International Journal of Environment, Agriculture and Biotechnology, 5(6)
Nov-Dec, 2020 | Available: https://ijeab.com/

Effect of anthropization on macroinvertebrate communities in the Kou River, Burkina Faso.

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Received: 08 Nov 2020; Received in revised form: 15 Dec 2020; Accepted: 25 Dec 2020; Available online: 30 Dec 2020

Abstract— *The structuring of aquatic macroinvertebrate communities is used as an indicator of the effects of human activities on river ecosystems. This study focused on the distribution of macroinvertebrate communities along the Kou River in western Burkina Faso. Its objective was to characterize macroinvertebrate communities and water quality in the Kou River protected-site-manipulated site continuum in order to develop biological indicators for monitoring and assessing the overall health of aquatic ecosystems. Macroinvertebrate sampling, carried out using a cloud net and a Suber net, was carried out during the low-water period from January to April 2018. Their identification was carried out using a binocular magnifying glass and reference determination keys, and was limited to the systematic Family level. The study identified 04 Classes, 14 Orders and 54 Families of macroinvertebrates. The analysis of these results showed that 100% of the identified Orders and 98.15% of the identified Families were found in the protected site, compared to 64.29% of the Orders and 59.26% of the Families in the anthropized site. It also showed that the protected site is taxonomically richer than the anthropized site with the presence of 53 Families (98.15% of the Families identified), compared to 32 Families representing 59.26% of the Families identified for the anthropized site. Also, 22 taxa are specific to the protected site and remain absent in the anthropized site. This study also allowed the identification of 04 potential taxa bioindicators that would constitute excellent biological tools for monitoring aquatic systems. The agro-demographic pressure on natural resources has a negative impact on the diversity of species, the dynamics of which must be better monitored. The extension of the tools tested in the present study to river managers will strengthen their technical capacity for monitoring surface water quality.*

Keywords— ***Identification, Reference macroinvertebrates, Bioindicators, Continuum protected site, anthropized site, Specific diversity, Burkina Faso.***

I. INTRODUCTION

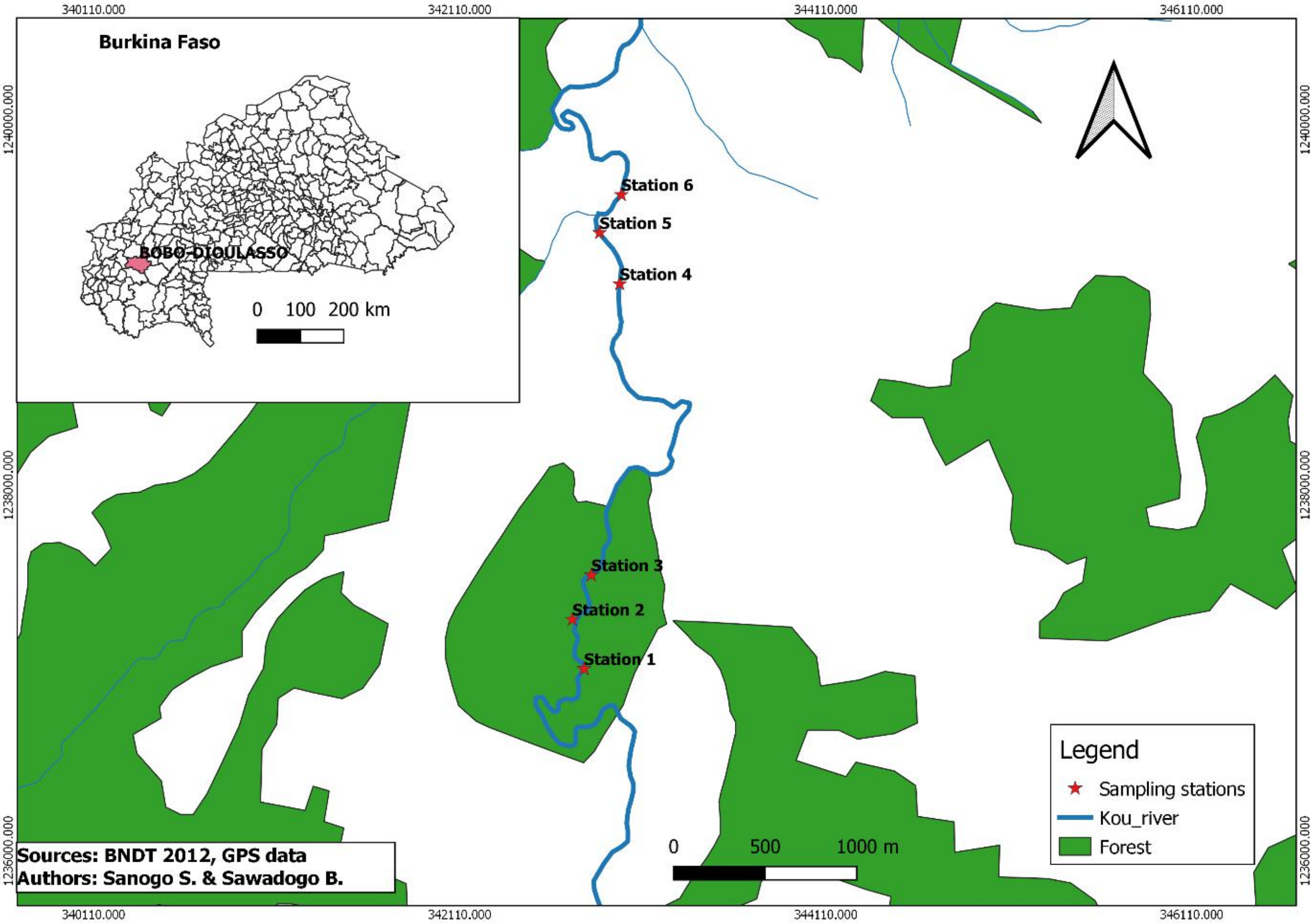
Located on the outskirts of the city of Bobo - Dioulasso (Western Burkina Faso), the Kou River offers many goods and services to the local population. The spring that feeds it provides drinking water to the population. Peri-urban and a rare perennial watercourse in the region, the Kou is suffering from the effects of anthropization like most of the watercourses that run through major African cities. According to Alhou (2007), these watercourses are used for watering market gardening crops, bathing, laundry, and also for the disposal of domestic and industrial effluents. These multiple uses of water alter its quality and disrupt the balance of the local biocenosis as well as the general functioning of this ecosystem (Bruslé and Quignard, 2004;

