Taxonomic richness and population structure of benthic macroinvertebrates in marshy environments of the Central Cameroon region (MEFOU-ET-AKONO; MFOUNDI; MEFOU-ET-AFAMBA)

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Summary: With the aim of assessing the anthropogenic impact on the swamps of Mbankomo, Nkozoa and Ayene in the Center Region, an analysisphysicochemical, coupled with that of macroinvertebratesywas conducted from September 2022 to April 2023.The samples were taken following a seasonal frequency.Physicochemical analyzes reveal that the waters studied are poorly oxygenated (16.05 ± 7.77%),very little mineralized with a low value for conductivity (214.62±33.01 µs/cm) and oxidizability(44.60 ± 16.07), orthophosphate values are high(244.11 ± 146 mg/L)thus showing that the waters of the Mbankomo, Nkozoa and Ayene swamps are of poor quality.A total of 1359 macroinvertebrate individuals were identified and divided into 26 families.The IndexStandardized Global Biotics (IBGN)reveals watersdisturbed by anthropogenic activities and are therefore of very poor ecological quality. In view of the results and discussion it emerges that the best indicators of the water quality of the marshes ofMbankomo, Nkozoa and Ayeneare aquatic macroinvertebrates, the vast majority being hexapods (chironomidae).

Keywords: Evaluation, Human activities, Marshes, MEFOU-ET-AKONO, NFOUNDI, MEFOU-ET-AFAMBA.

Abstract: In order to assess the anthropogenic impact on the Mbankomo, Nkozoa and Ayene marshes in the Central Region, a physicochemical analysis, coupled with macroinvertebrate analysis, was carried out from September 2022 to April 2023. Samples were taken on a seasonal basis. Physicochemical analyzes revealed that the waters studied had low oxygen content (16.05 ± 7.77%), very low mineral content, with low values for conductivity (214.62 ± 33.01 µs/cm) and oxidizability (44.60 ± 16.07), and high orthophosphate values (244.11 ± 146 mg/L), indicating that the water quality in the Mbankomo, Nkozoa and Ayene marshes is poor. A total of 1,359 macroinvertebrates were identified, divided into 26 families. The Standardized Global Biotic Index (SGBI) reveals waters disturbed by anthropogenic activities and therefore of very poor ecological quality. The results and discussion show that the best indicators of water quality in the Mbankomo, Nkozoa and Ayene swamps are aquatic macroinvertebrates, the vast majority of which are hexapods (chironomidae).

Keywords: Evaluation, Human activities, Swamps, MEFOU-ET-AKONO, NFOUNDI, MEFOU-ET-AFAMBA.

INTRODUCTION

Biodiversity is the major driver of ecosystem functioning (Hopper et al., 2005).It designates the total number of species of living beings present in an environment at a given time (Zébazé Togouet et al., 2000). It is a powerful tool for assessing the state of trophy of aquatic environments that can make it possible to develop sustainable management strategies for these vulnerable environments (Alain Peeters et al., 2004). It is necessary to protect, conserve and manage biological diversity which is a primordial heritage (Johan Milian et al., 2010). In addition, the digitization of this biodiversity opens up new opportunities for scientific analysis of data and makes it possible to acquire new knowledge on the conservation and management of natural ecosystems (Johan Milian et al., 2010). High urbanization, the intensification of agriculture and the growing industrialization of cities are at the origin of a considerable production of solid and liquid waste (Oula Amroui et al., 2020) leading to a considerable increase in water loads. domestic and industrial in organic matter and dissolved substances which flow towards the terminal receptacles which are aquatic environments, mainly swamps.

The management of aquatic ecosystems has therefore become a priority theme for both scientists and users. According to the Ramsar convention, wetlands are areas of fen marshes, peat bogs, natural or artificial, permanent or temporary water where water is stagnant or running, fresh, brackish or salty, including areas of marine water whose depth at low tide does not exceed six meters.

In addition, their waters are home to numerous animal and plant organisms which maintain close relationships with their living environment (AMAIRD Jean-Claude et al., 2008). macroinvertebrates are also used in water diagnosis in fact they include all aquatic organisms visible to the naked eye and lacking an ossified skeleton or cartilage (Moisan and Peletier 2006); They are established as good indicators because of their rapid and different reaction depending on the species to toxicants, their sedentary lifestyle, their varied life cycle, their great diversity and their variable tolerance to pollution and habitat degradation (Moisan and Pelletier, 2008;

In Cameroon and in Yaoundé in particular, work aimed at studying macroinvertebrates was carried out in several lentic and lotic environments. However, there is very little data on the swamps of the central Cameroon region, hence the need to record the physicochemical parameters and study their invertebrate diversity. In these aquatic macroinvertebrates, movements (mainly larvae) are low, hence recolonization of polluted sectors can only take place from adults of the next generation, coming from unpolluted sectors (Cosme Z et al., 2017). .
The best understanding of the functioning of an aquatic ecosystem requires knowledge of its physicochemical quality, which has a direct influence on the biodiversity and distribution of macroinvertebrates in an aquatic environment. It is with this in mind that our study falls with the general objective of assessing the impact of human activities on the water quality of the Mbankomo, Nkozoa and Ayene swamps. More specifically, it is:to evaluate the physicochemical characteristics of the waters of these different swamps in order to decide on its state of trophy;ofdetermine the structure of macroinvertebrate populations;ofestablish the links between the physicochemical quality of water and the distribution of its macroinvertebrate populations.

2. Materials and methods

2.1. Study site

2.1.1. Geographic location

The Central Cameroon region is located between 3°30' - 3°58' North latitude and between 11°20' - 11°40' East longitude (INC, 1980). The average altitude is around 750 m, its relief is generally rugged and the urban area extends over several hills 25 to 50 m high above the plateau (Santoir, 1995). The climate is equatorial with bimodal rainfall characterized by moderate precipitation (1576 mm/year) oscillating between 1500 and 1700 mm per year (Kodjo, 1988), with temperatures that vary little over time (Suchel, 1972). There are four seasons, unevenly distributed and varying in length from one year to the next (Kuete, 1987). The vegetation is of the secondary dense forest type and the hydrographic network is dense. Petrographically, the soils present themselves as throughout South Cameroon under three types including ferralitic soils, hydromorphic soils and poorly evolved soils (Onguéné, 1993).

