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State of knowledge on the development of multimetric index based on benthic macroinvertebrates in West Africa

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Abstract

The use of bioindicators is a widely used approach to assess the ecological status of aquatic ecosystems with respect to its many benefits. This work provides a literature review on the state of knowledge on the development of multimetric index based on benthic macroinvertebrates in West Africa. Thus, after a brief definition of benthic macroinvertebrates, the reasons for the use of benthic macroinvertebrates in bioindication were presented. This was followed by a presentation of the different methods of water quality assessment based on benthic macroinvertebrates. Finally, the different multimetric indexes based on benthic macroinvertebrates developed in West Africa were summarized. The development of multimetric index based on benthic macroinvertebrates is a recent approach in West Africa. African researchers have therefore adopted this approach, which can be used for the assessment of aquatic ecosystems in sub-Saharan Africa. This innovative approach opens the prospect of the elaboration of Beninese multimetric index based on bio-indicators present in the waters of coastal lagoons and channels of Benin in the perspective of a better knowledge of the richness of these environments.

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Introduction

Human activities such as industry, agriculture, urbanization, fishing and tourism are at the origin of the emission into the environment of a cocktail of various types of pollutants (physical, chemical and microbiological) that are often harmful to ecosystems and humans (Beauchamp, 2003; Bergé, 2012). Coastal and estuarine areas are final receiving environments for these chemicals transported from the continent (Bloundi, 2005; Leaute, 2008). This has led to increasing global calls for sustainable management of aquatic ecosystems (Kangalawe and Liwenga, 2005). Maintaining or restoring aquatic ecosystem health requires adequate conservation of all biological, physical and chemical components (Barbour *et al.*, 2000; Barbour and Paul, 2010).

The use of biological signatures to detect the impacts of human activities in aquatic environments is a long-standing practice (Sharma and Moog, 1996). This method uses the response of an organism or group of organisms to changes in environmental quality (Tachet *et al.*, 2010; Murphy *et al.,* 2013; Ben Moussa *et al.,* 2014). Alongside different groups of organisms such as diatoms, macrophytes, fish, benthic macroinvertebrates are by far the most widely used for the bioassessment of anthropogenic impacts (Hering *et al.*, 2006a).

In fact, macroinvertebrates are the most commonly used group of organisms for biomonitoring and assessing the overall health of aquatic systems (Adandédjan, 2012; Sanogo, 2014; Agblononon Houélomè, 2018). The interest of macrobenthic organisms relative to other biological groups stems from the fact that macroinvertebrate communities are able to respond to nutrient enrichment, oxygen availability, and changes in habitat structure (Lücke and Johnson, 2009). Thus, differences in environmental requirements between taxa produce community characteristics that reflect ecological conditions (Bonada *et al.,* 2006; Gabriels *et al.,* 2010). In addition, macroinvertebrates constitute a very heterogeneous taxonomic group that includes several phyla (Friberg *et al.*, 2011; Adandédjan, 2012). Sampling procedures for benthic macroinvertebrates are relatively well developed and can be carried out by a person working alone (Metcalfe, 1989; Friberg *et al.*, 2011). Finally, benthic macroinvertebrates consist of living organisms found on all types of substrate in all seasons and are therefore ideal for the implementation of large-scale environmental monitoring programmes (Adandédjan, 2012; Agblononon Houélomè, 2018). Benthic macrofauna improves oxygen and nutrient flows between sediments and the water column (Gilbert *et al.*, 2007) by participating in the recycling of organic matter, a process also called bioturbation. Oxygen and nutrients are essential for the survival of all species present, animal or plant, wild or farmed. The benthic macrofauna is therefore an indispensable link in aquatic ecosystems.

Biomonitoring methods based on bio-indicators emerged in developed countries after the development of the saprobial index by Kolkwitz and Marsson (1902). More recently, the multimetric approach (Karr, 1981; Barbour *et al.*, 1995; Ofenböck *et al.,* 2004; Gabriels *et al.,* 2010) and the multivariate approach (Reynoldson *et al.,* 1995; Kokes *et al.,* 2006) have been developed. The first multimetric index was developed for fish assemblages in streams in the Midwestern United States (Karr, 1981). Subsequently, various types of multimetric index have been proposed using different biological communities, including periphyton (Hill *et al.,* 2003), macrophytes (Nichols *et al.,* 2000), birds (Bryce *et al.*, 2002), amphibians (EPA, 2002), terrestrial invertebrates (Kimberling *et al.,* 2001) and benthic macroinvertebrates (Klemm *et al.,* 2002; Ofenböck *et al.*, 2004; Hering *et al.,* 2006b; Gabriels *et al.,* 2010; Mereta *et al.,* 2013). The multimetric approach has become a popular method for routine biomonitoring programs in European states (Ofenböck *et al.*, 2004; Hering *et al.*, 2006b) because it integrates different biological measures (richness, composition, tolerance and trophic status) into a single value that can potentially reflect the impact of multiple anthropogenic pressures (Hering *et al.*, 2006b).

