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INTERFACES CIENTÍFICAS

SPATIAL DISTRIBUTION OF LOTIC MACROINVERTEBRATES AND SURFACE WATER QUALITY IN PEDRA BRANCA STATE PARK

DISTRIBUIÇÃO ESPACIAL DE MACROINVERTEBRADOS LÓTICOS E QUALIDADE DAS ÁGUAS SUPERFICIAIS NO PARQUE ESTADUAL DA PEDRA BRANCA

DISTRIBUCIÓN ESPACIAL DE MACROINVERTEBRADOS LÓTICOS Y CALIDAD DEL AGUA SUPERFICIAL EN EL PARQUE ESTATAL PEDRA BRANCA

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ABSTRACT

The presence of bioindicator organisms is directly related to the conservation of aquatic environments, considering that they can be sensitive to organic and inorganic substances and changes in the limnological characteristics of the water. To carry out this work, field parameters of two rivers in Pedra Branca State Park were analyzed during the dry season in June 2018, and sediments with aquatic macroinvertebrates were sampled to identify taxa. The collected data were evaluated using non-metric multidimensional scaling to analyze the similarity of the species composition in the sampled sites. A redundancy analysis was also performed to investigate the relationships between biotic and abiotic factors. Through the quantitative results of the taxa found, the indices EPT (Ephemeroptera, Plecoptera and Trichoptera), BMWP (Biological Monitoring Working Party) and FBI (Family Biotic Index) were used to obtain qualitative results on the quality, conservation and pollution levels of the rivers. The results obtained are of great environmental and urban importance, since the rivers of the Pedra Branca State Park are essential for the water supply of the surrounding neighborhoods and directly influence the climate of the city of Rio de Janeiro.

KEYWORDS

Bioindicator; preservation; EPT; NMDS; RDA.

RESUMO

A presença de organismos bioindicadores está diretamente associada à preservação dos ambientes aquáticos, tendo em vista que eles podem apresentar sensibilidade a poluentes orgânicos e inorgânicos e a alterações nas características limnológicas da água. Para realizar este trabalho, parâmetros de campo de dois rios do Parque Estadual da Pedra Branca foram analisados durante a estação seca em junho de 2018, e sedimentos com macroinvertebrados aquáticos foram amostrados para a identificação de táxons. Os dados coletados foram avaliados por meio da escala multidimensional não métrica para analisar a similaridade entre a composição dos organismos nos locais amostrados. Foi feita também uma análise de redundância para investigar as relações entre fatores bióticos e abióticos. Por meio dos resultados quantitativos dos táxons encontrados, os índices Ephemeroptera, Plecoptera e Trichoptera (EPT), Biological Monitoring Working Party (BMWP) e Family Biotic Index (FBI) foram usados para obter resultados qualitativos sobre os níveis de qualidade, preservação e poluição dos rios. Os resultados obtidos são de grande importância ambiental e urbana, pois os rios do Parque Estadual da Pedra Branca são indispensáveis para o abastecimento de água dos bairros do entorno e influenciam diretamente no clima do município do Rio de Janeiro.

PALAVRAS-CHAVE

Bioindicador. Preservação. EPT. NMDS. RDA.

RESUMEN

La presencia de organismos bioindicadores está directamente asociada con la preservación de los ambientes acuáticos, considerando que pueden ser sensibles a contaminantes orgánicos e inorgánicos y cambios en las características limnológicas del agua. Para realizar este trabajo, se analizaron parámetros de campo de dos ríos del Parque Estatal Pedra Branca durante la estación seca en junio de 2018 y se tomaron muestras de sedimentos con macroinvertebrados acuáticos para identificar taxones. Los datos recopilados se evaluaron utilizando escalas multidimensionales no métricas para analizar la similitud entre la composición de los organismos en las ubicaciones muestreadas. También se llevó a cabo un análisis de redundancia para investigar las relaciones entre factores bióticos y abióticos. A través de los resultados cuantitativos de los taxones encontrados, se utilizaron los índices EPT (Ephemeroptera, Plecoptera y Trichoptera), BMWP (Biological Monitoring Working Party) y FBI (Family Biotic Index) para obtener resultados cualitativos sobre la calidad, preservación y niveles de contaminación de los ríos. Los resultados obtenidos son de gran importancia ambiental y urbana, ya que los ríos del Parque Estatal Pedra Branca son esenciales para el abastecimiento de agua de los barrios circundantes e influyen directamente en el clima de la ciudad de Río de Janeiro.