2.1.2. Historical

The Mbankomo swamp is located on the edge of the national road number 3 below the first bridge just after the landscape going towards the coast. Right next to a very large rice processing factory which dumps its waste into the swamp, this swamp is made up of small shrubs with short and abundant vegetation and also a mini stream which crosses it with its source all upstream below a hill. In certain areas of the swamp where there are stones, the populations have slightly adapted them to do their laundry and other things. After the construction work on national road number 3, the road passes above the swamp and we can see at the edge the mini garbage deposits which form there periodically, the water from leaching of the tar, pours directly into the swamp; This swamp does not really show traces of a particular agricultural culture made by men. This is due to the vast extent of its surface area and the difficulties of access but also the presence of shrubs which brings it closer to the mini forest located just behind.

As for the Ayene swamp, it is located in the center of the city of Yaoundé, more precisely behind the UCB beverage depot and the brewery located at the CAMI TOYOTA crossroads, near the Cameroun brewery. This drinking depot, has part of its premises built on the swamp and where we observe part of their waste which spills onto the ground, a channel crosses the swamp, and drains the water coming from both sides from the city. Houses and a tarmac road cross the swamp on a large slope, thus justifying the presence of garbage deposits on the swamp every ten meters. Faecal sludge lines both sides of the swamp from the toilets of the surrounding houses. This swamp is also overexploited by

high and permanent agricultural and even fish farming activity in certain places developed by the population in the gigantic furrows of market gardening. It is mainly supplied with water by the water table.

Regarding the Nyom swamp, it is located 500 meters from the national road number 1 on the Yaoundé-Obala axis. It is below a side of cliffs and is bordered in its front part by residential houses. , the surrounding populations built apartments under the swamp which were swallowed up by water and the seagrass, they set up fish farming areas and pigsties on stilts, all of which dumped their waste into the swamp. The surroundings of the swamp are littered with small piles of garbage from households. The vegetation is quite dense and consists mainly of creeping plants and lianas; the main water supply is through the water table. Recurrent landslides from the side of the cliff fill the rear part of the swamp with earth like a natural embankment, which raises the water level of the swamp and encourages the swamp to advance towards the houses.of dwellings.

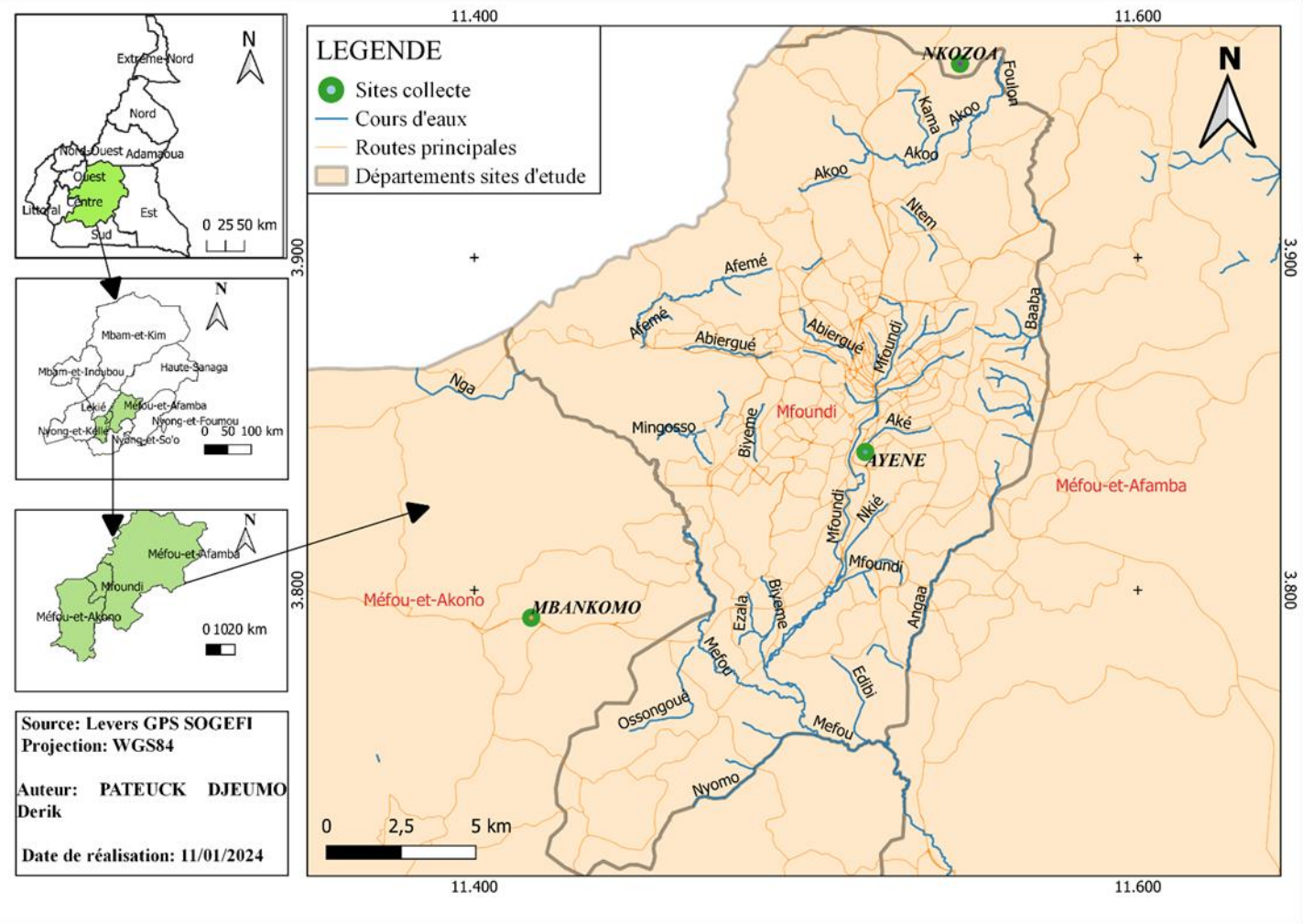

Figure 1 :partial view of the different swamps (MBANKOMO, AYENE, NKOZOA)