In Africa, benthic macroinvertebrates have been widely used for the bio-evaluation of rivers and water bodies through the calculation of metrics and biotic index (Kouadio *et al.*, 2008; Adandédjan, 2012; Diomandé *et al.,* 2013; Odountan and Abou, 2015; Agblononon Houélomè *et al.,* 2016; Kaboré, 2016; Agblononon Houélomè *et al.,* 2017; Zinsou, 2017; Capo- Chichi *et al.,* 2018; Tampo *et al.,* 2020). And the use of a multimetric approach based on benthic macroinvertebrates for the biological assessment of the quality of aquatic ecosystems is recent and continues to generate unprecedented interest and growth in sub-Saharan Africa (Raburu *et al.*, 2009; Masese *et al.,* 2009; Odume *et al.,* 2012; Mereta *et al.,* 2013; Nyamsi *et al.,* 2014; Lakew and Moog 2015; Kaboré 2016; Aura *et al.*, 2017; Chirwa and Chilima, 2017; Edegbene *et al.,* 2019a; Tampo *et al.,* 2020).

The main objective of this work is to synthesize the state of knowledge of multimetric index developed from benthic macroinvertebrates in West Africa.

Materials and methods

In this review, we have considered papers dealing with multimetric index based on benthic macroinvertebrates in West Africa. The key words we used in the literature search are: benthic macroinvertebrates, multimetric index, bio-indication and West Africa. These keywords were used alone and/or combined. The search engines we used to search for publications were Google scholar, Pubmed, Agora and Research gate. We also used resource persons located in laboratories similar to the Laboratory of Hydrobiology and Aquaculture (LHA)/University of Abomey-Calavi such as the Laboratory of Environment and Applied Biology (LEBA)/University Nangui Abrogoua (Ivory Coast) and the Laboratory of Hydrobiology and Water Ecotechnology (LHEE)/University Felix Houphouet Boigny de Cocody (Ivory Coast).

The analysis of these documents made it possible to highlight, first of all, the definition of macrobenthic organisms. In a second step, water quality assessment methods based on benthic macroinvertebrates were developed. We also highlighted the multimetric index based on benthic macroinvertebrates developed in West Africa and finally, the criteria for defining reference sites were discussed.

Definition of benthic macroinvertebrates

Benthic macroinvertebrates are aquatic organisms that lack a backbone and are visible to the naked eye (Tachet *et al.,* 1987; Adandédjan, 2012).

These organisms can be sessile (when they are permanently fixed), sedentary (when they are capable of slow movements and low amplitudes) or vagile (when they are highly mobile) (Adandédjan, 2012). Incontinental hydrosystems, benthic macroinvertebrates are part of the benthos, i.e. they live at the (benthic) bottom of streams, lakes, and marshes. Their habitats are made up of several types of substrates, ranging from the hardest (boulders, stones, ...), to soft substrates (gravel, sand, silt, mud, clay), macrophytes (algae, mosses, phanerogams) and finally organic debris (branches and leaves) (Tachet *et al.*, 1987). They are found in wetlands, streams, rivers, lakes, ponds and reservoirs, estuaries and lagoons. They constitute an essential group especially in the transformation of organic matter, fish food and pollution (Adandédjan, 2012). Some live permanently in the aquatic environment (Annelids, Molluscs and Crustaceans); others live temporarily (larval or nymphal stages of insects, sometimes adult stages only in some beetles) (Menétrey Perrottet, 2009). The identification of benthic macroinvertebrates most often requires the use of a binocular magnifying glass. These are organisms large enough to be caught with a net or retained on a sieve with a mesh size of 250 to 1000 µm (Tachet *et al.*, 2002).

