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A saprobic index for biological assessment of river water quality in Brazil (Minas Gerais and Rio de Janeiro states)

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Abstract Based upon several years of experience in investigations with macrozoobenthos in rivers in the states of Minas Gerais and Rio de Janeiro, a biological assessment system has been developed to indicate pollution levels caused by easily degradable organic substances from sewers. The biotic index presented here is aimed at determining water's saprobic levels and was, therefore, named the "Saprobic Index for Brazilian Rivers in Minas Gerais and Rio de Janeiro states" (ISMR). For this purpose, saprobic valences and weights have been established for 122 taxa of tropical macrozoobenthos. Investigations were carried out in little, medium sized and big rivers in mountains and plains. Through ISMR, a classification of water quality and the respective cartographic representation can be obtained. Data collection and treatment methods, as well as the limitations of the biotic index, are thoroughly described. ISMR can also be used as an element to establish complex multimetric indexes intended for an ecological integrity assessment, where it is essential to indicate organic pollution.

Keywords Tropical rivers · Water quality assessment · Organic pollution · Biotic index · Saprobic index · Macrozoobenthos

Introduction

The assessment of river water quality by means of bioindicators and biotic indexes has been used in Europe for over 100 years: Kolkwitz and Marsson (1902), Schäfer (1985), Newman et al. (1992), Friedrich et al. (1992), Rosenberg and Resh (1993), and Karr (1994). Nowadays, it is also used in subtropical regions (Haase and Nolte 2007). The indexes have been adopted as technical standards, for example, in Germany (DIN 38410-1 2004) and in Austria (Ö-Norm 1995). In Brazil, the development and use of such methods is just beginning.

Although there are now many methodological variations for water quality assessment by means of bioindicators (De Pawn and Vanhooren 1983), most of those indicate the general pollution of the water, especially saprobity (Friedrich 1990;

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Friedrich and Herbst 2004), in which each water organism is characteristic for the different intensities of organic matter load and the status of self-purification in water courses.

It is well established to use benthic animals as important bioindicators because of their limited locomotory abilities, their attachment to solid substrates, and their relatively long life cycles. Thus, these organisms are well suited for monitoring water quality in flowing water.

Nowadays, water quality assessment systems are developed not only focusing on water pollution, but also for ecological evaluation, which is especially required in Europe according to the European Water Framework Directive (EG 2000). Therefore, multimetric assessment systems are being developed in which macrozoobenthos play a relevant role. These organisms reflect not only organic pollution by domestic and industrial effluents, but also the effects of acidification and morphological decay (AQEM 2002; Hering et al. 2004a, b).

Based upon experiments carried out over 20 years in rivers in the Brazilian states Minas Gerais and Rio de Janeiro, a system called "*um sistema saprobiótico para Minas Gerais e Rio de Janeiro*" (Saprobic Index for Brazilian Rivers in Minas Gerais and Rio de Janeiro states) (ISMR) has been developed. The aim of this approach is to identify the intensity of the effects on aquatic biota by easily degradable organic matter, the levels of saprobity. The new system can be applied to determine river pollution by urban and industrial sewers and assist in planning river cleaning. Furthermore, it will be an element of a complex multimetric ecological assessment system to be developed at a later stage.

Material and methods

The first step in developing the biotic index was to collect all available biological and physico-chemical data and information about abiotic factors influencing aquatic life in the regions of our studies. Most of the results are available in technical reports of limnological studies that used macrozoobenthos as bioindicators for water assessment in Minas Gerais and Rio de Janeiro. These studies were carried out by the authors together with other biologists mainly within projects of *Fundação Centro Tecnológico de Minas Gerais* (CETEC 1986, 1988, 1994, 1995, 1998, 2004, 2007) in several river basins in Minas Gerais (IGAM 2006) and in Rio de Janeiro within Brazil–German projects for environmental protection by *Fundação Estadual de Engenharia do Meio Ambiente* (FEEMA 1991) since 1986 (Friedrich et al. 1990; Araujo 2000). Therefore, a consolidated basis of data was obtained, which enabled the determination of saprobic valences for macrozoobenthos on the taxonomic level of families, genus, and species. The rivers under investigation were of different sizes from small creeks to middle-sized wadeable rivers in mountainous regions (up to 800 m + NN). In most sampling stations, the sediments mainly consisted of stones, gravel, and sand. Especially in some small rivers near the coast in Rio de Janeiro, only sand or, at heavily polluted places, mud was dominant in strengthened or canalized riverbeds.