II.2. Materials and methods

II.2.1. Physico-chemical

During this study, sampling for physicochemical and biological analyzes was carried out by season in accordance with the recommendations which suggest that this frequency is sufficient to account for 80% of the species present in the environment and their variations. The physicochemical parameters were collected using double-capped polyethylene bottles of 250 and 1000 cc without making bubbles, filled to the brim, then stored for analysis in the laboratory. The field sampling procedure and the method of analysis of each parameter in the laboratory are described in Table 1 below.

Table 1: Analytical methods for quantifying physicochemical variables

Parameters measured	Methods used
Dissolved oxygen	The dissolved oxygen content was measured by the Winkler volumetric method in the field, in a 125 ml Winkler bottle, 123 ml of sample was mixed with 1 ml of Winkler reagents and 1 ml of manganese chloride. This resulted in the formation of a white precipitate in the bottle. Back in the laboratory, the precipitate was dissolved by adding 1 ml of concentrated sulfuric acid to the solution (yellow coloring of the solution) then 50 ml of solution was then taken and titrated with sodium thiosulfate N/80 in the presence of 2 or 3 drops of starch as a colored indicator. The solution, initially blue, became colorless at the end of the titration. Finally, the results obtained in mg/L of sample which corresponds to the descent of the burette were converted into saturation percentages using the Mortimer chart.
Orthophosphates	The orthophosphate concentrations were measured on 10 mL of sample with Phosver III as reagent and the reading was taken at the wavelengthλ= 880nm. The results are expressed in mg/L of PO43-.
Total alkalinity	The Complete Alkalimetric Title (TAC) or alkalinity was determined in the laboratory by volumetry. To do this, 50 mL of water sample was introduced into a beaker, then a few drops of methyl bromocresol red green were added. The blue coloring solution obtained was then titrated with sulfuric acid (H2SO4) N/50 until the gray coloring. The results expressed in mg/L were obtained by the formula: **Alkalinity (in mg/L of HCO3-) = burette descent x 20**
Oxidability	Oxidizability was measured volumetrically. In an Erlenmeyer flask, 2 mL of monosodium carbonate was added to 200 mL of the sample and then brought to a boil on a hot plate. As soon as boiling began, 20 mL of potassium permanganate (KMnO4) N/80 were added. A few minutes later, everything was cooled with tap water. After cooling, 5 mL of 25% sulfuric acid and 20 mL of Mohr's salt were added to the preparation. The colorless solution thus obtained was titrated with potassium permanganate (KMnO4) N/80 until a persistent pink color appeared. The control is obtained following the same principle using distilled water instead of the sample. The results expressed in mg/L of O2 were calculated by the formula: **Oxidability (mg/L of O2) = [(sample burette descent – control burette descent) /2]×3.95**
Conductivity	The electrical conductivity was measured “in situ” using a HANNA Hi 99300 brand TDS-conductivity meter. The results are expressed in µS/cm.

II.2.2 Sampling and identification of macroinvertebrates

Sampling of benthic macroinvertebrates was carried out on a monthly basis, using a square-shaped trout measuring 30 cm on a side, fitted with a conical net with a mesh opening of 400 µm and a depth of 50 cm. . Sampling was done following the multihabitat approach proposed by Stark et al. (2001). At each study station and each sampling campaign, around twenty blows were carried out for an area of approximately 3 m² along a station of length equal to ten times the width of the bed. The troubleshootings were carried out in different microhabitats.

Each time, the organisms retained by the mesh of the net were collected using a pair of fine forceps, fixed in 10% formalin and stored in a pillbox. Back in the laboratory, the macroinvertebrate samples were rinsed thoroughly under running water to remove formalin. The samples were stored in pill bottles containing 70% alcohol and identified using the identification keys of Durand and Levêque (1980), Day et al. (2001), Tachet et al. (2006), Stals and de Moor (2007).

II.2.3. Data analysis and statistical tests

II.2.3.1. Kruskal-Wallis H test andby Mann-Whitney

The Kruskal-Wallis test allowed us to see if the data obtained varied significantly from one sampling station to another and from one month to another and that of Mann Whitney allowed us to compare these densities two to one. two. These two tests were carried out using PAST software.

II.2.3.2.Standardized Global Biological Index (IBGN) (AFNOR, 2004)

The IBGN method is based on the simplified study of the benthic macroinvertebrate fauna. The index is given by a table involving the nature of the wildlife collected (indicator groups of different sensitivity to disturbance) and its variety. The calculation of the IBGN consists of determining: The taxonomic variety (VT), that is to say the total number of taxa identified, regardless of the number of individuals found per taxon and the indicator group (GI) or the most "polluosensitive" reference group (GR), that is to say the indicator taxon having a significant presence in the station (at least 3 or 10 individuals depending on the taxa) and having the highest possible index. The IBGN is calculated from a double-entry analysis table, including taxonomic variety classes on the abscissa (class 1 to 14) and indicator faunal groups on the ordinate, classified in descending order (index 9 to 1).) sensitivity to pollution. The iStandardized Global Biological Index (IBGN) can also be calculated according to the relationship: IBGN=GI+VT-1, with IBGN ≤ 21. GI = indicator faunal group; VT = taxonomic variety of the sample. The results obtained will be compared to the values in Table 2 below:

Table 2: Classification table based on IBGN value

IBGN	**17 to 20**	**13 to 16**	**9 to 12**	**5 to 8**	**<4**
Class	Blue	Green	YELLOW	Orange	Red
Quality	Very good	Good	Fair	Bad	Very bad

III. Results and discussion

Table 3: Summary of records of maximum values, minimum values, average values and standard deviations of physicochemical parameters of the MBANKOMO, AYENE, NKOZOA swamps during the study period.