Hepp et *al.*, 2010). Therefore, special attention must be paid to monitoring these aquatic ecosystems to ensure their sustainability. This monitoring must be done through the use of reliable and adequate indicators such as biological indicators (Ben Moussa et *al.*, 2014). Today, macroinvertebrates are the most commonly used organisms for biomonitoring and assessment of the overall health of aquatic ecosystems (Adandedjan, 2012; Ben Moussa et *al.*, 2014; Camara et *al.*, 2014; Sanogo et *al.*, 2014). In Burkina Faso, despite multiple studies on freshwater macroinvertebrates, none have provided the data needed to develop biological indicators based on these integrative groups (Kaboré et *al.*, 2015). This study is part of this dynamic, with the general objective of identifying reference macroinvertebrate taxa in a comparative study between differently used sections of a river.

II. MATERIALS AND METHODS

Study area

The study was carried out at the Kou River (located between latitudes 11° 05' and 11° 25' North and longitudes 4° 20' and 4° 30' West) where the water is always transparent. Two study sites were established. A first site, called a protected site, is located in the portion of the watercourse located in the classified forest of Kou which is free of all anthropic activities. The second site, known as a man-made site, is located in the portion of the watercourse downstream of the Kou classified forest where various agricultural, pastoral, domestic and leisure (swimming) activities are carried out. In each of the two (2) sites, three (3) stations have been established for macroinvertebrate sampling (map 1). Table 1 provides the characteristics of each station.



Map 1: Presentation of the stations in the study area

Table 1: Characteristics of Different Sampling Stations

Sites	Stations	geographical coordinates	characteristics
Protected site	Station 1	11°11'11,81''N 04°26'23,48"W	Significant presence of trees and shrubs on the banks. Bottom substrate composed of silt, sand, wood and dead leaves.
	Station 2	11°11'20,59"N 04°26'25,63" W	Lots of trees on the banks Substrate of silt compound, dead leaves and dead woods
	Station 3	11°11'28,5"N 04°26'22,2" W	lots of trees on the banks Bottom substrate composed of sand, gravel, blocks and dead woods
Anthropised site	Station 4	11°12'20,35"N 04°26'17,4" W	Garden production at the riverbank level Bottom substrate composed of sand
	Station 5	11°12'29,45"N 04°26'21,06" W	Agricultural and pastoral activities on the banks. Bottom substrate composed of sand
	Station 6	11°12'36,24"N 04°26'17,17" W	Agricultural, pastoral and domestic activities at the riverbank level Bottom substrate composed of sand

Sampling

The methods adopted in this study for the sampling, processing and analysis of macroinvertebrate samples are those developed by the European Water Framework Directive (2010, 2016). Based on these methods, the NF T90-333 standard (September 2016) was applied for sampling, and the XP T90-388 standard (June 2010) was used for the treatment and analysis of macroinvertebrate samples.

