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Aquatic Macroinvertebrates diversity and assessment of urban water quality with the use of EPTC index in Daloa (Côte d'Ivoire; West Africa)

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Abstract

This study aimed to assess the biotic state of integrity of the urban waterbodies of Daloa. The sampling was carried out seasonally using a kick net and Van Veen on twelve stations. A total of 12718 individuals of 136 taxa belonging to 14 Orders and 59 Families were collected. Among these collected individuals 1988 belong to the complex Ephemeropters, Trichopters, Coleopters distributed on 17 families and 42 taxa. The most represented are the Coleopters (27 taxa), then Ephemeropters (12 taxa) and finally Trichopters (5 taxa). The Order of the Coleopters counts 7 families, Ephéméropters (6 families) and Trichopters (3 families). Any Plecopters was sampled and the ETC index calculated showed that urban hydro systems of Daloa is relatively poor quality but among them the pond at station 5 in a better state of integrity.

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Introduction

Water is essential to life, yet a number of factors limit greater availability. These factors include the population growth, the use for agricultural production as well as poor water resources management. Disruption of aquatic environments, resulting largely from human activities, causes changes in biological conditions and processes (Karr *et al.*, 1986). Overall, human societies depend on the water cycle, resources associated with it and the goods and services there under (Karr and Chu, 1999) especially in urban areas. These human activities might have an impact on the organisms living on these habitats. Macroinvertebrates are worldwide used as bioindicators to assess water quality (Rosenberg & Resh, 1993; Hessé *et al.*, 2014).

This new generation of water quality monitoring systems consisted in the establishment of biotic index from structure of benthic macroinvertebrates communities (Hellawell, 1986; Karr and Chu, 1999). Aquatic insects represent nearly 95% of all macroinvertebrates (Lee *et al.*, 2006), and play an important role in the functioning of aquatic ecosystems (Dunbar *et al.*, 2010). They have been used as indicators in the aquatic environment because of their limited mobility, long life period, their sensitivity to changes in their environment and tolerance of some to contamination (Metcalfe, 1989; Hessé *et al.*, 2014). Among these insects, Ephemeroptera, Plecoptera, Trichoptera and Coleoptera play a very important role in the functioning of aquatic ecosystems (Dunbar *et al.*, 2010). They are very polluo-sensitive, and are used to calculate the EPTC index.

This study aimed to assess the Water Quality of urban waterbodies in Daloa using EPTC Index. The results may serve as an important reference also for evaluating future water quality changes, as well as providing insights on how to protect these waterbodies and their biodiversity.

Materials and methods

Study site

Sampling was carried out in 12 sampling stations located in different water bodies in Daloa city in central-western Côte d'Ivoire (Fig. 1). These stations were chosen taking into account human activities and their accessibility. The study area is consisting of marsh, pond, artificial lake and stream