PALABRAS CLAVE

Bioindicador, preservación, EPT, NMDS, RDA

1 INTRODUCTION

Several parameters can be evaluated as indicators of water quality and their characterization depends on physical, chemical and biological factors that are directly related to the processes that occur in the water. When evaluating the interaction between living organisms and the environment, it is observed that while some organisms modify the physical and chemical properties of water during their metabolic activity, others are already suffering the effects of such changes (FUNASA, 2014).

According to Zalidis *et al*. (2002), environmental monitoring based on biological communities is a tool of great importance because organisms depend on the conditions of the habitat. Thus, changes in the richness and density of the taxa can efficiently indicate the impact of human or natural actions on the environment, since the decline of organisms populations can change the substrate characteristics and other abiotic factors such as decreased dissolved oxygen, increased acidity or nutrient concentration.

The type of substrate also affects the resilience of communities because it serves as a source of food, refuge, and egg deposition, and most of these animals spend most of their life cycle associated with the substrate (HERSHEY *et al*., 2010).

Aquatic macroinvertebrates are organisms that belong to communities with bioindicator potential. They are defined as organisms that can be retained on meshes with an aperture diameter of 200-500 µm (ROSENBERG; RESH, 1993; EATON, 2006). Santana *et al*. (2021) emphasize that they are one of the most representative groups of aquatic fauna due to their high abundance, biodiversity, wide distribution and relatively long life cycle. In addition, most of them have well-known ecological characteristics, being relatively sedentary and having limited mobility. Since they show different degrees of sensitivity to environmental stress, they are excellent indicators for assessing water quality through biological

Therefore, taxonomic groups can be monitored to evaluate surface environments, based on the behavior of ecological communities, where physicochemical and geochemical factors can subject these organisms to stress conditions as a result of humidity, vegetation suppression, landscape change or habitat loss (MUGNAI *et al*., 2010). One of the environmental monitoring tools is the calculation of biotic indices. Using these indices, it is possible to establish water quality classes based on the presence of benthic fauna families, using predetermined tolerance values for each taxon (SANTOS, 2021).

Finally, this research aimed to collect and identify the taxa of bioindicator benthic macroinvertebrates present in lotic environments in the study area, along with the results of each analyzed location, in order to associate them with the level of preservation of the streams of the Pedra Branca State Park.

2 METHODS

2.1 STUDY AREA

The Pedra Branca State Park (PEPB) is a Conservation Unit (UC) that is part of the metropolitan region of Rio de Janeiro, located in the western zone of the city. This makes it possible to observe numerous changes in the park's landscape, which is the target of human activities ranging from housing to various land uses. The dominant vegetation physiognomy in the PEPB is the dense ombrophilous forest, representing the submontane type (occupying 83.2% of the area, with altitudes between 50 and 500m) and the montanda type (occupying 16.8% of the area, with altitudes between 500 and 1000m). It is possible to classify this area as a vegetation mosaic formed by different successional stages of the Atlantic Forest biome, with endemic, threatened and very rare species of fauna and flora, signalling the importance of studies and conservation plans for their areas (INEA, 2013a).

The Pedra Branca State Park forms hydrographic complex, that contributes intensely to the region, where the volume and quality of water produced on its slopes are directly related with the quality of the forest; regulating hydrological, ecological, climatic and geomorphologic processes (INEA, 2013b).