Sampling plan

The sampling plan was established based on the gridding technique which consisted of nine (9) samples taken at each station. The nine (9) sampling points were distributed on either side of the watercourse, from the edge to the center along transects perpendicular to the direction of the water flow. At each sampling point, three (3) microhabitats (macrophytes, silt and water surface) were excavated for the collection of macroinvertebrates; and within each microhabitat, twelve (12) net hauls (elemental sampling) were carried out to capture macroinvertebrates. Elemental sampling was carried out from downstream to upstream to avoid any disturbance that could be caused by the possible disturbance of the water and to avoid damaging habitats not yet sampled.To ensure the representativeness of the sampling stations in relation to the study area, the size of each station was set according to the formula Length = 10*Width as recommended by the DCE (2016). Thus, the average width measured at the protected site stations is 3.6 meters, representing an average sampling area of 129.6 m². The average width of the stations at the anthropized site is 4.8 meters, corresponding to an average sampling area of 230.4 m².

Sample and data collection

From January to April 2018, six outings were organized with an interval of 14 days. Three microhabitats were the subject of macroinvertebrate collection at each station. These were mud, water surface and macrophytes (herbaceous plants, dead leaves and dead wood). The collection material consisted of a Surber-type net with a 25 cm diameter opening and a muddy net with a 30 cm diameter opening.

The Surber net for collecting benthic species was placed in the streambed facing the water current and then pulled over a distance of 01 meters by sampling. After capture, the macroinvertebrate species were sorted and preserved in 70% alcohol (DCE, 2016).

The cloud net was used to collect the species inferred to macrophytes. For 30 seconds the net was passed under the plants with back and forth movements. The contents of the net, consisting of plant parts, macroinvertebrates and mud, were rinsed with water, after which the macroinvertebrates were removed and stored in bottles with 70% alcohol; the remainder was stored in jars with 70% alcohol for sorting in the laboratory. This net was also used for the capture of surface species.

Identification and taxonomic analysis

Identification

The identification of macroinvertebrates was carried out using a binocular microscope and sometimes the naked eye. Insects have been identified using the identification keys of Durand and Levêque (1981), Merritt and Cummins (1984), Tachet et *al.* (2000), Stals and De Moor (2007), Moisan (2006). Molluscs were identified using the identification keys of Moisan (2010) and Brown (1980).

Annelids were identified using the identification keys of Lafon (1983) and Moisan (2010). Crustaceans were identified with the identification key of Tachet et*al.* (2000) and Moisan (2010). After identification, the individuals of each macroinvertebrate species were kept in a labelled bottle containing 70% alcohol. All vials containing macroinvertebrates from the same station were collected.

Taxonomic analysis

The taxonomic analysis of macroinvertebrate communities was based on the determination of taxa diversity and their occurrence (presence-absence of observed families). This analysis allowed the estimation of different metrics (taxonomic richness, taxonomic diversity, frequency of occurrence and biological indices) to assess the biological quality of the water at the two study sites.The level of identification and taxonomic analysis was limited to the family. Following identification, the reference taxa bioindicators were determined using the pollution tolerance scale for major taxonomic groups defined by Zimmerman (1993) and Moisan (2010) (Table 2). On the basis of this scale, all macroinvertebrates belonging to the sensitive orders Ephemeroptera, Plecoptera and Trichoptera (EPT) were considered to be reference pollution-sensitive bioindicator taxa.

Table 2: Pollution Tolerance Scale for Major Taxonomic Groups (Moisan, 2010)

Tolerance scale	**Taxonomic groups**
Sensitive	Ephemeroptera Trichoptera Plecoptera
Intermediate	Crustaceans (Decapods (Cambaridae)) Molluscs (Bivalves, gastropods with a lid) Odonates (Anisoptera and Zygoptera) Beetles Hemiptera Lepidoptera Megaloptera Diptera except Chironomidae Hydracarans
Tolerant	Crustaceans (Isopods, Amphipods, Ostracods, Cladocerans, Copepods) Molluscs (Gastropods without lid) Chironomidae (Diptera) Annelids (Oligochaetes, Leeches)

In order to analyze ecological diversity, the frequency of occurrence (F) of Dajoz (1985) and some ecological indices were calculated:

- **Frequency of occurrence (F)** of a taxon is the ratio between the number of samples (Pa) from a station where the taxon is present and the total number (P) of samples. $F = \frac{Pa}{P} * 100$

Pa: number of samples; P: total number of samples.

Three groups are thus defined by Dajoz (1985). The first concerns very frequent taxa with F ≥50%; the second group corresponds to frequent taxa with 25%≤F<50%; rare taxa form the third group with F<25%.

In this study, a fourth group is also defined: these are the absent taxa with F= 0%.

