychus* sp., *Limnogonus luctuosus, Laccotrephes ater*, *Ranatra* sp., *Anisops* sp., *Microvelia* sp. and *Rhagovelia reitteri*. This result highlights the preponderance of insects in the Tiemba watercourse.

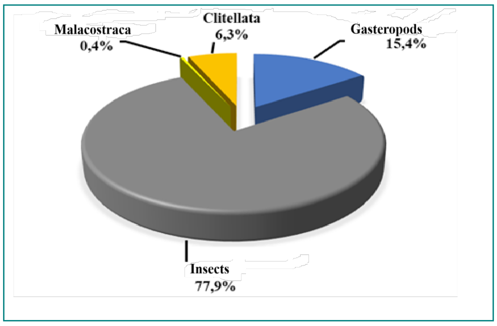
Analysis of taxon occurrences at sampling points shows that *Appasus* sp., *Anisops* sp., *Microvelia* sp., *Ranatra* sp. and *Tubifex* sp. are the constant taxa in the Tiemba River. In addition, the taxa *Aplexa waterloti*, *Afrogyrus rodrignezensis*, *Tomichia* sp., *Coenagriocnemis reuniense, Lanistes ciliatus*, *Polypedilum fuscipenne*, *Anopheles coustani*, *Diplonychus* sp., *Pseudagrion punctum* and *Zygomix torridus* constitute the accessory taxa of the river Tiemba. The other remaining taxa are considered to be accessory taxa to the River Tiemba.

3.3 Abundance of Benthic Macroinvertebrates in the Tiemba river

The study identified 253 individuals of macroinvertebrates at all four (04) stations, divided into three (03) phyla (Arthropods, Molluscs and Annelids). This aquatic fauna is dominated by Arthropods with 198 individuals (78% of total abundance). They are followed by Molluscs with 39 individuals, or 16% of the total abundance, and Annelids with 16 individuals, or 6% of the total abundance. Among the classes, Insects are the most dominant, with a relative abundance of 77.9%, followed by Gastropods (15.4%). The Clitellata class accounts for 6.3% of the total number of macroinvertebrates, while malacostracans account for only 0.4%. Among the Orders, the Hemiptera are the most represented with 98 individuals (38.74 %), followed by the Coleoptera (47 individuals (18.56 %) and the Caenogasteropoda (37 individuals (14.62 %). Among the families, Belostomatidae dominated with 30 individuals (11.86%), followed by Notonectidae (9.09%) and Dytiscidae (8.70%).



Relative abundance of phyla



Relative abundance of Classes

Figure 2. *Relative abundance of macroinvertebrates in the River Tiemba*

3.4 Proportions of Orders of Benthic Macoinvertebrates in the Tiemba River

Figure 3 shows the spatial variations in the nine (09) orders of macroinvertebrates identified in the River Tiemba. The order Hemiptera, which represents more than 30% of the organisms counted, dominates the macroinvertebrate communities at the stations (S1, S2 and S3). As for the Coleoptera order, it dominates at over 40% in station S4 on the Tiemba river. Basomatophores and decapods had proportions of less than 10% at stations S1 and S4, where they were collected. The proportion of Diptera was 20% at stations S1 and S2 on the Tiemba River.

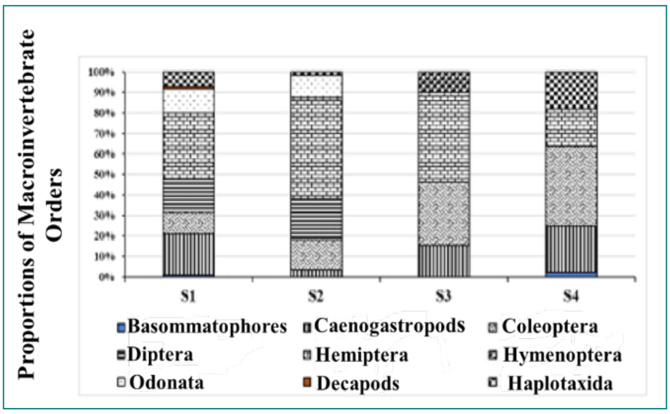


Figure 3. *Proportions of macroinvertebrate orders in the Tiemba River*

3.5 Spatial Variation in Taxonomic Richness and Abundance

Maximum taxonomic abundance was recorded at station S1 (95 individuals) and minimum taxonomic abundance was observed at station S3 (39 individuals). Station S1 recorded the highest taxon richness with 19 taxa, while the lowest taxon richness was recorded at station S3 with 7 taxa (Figure 3).