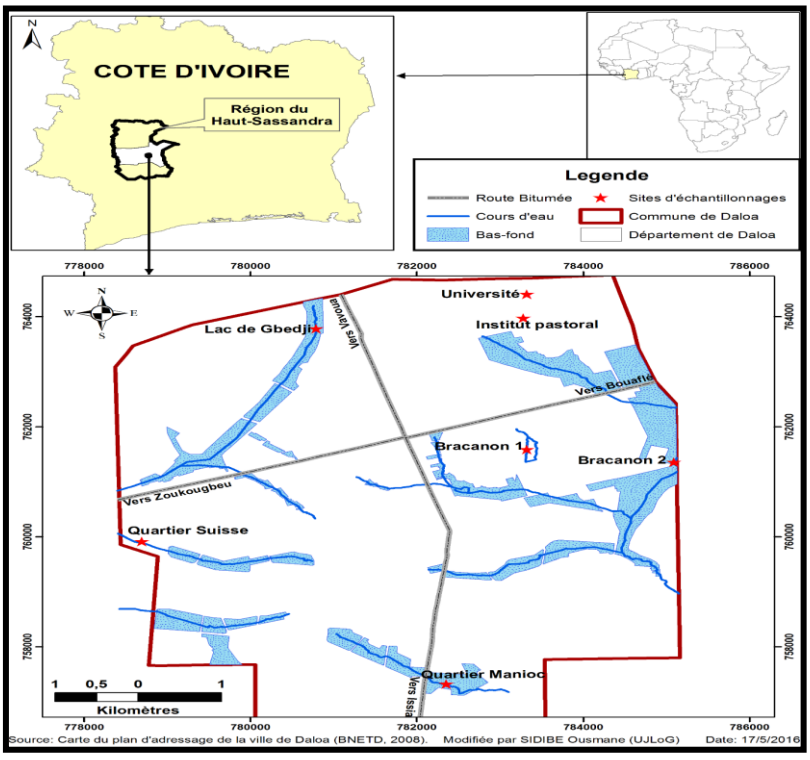

Fig. 1. Map showing the sampling stations in Daloa.

Sampling procedure

Benthic macroinvertebrates were collected seasonally by checking all type of substrates from 12 stations. The samples were collected for two to three minutes by submerging the kick net and dragging it into the water column. The net has also been banged against the bottom substrate to dislodge and collect sediment organisms. The collect was also done using a Van Veen grab. At each site, three (03) sediment samples corresponding to a total area of 0.15m² were taken at several depths. At the exit of water, the contents net were washed on a sieve of 0.5 mm. All samples were fixed in 70% alcohol. In the laboratory, all samples were sorted using a binocular microscope, counted and identified at the lowest taxonomic level by combining the appropriate key (Dejoux *et al.*, 1981; Mary, 2000; Moor & Day, 2003; Tachet *et al.*, 2003). At each campaign, each sampling site was characterized by measuring water temperature (°C), turbidity (NTU), pH and conductivity (µS/cm).

Data analysis

Percentage of occurrence (F)

It provides information on the preference of a species in an habitat type (Gray *et al.*, 1997; Paugy and Leveque, 1999). It's obtained by a number of samples containing species i out of total samples (F = Fix100/Ft where Fi = number of records containing species i and Ft = total of such records). Three groups of taxa are distinguished: constant taxa (F> 50%), by accessory taxa (25% <F <50%) and accidental taxa (F<25%).

EPTC index

EPTC index was also calculated by the percentage of all individuals of Ephemeroptera; Plecoptera; Trichoptera and Coleotera orders present on this station by the total number of individuals sampled.

$$\text{EPTC Index} = \frac{\text{EPTC Abundance}}{\text{Total abundance}} \times 100$$

Statistical analysis

The Shapiro-Wilk normality test was made to evaluate the normality of the different parameters. The Kruskal-Wallis (multiple comparisons) and Mann-Whitney (two-sample comparison) tests were performed for the different comparisons.

The taxa spatial distribution was performed with Factorial Correspondence Analysis presence/absence of species (matrix station/taxa) using PAleotological STatistic (PAST) software (Version 2.17c).

Results

Taxonomic composition and abundance of benthic macroinvertebrates

A total of 12,718 individuals of 136 taxa belonging to 59 families 14 orders were collected and identified during the study period. All these individuals are divided into five taxonomic groups that are arachnids, crustaceans, insects, molluscs and Oligochaetes. Insects are the best represented with 99 taxa (72.79%), followed by molluscs with 30 taxa (22.06%), Oligochaeta with 4 taxa (2,29%) Arachnids 2 taxa and Crustaceans are represented by one taxa (Fig. 2).

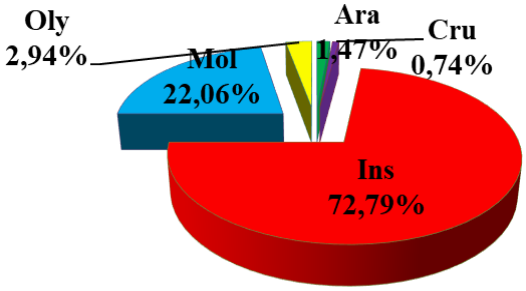

Fig. 2. Relative abundance of taxonomic groups of aquatic macroinvertebrates; Mol: Molluscs; Ara: Arachnids; Cru: Crustaceans; Oly: Olygochètes; Ins: Insects.