- ***The Shannon-Wiener diversity index H'*** was calculated as it is suitable for the comparative study of stands. It is independent of sample size and takes into account both the taxonomic richness and the relative abundance of each taxon (Peet, 1975) to characterise the equilibrium of the stand in an ecosystem. H' has the advantage of not being subject to any prior hypothesis on the distribution of species (families) and individuals (Blondel, 1979). Its expression is :

$$H' = -\sum P_i * \log_2 P_i$$

Pi = proportional abundance or percentage of importance of the species (family) :

Pi = ni /N; S, total number of species (here taxa); ni, the number of individuals of a species (family) in the sample and N, total number of individuals of all species (family) in the sample.

Pi is the proportion of taxon i in the sample considered.

- ***Coefficient de similitude (Cs) de Sorensen (1948)***:

$$Cs = \frac{2C}{A + B} * 100$$

CS: Sorensen's similarity coefficient; A: number of taxa from site A; B: number of taxa from site B; C: number of taxa common to A and B. Sorensen's coefficient of similarity (Cs) made it possible to compare macroinvertebrate populations between sites, taking into account the presence or absence of taxa. This index varies between 0 and 1 ;

Cs=0: There is no similarity between the two sites, and the two sites considered have no common species, and, Cs=1: There is total similarity between the two sites studied.

The venn software (Lin et *al.*, 2016) made it possible to make a comparison chart of the two sites.

III. RESULTS AND DISCUSSION

Results

Taxonomic composition

The total sampling resulted in the collection of two thousand seven hundred and eighty-eight (2788) macroinvertebrate individuals, including two thousand one hundred and sixty-six (2166) in the protected site and six hundred and twenty-two (622) in the anthropized site.

The captured macroinvertebrates are divided into four (4) classes: Insects, Clitellates, Malacostracans and Molluscs. Within these four classes, fourteen (14) orders and fifty-four (54) families were counted.The Insects that are the most represented include forty-eight (48) families and nine (9) Orders which are: the Coleoptera, the Diptera, the Ephemeroptera, the Heteroptera, the Lepidoptera, the Odonata, the Orthoptera, the Plecoptera and the Trichoptera. Beetles and Heteroptera were the most representative in this class of insects with respective rates of 18.97% and 25%. The Clitellates include three (3) families and two (2) orders which are the Purchasers and the Oligochaete. The Malacostracans are composed of two (2) families and two (2) orders which are Amphipods and Decapods. The Molluscs are represented by a single family and the only Order of Gasteropods.

Among the four (4) Classes, the Insects are the most represented with a rate of 64% of Orders and 89% of Families. At the level of Orders, Beetles and Heteroptera are dominant in terms of Families with respective rates of 20% and 22%.

Taxonomic richness

The number of families varies from station to station and site to site. Stations 1, 2 and 3, located in the protected site, have 53 families, while stations 4, 5 and 6, located in the anthropized site, have 32 families (Figure 1).

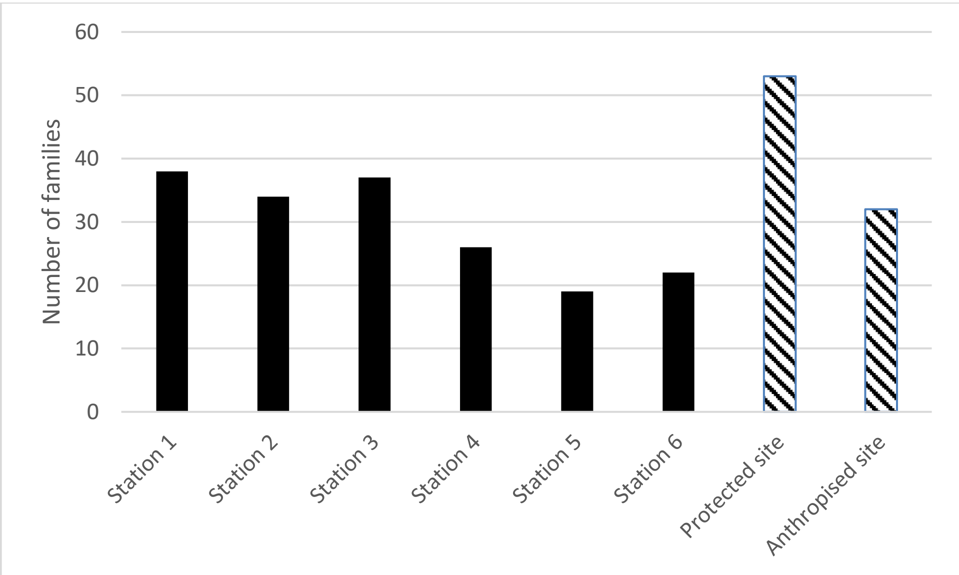


Fig.1: Relative Taxonomic Richness at Station and Site Levels

Taxonomic diversity of stations and sites

The identifications identified fifty-four (54) families of macroinvertebrates, which are diversely distributed among the stations and sites. Thus, analysis of these families based on the diversity index of Shannon and Weaver (1949) and the frequency of occurrence of Dajoz (1985) made it possible to assess the distribution of macroinvertebrate families according to stations and sites.