Water quality assessment methods based on benthic macroinvertebrates

Biological methods using macroinvertebrate communities can be divided into two broad groups (Rosenberg and Resh, 1993):

❖ Methods evaluating the impact of a specific environmental stress (eutrophication, organic pollution);

- Methods assessing the overall quality of the ecosystem.

Methods assessing the impact of a specific environmental stress (eutrophication, organic pollution).

They include biotic index and diversity/similarity index.

Biotic index

Index methods are the most widely used in the assessment of aquatic resource quality via macro-benthic communities (Bonada *et al.,* 2006). Hydrobiologists agree to attribute the beginnings of the concept of biological indicators in the aquatic environment to Kolkwitz and Marsson (1902) with the saprobial index. According to this system, each water quality class corresponds to a "saprobic state" based on the quantity of decomposable organic matter. The saprobic system allocates to each organism "saprobic valences" for each level of saprobicity (from xenosaprobic to polysaprobic) and a "saprobic index" that reflects the tolerance of the organism to organic substances. From this first index, many other index have been initiated in Europe and throughout the world (Sharma and Moog, 1996): (i) index based on a quality grid combining classes of varieties (taxonomic richness) and groups of indicator taxa (pollution- sensitivity) whose origin dates back to the work of Woodiwiss (1964) and which gave rise in France to the biotic index (Tuffery and Verneaux, 1968) and the IBGN (AFNOR, 2004), and (ii) index based on the assignment of taxa to pollution sensitivity levels such as the Biological Working Monitoring Party" (BMWP (Hellawell, 1978)) and the associated index, Average Score Per Taxon (ASPT (GREBE, 1991).

Diversity/similarity index

They are based on the distribution of the relative abundance of species within a community. Diversity index have been produced in large numbers (Shannon and Weaver, 1949; Simpson, 1949; Margalef, 1958; Menhinick, 1964; Cairns and Dickson, 1971; MacArthur, 1972; Keefe and Bergersen, 1977). However, Washington (1984) has shown that most diversity index are inadequate to qualify the ecological quality of aquatic environments because the values obtained vary greatly according to factors other than pollution (fluctuation of populations during breeding periods, sample size, sampling method used, etc.). The major disadvantage of these two types of index is the considerable sampling effort that must be quantitative in order to provide the abundance of each species. The validity of these index hardly goes beyond the limits of the national or even regional context in which they are defined (Usseglio-Polatera *et al.*, 2000). Indeed, biotic index or diversity index do not integrate the natural temporal and spatial fluctuations of living communities (Charvet *et al.,* 1998). Conventional index methods transforming biological observations into notes reduce ecological information and may introduce biases in bio- assessment (Cao and Hawkins, 2005).

Methods assessing the overall quality of the ecosystem

Methodologies for assessing general ecosystem quality are based on three different types of approaches: the multimetric method, multi-variate analyses and biological traits.

The multimetric method

The use of biological metrics is an approach aiming at new synthetic expressions of biological responses to anthropogenic disturbances. A multimetric index is a value that can potentially reflect multiple effects of human impact on aquatic ecosystem structure and function using a combination of different individual biological measures (Barbour *et al.*, 1995; Applegate *et al.,* 2007; Menetrey *et al.,* 2011). These different biological measures are referred to as metrics. In a multimetric index, each metric represents a physical, chemical or biological component of ecosystem quality or biological variables (Gerhardt *et al.*, 2004; Gabriels *et al.,* 2010; Van Den Broeck *et al.,* 2015). The first multimetric index were developed in the 1980s for the assessment of river quality based on fish fauna (Karr, 1981). Subsequently, various types of multimetric index have been proposed using different biological communities, including periphyton (Hill *et al.,* 2003), benthic macroinvertebrates (Barbour *et al.*, 1995; Klemm *et al.*, 2002; Gabriels *et al.,* 2010; Mereta *et al.,* 2013), macrophytes (Nichols *et al.,* 2000), birds (Bryce *et al.,* 2002*),* amphibians (EPA, 2002) and terrestrial invertebrates (Kimberling *et al.,* 2001). Widely used in the United States, the method has been imported into Europe (Hering *et al.*, 2006b).