Sampling was carried out by kick-sampling using a hand net with 500 μm mesh size according ISO 7828 (ISO 1985). Additionally, direct collection of animals was done by hand with tweezers and brushes. For muddy stations, a metal net, according to Friedrich and Herbst (1971), was used. At deep stations, additionally, artificial substrates, according to Wantzen and Pinto-Silva (2006) and Araujo et al. (1998), were implemented.

For taxonomic identification, the following keys were utilized: Brinkhurst and Marchese (1989), Costa et al. (1988), Dominguez et al. (1992), Edmondson (1959), Flint (1982), Froehlich (1984), Heckman (2002a, b), Holzenthal (1998), Lopretto and Tell (1995), Merrit and Cummins (1996), Péres and Roldan (1988), Trivinho-Strixino (1995), and Wiggins (1978). While collecting macrozoobenthos, field sheets were filled out in order to obtain important physiographic (ecomorphological) information for the biological study with the data listed in Table 1.

The sampling area for limnological studies in the present work included in little, medium sized and big rivers in several river basins of the states Minas Gerais and Rio de Janeiro, as follows:
State Minas Gerais:

- Rivers in the watersheds of Rio Jequitinhonha, Rio Paranaíba, and Rio

Table 1 Parameters for the standardized field sheet

General description of the river (name, geographical location, river basin, number of the station, and site and place in the river)
Name of monitoring program, date and time of sampling
Exposure to light, weather condition
Hydrological data: size, depth, type of water course and velocity (approximate), turbidity
Water level
Water color, smell (spume)
Habitat: lotic, lenitic (pool)
Structures of the substrate: rocks, stones, boulders, sand, mud, concrete, wood
Aquatic vegetation: macrophytes, mosses, filamentous algae
Marginal vegetation: gallery forest, reed, shrub, grass
Hydraulic measures
Use of the banks: houses, agriculture, pasture, animal quenching, leisure, etc.
Visible pollution and damages
Litter in water or banks, sewer dumping, etc.
Reduction in the sediment (black spots, black layers, gas bubbles)
Erosion at the banks and in the water bed, extraction of sand or others, sedimentation of anorganic substances, industrial wastes
Physicochemical data in the field: air and water temperature, pH, oxygen content and conductivity

São Francisco, with samples from Rio São Francisco; Rio Paraopeba, Rio Verde Grande, and Rio das Velhas (especially the upper part was investigated intensively and repeatedly)

State of Rio de Janeiro:

- Watersheds of Guanabara Bay, Sepetiba Bay; and Lagoa Jacarepaguá
- Small rivers to Paraíba do Sul, medium section

State Minas Gerais and Rio de Janeiro:

- Middle and lower Rio Paraiba do Sul and tributaries

The investigated rivers can be characterized as

- Small mountain rivers with predominant stony sediments
- Small mountain rivers with predominant sandy sediments
- Medium size (wadeable) mountain rivers with predominant stony sediments
- Medium size (wadeable) mountain rivers with predominant sandy sediments
- Medium size (wadeable) lowland rivers with sandy sediments
- Small lowland rivers with predominant sandy sediments
- Small lowland rivers with muddy sediments
- Big not wadeable rivers (Paraiba, Guandú) with predominant sandy sediments

The data bank comprised over 1,000 samples of macrozoobenthos treated and related to the physicochemical water analyses of their habitats in order to determine the saprobic indexes and saprobic valences of the taxa.

Determination of the saprobic valence (s_i) and indication weight (G)

The determination of saprobic indexes and saprobic valences for macroinvertebrates in Brazilian tropical lotic environments according to the method for the saprobic system, successfully used in temperate zones, allows advances in our knowledge about tolerance limits of native species regarding different levels of organic loads. Therefore, it is the basis for a system for water quality assessment.