It emerges that stations 1, 2 and 3 have 70%, 63% and 68% of the families identified, respectively, while stations 4, 5 and 6 have only 48%, 39% and 37% of the families identified, respectively. Thus, the protected site, consisting of stations 1, 2 and 3, has the greatest taxonomic diversity with the presence of 98% of the families identified, while the anthropized site has only 59% of the families identified.

The Shannon - Weaver (1949) diversity indices calculated for the two sites and the six stations that comprise them are shown in Table 3.

Table 3: Shannon-Weaver (1949) Diversity Indices for Stations and Sites

	S1	S2	S3	S4	S5	S6	SP	SA
H	2,769	2,841	2,897	2,617	2,358	2,666	3,076	2,927

H : Index of Shannon et Weaver (1949) S : Station SP : protected Site SA : Anthropised Site

Analysis of the indices shows that the diversity of taxa is average in the two study sites.

However, these indices show greater taxonomic diversity at the protected site level (Figure 2). Indeed, stations S1, S2 and S3 (located in the protected site) present the best indices showing that the taxa in the protected site are more diverse than those in the anthropized site.

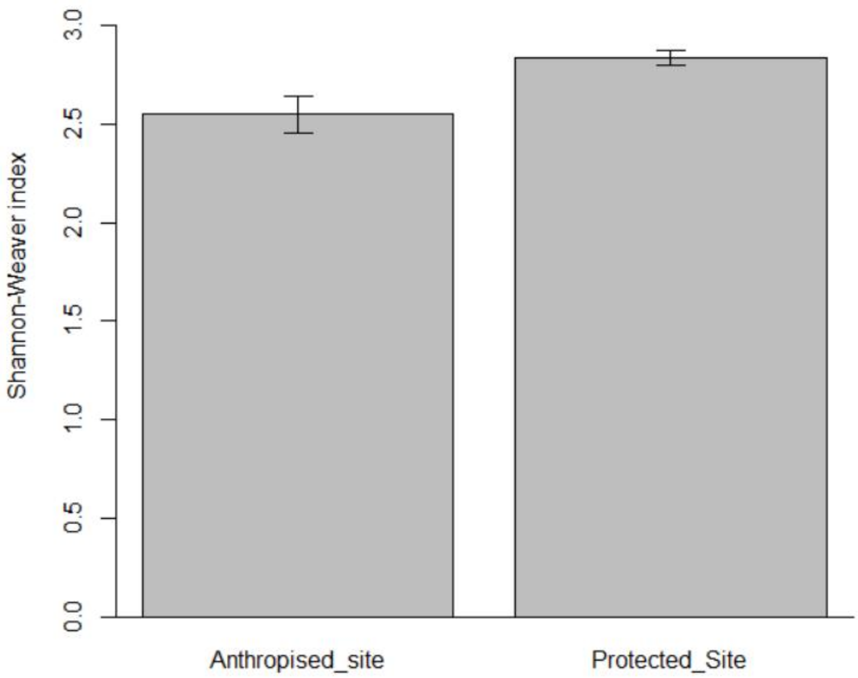


Fig.2: Comparison of Shannon Index Means at the Two Sites

Taxonomic classification

The taxonomic classification allowed to establish the state of taxonomic similarity between the protected site and the anthropized site, through the determination of Sorensen's coefficient of similarity. From the inventory of taxa, thirty-one (31) families common to the two sites, fifty-three (53) families in the protected site, and thirty-two (32) families in the anthropized site emerged. Calculating Sorensen's (1948) coefficient of similarity, a value of 0.73 is found. This value indicates that there is a taxonomic similarity between the two sites, so that this similarity is partial, as shown in the diagram in Figure 3, which presents twenty-two (22) taxa specific to the protected site, one (1) taxon specific to the anthropized site and thirty-one (31) taxa common to both sites. This classification shows that the protected site is richer and more diversified in taxa than the anthropized site.