Four main categories of metrics are considered in the multimetric approach (Dolédec, 2009): (i) composition and abundance metrics (e.g. relative proportion of specific taxa), (ii) richness and diversity metrics (e.g. number of species, diversity index), (iii) sensitivity and/or tolerance metrics (e.g. pollution-sensitivity of taxa), and (iv) "functional" metrics (e.g. mode of nutrition, ecological preferences). The process of developing a multimetric index begins with the selection of metrics. The calculation of the metrics continues to (i) exclude numerically unstable metrics, (ii) correlate the metrics with the selected anthropogenic gradient, (iii) select candidate metrics by considering a balance between the four types above, and (iv) derive the most robust metrics (best response to the gradient) (Dolédec, 2009). The multimetric index itself is generated by combining the metrics, thus simplifying the decision-making process by using a single value (as with index methods) and determining the biological quality class of the study site (Dolédec, 2009). The combination of metrics thus provides an integrated picture of ecosystem health, but their selection must be carefully considered to avoid redundancy (Ofenböck *et al.*, 2004).

Compared to index methods, multimetric methods provide biologically interpretable (metric) levers on which managers can act more easily. According to Barbour *et al.* (1999), multimetric index are reliable indicators of the overall impact of human activities. However, the natural variability inherent in many metrics or regional variations in the reliability of the ecological quality assessment of these index may limit the spatial extent of their application.

Multivariate analysis

The development of computer tools, as well as the existence of appropriate statistical techniques to synthesize the composition of communities (e.g., Ter Braak and Verdonschot (1995)), allowed the emergence of predictive bioassessment tools in the early 1980s. The first predictive tool is the River Invertebrate Prediction And Classification System (RIVPACS) (Wright *et al.*, 2000). It is a system that produces a diagnosis of anthropogenic impacts by comparing the stands observed in one or more study sites with the conditions expected in these sites in the absence of human pressure. The baseline is based on the biological classification of undisturbed sites (614 in the RIVPACS III version (Wright *et al.*, 2000)). The statistical approach uses a Non Metric Multidimensional Scaling procedure and provides the list of expected taxa based on predictions made from 11 environmental variables describing the physical and chemical universe of the study site (Moss, 1999). The list of predicted taxa is compared with the list of taxa obtained from field sampling. From the list of predicted taxa, the calculation of a biological index (e.g. BMWP, ASPT) expected in the absence of human disturbance is compared with the observed biological index. The diagnosis is based on the examination of the ratio between observed and predicted value (O/E ratio) which provides an index of ecological quality. Six ecological quality classes constitute the diagnostic grid, from the most impacted conditions (O/E <0.50) to those free of anthropogenic impact (O/E = 1.00). Initially developed in the United Kingdom for rivers, the RIVPACS approach has been adopted on other continents (AUStralian RIVer Assessment Scheme, (Parsons and Norris (1996); Turak *et al.* (2000)) in Australia; Assessment by Nearest Neighbor Analysis, (Linke *et al.*, 2005) or for lakes (BEnthic Assessment SedimenT, (Reynoldson *et al.* (1995); Sylvestre (2006)) in Canada). Such approaches are defined for homogeneous groups of reference stations and the transfer of these methods to other regional situations (other EU countries) requires a complete redefinition of the reference lists and/or a significant extension of the reference databases (Verdonschot and Nijboer (2004)). These predictive tools have been successfully tested in several countries using the computer program TWINSPAN.

A part from predictive models, the most widely used multi-variate methods for macroinvertebrates include self-organizing map (SOM) and discriminant analysis (DA), cluster analysis (CA), factor analysis (FA), Principal Component Analysis (PCA), canonical correspondence analysis (CCA), redundancy analysis (RDA) (Adandédjan, 2012; Agblonon Houélomè, 2018; Zinsou, 2017; Odountan and Abou, 2015).

Similar to a bioassessment using one or more metrics, multi-variate approaches assess human impacts by comparing the patterns observed at a site with those expected in the absence of human impact, i.e. the reference condition (Bonada *et al.*, 2006). Thus, multi-variate analyses are recommended for assessing the quality of lentic and lotic environments (Chevenet *et al.*, 1994; Rossaro *et al.,* 2007).

Traits method

The "traits" in ecology are the set of measurable characteristics that describe the morphology, physiology, behaviour or ecological preferences of a species (Vieira *et al.*, 2006; Menezes *et al.*, 2010; Cadotte *et al.*, 2011; Trichet-Arce, 2013). They fall into three main groups, namely biological, physiological and ecological traits (Tachet *et al.*, 2010).