STATION	MONTH	Conductivities (µs/cm)	O2(desaturation)	Orthophosphate (Mg/l)	Alkalinity (Mg/l)	Oxidability (Mg/l)
MBANKOMO	December 28, 2022	29	33	163	60	87
	02-Mar-23	37.5	6.93	161	664	28.63
	21-Apr-23	153.1	6.23	732	500	51.35
	Minimum	**29**	**6.23**	**161**	**60**	**28.63**
	Average G	**73.2**	**15.38666667**	**352**	**408**	**55.66**
	Spreader G	**69.32582**	**15.25760903**	**329.0912**	**312.3331555**	**29.42271741**
	Maximum	**153.1**	**33**	**732**	**664**	**87**
NKOZOA	December 28, 2022	95.8	50	67	100	20
	02-Mar-23	93.2	6.38	122	740	78.01
	21-Apr-23	89.2	6.7	138	570	82.95
	Minimum	**89.2**	**6.38**	**67**	**100**	**20**
	Average G	**92.73333**	**21.02666667**	**109**	**470**	**60.32**
	Spreader G	**3.324655**	**25.09215282**	**37.24245**	**331.5116891**	**35.0053953**
	Maximum	**95.8**	**50**	**138**	**740**	**82.95**
AYENE	December 28, 2022	446.8	23	371	340	13.13
	02-Mar-23	467	6.58	392	240	22.71
	21-Apr-23	520	5.65	51	100	17.7
	Minimum	**446.8**	**5.65**	**51**	**100**	**13.13**

	Average G	**477.9333**	**11.74333333**	**271.3333**	**226.6666667**	**17.84666667**
	Spreader G	**37.80494**	**9.759643095**	**191.1029**	**120.5542755**	**4.791683768**
	Maximum	**520**	**23**	**392**	**340**	**22.71**
	AVERAGE GENERAL	**214.6222**	**16.05222222**	**244.1111**	**368.2222222**	**44.60888889**
	GENERAL GAP	**33.01164**	**7.767793934**	**145.9963**	**116.6547508**	**16.07649669**

III.1. Results

III.1.1 Electrical conductivity, Oxygen (O2)

Regarding electrical conductivity, the highest value was obtained in the month of December (520 µS/cm) and the smallest value obtained in the month of April with an average of (214.62± 33.01 µS/cm). The Kruskal-Wallis test shows that there is no significant difference spatially and temporally ($p>0.05$) (Figure 2A). The maximum dissolved oxygen saturation rate was obtained in the month of December (50%) and the minimum saturation rates in the month of April (5.65%) (Figure 2B). These values oscillate around an average of 16.05 ± 7.77% testifying to the poor oxygenation of the quarry lake of the MBANKOMO, AYENE and NKOZOA swamps. The Kruskal-Wallis test shows that there is no significant difference spatially and temporally ($p>0.05$).

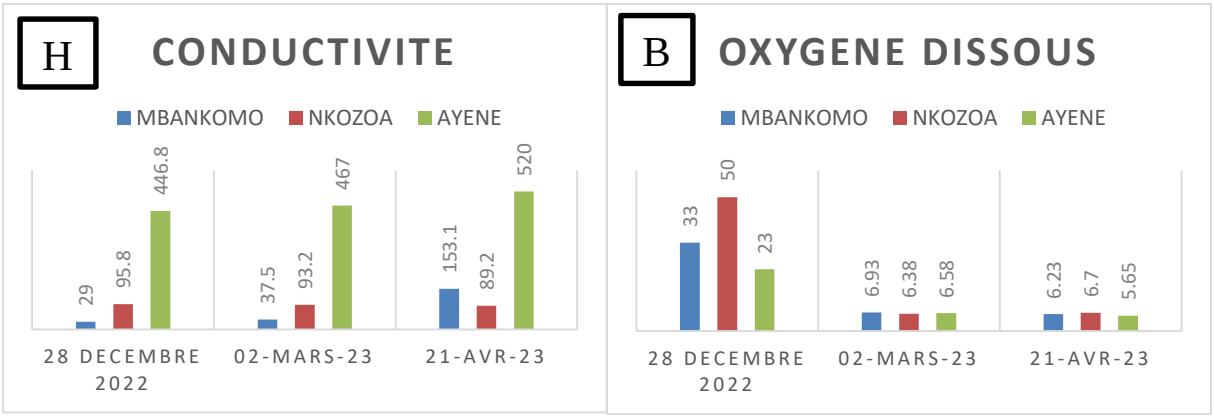

Figure 2: Spatio-temporal variation of conductivity (A) and oxygen (B) obtained during the study period in the MBANKOMO, AYENE and NKOZOA swamps.

III.1.2.Alkalinity, oxidizability

Alkalinity values varied between 60 mg/L at MBANKOMO in December to 740 mg/L at NKOZOA in March with an average of (368.22± 116.65 mg/L). The Kruskal-Wallis test shows that there is no significant difference spatially and temporally ($p>0.05$) (Figure 3A). During the study period, the highest oxidizability value is 87 mg/L obtained in the month of December at MBANKOMO (Figure 3B) and the lowest value 13.13 mg/L was obtained in the month from December to AYENE. With an average of 44.60 ± 16.07. The Kruskal-Wallis test shows that there is no significant difference spatially and temporally ($p>0.05$).