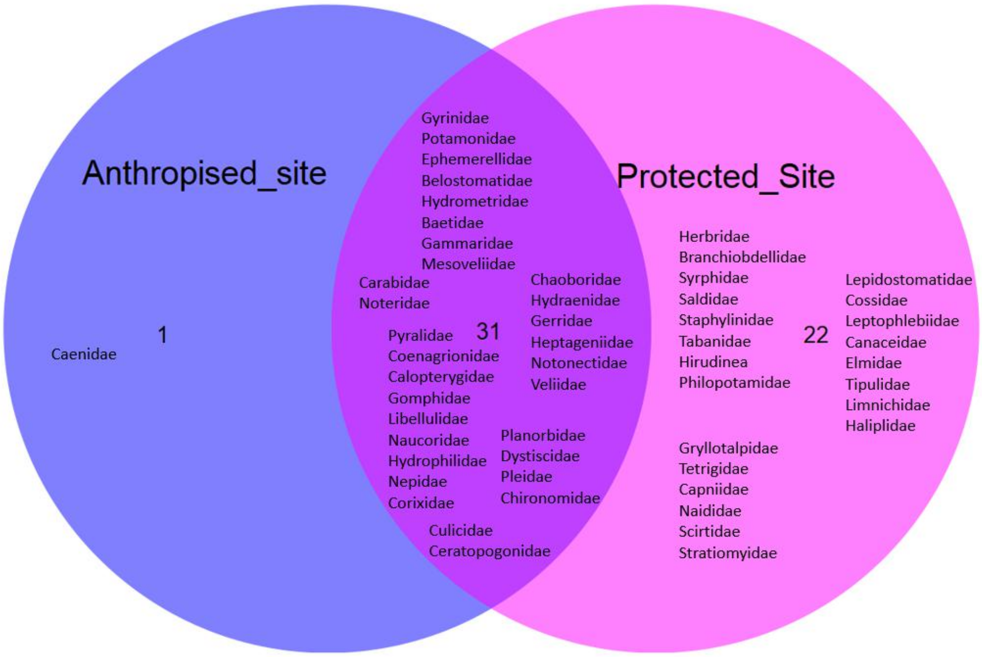


Fig.3: Distribution Chart of Families in the Two Study Sites

Characterization of taxa bioindicators of water quality

Out of all identified macroinvertebrates, ten (10) orders belong to the group of bioindicators. Among these ten (10) orders, the tolerance levels are the following:

- three (03) orders are sensitive: Ephemeroptera, Trichoptera and Plecoptera;
- four (04) orders are medium: Odonates, Coleoptera, Heteroptera and Lepidoptera;
- three (03) orders are tolerant: Amphipods, Diptera and Oligochaetes.

Sensitive bioindicators

In the order of Ephemeroptera, five (05) families of sensitive bioindicators have been identified. They are Ephemerellidae, Heptageniidae, Baetidae, Caenidae and Leptophlebiidae. In Trichoptera, the two (2) families identified are Lepidostomatidae and Philopotamidae. The only family of Capniidae was observed in the Plecoptera.

Table 4 gives the frequency classes of occurrence of the different families of sensitive bioindicators found in the two study sites.

Table 4: Sensitive bioindicators

Order	**Families**	**Protected site**	**Anthropised site**
Ephemeroptera	Ephemerellidae	+++	+++
	Heptageniidae	+	+
	Baetidae	++	+
	Caenidae	-	++
	Leptophlebiidae	+	-
Plecoptera	Capniidae	+	-
Trichoptera	Lepidostomatidae	+	-
	Philopotamidae	+++	-

- : F = 0% (taxa absent) + : F ≠ 0% and less than 25% (rare taxa)

++ : 25%≤F< 50%(frequent taxa) +++ : 50% ≥ F (very frequent taxa)

Moreover, among the sensitive bioindicators identified in this study, the Ephemeroptera (62.5% of the EPT group) are the most represented, followed by the Trichoptera (25% of the EPT group) and the Plecoptera (12.5% of the EPT group).

The protected site has many more sensitive bioindicators than the anthropized site (87.5% of FTE families in the protected site versus 50% of EPT families in the anthropized site). Also, the four (04) EPT families (Leptophlebiidae, Capniidae, Lepidostomatidae and Philopotamidae) found in the protected site and absent in the anthropized site can be considered as potential sensitive taxa. In general, we note the absence of Trichoptera, Plecoptera and Leptophlebiidae (Ephemeroptera) in the anthropised site.

Medium bioindicators

The average bioindicators found in the order of Odonates, numbering four (04) families, are Calopterygidae, Coenagrionidae, Gomphidae and Libellulidae.

Among the Beetles, the eleven (11) families encountered are the Carabidae, Dystiscidae, Gyrinidae, Haliplidae, Hydraenidae, Hydrophilidae, Limnichidae, Staphylinidae, Elmidae, Noteridae and Scirtidae.

The Heteropterans recorded, twelve (12) families, are the Belostomatidae, Gerridae, Herbridae, Hydrometridae, Mesoveliidae, Nepidae, Notonectidae, Pleidae, Veliidae, Corixidae, Naucoridae and Saldidae.

In the order of Lepidoptera, there are two (02) families that are the Cossidae and Pyralidae.