The mathematical approaches of Kolkwitz and Marsson (1902) and Zelinka and Marvan (1961) are based on the taxonomic level of species. However, at the present limitations of taxonomic knowledge of aquatic macrozoobenthos in Brazil, it is still not possible to identify all or most of the immature forms at the taxonomic level of species, depending on the status of taxonomy of neotropical water organisms. Thus, the data presented here were treated mainly to the level of genus and family. However, the determination of the saprobic value and establishing a saprobic system is still possible.

Along with the analysis of data from the data banks, further experiences of the authors were also considered. Field surveys were carried out supervised by taxonomy experts when it came to adjusting taxa saprobic valences. This procedure was required especially because of the fact that, among the environments under study, alpha-mesosaprobic and polysaprobic situations were much less frequent than others.

Table 2 Water chemical data on different saprobic levels, according to LAWA (1990), modified according to own data

Saprobity level	Saprobiotic index s_i	Degree of organic pollution	Physical and chemical parameters			
			Dissolved oxygen O_2		BOD_5 (mg/l) 20°C	NH_4–N (mg/l)
			Saturation deficit (%)	Oversaturation (%)		
Oligosaprobic	1.0–<1.5	Not to lightly loaded	0–<5	0–<3	0.0–<0.5	<0.1
Oligosaprobic–beta-mesosaprobic	1.5–<1.8	Lowly loaded	5–<15	3–<10	0.5–<2.0	0.1
Beta-mesosaprobic	1.8–<2.3	Moderately loaded	15–<30	10–<25	2.0–<4.0	>0.1–<0.3
Beta-mesosaprobic–alfa-mesosaprobio	2.3–<2.7	Critically loaded	30–<50	25–<50	4.0–<7.0	0.3–<0.7
Alpha-mesosaprobic	2.7–<3.2	Heavily polluted	50–<75	50–<100	7.0–<13.0	0.7–<3.0
Alpha-mesosaprobic–polysaprobic	3.2–<3.5	Very heavily polluted	75–<90	>100	13.0–<22.0	3.0–<9.0
Polysaprobic	3.5–4.0	Excessively polluted	>90	–	>22	>9.0

The saprobic indexes of the used taxa, expressing their tolerance limits to organic pollution, were established based upon the frequency of their occurrence (percentage of occurrence) in the different saprobic levels of water in the habitats where they were found (see Table 2).

In order to identify the habitats' saprobic levels, the concentration of chemical indicators for organic load were used as one reference, obtained through the levels of dissolved oxygen (saturation and deficit), biochemical demand of oxygen (BOD), and ammoniac nitrogen in the water (NH^4–N), following LAWA (1990) with modifications (Junqueira and Campos 1991), as shown in Table 2. Other quality indicators like nitrate or electric conductivity are not included in Table 2 besides the fact that they can be good indicators of human impacts. Conductivity rises parallel with the share of polluted water in a river. This effect may be used only along one specific river without significant natural change of conductivity because of rock quality. Nitrate, another generally good indicator of pollution, may often be an effect of farming and, therefore, may overlap the effect of polluted effluents.

The concentrations in Table 2 indicating O_2, BOD_5, and NH^4–N are not limit values but were observed very frequently during low-water seasons. Because the concentrations of oxygen can vary during the day and in fast-flowing rivers, reaeration is high and sometimes significantly higher than in slow-flowing waters and the data given are to be recognized as "normal."

The saprobic valence of the taxa was applied to identify their saprobic index "s_i" by calculating according to the formula from Wegl (1983), modified for seven steps of saprobity.

Formula 1
Calculation of the saprobic value *s* of new taxa

$$s = \frac{\begin{array}{l}1\text{ oligosaprobic} + 1.5\text{ oligo} - \text{beta-mesosaprobic} + 2\text{ beta-mesosaprobic} + 2.5\text{ beta-mesosaprobic}\\ - \text{alpha-mesosaprobic} + 3\text{ alpha-mesosaprobic} + 3.5\text{ alpha-mesosaprobic} - \text{polysaprobic}\\ + 4\text{ polysaprobic}\end{array}}{10}$$

where $s =$ is the saprobic value of a taxon.