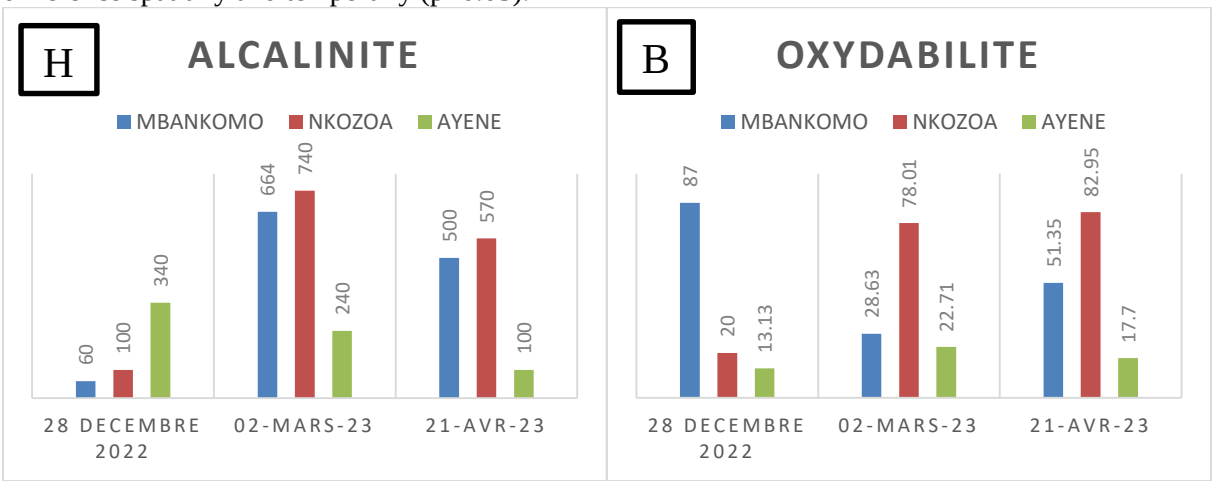

Figure 3: Spatio-temporal variation of alkalinity (A) and oxidizability (B) obtained during the study period in the swamps of MBANKOMO, AYENE and NKOZOA.

III.1.3.Orthophosphates (PO43-)

The orthophosphate contents of water have values between 51 mg/L (April) in AYENE and 732 mg/L (April) in MBANKOMO for an average value revolving around 244.11± 146 mg/L (Figure 4A). The Kruskal-Wallis test shows that there is no significant difference spatially and temporally ($p>0.05$.

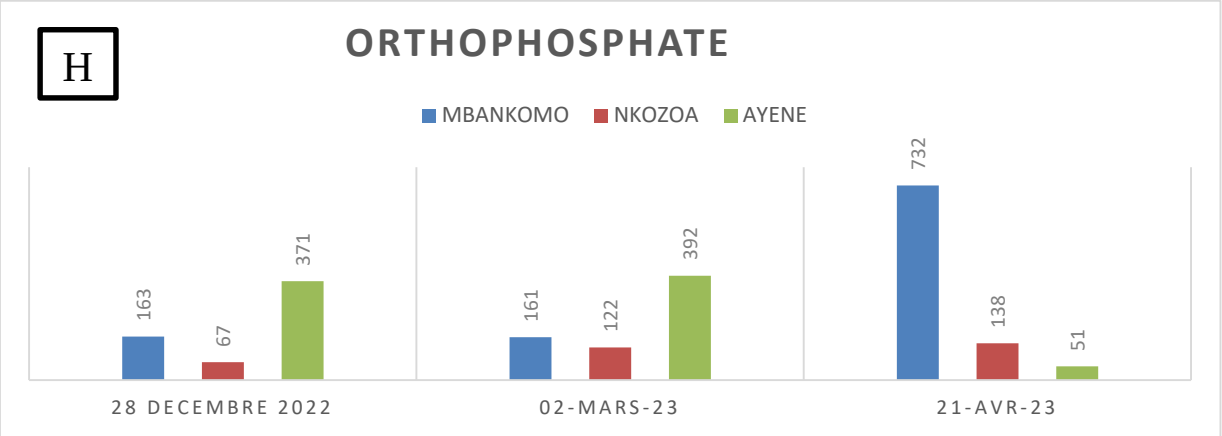

Figure 4: Spatio-temporal variation of orthophosphate (A) content values obtained in the MBANKOMO, AYENE and NKOZOA swamps during the study period.

III.1.4. Benthic macro invertebrates

Table 4: Abundance of different taxa of benthic macroinvertebrates collected in each station during the study period

BRANCHES	CLASSES	ORDERS	FAMILIES	GENRES	SPECIES	MBANKOMO	NKOZOA	AYENE
ARTHRO-PODS	Hexapods	Diptera (Nematoceres 1)	Ceratopogonidae	bezzia	Bizzia sp	81	118	18
			chironomidae	chironominae		130	80	188
			muscidae	dolichopodidae		0	0	2
			brachycera	tabanidae		0	8	2
			limonidae	hexatomini		5	0	17
		Diptera (Nematocera 2)	culicidae	culex		22	30	63
		Odonates (anisoptera)	gomphidae	Ophiogomphus (ictinogomphus)	Ictinogomphus ferox	5	0	0
			libellulidae	Brachythemis leucostica	leucostica	42	8	0
				leucorrhinia		13	0	0
				orthotrum		0	11	0
		Odonata (zygoptera)	platycnemididae	allocnemis	Allocnemis leucostica	4	12	30
						12	0	0
		Beetles	Dysticidae	grophorerus		2	0	0
			hydrophilidae	Hydrobius		0	2	1