In Diptera (except Chironomidae), the eight (08) families encountered are Ceratopogonidae, Stratiomyidae, Canaceidae, Chaoboridae, Culicidae, Tabanidae, Tipulidae and Syrphidae.

Table 5 gives the frequency classes of occurrence of the different families of average bioindicators found in the two study sites.

Table 5: Medium bioindicators

Order	Families	Protected site	Anthropised site
Odonata	Calopterygidae	+++	+
	Coenagrionidae	+++	+++
	Gomphidae	+++	+++
	Libellulidae	+++	+++
Coleoptera	Carabidae	+++	++
	Dystiscidae	+++	+++
	Gyrinidae	+++	+++
	Haliplidae	+	-
	Hydraenidae	+++	+++
	Hydrophilidae	+++	+++
	Limnichidae	++	-
	Staphylinidae	++	-
	Elmidae	++	-
	Noteridae	+++	+++
	Scirtidae	+++	-
Heteroptera	Belostomatidae	+++	+++
	Gerridae	+++	+++
	Herbridae	+++	-
	Hydrometridae	++	+
	Mesoveliidae	+++	++
	Nepidae	+++	++

	Notonectidae	+++	+++
	Pleidae	+++	+++
	Veliidae	+++	+++
	Corixidae	+	++
	Naucoridae	++	+++
	Saldidae	+	-
Lepidoptera	Cossidae	+	-
	Pyralidae	+	+
Diptera except Chironomidae	Ceratopogonidae	+++	++
	Stratiomyidae	+	-
	Canaceidae	+	-
	Chaoboridae	+	+
	Culicidae	+++	+++
	Tabanidae	+++	-
	Tipulidae	+++	-
	Syrphidae	+	-

- : F = 0% (taxa absent) + : F ≠ 0% and less than 25% (rare taxa)

++ : 25%≤F< 50% (frequent taxa) +++ : 50% ≥ F (very frequent taxa)

In this group of average bioindicators identified, Heteroptera (36.36%) are dominant, followed by Beetles (33.33%), Diptera (24.24%), and Lepidoptera (06.06%).The protected site contains all the average bioindicators listed, while the anthropized site has only 60.61%.

Tolerant bioindicators

In the order of Diptera, the only family of Chironomidae is considered as tolerant bioindicators. It was encountered in this study.In Amphipods, the only family identified is represented by the Gammaridae.Oligochaetes are also represented by the single family Naididae.Table 6 gives the frequency classes of occurrence of the different families of tolerant bioindicators found in the two study sites.

Table 6: Tolerant bioindicators

Order	Familles	SP	SA
Diptera	Chironomidae	+++	++
Amphipods	Gammaridae	+++	+++
Oligochaete	Naididae	+	-

- : F = 0% (taxa absent) + : F ≠ 0% and less than 25% (rare taxa)

++ : 25%≤F< 50% (frequent taxa) +++ : 50% ≥ F (very frequent taxa)

The orders of tolerant bioindicators identified in this study each have a single family. However, the anthropized site has one family less than the protected site.

Identification of taxa bioindicators

From the analysis of sensitive bio-indicator taxa, it appears that 87.5% of ETP families were found in the protected site, compared to 50% of ETP families in the anthropized site.

Among these ETP families, four (04) were specific to the protected site and are considered as potential sensitive taxa. These are the Leptophlebiidae, Capniidae, Lepidostomatidae and Philopotamidae. These four families of ETP would be reference bioindicators that can attest, by their presence in a watercourse, to the good biological health of that watercourse.

In addition, two other taxa, namely Caenidae and Elmidae, can be associated with this list of reference taxa, as these two taxa have been particularly marked by their presence and absence on either side of the two sites. The Elmidae were specifically found in the protected site, while the Caenidae were found in the anthropized site.

IV. DISCUSSION

Characterization of taxa bioindicators of water quality

In this study, the level of identification is the family. Indeed, several studies or environmental monitoring programmes based on the occurrence (presence-absence) or abundance of macroinvertebrates have shown that a taxonomic analysis at the family level can provide similar information to that obtained with a finer analysis at the genus level, even if more indicator taxa are found at the genus level (Jones, 2008; Masson et *al.*, 2010; Neeson et *al.*, 2013). Furthermore, according to Usseglio-Polatera and Beisel (2003), the family is the systematic level generally recommended for standardised methods for assessing the biological quality of watercourses.