The second parameter to calculate the "quality" of a taxon as an indicator was the

Table 3 Classification of the standard deviation and of the indicative weights

Standard deviation	Indicative weight
0.0 to 0.2	16
>0.2 to 0.4	8
>0.4 to 0.6	4
>0.6 to 0.8	2
>0.8 to 1.0	1
>1.0	Not to be used as an indicator for saprobity

determination of the saprobic indication weight "*G*." This was conducted according to Table 3, as is described by Friedrich and Herbst (2004). Factor ×2 for instance of the indicative values was used in order to give more weight to species with restricted ecological value than for those with broader ones. At the same time, this procedure can minimize the centripetal effect by building an index.

Along with the study to adapt the saprobic system methodology, the identification of macrozoobenthos valences at the genus level has also allowed an advance in knowledge that improved the adaptation of "scores" of macrozoobenthos families in the "Biological Monitoring Work Party Score System" adapted for rivers in the state of Minas Gerais by Junqueira and Campos (1998) and Junqueira et al. (2000).

Results

The results of data analysis for all samples collected during our studies in the Brazilian rivers in Minas Gerais and Rio de Janeiro states are presented in Table 8 at the end of the text. All taxa are listed together with their saprobic valences (or saprobic indexes of the single taxa) s_i, as well their weight as bioindicators G calculated based upon their occurrence (percentage at different saprobic levels).

In Table 8, only those taxa are included for which there was sufficient information to determine their saprobic valence. Some more taxa seem to be good indicators as well, but they are not included because of insufficient data. The s_i was determined for a total of 122 taxa. It is a preliminary list that may be improved and increased with new taxa on the basis of new studies. Within the 122 taxa, insects, represented mainly by the Trichoptera and Ephemeroptera, are the most numerous. Among the other macroscopic indicators with valences at the level of genus and species are insects of the orders Plecoptera, Diptera, Odonata, Coleoptera, and Megaloptera, with decreasing numbers. Mollusca, Oligochaeta, and Hirudinea could be taken as indicators as well. The only exception is the bacterium *Sphaerotilus natans*. It is a microorganism, but in heavily polluted sites, it develops so intensely that it becomes visible to the naked eye. Therefore, it was considered to add this bacterium to the list as it is an excellent indicator of high organic pollution. Being visible, its abundance class is at least 3.

Finally, this adaptation of the principles of the saprobic system represents significant progress in the standardization of methodologies for the evaluation of aquatic ecosystems in Brazil, considering that it is already implemented thoroughly and consolidatedly in other countries with proven efficiency in the assessment of organic pollution effects on aquatic life.

Application of ISMR

In order to apply the saprobic index, the examiner must be qualified with knowledge of limnology, water ecology, hydrobiology, and taxonomy, as well as field experience in the collection of benthonic macroinvertebrates. Water quality can be assessed by means of the saprobic system methodology using the formula of Zelinka and Marvan (1961) to determine the saprobic index at sampling site "*S*" as described below. For determining the abundance, the scaling in Table 4 was used. It is comparable with other tables widespread in use.

Formula 2

$$S = \frac{\sum_{i=1}^{n} s_i \times A_i \times G_i}{\sum_{i=1}^{n} A_i \times G_i}$$

where S is the saprobic index at the station or sampling site, s is the taxon saprobic index (valence), A is the taxon abundance class, G is the taxon weight as bioindicator, and i is the running

Table 4 Macrozoobenthos abundance classes adopted for the ISMR, following DIN (2004), changed

Class	Abundance	Macrozoobenthos (number of individuals/m^2)
1	Single find	1–2
2	Few	3–10
3	Few to medium	11–30
4	Medium	31–71
5	Medium to frequent	72–150
6	Frequent	151–360
7	Abundant	>360

number of the taxon. Seven levels can be adopted to determine macrozoobenthos abundance classes "A," as shown in Table 4.