				enochrus	Enochrus sp	**0**	**6**	**13**
			syrphidae			**0**	**0**	**2**
			ephydridae			**0**	**0**	**1**
		Heteroptera	geromorpha	microvelia		**2**	**0**	**0**
			corixidae	corixinae	haspererocorixa	**21**	**0**	**0**
			Gerridae	Limnogonus	Limnogonus sp	**0**	**3**	**4**
				neogerris	Neogerris sp	**0**	**8**	**3**
			belostomatidae	diplonochus	Diplonochus sp	**0**	**7**	**2**
			mesovelidae	mesovelia	Mesovelia sp	**0**	**8**	**0**
			nepidae	laccotrephes	Laccotrephes sp	**0**	**3**	**0**
			veliidae	hierovelia	Hierovelia sp	**0**	**0**	**2**
MOLLUSKS	Gasteropoda	basommatophora	lymnaeidae	radix		**0**	**7**	**0**
			physidae	Physa acuta		**0**	**0**	**219**
			thiaridae	melanoids	Melanoides tuberculata	**0**	**0**	**11**
ANNELIDES	Oligochetes	Haplotaxida	naididae			**1**	**0**	**0**
	Buy	rhynchobdellida	glossiphoniidae	haementeria	Haementeria costata	**0**	**0**	**2**
NEMATHELMINTHS	cordial					**41**	**0**	**3**
SHELLFISH	malacostraca	decapods	atyidae	caridina	Caridina africana	**84**	**0**	**0**
TOTAL						**465**	**311**	**583**
						1359		

III.1.4.1. Taxonomic richness and relative abundance

During the study period, a total of 1359 individuals were counted and divided into 03 phyla: Arthropods (72.92%), Molluscs (17.44%), Crustaceans (6.18%), Nemathelminthes (3 .24%) and Annelids (0.22%) and. These organisms belong to 04 classes, 09 orders and 16 families (Figure 5A).

The hexapod class is the most represented with 72.92%, it has 4 orders, 21 families and 21 genera. It is followed by the class of gastropods with 17.44%, including: 01 order, 03 families and 03 genera, the class of malacostracae with 6.18% including 01 order, 01 family and 01 genera followed by the class of gordiaceae with 3.24% then the class of purchases with 0.15% including 01 order, 01 family and 01 genus and finally the class of oligochaetes represents only 0.7% with: 01 order, 01 family and 01 genus (Figure 5B).

Of the 08 orders sampled, Diptera dominate with 56.22%, followed by Basommatophora, Odonata, Decapoda, Heteroptera, Coleoptera, Rhynchobdellida and Haplotaxida, and with respective relative abundances of 17.44%, 10 .08%, 0.23%, 6.18%, 4.63%, 1.99%, 0.17%, 0.07% (Figure 5C)

Among the 26 families recorded, 07 belong to the order of Heteroptera, 03 to the order of Basommatophora, 03 to the order of Odonata, 06 to the order of Diptera, 04 to the order of Coleoptera. The orders Haplotaxida, Rhynchobdellida and Decapoda each have 01 family. (Figure 5D).

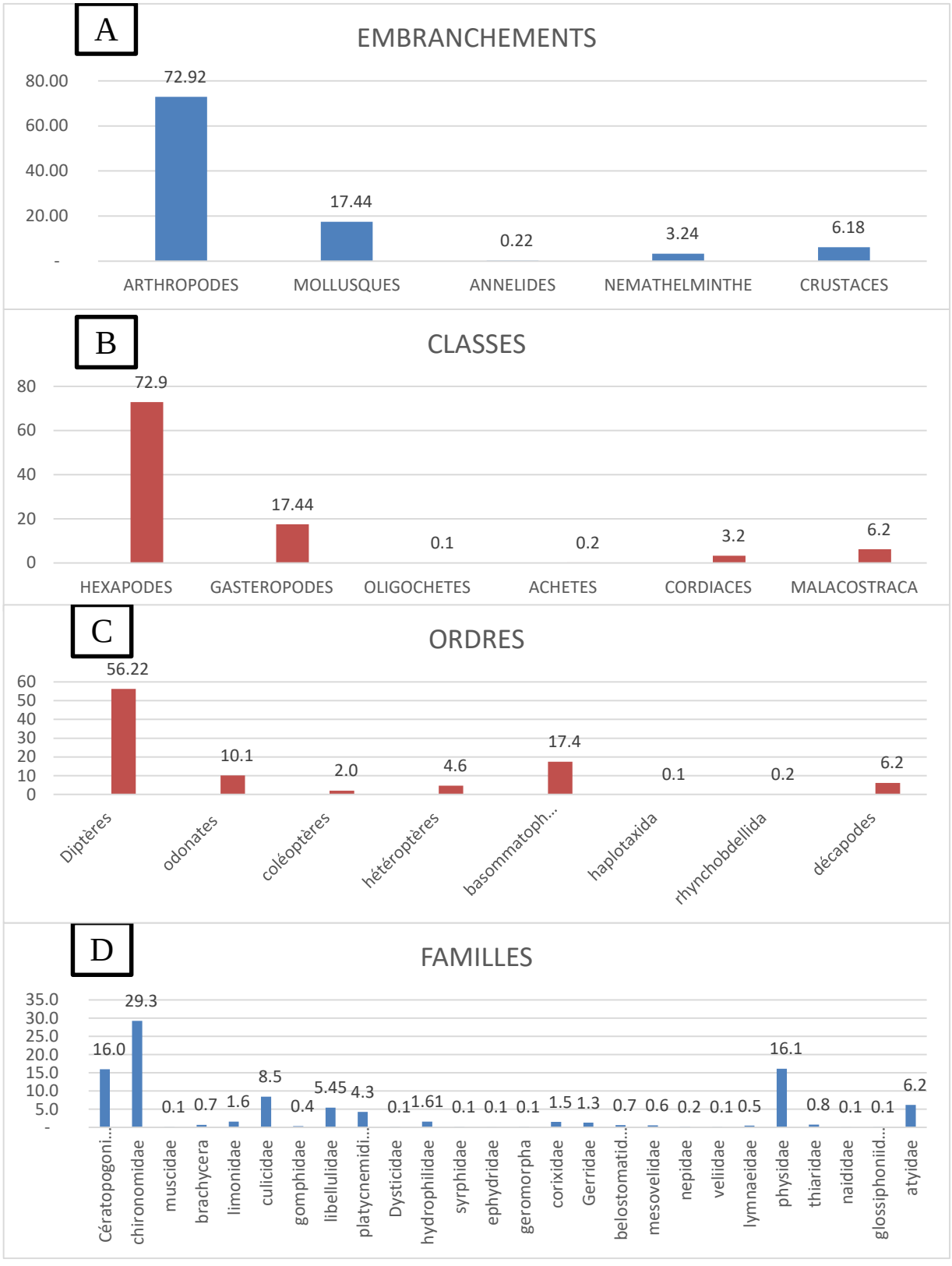

Figure 5: Relative abundance of Orders (C), classes (B), and families by order (D) of phyla (A) of benthic macroinvertebrates in the swamps of MBANKOMO, AYENE and NKOZOA during the study period.