The analysis of taxonomic diversity shows a low number of sensitive bioindicator taxa in the anthropized site (50% of ETP families), compared to the protected site where this number is high (87% of ETP families in the protected site). The same finding was made by Kaboré et *al* (2016) in semi-arid rivers (the Volta River and the Comoé dam lake) in Burkina Faso, where there is a gradual decrease in sensitive ETP taxa between protected, agricultural and urban sites: ETP taxa were dominant in protected sites, less dominant in agricultural sites, and completely absent in urban sites. Grenier (2007) also showed that reference conditions are characterized by the abundance of sensitive families of ETP such as Philopotamidae, Rhyacophilidae, Leptophlebiidae and Chloroperlidae, and that this type of reference environment favors a greater abundance of taxa, especially Trichoptera and Plecoptera. The same is true for Foto et *al* (2010), who noted that the percentage of ETP taxa in the Nga River (reference site) is much higher than that observed on the Biyémé in Cameroon, which is a man-made river in the same ecological region.The results of our study are therefore in line with those of these authors. In our study, the low representativeness of ETP could be explained by the fact that agricultural activities carried out along the river at the anthropized site, with the use of chemical fertilizers and pesticides, would degrade the quality of the water which no longer offers favorable conditions for the existence of these sensitive taxa. In addition, these practices, which are carried out along the banks of the watercourse at the level of the anthropized site, are increasingly causing the silting up of this area, thus depriving these taxa of their privileged habitat.

Trichoptera, Plecoptera and Leptophlebiidae (Ephemeroptera), which are generally cited among the groups sensitive to pollution (Muli and Mavuti, 2001), were present in the protected site and absent in the anthropized site. This confirms the sensitivity of these taxa to water pollution. This confirmation is consolidated by considering the work of other authors who have found that Ephemeroptera, Plecoptera and Trichoptera are particularly sensitive to variations in environmental conditions to be found (Lenat, 1988) and to chemical and organic pollution (Rosenberg and Resh, 1993).

In addition, the 04 families of Beetles (consisting of Dystiscidae, Gyrinidae, Hydraenidae and Hydrophilidae) and the 02 families of Odonates (Gomphidae and Libellulidae), which recorded 100% frequency of occurrence in the protected site, would be excellent bioindicators of water quality. These results corroborate those of Oertli et al (2005; 2010a; 2010b), for the characterization of good water quality in European ponds and ponds, which associated Beetles and Odonates in good water quality.

The tolerant bioindicators were much more present in the protected site than in the anthropized site. This could be explained by the fact that the latter have their preferred habitat in the protected site. Indeed, the bottom substrate in the protected site is of muddy nature (preferred habitat of Chironomidae larvae) while in the anthropized site the bottom substrate is of sandy nature.

Taxa bioindicators reference

For this first inventory study of macroinvertebrates during the low-water period in the Kou River, the identification of taxa at the two sites, coupled with their frequency of occurrence, allowed the identification of potential pollution-sensitive taxa. Indeed, these taxa are only present at the level of the protected site, and totally absent in the anthropized site; they are the Leptophlebiidae, Capniidae, Lepidostomatidae and Philopotamidae). These taxa could therefore serve as a reference to attest to the good biological health of aquatic ecosystems. In addition, Baetidae, Philopotamidae, Leptophlebiidae, Capniidae (Plecoptera) and Heptageniidae are relatively more represented in the protected site. Our results corroborate those of Grenier (2007) who found that reference sites are characterized by the abundance of susceptible families of EPT such as Philopotamidae, Rhyacophilidae, Leptophlebiidae and Chloroperlidae and the abundance of mayflies, such as the moderately susceptible families Baetidae and Heptageniidae, and a susceptible family of Plecoptera.

In addition, Elmidae that have marked their absence in the anthropized site can be associated with this list of reference taxa. This result corroborates that of Rosenberg and Resh (1993), who found that the presence of various EPT larval communities, as well as Elmidae and Psephenidae, is associated with low-polluted and well-oxygenated streams. It also corroborates that of Bispo et *al*. (2006) who also found that Elmidae can also be associated with well-preserved riparian vegetation.

Furthermore, analysis of the distribution of bioindicator macroinvertebrates between the protected site and the anthropized site shows that Caenidae are specific to the anthropized site. This result confirms Grenier's (2007) finding that Caenidae occupy the biotypes of the more altered environments. This specificity of the Caenidae to the anthropized site allows us to confirm the status of the reference site that we propose to the protected site.

V. CONCLUSION

The aquatic macroinvertebrates of the Kou River are extremely diverse and abound in potential sentinel species (pollution-sensitive and pollution-tolerant). This comparative study between contrasting sites of the same river also allowed the identification of reference taxa, namely Leptophlebiidae, Capniidae, Lepidostomatidae and Philopotamidae. These bioindicators identified in the protected site could constitute excellent tools for an assessment of the state of health of the hydrosystems. Their association with traditional monitoring tools (measurements of physico-chemical parameters) of aquatic environments would allow to report on the overall level of health of aquatic ecosystems.

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