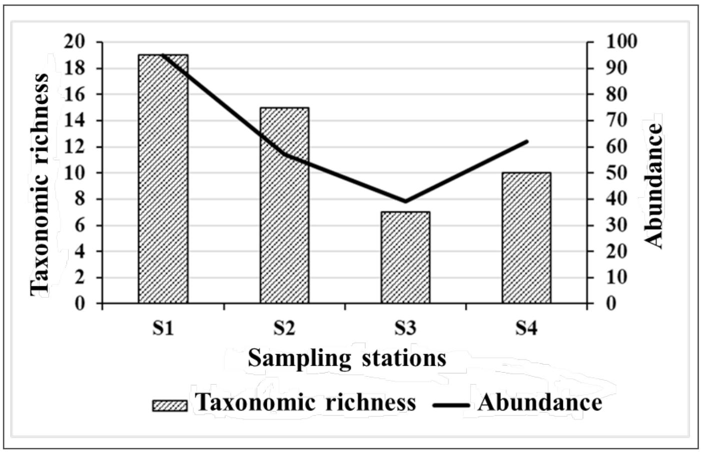


Figure 4. *Spatial evolution of the abundance and specific richness of macroinvertebrates in the Tiemba River*

3.6 Spatial Variation of the Shannon Diversity Index (H) and Equitability Index (E)

Figure 4 shows the spatial variation in the Shannon diversity and Piélou equitability indices. It shows that the highest value of the Shannon diversity index (2.78bits) is observed at station S1, while the lowest value of this index (1.65bits) is recorded at station S3. Similarly, the Piélou equitability index follows a similar pattern to that of the Shannon index. The maximum equitability value (0.94) is observed at station S1, while the lowest index value (0.85) is recorded at station S3 on the Tiemba river. Analysis of the indices using the Kruskal-Wallis test revealed no significant difference between stations ($p > 0.05$).

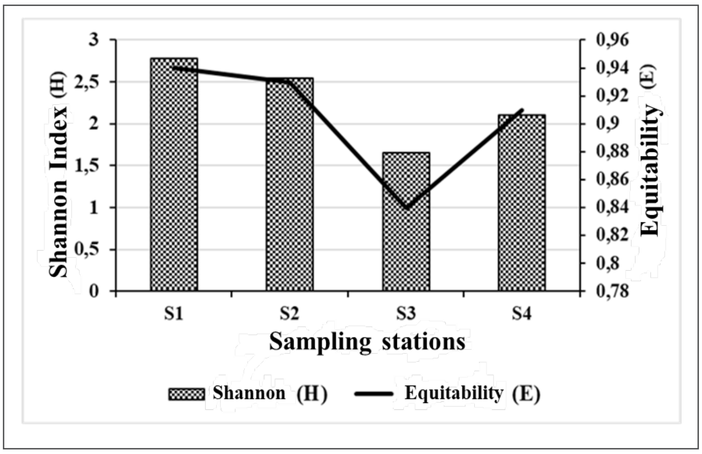


Figure 5. *Spatial evolution of the Shannon Diversity Index (H) and Equitability Index (E) for macroinvertebrates in the Tiemba River*