III.1.4.2. Spatio-temporal variation in total abundance of benthic macroinvertebrates.

The profile of abundances of benthic macroinvertebratesin swamps during the study periodpresent on the spatial level, the values of 465 individuals atMBANKOMO, 311 individuals toNKOZOAand 583 individuals toAYENE(Figure 6A).

Temporally, the abundances of benthic macroinvertebrates show an irregular evolution with a maximum of 557 individuals in the month of APRIL and a minimum of 376 individuals in the month of DECEMBER, with an average of 453 ± 93.47 individuals per month (Figure 6B). However, no significant differences were observed at the station level and from one month to the next ($p > 0.05$).

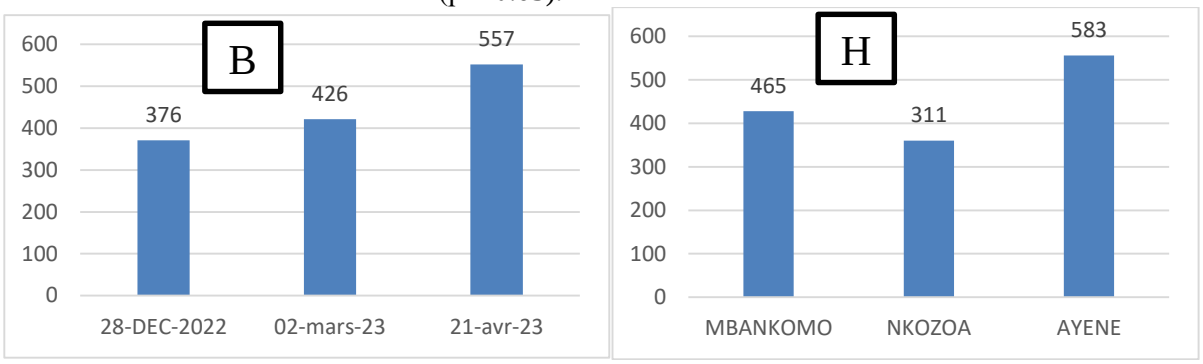

Figure 6: Spatial (A) and temporal (B) variation of the total abundance of MIBs in the MBANKOMO, AYENE and NKOZOA swamps during the study period.

III.1.4.3. Spatio-temporal variation in taxonomic abundance

The total number of macroinvertebrate families counted is 26.It varies from 16 in AYENE to 12 and 12 respectively MBANKOMO and NKOZOA for the respective relative abundances of 61.54%, 46.15% and 46.15% (Figure 7A). The family Chironomidae predominates with a relative abundance of 29.3%, followed by Physidae (16.1%) and Ceratopogonidae (16.0%). Next come 23 other families with relative abundances ranging from 8.5% to 0.1%.
Temporally, the highest number of families is 15 obtained in the months of March and April, the lowest is 14 families obtained in the month of December (Figure 7B). However, no significant difference was observed between the sites and between the different months ($p > 0.05$).

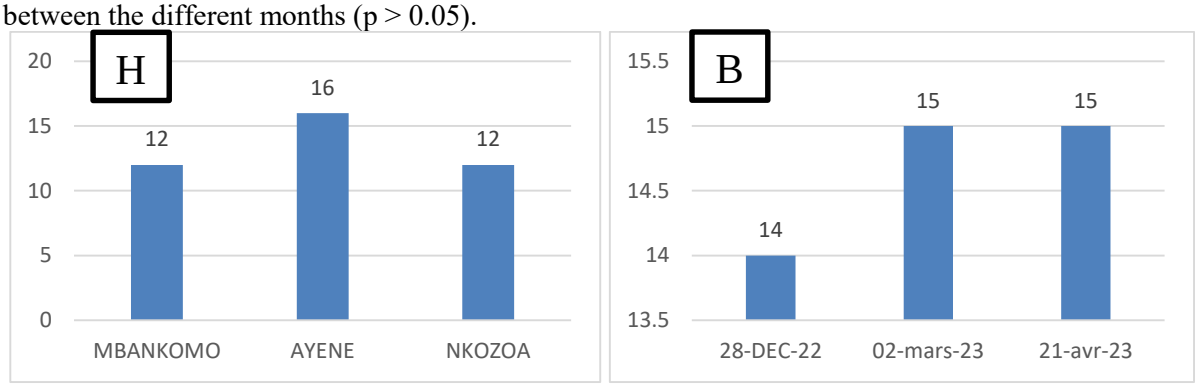

Figure 7: Spatial (A) and temporal (B) variation in the number of families sampled in the MBANKOMO, AYENE and NKOZOA swamps during the study period.

The calculation of the Standardized Global Biological Index at the MBANKOMO and NKOZOA stations gave the same value of 4 revealing water of very poor quality and that of the AYENE station gave a value of 6 indicating water of poor quality.