It is recognized as one of the largest forests in urban areas in the world and the largest in Brazil, as there is a preservation of the largest forest fragment in the area. Atlântica, located in the municipality of Rio de Janeiro, characterized as a submontane dense ombrophilous forest, with a subhumid climatic typology, with little or no water deficit (SOUSA *et al*., 2009).

The PEPB protects more than 50% of the remaining Atlantic Forest in the city of Rio de Janeiro, which is considered one of the richest and most threatened biomes in Brazil and world. The hydrography of the PEPB presents numerous small watercourses that flow towards the slopes of the Pedra Branca relief. It acts as the main water divider in the city of Rio de Janeiro, directing water flows to the north, east and west (INEA, 2013a).

The designated sampling points (sites) are located in the regions of Pau da Fome (Taquara) and Vargem Grande, as they are home to rivers that collect water for human use. The administrative headquarters of the Park is located at the Pau da Fome, which also manages the Vargem Grande Advanced Base (INEA, 2013b). The two selected sites have a strong human influence, since in addition to the watershed, there are activities for public tourist use, agriculture and housing in their surroundings.

The collection sites of the Vargem Grande Advanced Base are of great importance, as they contain some of the best preserved forest remnants in the Park. They are located in areas with less easy human access than the Pau da Fome headquarters, and are centered around the Cafundá Astrogilda quilombola community.

In Vargem Grande, there is a strong influence of agricultural activities, with dense forests in medium or advanced stages. The quilombola community carries out agroforestry, ecotourism and environmental education activities. The collection sites in Vargem Grande are described below:

- Site 1: Low light, dense forest, with shallower water volume than other sites in this area. Located above the Cafundá Astrogilda quilombola community.

- Site 2: Medium light, dense forest with clearings, with deeper waterfalls and wells, and greater abundance of water than Site 1. Located above the Cafundá Astrogilda quilombola community.

- Site 3: High light, more open forest, with a large extension of the river at shallow depth, very close to the quilombola community, and with high human visitation activity. It presents water with a lower flow velocity than the other sites in this neighborhood.

- Site 4: Medium light, moderately dense forest, with a large extension of the river at shallow depth, and the presence of a lot of organic material. Located below the quilombola community. It presents the incidence of human activity.

The collection sites in the Pau da Fome nucleus are of great importance, since this nucleus contains part of the remaining forests important for the Park. They are located in areas with easy human access; and are located around the Pau da Fome reservoir, the Padaria ruins and the Rio Grande reservoir (INEA, 2013a).

The collection sites in Rio Grande (Pau da Fome - Taquara) are described below:

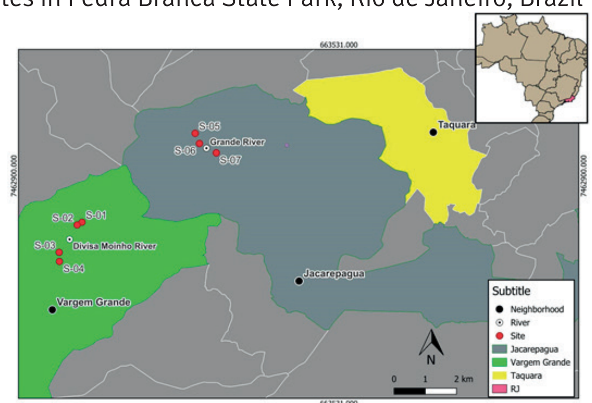
- Site 5: Low light, with an opening in the forest close to the Pau da Fome dam, but the water from this site does not go to the dam. The site is very dry, with small volumes of non-flowing and shallow water, allowing for fewer collection points than other sites. It is located directly above residences built in and around the UC area.

- Site 6: High light, even surrounded by dense forest. It houses the Rio Grande Dam and the Mãe d'Água Well, which has a waterfall, a well with an abundant volume of water, and the greatest depth among the sites in this neighborhood. Its water flows to the Pau da Fome Reservoir, where it is treated and contributes to the supply of the entire surrounding area.