3.7 Relationship between Macroinvertebrates and Physico-Chemical Parameters of the River Tiemba

A canonical correspondence analysis (CCA) was carried out between the physico-chemical parameters and the abundances of benthic macroinvertebrates in the Tiemba River (Figure 6). The information contained in the variables is 91.7% controlled by the axes 1 and 2 system. The first axis is negatively and strongly correlated with temperature, while the second axis is negatively and strongly correlated with Conductivity, Dissolved Oxygen and Nitrite. pH and Depth are strongly and positively correlated with the second axis. Thus, temperature, conductivity, pH, Nitrite, dissolved oxygen and depth are the parameters that most influence the distribution of macroinvertebrates. On axis 2, there was a strong negative correlation between *Lobogenes michaelis*, *Heterhydrus* sp., *Enochrus* sp., *Polypedilum fuscipenne*, *Anopheles coustani*, *Diplonychus* sp., *Limnogonus luctuosus*, *Laccotrephes ater*, *Rhagovelia reitteri*, *Pseudagrion punctum*, *Zygomix torridus*, *Caridina nilotica*, *Tubifex* sp. and Conductivity, Nitrite and Dissolved Oxygen at stations S1 and S2. On axis 1, there was a negative association between *Microvelia* sp., *Tomichia* sp. and Temperature.

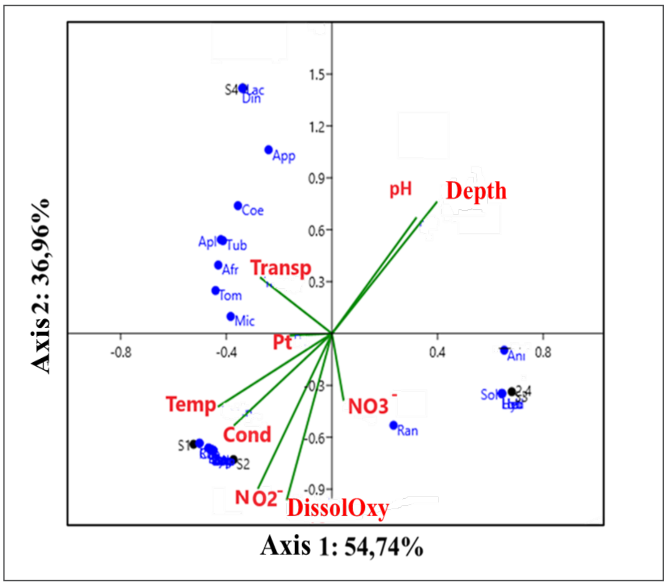


Figure 6. *Canonical Correspondence Analysis of Benthic Macroinvertebrates and Physical-Chemical Variables in the River Tiemba*

Legend : *Apl : Aplexa Waterloti, Afr : Afrogyrus rodrignezensis, Tom : Tomichia sp. , Lan : Lanistes ciliatus , Lob : Lobogenes michaelis, Het : Heterhydrus sp., Hyd : Hydroglyphus sp., Lac : Laccophilus luctuosus Din : Dineutus sp., Eno : Enochrus sp., Pol : Polypedilum fuscipenne, Ano : Anopheles coustani, App : Appasus sp., Dip : Diplonychus sp., Lim : Limnogonus luctuosus, Lac : Laccotrephes ater, Ran : Ranatra sp., Ani : Anisops sp., Mic : Microvelia sp., Rha ; Rhagovelia reitteri, Sol : Solenopsis sp., Coe : Coenagriocnemis reuniense , Pse : Pseudagrion punctum, Zyg : Zygomix torridus, Car : Caridina nilotica, Tub : Tubifex sp. Temp : Temperature, Cond : Conductivity, NO2- : Nitrite, NO3- : Nitrate, Pt : Total phosphorus, DissiOxy: Dissolved oxygen, Transp: Transparency, Depth and pH*