Distribution and population structure of EPTC complex

A total of 1988 individuals of 42 taxa belonging to 17 families from Ephemeroptera, Trichoptera and Coleoptera order were identified. Plecoptera were not collected. Coleoptera was the best represented order with 27 taxa from 7 families, followed by Ephemeroptera (12 taxa; 6 families), and Trichoptera (5 taxa; 3 families) (Table 1). The analysis of the occurrences of taxa of ETC complex shows that two Ephemeroptera (*Pelocarantha titan* and *Centroptilum* sp) appeared consistently in the study stations. Three taxa (*Thraulus*, *Caenis* sp., *Xeuthyplocia*) Fig.d accessorily and five taxa (*Adenophebiodes*, *Centroptiloides* sp., *Povilla adusta*,

Ecdyomurus sp., Notonurus) are described as accidental. The Trichoptera *Hydroptila* and *Oecetis* are constantly present. The other taxa *Hydrotila grucheli*, *Leptonema* sp., *Polymorphanisus* sp. appeared accidentally in the various stations. Coleopterans in the Cybister taxa *tripunctatus*, *Guignotus*, Potamodytes, *Colestoma* sp., *Enochrus* sp., *Laccobius starnuehlneri*, Amphiops appear consistently in the sampling stations. As for taxa *Laccophilus* sp., *Hydraenidae* sp., Hydrobiidae, they are present in the stations accessories. Other *Bagous* sp taxa. Neochetina, Hydroporinae bidessini, *Laccophilus vermiculosus*, *Canthydrus xanthinus*, *Cannthydrus minutus*, *Bidessus* sp., *Hydaticus vitticollis*, *Hyphydrus* sp., *Hyphidrus africanus*, *Hydrocanthus*, *Helodidae* sp., *Afropsephenoides* Sphaeriinae, *Laccobius* spp., Berosus are accidentally present in the stations sampled.

Table 1. taxonomic composition and occurrences of complex Ephemeroptera, Trichoptera, Coleoptera, +++= constant, ++ = accessory, accidental = +

ORDERS	FAMILIES	TAXA	%(F)	Code
Ephéméroptera	Leptophlebiidae	*Pelocarantha titan*	83.33	+++
		Adenophebiodes	16.66	+
		Thraulus	25	++
	Baetidae	*Centroptilum*	83.33	+++
		Centroptiloides sp.	8.33	+
	Caenidae	*Caenis* sp.	25	++
	Polymitarcyidae	*Povilla adusta*	8.33	+
	Euthyplociidae	*Exeuthyplocia*	41.66	++
	Heptageneidae	*Ecdyomurus* sp.	16.66	+
		Notonurus	16.66	+
Tricoptera	Hydroptilidae	*Hydroptila*	75	+++
		Hydrotila grucheli	8.33	+
	Hydropsychidae	*Leptonema* sp.	8.33	+
		Polymorphanisus sp.	8.33	+
	Leptoceridae	*Oecetis*	50	+++
	Curculionidae	*Bagous* sp.	8.33	+
		Neochetina	8.33	+
Coléoptera	Dytiscidae	*Cybister tripunctatus*	75	+++
		Hydroporinae bidessini	8.33	+
		Laccophilus sp.	25	++
		Laccophilus vermiculosus	8.33	+
		Canthydrus xanthinus	8.33	+
		Cannthydrus minutus	16.66	+
		Bidessus sp.	8.33	+
		Hydaticus vitticollis	8.33	+
		Hyphydrus sp.	8.33	+
		Hyphidrus africanus	8.33	+
		Hydrocanthus	8.33	+
		Guignotus	75	+++
	Elmidae	*Potamodytes*	83.33	+++
	Helodidae	*Helodidae* sp.	8.33	+
	Psephenidae	*Afropsephenoides*	8.33	+
	Haliplidae	*Haliplus*	8.33	+
	Hydraenidae	*Hydraenidae* sp.	25	++
	Hydrophilidae	*Colestoma* sp.	66.66	+++
		Enochrus sp.	58.33	+++
		Laccobius starnuehlneri	66.66	+++
		Sphaeriinae	8.33	+
		Laccobius spp.	8.33	+
		Amphiops	50	+++
		Berosus	8.33	+
		Hydrobiinae	25	++