- Location 7: Less light, denser forest. Located above Site 6, Site 7 has an abundant volume of deep running water, as it is the part of the river that flows toward the Rio Grande dam and the Mãe d'Água well.

Seven sampling sites were analyzed into two rivers in the Pedra Branca State Park (Figure 1). The Divisa/ Moinho River (River 1) - Vargem Grande, which was analyzed in 4 sites (Site 1, Site 2, Site 3 and Site 4) of different altitudes on 06/28/2018; and Rio Grande (River 2) - Pau da Fome/ Taquara, which was analyzed in 3 sites (Site 5, Site 6 and Site 7) of different altitudes on 06/29/2018.

Figure 1 – Collection sites in Pedra Branca State Park, Rio de Janeiro, Brazil



Source: Prepared by the authors.

To analyze the environment found at each sampling site, the following parameters were verified: location and elevation, light incidence, water pH, water temperature and river depth. These abiotic parameters were verified *in situ* using specific equipment, such as an EQUITHERM LUX 204 (Equitherm® Comércio e Serviços LTDA.) lux meter, a portable digital pH and temperature meter HI98130 (HANNA® instruments Brasil Exp. e Imp. LTDA) and a eTREX 30 (Garmin© Ltd) GPS receiver to obtain location end elevation. River depth was measured with a ruler.

For sampling of organisms, 10 collection points (P1 to P10) were selected in each analyzed site, with the exception of site 5, which, as it is a place with little water, it was possible to analyze only 5 points (P1 to P5). At each point, river sediments were collected with aquatic macroinvertebrates in the immature phase. They were separated into bags with 70% ethanol and the bags identified by the site and collection point.

All data collected were applied in different statistical indices in order to obtain results that represent the qualitative characteristics of river water and its environments.

In order to characterize the levels of quality, preservation and pollution of rivers, three biotic indices were used: Ephemeroptera, Plecoptera and Trichoptera (EPT), which refers to the level of water preservation, according to the number of families found in the orders ephemeroptera, plecoptera and trichoptera; Biological Monitoring Working Party (BMWP), which indicates the level of water quality, and is calculated according to the variety of macroinvertebrate families/bioindicators found; Family Biotic Index (FBI), which indicates the level of pollution and water quality, according to the number of individuals found in the macroinvertebrate bioindicator families.

To analyze the similarity between the composition of organisms at the sites, Non-Metric Multidimensional Scaling (NMDS) was used, while to investigate the relationships between biotic and abiotic factors, a Redundancy Analysis (RDA) was used.

3 RESULTS AND DISCUSSION

A total of 929 immature insects were collected, all of which were photographed and identified in the Meio Ambiente e Saúde Laboratory at the Universidade do Estado do Rio de Janeiro – Campus Zona Oeste; using a Motic stereoscopic microscope coupled with Moticam 5 image capture device using image analysis software and identified according to Mugnai *et al*. (2010).

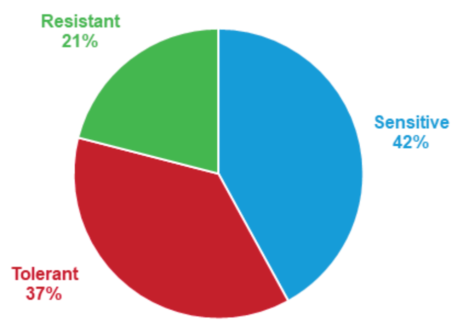
Aquatic macroinvertebrates were quantified and classified in Order and Family level. The insects used in this research belong to the Phylum: Arthropods (Sub-Phylum: Atelocerata), Class: Insecta (Superclass: Hexapoda), Orders: Ephemeroptera, Plecoptera, Tricoptera, Odonata, Diptera, Coleoptera, Hemiptera, Lepidoptera and Collembola; and represent the Families: Baetidae(21), Leptophebiidae(11), Leptohyphidae(7), Perlidae(53), Gripopterygidae(2), Hydropsychidae(36), Calamoceratidae(26), Leptoceridae(4), Hydrobiosidae(1), Simuliidae(608), Chironomidae (70), Syrphidae(1), Tipulidae(7), Dixidae(4), Calopterigidae(7), Libellulidae(4), Dicteriadidae(1), Staphilinidae(21), Elmidae(55), Torridincolidae(2), Veliidae(5), Helotrephidae(2), Hebridae(1) and Mesoveliidae(1).