Table 5:IBGN values and interpretation

Stations	MBANKOMO	AYENE	NKOZOA
Taxonomic Variety (VT)	<4	5 to 8	<4
Variety Class	4	5	4
Indicator group (GI)	1	2	1
IBGN value	4	6	4
Color	Red	Orange	Red
Qualities	Very bad	Bad	Very bad

III.2. Discussion

III.2.1.Physicochemical parameters

The percentage of dissolved oxygen saturation (16.05 ± 7.77%) shows thatthe swamps of MBANKOMO, AYENE and NKOZOA havea poor suitability class (red) which shows very low oxygenation of the waters of the different swamps;

this character of urban water hypoxia had already been noted by Foto Menbohan (2012) and Dhillon et al. (2013). This would reflect poor photosynthetic activity and an absence of the phenomenon of dissolution from atmospheric oxygen in these swamps, which is justified by the biofilms present on the surface of all these swamps throughout the study period which prevents the migrations of oxygen molecules in the air/water interface and the entry of solar rays into the water. In this regard, CRE (2009) emphasizes that at the air/water interface, oxygen molecules diffuse from air to water or from water to air, depending on the degree of saturation of the air. water with oxygen. According to the same author during the day, plants, algae and certain bacteria use solar rays and carbon dioxide (CO).2) in order to make their food and release oxygen into the water through the phenomenon of photosynthesis. The alkalinity values vary very little on a spatio-temporal level and the average value obtained (368.22± 116.65 mg/L) this would be due to the increase in the content of free alkalis, carbonates and hydrogen- carbonates by water from groundwater aquifers. Surface water, generally less rich in carbonic acid and dissolved oxygen than groundwater, has a lower hardness than the latter, as pointed out by Rodier et al. (2009).
The orthophosphate levels recorded in these swamps are well above the 0.5 mg/L recommended by Rodier et al. (2009). This would result from a very high discharge of urban, industrial and agricultural waste into these swamps. Rodier et al. (2009) assert to this effect that the orthophosphate content in a body of water depends on exogenous inputs.

The electrical conductivity values recorded during the study period would translate according to the classification of Rodier et al. (2009) low mineralization of water bodies in different swamps. The highest value obtained in December (520 µS/cm) would reflect low mineralization. This could be explained by the abundance of organic matter in these different swamps CPEPESC (2022)
The low oxidizability values exhibiting aaverage value(44.60 ± 16.07) could be due to the strong resilience of these swamps although subject to exogenous inputs such as fecal sludge, industrial waste and household waste.
The results from physicochemical analyzes generally reflect poor ecological quality of the water.in the swamps of MBANKOMO, AYENE and NKOZOA during the study period.

III.2.2. Biological parameters
The taxonomic richness of benthic macroinvertebratesin the swamps of MBANKOMO, AYENE and NKOZOA during the study periodis made up of 1359 individuals. The predominance of hexapods (72.92%) and gastropods (17.44%) seems to reflect the high degree of pollution in these watersheds and the poor ecological quality of the water, because according to Charvet (1995), Tachet and al., (2006), Moisan and Pelletier (2008), the majority of aquatic gastropods and hexapods are very insensitive to pollution and are therefore among the last to disappear in a disturbed environment. However, the Chironomidae (29.3%) in polluted and oxygen-poor environments come up to breathe on the surface but also thanks to their hemoglobins which are an oxygen reservoir, they resist water pollution longer than certain organisms of the same class. taxonomic Zerguine Karima (2021) and the physidae (16.1%) have pulmonated respiration allowing them to live underwater even if the environment is polluted thanks to their lungs they breathe using the atmospheric area.The limnaea must approach the surface, attached to an aquatic plant, on its side, a siphon opens and thus allows the renewal of the air in its lung (Dedieu, 2011). So, inthe swamps of MBANKOMO, AYENE and NKOZOA, hexapods are mainly made up of chironomidae and ceratopogonidae which resist pollution largely thanks to their trachea system which allows them to breathe underwater Zerguine karima (2020).

THEAnnelids (0.22%) constitute entirely Oligochaetes and Achaetes with their presence in these marshy environments effectively shows that these waters are not of good quality, because organic matter is a favorable factor for their proliferation (Karim Arifi et al. , 2018) and according to Charvet (1995), Tachet et al., (2006), Moisan and Pelletier (2008), the majority of Annelids are not very sensitive to pollution and/or modification of the habitat and are therefore among the last to disappear in a disturbed environment. Furthermore, Heteroptera (4.6%),have an average tolerance rating, since being good swimmers they can avoid the most degraded areas and they also practice air breathing (Dedieu, 2011). So,in the swamps of MBANKOMO, AYENE and NKOZOA, Hexapoda are mainly made up of Diptera, Odonata, Coleoptera and Heteroptera. According to Dedieu (2011),THEodonates and beetles are taxa sensitive to environmental disturbance. Environmental stress could therefore promote the reduction of certain ecological niches occupied by these types of organisms. The slightly significant representation of Odonates (10.1%) in these environments could be explained by the large vegetation found in the waters of these different marshes..decapods (6.2%) for their part have a great capacity for adaptation and are important for the biodiversity of marshy environments. Their presence could be explained by the fact that lotic environments can serve as ecological corridors for decapods in order to colonize marshy environments which are meeting areas between different natural environments Klaus Anger (2016).

III.2.3.Biocenotic indices

The values of the Global Normalized Biological Index (NBGN) obtained reflect poor ecological quality (Poor)for the AYENE swamp and very poor ecological quality of the waters of the MBANKOMO and NKOZOA swamps,dominated by pollutant-resistant species due to lateral effluent inputs (MDDEFD, 2013).

IV. Conclusion

At the end of this study which had the general objectiveto evaluate the impact of some physicochemical parameters on the distribution of benthic macroinvertebratesin the swamps of MBANKOMO, AYENE and NKOZOA,It appears that these waters are poorly oxygenated, with average hardness and alkalinity, high orthophosphate values and very little mineralization. Which shows that the watersin the swamps of MBANKOMO, AYENE and NKOZOAseem to be greatly disturbed by anthropogenic activities and are subject to multiple sources of pollution. The population of benthic macroinvertebrates is also diverse with a total of 1359 individuals sampled divided into 5 phyla, 6 classes, 8 orders, 26 families and more than 27 genera. The taxonomic diversity, coupled with the Normalized Global Biological Index (IBGN), reveals an environment affected by anthropogenic activities and consequently, poor water quality that needs to be restored.

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