Spatial distribution of ETC and typology of stations

The results of the Factorial Correspondences Analysis (AFC) performed on the matrix of presence/absence of twelve stations and 42 taxa are shown in Fig. 3A. The first two axes (F1 and F2) express 61.94% of the information (F1; 37.67% and F2; 24.27%). AFC indicates that the stations ST3 and ST1 are characterized by *Thraulus* taxa *Adenophebiodes*, *Ecdyomurus* sp., *Exeuthyplocia*. While Hydraenidae sp., *Hyphidrus africanus*, *Colestoma* sp., And Hydrobiinae are associated with stations ST10 and ST7. the station ST8 is characterized by *Hydraenidae* sp. and *Caenis* sp. The cluster analyses displayed 4 groups (Fig. 3B), the group I consists of station ST10,

the second group contains the stations ST6, ST7, ST12, ST11, ST4. The third group includes lakes stations ST1 and ST3, and Group IV ponds and lakes station ST8, ST2, ST5, ST9.

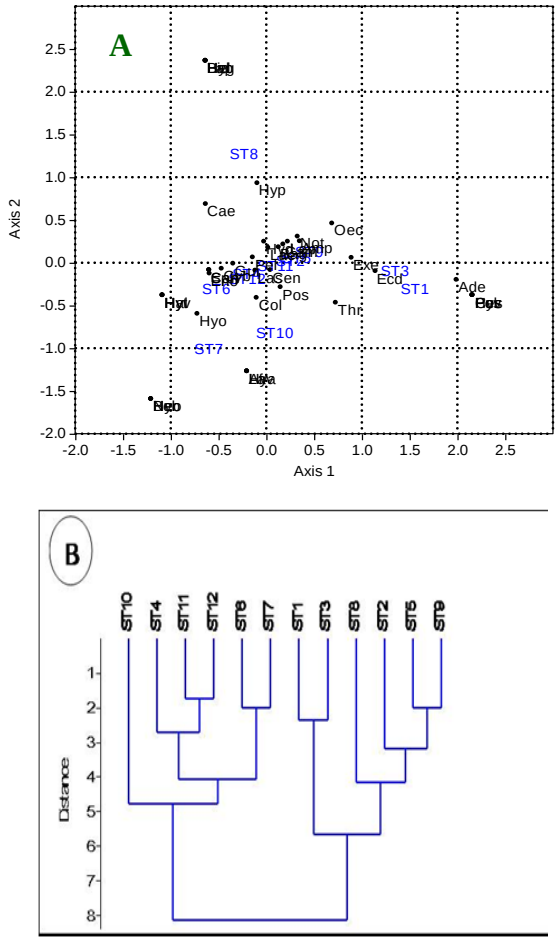

Fig. 3. Factorial Correspondences Analysis (CFA) from the matrix presence/absence of taxa (A) and Hierarchical cluster analysis with Ward algorithm and Euclidean distance summarizing the faunal similarities (B).

ETC Index

The 12 stations studied do not include any species belonging to the order Plecoptera then EPTC index becomes ETC index. The station 5 displayed the highest index ETC (4.996%) and the pond at the station 11 the lowest value (0.134%).

The test stations ST5 show that the pond has a better state of biotic integrity in relation to other stations while the pond 11 is characterized by a most degraded state of integrity (Fig. 4).

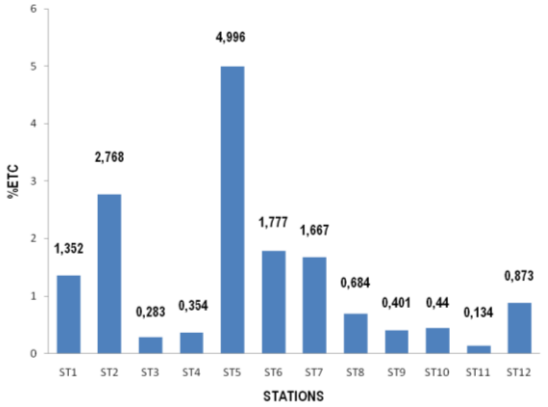

Fig. 4. Histogram showing percentage of ETC in sampling stations.