There are significant advantages in using biological indices based on macroinvertebrates, identified by order and family. The biotic analysis helps to identify possible impacts, since the predominance of orders and families that are sensitive or resistant to pollution, indicates the level of conservation of the rivers (ZAMORA-MUÑOZ *et al*., 1995).

Despite the classification of taxa by sensitivity, it is important to have a wide variety of taxa, including sensitive, tolerant and resistant insects to impacts and changes in the water body and its surroundings to consider a healthy aquatic ecosystem (CALLISTO *et al*., 2001)

Among the bioindicator families used in the calculation of the BMWP biological index, which indicates water quality; 19 families were found in this research, among them: 8 sensitive to organic pollution (Leptophlebiidae, Perlidae, Leptoceridae, Calamoceratidae, Calopterygidae, Libellulidae, Hydrobiosidae and Gripopterygidae), 7 families tolerant to organic pollution (Leptohyphidae, Elmidae, Hydropsychidae, Tipulidae, Simulidae, Baetidae and Dixidae) and 4 resistant to organic pollution (Mesoveliidae, Veliidae, Chironomidae and Syrphidae). The 19 families were organized in percentage by tolerance to organic pollution through Figure 2.

Figure 2 – Percentage of the classification of bioindicator families by the level of tolerance to organic pollution, collected in the Pedra Branca State Park, Rio de Janeiro, Brazil



Source: Research Data

The comparison of the environments found in the collection sites is a factor of great importance for this research because according to the literature, the distribution of aquatic biota is directly or indirectly influenced by the abiotic gradients of the rivers (BRIGANTE; ESPÍNDOLA, 2003).

The environmental data obtained in this research are related with the results of the field parameters: location, pH, temperature, light incidence and depth. It was observed that the incidence of light showed great variation between the collection points. The results of the parameters tested in the field at the river sampling sites: Divisa/ Moinho rivers (R1) and Rio Grande (R2) were described by Tables 1 and 2.

Table 1 – Results of the parameters analyzed in the field in the sampling sites of Rio da Divisa/ Moinho – R1 (Vargem Grande), Pedra Branca State Park, Rio de Janeiro, Brazil

Place	Location	pH	Temperature	Light Incidence	Depth
1	S22°50.224’ W043°30.157’ Elevation: 131 m	77.4	22°C	94.3 FC	21 cm
2	S22°57.067’ W043°29.155’ Elevation: 178 m	66.3	24°C	304 FC	44 cm
3	S22°57.164’ W043°29.270’ Elevation: 154 m	55.8	23°C	237 FC	27 cm

Source: Research Data.

Table 2 – Results of the parameters analyzed in the field at the sampling sites in Rio Grande – R2 (Pau da Fome, Taquara), Pedra Branca State Park, Rio de Janeiro, Brazil