For handling the data, very good experiences are made by using classes of frequency instead of total numbers of individuals; see Friedrich and Herbst (2004). Very low numbers of taxa together with low numbers of specimen demonstrate disadvantageous situations at the sampling site, for example, because of permanently or frequently moving sand caused by intensive erosion or digging, intensive manmade sedimentation, heavy hydraulic measures such as a concrete water bed, or toxic effects. Therefore, the index must be checked for validity.

The saprobic index (ISMR) is valid if the minimum number of taxa is five. If it is lower, the abundance of one or more taxa must reach frequency class 3 or higher, but this is an exception and should be explained.

Another condition for a valid ISMR index is a minimum of abundance. The sum of abundance in one sample must be 10 or more. The sum of abundance in one sample is the sum of the abundances of all taxa found in that sample, for example, two taxa in abundance class 3, one taxon in abundance class 2, and two taxa in abundance class 1. The sum of abundances in the sample is 10. In other cases, the ISMR may not be calculated or must be declared as invalid: (ISMR X, y_{inval}). Exceptions are very highly polluted rivers with huge quantities of red *Chironomus* (*Chironomus decorus* gr.), *Sphaerotilus natans*, or Tubificidae. Under these extreme circumstances, only very few species can survive, and in extreme cases, only one, however, in large quantities, of abundance

Table 5 Example of calculating the ISMR

Taxon	A	s_i	G
Chironomidae	7		
Chironommus sp.	4	3.3	4
Simulium sp.	5	1.7	4
Empidoidea	2	1.7	4
Libellulidae	1	1.7	4
Baetidae	2	2.0	4
Americabaetis sp.	3	2.0	4
Farrodes sp.	2	1.6	4
Tricorythopsis sp.	3	1.8	8
Tricorythodes sp.	2	1.7	4
Elmidae	3	1.7	4
Smicridea sp.	7	2.3	4
Nectopsyche sp.	2	1.5	4
Ochrotrichia sp.	2	1.8	8
Tubificidae	3	3.6	4
Placobdella sp.	2	2.5	4
Planariidae	2	2.2	2
Corbicula fluminea	2	2.3	4
Total abundance	47		
Saprobic index S of the sample: beta-mesosaprobic	2.12		

Rio Pomba upstream Rio Patiencia Minas Gerais July 2006, sampling with artificial substrates

class 5 or higher. Tables 5 and 6 give two examples for calculation the ISMJ.

Presentation of the results

The biological index ISMR can be implemented to classify the results into biological water quality classes. The range of indexes is divided into five classes. Besides this, the saprobic system allows seven steps. It may be better to shorten them to

Table 6 Example of calculating the ISMR

Taxon	A	s_i	G
Chironomus decorus	3	3.3	4
Sphaerotilus natans	3	3.6	8
Helobdella sp.	2	2.7	4
Gomphidae	1	1.9	4
Erpobdella sp.	1	2.9	8
Berosus sp.	1	1.6	2
Total abudance	12		
Saprobic index S of the sample: -alpha-mesosaprobic	3.13		

Rio Grande downstream of a little suburb, Rio de Janeiro Oktober 1987, hand net kick sampling

Table 7 Water quality classes according to saprobic index ISMR

Saprobity stage	Saprobic index	Water condition	Color in a map
Oligosaprobic-	1.0–<1.5	Very good	Blue
Oligosaprobic-beta-mesosaprobic	1.5–<1.8		
Beta-mesosaprobic	1.8–<2.3	Good	Green
Beta-mesosaprobic–alpha-mesosaprobic	2.3–<2.7	Moderate	Yellow
Alpha-mesosaprobic	2.7–<3.2	Bad	Orange
Alpha-mesosaprobic–polysaprobic	3.2–<3.5	Very bad	Red
polysaprobic	3.5–4.0		

five by combining their outer parts in accordance with international usage; see Table 7.

To transform the index into a water quality class, it is necessary to take some precautions. Firstly, it is a general problem to change a continuum into a step-like classification. At the border from one class (step) to another, a decision is necessary. Each biological index has a slight uncertainty, which may arise from problems during sampling or seasonal changes, e.g., flow and weather conditions, unsuitable sampling site, and so on. This has to be noticed. Therefore, it is necessary to look for further information, such as river bed morphology; flow conditions during or in advance of the sampling; physicochemical data, especially oxygen content; BOD; ammonia; type of sediment; or changes in the sediment caused by pollution, e.g., black spots, totally reduced surface of the sediment, or gas bubbles from the bottom. If no plausible conclusion is possible, at least a new sampling may be necessary.