Discussion

The taxonomic composition of benthic macroinvertebrates highlighted that molluscs are clearly dominant, they account for 40.27% (5121 individuals) of the total fauna. Among the insects, the order Coleoptera is best represented with 27 taxa, followed Hemiptera (21 taxa), Diptera (19 taxa), Odonata (16 taxa) and mayfly (10 taxa), Trichoptera (5 taxa). The most diversifed family of insects is Dytiscidae with 12 taxa. Spatial variations of the abundances of macroinvertebrates in our study sites could be attributed to human influence on these environments. Indeed, disruption of a body of water creates unfavorable conditions for polluo-sensitive organisms (Ben *et al.*, 2013). The settlement of the channel is ST8 diversified and balanced compared to other water systems. This could be related to the natural anthropogenic influencing water systems such as the presence of cow dung and tar débrits torn renovation lanes in the department, including restrooms drains lead directly to the lake Gbedji. Ephemeroptera, Trichoptera and Coleoptera highlights four main areas. Thus, the stations ST3 and ST1 are characterized by Thraulus taxa *Adenophebiodes* (Leptphlebidae) *Ecdyomurus* sp. (Heptageniidae) Exeuthyplocia (Ethyplociidae) while *Hydraenidae* sp (Hydraenidae) *Hyphidrus africanus* (Dyscidae) *Colestoma* sp (Hydrophilidae), and are associated with Hydrobiinae ST10 stations ST7. ST8 is characterized by the presence of taxa and Caenis Hydraenidae sp (Caenidae). The presence of these taxa in areas under human influences shows that

these individuals have a wide ecological tolerance and are thus in their preferred habitat. Urban hydro-systems in Daloa generally have a poor biotic integrity according to the ETC index calculated. The pond at the station 11 having the state of worst ecological integrity and presents a largely taxonomic diversity dominated by species of the most tolerant groups degradation such as Diptera (Chironomidae, Simulidae), molluscs (*Melanoides tuberculata*), moderately tolerant and groups such as beetles (Dytiscidae). Indeed, most taxa of chironomidae families and Simulidae are very dependent to the water quality (Haouchine, 2011).

Fish ponds have water of acceptable quality, because of the constant renewal of their water and sewage by the farmer. The pollution of lakes, ponds, stream channel and could be due to lack of maintenance especially after all the pressure in borders of their banks namely waste from cattle who regularly drink from it, washing and the car wash, waste from a pigsty, the use of water for watering rubber nurseries. There is a total absence of very polluo-sensibles stoneflies, thus highlighting multiple degradation caused by human pressure dominated by agriculture. The evaluation of the quality of surface water system assess the water quality and its ability to provide certain functionality including: maintaining biological balances, production of drinking water, recreation and water sports, aquaculture, watering of animals, irrigation for agricultural parcels. Given the many advantages involved in using benthic macroinvertebrates, it is relevant and appropriate to use them to assess the state of degradation of hydro-systems of the city of Daloa. It would be prudent to address an issue as important as the quality of the water, from a holistic approach rather than a piecemeal approach.

The use of benthic macroinvertebrates allows such an approach, since they are living organisms that incorporate elements of their environment. The MIB are relatively sedentary, qui Makes Them Good Witnesses of local circumstances (Camargo *et al.*, 2004). Unlike fish that can escape a source of pollution, macro-invertebrates are exposed to problems that may arise in their environment, which can change their physiology, behavior, morphology, their tissues and their survival rate.

Conclusion

The settlement of benthic macroinvertebrates in urban waters in Daloa is dominated by molluscs, Diptera and Coleoptera, Spatial distribution of macroinvertebrate groups shows that some species are specific to river systems while others are ubiquitous. The study of the hydrobiological quality index appreciated by ETC shows that all urban waters Daloa have a degraded state of biotic integrity but among them the pond at station 5 to the best health state. The use of EPTC is an appropriate approach to assess the health state of urban water bodies in Daloa

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