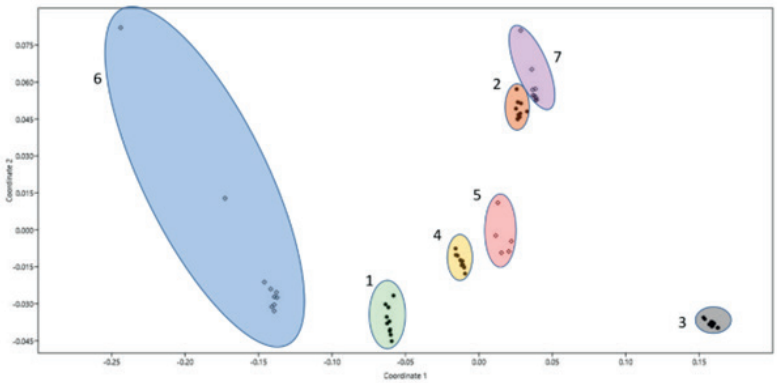
Place	Location	pH	Temperature	Light Incidence	Depth
5	S22°52.922’ W043°26.651’ Elevation: 115 m	55.3	19.2°C	162 FC	10 cm
6	S22°55.987’ W043°26.667’ Elevation: 148 m	55.8	19.8°C	46.5 FC	100 cm
7	S22°56.009’ W043°26.735’ Elevation: 151 m	55.7	18.2°C	320 FC	30 cm

Source: Research Data.

The result of the Non-Metric Multidimensional Scaling (NMDS) (FIGURE 3) showed that the collection points of each site were similar to each other in most sites, forming groups, where at site 6 there was a greater difference between the collection points, generated by the waterfall environment.

There was also a greater similarity between the collection points at site 2, in river 1 and at site 7, in river 2; and between site 4, in river 1 and site 5, in river 2. Such “doubles of sites” presented considerably similar results for the analysis carried out in the field. Dispersion is observed in terms of similarity between the collection points of each analyzed site, in the Divisa/ Moinho Rivers (river 1) and Rio Grande (river 2).

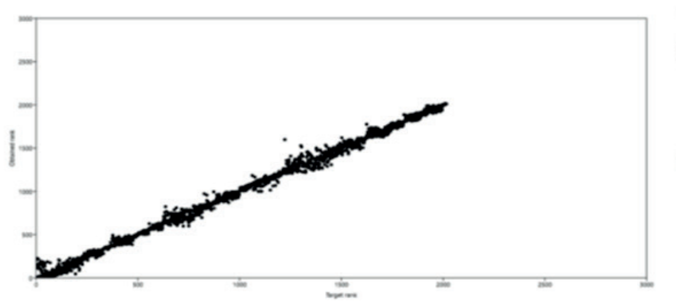
Figure 3 – Clusters of collection points according to the Bray-Curtis similarity index, in the Pedra Branca State Park, Rio de Janeiro, Brazil



Source: Research Data.

The observed stress (*Standardized Residual Sum of Squares*) was 0.03815 and the axes result was: R2 axis 1=0.8252 and axis 2=0.1086. The *Stress* of the NMDS resolution indicated by Shepperd Plot, where it was considered satisfactory (Figure 4), since the result was smaller than 0.05, suggesting that the distances in the diagram reflect the original distances well, without data loss (MELO; HEPP, 2008).

Figure 4 – *Stress* of the Non-Metric Multidimensional Scaling (NMDS) resolution (Stress=0.0385) R2 axis 1= 0.8252 and axis 2= 0.1086



Source: Research Data

Redundancy Analysis (RDA) refers to “explained variability”, with RDA being one of the most complete and efficient methods of canonical sorting (BARBOZA; PAIVA, 2014). The RDA also applies to biotic factors, as it was suitable for biological matrices (BARBOZA; PAIVA, 2014). The RDA showed significance only for the temperature and luminosity results.