Final considerations

This study applies the saprobic indexes method to tropical rivers in Brazil. It is based on over one thousand biological and physicochemical collections of water in the rivers. The ISMJ index could also be used as a foundation for the development of more complex multimetric indexes for the evaluation of the ecological status of Brazilian rivers.

It must be emphasized that this determination of saprobic weights and valences for macrozoobenthos

Table 8 List of macrozoobenthos used for the ISMR with the saprobic index (s_i) of each taxon and its respective saprobic weight (G)

Taxa	s_i	G
Turbellaria		
Dugesiidae	1.7	2
Planariidae	2.2	2
Oligochaeta		
Tubificidae	3.6	4
Branchiura sowerbyi Beddard, 1892	2.1	8
Tubifex sp. Lamarck, 1816	3.5	4
Limnodrilus sp. Claparede, 1862	3.3	4
Naididae	3	4
Dero sp. Oken, 1815	3	8
Hirudinea		
Erpobdellidae	2.9	4
Erpobdella sp. De Blainville, 1818	2.9	4
Glossiphoniidae	2.7	4
Placobdella sp.	2.5	4
Helobdella sp. (Linneus 1758)	2.7	4
Gastropoda		
Physa sp. (Linneus 1758)	2.8	4
Physa cubensis Pfeiffer, 1839	2.8	4
Planorbidae	2.5	4
Biomphalaria glabrata Say, 1818	2.5	4
Ancylidae	1.9	4
Lymnaea sp. Say, 1817	1.8	2
Pomacea haustrum (Reeve 1856)	2.3	2
Thiaridae	2.3	4
Melanoides tuberculata O.F.Müller, 1774	2.3	4
Bivalvia		
Corbicula fluminea O.F.Müller, 1774	2.3	4
Sphaeriidae	1.9	2
Diplodon sp. Spix, 1827	1.8	8
Ephemeroptera		
Baetidae	2	4
Baetodes sp. Needham & Murphy, 1924	1.9	4
Americabaetis sp. Kluge, 1992	2	4
Camelobaetidius sp. Demoulin, 1966	1.5	8
Leptophlebiidae	1.6	4
cf. *Meridialaris* sp. Peters & Edmonds, 1972	1.5	16
Farrodes sp. Peters, 1971	1.6	4
Thraulodes sp. G.Ulmer, 1920	1.5	8
Traverella sp. Edmunds, 1948	1.5	8
Hermanella sp. Needham & Murphy, 1924	1.5	4
Ulmeritus sp. Traver, 1956	1.5	4
Leptohyphidae	1.8	4
Leptohyphes sp. Eaton, 1882	1.5	4
Tricorythodes sp. G. Ulmer, 1920	1.7	4
Tricorythopsis sp. Traver, 1958	1.8	8
Caenidae	2	8
Polymitarcyidae	1.7	8
Asthenopus sp. Eaton, 1871	1.7	8

Table 8 (continued)