The use of traits is based on the River Habitat Templet theory (Townsend and Hildrew, 1994) according to which temporal and spatial changes in habitat induce a mosaic of biotic and abiotic conditions that play a fundamental role in the organization of aquatic communities. This means that the distribution of organisms (plants or animals) is strongly related to the frequency of disturbances (defined as natural or anthropogenic events that disrupt the ecosystem, communities or population structure), which alter resources, habitat availability and the physical environment. These habitat characteristics are therefore considered as filters for biological and ecological traits of species, allowing for the linking of environmental traits and gradients.

Studies conducted on invertebrate communities using a trait-based approach have highlighted the ability of combinations of traits to provide a specific response for different types of disturbance (Archaimbault, 2003). Thus, traits are relevant to reveal natural or anthropogenic disturbances, induced by organic matter contamination (Charvet *et al.*, 1998; Lecerf *et al.*, 2006), sediment toxicity (Archaimbault *et al.,* 2010; Colas *et al.*, 2011), hydraulic conditions (Snook and Milner, 2002), introduction of non-native species (Devin *et al.,* 2005) or multiple stresses (Dolédec *et al.*, 1999; Usseglio-Polatera and Beisel, 2002; Gayraud *et al.,* 2003). In addition, trait-based invertebrate community response is relatively stable at large spatial scales (Statzner *et al.*, 2001; Archaimbault *et al.*, 2005).

The use of strokes is also easy. Indeed, the determination of taxa at the systematic level of gender or even family may be sufficient for the efficient use of a community's trait profiles (i.e. the frequency of use of different trait modalities by individuals composing this community) in bioindication (Dolédec *et al.*, 2000; Archaimbault, 2003; Gayraud *et al.* , 2003). The process of developing such a tool is based on (i) the quantification of biological traits, (ii) the description of the behaviour of biological traits in reference situations and (iii) in variously disturbed situations (Dolédec, 2009). The first databases (Bournaud *et al.,* 1992; Statzner *et al.,* 1994; Usseglio-Polatera *et al.,* 2000) made it possible to quantify the biological traits of many invertebrate taxa using a coding procedure or assigning an affinity score to each taxon for a modality of biological traits ranging from "0" (no affinity) to "3" (high affinity). Moreover, since traits are fewer in number than species, this mathematically allows dimensions to be reduced when multivariate methods are used (Haybach *et al.*, 2004). The many advantages cited above explain the recent development of bioassessment tools that incorporate the use of benthic macroinvertebrate traits (Marzin *et al.*, 2012; Mondy *et al.*, 2012; Mondy and Usseglio- Polatera, 2013).

Multimetric index based on benthic macroinvertebrates developed in West Africa

Multimetric index are increasingly applied for conservation actions, as they allow water resource monitoring agencies to gain insight into complex biological data and provide policy-relevant information for regulatory agencies and decision-makers (Karr and Chu, 1999).

The development of multimetric index based on benthic macroinvertebrates for assessing the health of aquatic ecosystems is recent in Africa. Thus, in West Africa, four countries have at least one multimetric index based on benthic macroinvertebrates to assess the ecological status of their water bodies. These are Cameroon (Nyamsi *et al.*, 2014; Kengne Fotsing, 2018); Burkina Faso (Kaboré, 2016); Nigeria (Edegbene *et al.,* 2019a;b) and Togo (Tampo *et al.,* 2020).

In Cameroon, two multimetric indexes reflecting biological integrity, based on benthic macro-invertebrates, have been developed respectively for rivers in the south central forest region of Cameroon by Nyamsi *et al.* (2014) and the western region of Cameroon by Kengne Fotsing, 2018. These are respectively the Multimetric Index of Benthic Macroinvertebrates Yaoundéens (IMMY) and the Multimetric Index of Macroinvertebrates of the Western Region of Cameroon (IMMOC). The metrics that have been taken into account for the calculation of the IMMY are: taxon richness, number of taxa EPT, percentage of taxa EPT, percentage of Chironomids, equitability index and Hilsenhoff biotic index. The IMMOC is composed of 2 metrics derived from taxonomic diversity (Shannon diversity index) and taxonomic composition (1 - GOLD).

In Burkina-Faso, a multimetric index assessing the ecological quality of rivers was developed by Kaboré (2016) to evaluate their ecological status in the West African Sahel and Upper Sudan ecoregions. This is the BBIMI (Burkina Benthic macroinvertebrate multi-metric index) which is composed of the metrics: %Non-diptera Insects, %diptera tolerant, EPT-families, the ASPT- NEPBIOS index and the ASPT-BMWP index.