4. Discussion

The results obtained during this study showed that the mean values of the various physico-chemical parameters did not differ significantly in the different sampling stations of the Tiemba river. Average temperature values ranged from 25.2°C (S3) to 28.4°C (S4). These temperature values above 25°C are attributable to the relatively high ambient temperature in the Odienné Department (average 26.3°C). These values are in line with those observed by *[12]*, who indicates that in tropical environments, the water is almost always warm throughout the year, with an average temperature always above 20°C. These results are also similar to other work on surface waters, such as that of *[13]*, who report that in humid tropical zones, the average water temperature is around 30°C. These temperature values favour the speed of chemical and biological reactions in the different trophic levels through bacterial decomposition and photosynthesis. These temperature values favour the speed of chemical and biological reactions in the various trophic levels through bacterial decomposition and photosynthesis. These recorded water temperature values also reflect the impact of human activities on the river. The average pH of the river’s waters is between 7.6 (S2) and 7.20 (S4), which is within the tolerable limit (5 to 9) for most aquatic species *[14]*. These average values for the water at the various stations show that the water in the Tiemba River is not very aggressive. These results corroborate the work of *[15]*. The average electrical conductivity varies from 82.5 µS/cm (S4) to 94.2 µS/cm (S1). This shows that the river water is poorly mineralised and therefore does not contain enough dissolved mineral salts. These electrical conductivity values are similar to the results of previous studies by *[16]*. Furthermore, the average dissolved oxygen concentrations at the river stations fluctuate between 5.2 mg/l and 5.8 mg/l. These values show that the water at the stations in the river is moderately oxygenated. This range of variation in the river is consistent with those recorded in several African freshwaters such as the Bandama river *[17]* where dissolved oxygen levels range from 2 mg/l to 11 mg/l. Average nitrate concentrations ranged from 3.8 mg/l (S1) to 5.53 mg/l (S2). These values are above the 0.2 mg/l threshold. These high nitrate levels in the water are thought to be greatly influenced by human activities such as farming, which is sometimes located close to the water. Nutrient salts are also transported during the rainy season to the various watercourses by run-off. Studies by *[18] ; [19]* and *[20]* have shown the impact of human activities on the mineralisation of surface waters. The nutrient concentration values for total phosphorus (0.03 mg/l (S4) ; 0.09 mg/l (S2) and nitrite (0.03 mg/l (S4) ; 0.06 mg/l (S2)) are below the 0.2 mg/l threshold. These values indicate slight pollution of the river water, which would be inherent in an incomplete organic matter degradation process.

During this study, 243 individuals were collected belonging to 3 phyla, 04 Classes, 09 Orders, 20 families and 26 taxa. The phyla are represented by the Arthropods with 198 individuals, i.e. 78% of relative abundance, 39 individuals for the Mollusc phyla, i.e. 16% of relative abundance, and 16 individuals for the Annelids, i.e. 6% of relative abundance. The Insect class is the most dominant with a relative abundance of 77.9%, followed by Gastropods (15.4%). The Clitellata class represents 6.3% of the total number of macroinvertebrates, while malacostracans represent only 0.4%. This dominance of insects in terms of taxonomic richness is due to the fact that, according to *[21],* they represent the most diverse taxonomic group among aquatic macroinvertebrates, accounting for nearly 95% of the organisms present in the environment *[22]*. This result corroborates several studies that have shown the predominance of the Insect class in aquatic environments *[23].* The Shannon diversity index and Piélou equitability index were calculated to assess the level of organisation of the macroinvertebrate population in the Tiemba River. The maximum values of the diversity index and equitability obtained were 2.78 (S1) and 0.94 (S1) respectively, while the lowest values of these indices were 1.65 (S3) and 0.85 (S3) respectively. These variations could be explained by the high abundance of organisms at station S1 (95 individuals) and a low abundance at station S3 (39 individuals). The higher the diversity index, the lower the Piélou equitability index. These results corroborate those of *[24],* who state that Shannon and Weaver's H' diversity index decreases when a taxon has a very high relative abundance. These high index values suggest that the Tiemba river community is diverse and well organised. Canonical correspondence analysis (CCA) was used to correlate macroinvertebrates, physico-chemical parameters and stations. This analysis shows that temperature, conductivity, pH, nitrite, dissolved oxygen and depth are the parameters that most influence the distribution of macroinvertebrates. This result correlates with the ecological concept that macroinvertebrate populations are highly sensitive to physical and chemical fluctuations in the environment *[25]*. This result would also be justified by the impact of discharges from anthropogenic activities *[23]*.