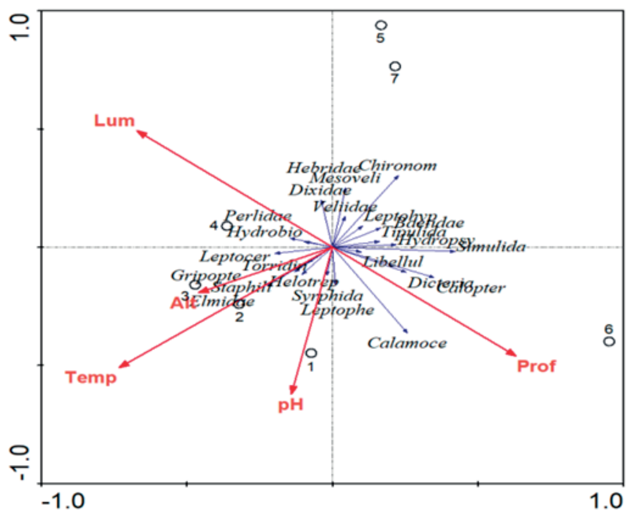
The Helotrephidae family of the Hemiptera order, and all the families found in the Coleoptera order (Elmidae, Staphilinidae and Torridincolidae) showed positive correlations with temperature; the two orders are associated with calm waters, low currents and higher temperatures, since they have no affinity for very low temperatures.

The Chironomidae family of the Diptera order, and two families of the Ephemeroptera order (Leptohyphidae and Baetidae) showed negative correlations with temperature, which corroborates data from other authors who associate the Ephemeroptera order with lower temperature waters, but also a wide temperature range (BIS; KOSMALA, 2005; DOMINGUEZ *et al*., 2006). However, it is important to understand the correlations between Chironomidae and environmental variables because the family Chironomidae is generally associated with polluted environments, as confirmed by Mazzoni *et al*. (2014), who found Chironomidae only in highly polluted environments in their study.

The Perlidae family of the Plecoptera order, and the Hydrobiosidae family of the Trichoptera order showed positive correlations with luminosity, both families are associated with luminosity. The family Calmoceratidae of the order Trichoptera, and all the families found of the order Odonata (Libellulidae, Calopterigidae and Dicteriadidae) presented negative correlations with the luminosity.

The order Odonata is associated with places with vegetation, where it is found between rocks and leaves, preferring to stay in places with less light in the river. Furthermore, the communities of the order Odonata may differ depending on the presence or absence of riparian forest and because of this, some species have the potential to be bioindicators (BIS; KOSMALA, 2005; RODRIGUES *et al*., 2019). The Calamoceratidae family makes cocoons with leaves from river sediments to pupate, thus remaining in contact with low light (MUGNAI *et al*., 2010). We can observe the vectors of the redundancy analysis between biotic and environmental factors (Figure 5).

Figure 5 – Redundancy Analysis (RDA) showing the correlations between the insect families sampled and the results of the parameters analyzed in the field, Pedra Branca State Park, Rio de Janeiro, Brazil



Source: Research Data

The EPT index evaluates the number of families of three bioindicator orders (Ephemeroptera, Plecoptera and Trichoptera), considered sensitive to organic pollution, to analyze the level of water conservation; which is a determining factor for the presence of these organisms in aquatic environments (QUEIROZ *et al.*, 2008). River 1 showed the highest level of qualitative conservation; while river 2 had one collection point with a good level of conservation, and two collection points with a moderate level of conservation (Table 3).

Table 3 – Quantitative and qualitative results of the EPT (Ephemeroptera, Plecoptera and Trichoptera) index, indicating the level of water conservation of the collection sites of the analyzed rivers, Pedra Branca State Park, Rio de Janeiro, Brazil

Analyzed river	Collection site	EPT Result	Preservation level
River 1 – Rio da Divisa/ Moinho (Vargem Grande)	1	6	Good
	2	5	Moderate
	3	7	Good
	4	6	Good
River 2 - Rio Grande (Pau da fome)	5	3	Moderate
	6	6	Good
	7	3	Moderate

Source: Research Data

The BMWP index, which indicated the water quality and its classification by color analyzing families sensitive and tolerant to organic pollution (ALBA-TERCEDOR; SÁNCHEZ-ORTEGA, 1988; BACCA *et al.*, 2023), and the results obtained can be seen in the Table 4.