In Nigeria, two multimetric index have been developed to assess the ecological quality of rivers. Edegbene *et al.* (2019a) developed a multimetric index for the Chanchaga River in Niger State in north-central Nigeria (MMIchanchaga) and a multimetric index for assessing the ecological quality of urban rivers in the Niger Delta region of Nigeria (MINDU) (Edegbene *et al.*, 2019b). The metrics used in the calculation of MMIchanchaga are :%EFA, EFA richness, abundance Diptera, Margalef index, Shannon index, abundance Beetles + Hemiptera, abundance Decapods, abundance Molluscs, abundance Odonates, %Coloptera + Hemiptera, %Decapods, richness Hemiptera + Diptera, %Chironomidae + Oligochaete. Those used in the calculation of the MINDU are: abundance Hemiptera, %Coloptera + Hemiptera, %Coloptera + Hemiptera, %Chironomidae + Oligochaetes, equitability index and Logarithm of relative abundance of species (>40-80 mm).

In Togo, Tampo *et al.* (2020) developed the Multimetric Index of Zio River Basin (MMIZB) for a watershed in Togo. The metrics taken into account for the calculation of the MMIZB are : IBGN, ETO (Ephemeroptera, Trichoptera and Odonata richness), ratio EPT/Diptera, Shannon index, modified FBI and total number of taxa.

These various works have resulted in multimetric index composed of a variable number of metrics. Thus, the number of metrics varies from two (Kengne Fotsing, 2018), five (Kaboré, 2016; Edegbene *et al.,* 2019b), six (Nyamsi *et al.,* 2014; Tampo *et al.,* 2020) and thirteen (Edegbene *et al.,* 2019a). West African scientists thus have some experience in developing multimetric index based on benthic macroinvertebrates.

The development of multimetric index based on benthic macroinvertebrates for monitoring aquatic ecosystems is therefore a new approach in West Africa.

Criteria for defining reference sites

One of the most efficient techniques for biomonitoring and assessing the ecological status of aquatic ecosystems is the reference condition approach (Kaboré *et al.*, 2017). According to Barbour *et al.* (1996), Ollis *et al. (*2006) and Stoddard *et al.* (2006), the reference condition is defined as the condition that is representative of a group of undisturbed sites, organized according to selected physical, chemical and biological characteristics and represents the expected condition for a particular biotic component. The reference condition thus serves as a model for comparing data from a monitoring site. With the reference condition approach, the biological community of a potentially stressed water body is compared to that of relatively undisturbed reference sites with similar environmental conditions. However, several authors have pointed out that reference conditions must be systematically identified because all ecosystems experience some level of human disturbance and truly pristine sites are virtually non-existent (Thorne and Williams 1997; Wallin *et al.*, 2003). A number of methods can be used to establish the reference condition (Rosgen, 1998; Apfelbeck, 2001).

Some of these methods include a thorough spatial study, predictive modelling, historical data and expert judgement (Alonso *et al.*, 2011). Each method for determining the reference state has its own strengths and weaknesses (Economou, 2002; Sommerhäuser *et al.*, 2003). In some geographical areas, the authors have developed a priori criteria based on the different pressures derived from human activities that may affect ecological conditions to define a reference site (Moog and Sharma, 2005; Alonso *et al.*, 2011). The criteria selected as a *priori* should define the lowest level of environmental disturbance caused by human activities (Stoddard *et al.*, 2006), and most of these criteria should be met by the selected reference sites in order to clearly define the reference ecosystem as one that is healthy according to current policy objectives (Bailey *et al.*, 2004; Alonso *et al.*, 2011). Commonly used criteria include physico-chemical parameters, hydro- morphological characteristics, land use pattern and riparian vegetation (Moog and Stubauer, 2003; Nijboer *et al.*, 2004). The reference condition approach is therefore important in the development of ecosystem health assessment tools to rigorously take into account the unique characteristics of a geographic area.

Conclusion

Good ambient water quality is essential for the preservation of aquatic ecosystems and the services they provide, such as fisheries resources. It is equally important for human health when humans choose to use water for recreation, drinking and domestic purposes. The assessment of water quality in aquatic ecosystems is therefore essential. For this purpose, several organisms are used as bio-indicators. Among them benthic macroinvertebrates are increasingly used because of the many advantages they possess. The use of benthic macroinvertebrates for the development of multimetric index is a new approach in West Africa.

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