5. Conclusion

This work made it possible to characterise the benthic macrofauna of the Tiemba river. It also enabled us to carry out a physico-chemical characterisation of the river. Generally speaking, the water is basic, with low conductivity, medium oxygen content and low concentrations of nitrogen and phosphorus. The present study enabled 253 macroinvertebrate individuals to be inventoried, corresponding to 3 faunal groups (Annelids, Molluscs, Arthropods), 04 Classes, 09 Orders and 20 families, the most dominant of which are the Belostomatidae (30 individuals), the Notonectidae (23 individuals) and the Dytiscidae (22 individuals). Among these different classes, insects were the most abundant and diverse taxonomic group. Analysis of the structure of the benthic fauna at the various stations reveals a diverse and well-organised population. As a result, the water at the stations studied is of average quality and does not currently seem to be showing any signs of major disturbance. Canonical correspondence analysis showed that temperature, conductivity, pH, nitrite, dissolved oxygen and depth are the parameters that most influence the distribution of macroinvertebrates. More in-depth studies on these groups are essential to improve knowledge of the different macroinvertebrate species that colonise the River Tiemba. In view of the future implementation of the Séguéla-Odienné road asphalting project planned for this region, it would be wise to extend the characterisation of the entire hydrographic network in the area in order to take stock of the macroinvertebrates present and assess the state of ecological health of these aquatic environments.

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6. References

1. Siddo.S. I., Adamou M. M., Ill. & Idé.I. (2022). Évaluation Temporelle des Paramètres Physico-Chimiques des eaux du fleuve Niger à Niamey. Rev. Ivoir. Sci. Technol., 39 (2022) 364 - 375
2. Chikou A. (2006). Etude de la démographie et de l'exploitation halieutique de six espèces de poissons-chats (Teleostei, Siluriformes) dans le delta de l'Ouémé au Bénin, Thèse de doctorat, Université de Liège, Belgique,459 p.
3. Gnohossou P. (2006). La faune benthique d'une lagune ouest Africaine (le lac Nokoué au Bénin), diversité, abondance, variations temporelles et

spatiales, place dans la chaine trophique, Institut National Polytechnique de Toulouse, 2006. Thèse de Doctorat. Institut National Polytechnique de Toulouse. SEVAB, 169 p.