Taxa	s_i	G
Plecoptera		
Perlidae	1.3	4
Anacroneuria sp. Klapálek, 1909	1.3	4
Kempnyia sp. Klapálek, 1914	1	8
Gripopterygidae	1.2	8
Paragripopteryx sp. Enderlein, 1909	1.2	8
Gripopteryx sp. Pictet, 1841	1	16
Tupiperla sp. Froehlich, 1969	1.2	8
Tupiperla cf. *gracilis* Burmeister, 1839	1.2	8
Odonata		
Libellulidae	1.7	4
Aeshnidae	1.4	4
Gomphidae	1.9	4
Aphylla sp. Selys, 1854	1.9	16
Lestidae	1.5	4
Coenagrionidae	1.8	8
Argia sp. Rambur, 1842	1.8	8
Calopterygidae	1.8	8
Hetaerina sp. Drury, 1773	1.8	16
Megaloptera		
Corydalidae	1.7	4
Corydalus sp. Latreille, 1802	1.7	4
Coleoptera		
Elmidae	1.7	4
Chrysomelidae	2	8
Psephenidae	1.2	4
Psephenus sp. Dekay, 1844	1.2	4
Hydrophilidae	1.6	4
Berosus sp. Leach 1817	1.6	2
Staphylinidae	1.9	8
Dytiscidae	1.9	4
Curculionidae	2	4
Limnichidae	1.5	8
Dryopidae	1.6	8
Trichoptera		
Hydropsychidae Curtis, 1835	2.3	4
Smicridea sp. R. McLachlan, 1871	2.3	4
Leptonema sp. F.E. Guerin, 1843	2.2	4
Synoestropsis sp. G. Ulmer, 1905	1.4	4
Macronema sp. F.J. Pictet, 1836	1.5	16
Glossosomatidae H.D.J. Wallengren, 1891	1.6	8
Protoptila sp. N. Banks, 1904	1.6	8
Polycentropodidae G. Ulmer, 1903	2	4
Polycentropus sp. J. Curtis, 1835	2	8
Cernotina sp. H.H. Ross, 1938	1.7	4
Cyrnellus sp. N. Banks, 1913	1.7	8
Hydroptilidae J.F. Stephens, 1836	2	4
Leucotrichia sp. M.E. Mosely, 1934	1.5	4
Alisotrichia sp. O.S. Flint, 1964	1.8	4
Hydroptila sp. J.W. Dalman, 1819	1.8	4
Ochrotrichia sp. M.E. Mosely, 1934	1.8	8
Neotrichia sp. K.J. Morton, 1905	1.4	4
Oxyethira sp. A.E. Eaton, 1873	1.5	4
Hydrobiosidae G. Ulmer, 1905	1.3	4
Atopsyche sp. N. Banks, 1905	1.3	4
Philopotamidae J.F. Stephens, 1829	1.5	8
Chimarra sp. J.F. Stephens, 1829	1.5	8
Leptoceridae W.E. Leach, 1815	1.8	4
Oecetis sp. R. MacLachlan, 1877	1.8	8
Nectopsyche sp. F. Müller, 1879	1.5	4
Calamoceratidae G. Ulmer, 1905	1.2	4
Phylloicus sp. F. Müller, 1880	1.2	4
Odontoceridae H.D.J. Wallengren, 1891	1.2	16
Marilia sp. F. Müller, 1880	1.2	16
Helicopsychidae G. Ulmer, 1906	1.4	8
Helicopsyche sp. C. v. Siebold, 1856	1.4	8
Lepidoptera		
Pyralidae	1.7	4
Noctuidae	1.9	4
Diptera		
Blephariceridae	1.3	8
Rheotanytarsus sp. Thinemann and Bause, 1913	2	4
Chironomus sp. Meigen, 1803	3.3	4
Chironomus decorus Johansen, 1905	3.3	4
Empidoidea	1.7	4
Tabanidae	1.9	2
Ceratopogonidae	1.8	4
Psychodidae	3.4	4
Tipulidae	1.8	4
Simuliidae	1.7	4
Simulium sp. Latreille, 1802	1.7	4
Muscidae	2	8
Athericidae	1.8	8
Stratiomyidae	3	4
Syrphidae	3.5	8
Bacteria		
Sphaerotilus natans Kützing 1833—only macroscopical stands	3.6	8

is an initial adaptation of the saprobic system methodology for tropical lotic environments in Brazil, which may be improved by usage and due to increasing taxonomic knowledge. However, it is an advance in the standardization of methodologies to assess aquatic ecosystems. Its efficacy in the assessment of organic pollution has been proven over a long period of time in temperate regions. It will yield more precise answers in biomonitoring because it can detect subtle variations in environmental changes.

This methodological appropriation in biomonitoring tropical aquatic environments could be a contribution to the standardization of biotic indexes. This can promote the advances required for the application of biomonitoring in the management of river basins aiming at subsidizing legal environmental guidelines of water course classification by organisms responsible for pollution surveillance and control.

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