4. Moisan J., Pelletier L., Gagnon E., Piedboeuf N., & Laviolette N. (2013). Guide de surveillance biologique basée sur les macroinvertébrés benthiques d'eau douce du Québec, Ministère Dév. Durable Parcs, 88 p.
5. AFNOR, (1992). Détermination de l'Indice Biologique Global Normalisé (IBGN). Essai des eaux, NF T90-350, Association Française de Normalisation, déc 1992, 9 p.
6. Dickens C.W.S. & Graham P.M. (2002). The South African Scoring System (SASS) Version 5 rapid bioassessment methods for bergers. African Journal of Aquatic Sciences, 27 : 1- 10.
7. Dejoux C. (1981). Les Chironomides. In Flore et faune aquatiques de l'Afrique sahélo soudanienne. Tome II. J. -R. Durand & Lévêque C. (Eds) : 583-616.
8. Brown D.S. (2005). Freshwater Snails of Africa and their medical impor-tance. Edition Taylor and Francis Ltd, London, 673 p.
9. Ramade F. (2003). Elément d'écologie : Ecologie fondamentale. Dunos édition, Paris, 2, 190 p.
10. Dajoz R. (2000). Précis d'Ecologie. Ecologie fondamentale et appliquée 7ème édition, Dunod, Paris, France, 615 p.
11. Zinsou L. H., Agadjihouede H., Gnohossou P. & Laleye P. (2017). Analyse et illustration de la valeur indicatrice des espèces macrobenthiques du Delta de l'Ouémé au Bénin, Eur. Sci. J. ESJ, Vol. 13, No 5 333 -351
12. Lemoalle J. (2006). La diversité des milieux aquatiques. *In :* Les poissons des eaux continentales africaines : diversité, écologie, utilisation par l'Homme (Lévêque C. & Paugy D., eds). Editions IRD, Paris, France, 11-30
13. Eblin, A. P. G., Sombo Soro., N.Aka., O. Mbiré . N. & Oro. (2014). Hydrochimie des eaux de surface de la région d'Adiaké (sudest côtier de la Côte d'Ivoire). Journal of Applied Biosciences 75 :6259– 6271 ISSN 1997– 5902
14. Montcho S. A., Chikou A., Lalèyè P. A. & Linsenmair K. E., (2011). Population structure and reproductive biology of Schilbe intermedius (Teleostei : Schilbeidae) in the Pendjari River, Benin, Afr. J. Aquat. Sci., Vol. 36, No 2 139 – 14
15. Yao K. A. F. (2018) Développement d'une méthodologie pour une meilleure évaluation des impacts environnementaux de l'industrie extractive : cas de la mine d'or d'Afema (Sud-est de la Côte d'Ivoire). Thèse de doctorat, Université de Montpellier, France, 210 p.
16. Goloma S. & Symoens J.J. (1990). Caractéristiques physiques et chimiques de quelques cours d'eau de Kisangani (Zaïre). *Bulletin des Séances Académie Royale*, Sc. Outre-Mer, 35 : 145-157.
17. Kressou A., Bony K.Y., Allouko J-R. & Djene R. (2019). Biosedimentary index (IBS) and biological quality of the water courses in the upper Bandama fauna and flora reserve (North-center Côte d'Ivoire). Journal of Entomology and Zoology Studies, 7(6) : 330-335.
18. Lakhili F., Benabdelhadi M., Bouderka N., Lahrach H. & Lahrach A. (2015). Etude de la qualité physicochimique et de la contamination métallique des eaux de surface du bassin versant de Beht (Maroc). European Scientific Journal, vol.11, No.11, pp. 1857- 7431
19. Chaouay A., Okhrib R., Hilali M., Bazzi L., Chahid A. & Khiri F. (2016). Contribution à l'étude de l'analyse physico-chimique et de la contamination métallique de l'eau de mer du littoral d'Agadir (Sud du Maroc). Journal of Materials and Environmental Sciences, 7 (8), pp. 2748-2759
20. Adjagodo A., Agassounon D. T. M., Kelomè N.C., Vissin E.W., Agbossou E. (2017). Pollution Physique et Bactériologique de l'eau du fleuve dans la Basse Vallée de l'Ouémé pendant les périodes de Basses et Hautes eaux au Bénin. European Scientific Journal, Vol.13, No.33, pp. 1857 – 7881
21. Gagnon E. & Pedneau J. (2006). Surveillance Volontaire (SurVol) Benthos, guide du volontaire, programme de surveillance volontaire des petits cours d'eau. CVRB, Québec, Canada, 25 p.
22. Lee S.J., Park J.H. & Ro T.H. (2006). Ephemeropteran community structure and spatial stability of local populations of the major species group in the Keumho Berger. *Entomological Research*, 36: 98-106
23. Allouko J.R., Bony K.Y., Edia O.E. & Konan K.F. (2016). Composition, distribution and abundance of Macroinvertebrates in Aghien lagoon (Ivory Coast; West Africa). *International Journal of Innovative Research in Science, Engineering and Technology,* 5(6): 10104-10111
24. Foto.M. S. Zebaze. S. H., Tchatcho N. N. & Njine N.T. (2010). Macroinvertébrés du cours d'eau Nga: Essai de Caractérisation d'un Référentiel par des Analyses Biologiques, European Journal of Scientific Research, 1 : 96-106
25. Mary N. & Archaimbault V. (2011). Indices Biotique de la Nouvelle-Calédonie (IBNC) et Indice Biosédimentaire (IBS) : guide technique, DAVAR, Pôle de l'observatoire de la ressource en Eau, 58p.