Table 4 – Quantitative and qualitative results of the Biological Monitoring Water Party (BMWP) index for each collection site, indicating the water quality and its classification by color, Pedra Branca State Park, Rio de Janeiro, Brazil

Analyzed river	Site	BMWP Result	Water quality	Color sort code
River 1 – Rio da Divisa/ Moinho (Vargem grande)	1	66	Good	Green
	2	37	little polluted	Yellow
	3	61	Good	Green
	4	47	little polluted	Yellow
River 2 - Rio Grande (Pau da Fome)	5	46	little polluted	Yellow
	6	62	Good	Green
	7	39	little polluted	Yellow

BMWP - Biological Monitoring Water Party
Source: Research Data.

Like the BMWP index, the FBI indicates water quality and the FBI calculation also presents results related to the level of organic pollution in rivers, analyzing the bioindicator families found (ZIMMERMAN, 1993). River 1 was rated excellent water quality and no apparent organic pollution, and River 2 was rated fair water quality and reasonably significant organic pollution. In Table 5 it is possible to observe the results.

Table 5 – Quantitative and qualitative IPF results of the water, with the degree of pollution of each analyzed river, Pedra Branca State Park, Rio de Janeiro, Brazil

Analyzed river	BF Result	Water quality	Degree of pollution
River 1 – Rio da Divisa/ Moinho (Vargem grande)	3,345	Great	No apparent organic pollution
River 2 - Rio Grande (Pau da Fome)	5,694	Reasonable	Fairly significant organic pollution

Source: Research Data.

From the evaluation of all data presented, it was concluded that the taxonomic diversity among the organisms sampled was satisfactory, since it was possible to find a good distribution of insects of the three classifications of resistance to organic pollution (sensitive, tolerant and resistant).

The sites chosen for this research are located in low points of the PEPB with little variation in elevation between them, in order to analyze places with greater probability of urban impact, easy access by the population and with points of water abstraction. Depth in each river were the sites that present a waterfall environment, being site 2 in river 1 and site 6 in river 2 differentiated from all other collection sites, and stood out in the RDA analysis for presenting less similarity between the points.

Light incidence and temperature, respectively, were the parameters that showed the greatest variation between the collection sites, both in river 1 and in river 2, thus being the analyzes with greater significance. River 2 had lower pH and temperature than River 1.

In River 1 there was a greater pH variation between the collection points, ranging from 5.6 to 7.4; while in Rio 2 the pH varied between the sites from 5.3 to 5.8. The MNDS analysis showed a Stress = 0.03815, which is satisfactory, indicating that the distances in the diagram well reflected the original distances found between the evaluated sites.

The similarity found by NMDS between site 2, in Rio 1 and site 7, in Rio 2; which are places with intense water volume and strong currents, was confirmed by the EPT and BMWP indexes, where both showed a moderate level of conservation, with water of little polluted quality and classification of yellow color. The similarity found by NMDS between site 4, in river 1 and site 5, in river 2; which are places of moderate to low volume of water and with weak current, was confirmed by the BMWP index, where both presented little polluted water, with yellow color classification, with almost no difference in the quantitative result (46 and 47).

According to the quantitative and qualitative results of the EPT, BMWP and FBI indices; River 1 (Rio da Divisa/ Moinho – Vargem Grande) is classified as preserved, with good to moderate water quality and no apparent organic pollution. River 2 (Rio Grande – Pau da Fome) is classified as moderately preserved, with water quality between good, moderate and little polluted in the analyzed sections and with reasonably significant organic pollution.

Therefore, the Rio da Divisa/Moinho (river 1) presents better conditions of water quality, level of conservation and level of organic pollution, than Rio Grande (river 2). River 1 is located in the Vargem Grande district, where it is protected and managed by INEA and the Quilombola Cafundá Astrogilda Community; around it, the community carries out agricultural activities in the agroforestry model, without the use of pesticides; in addition to various environmental conservation and ecotourism activities. River 2 is located in Pau da fome, in the Taquara district, where it is managed by INEA and CEDAE, and supplies a water collection station for treatment and supply to the Jacarepaguá region; the site receives visitors with easier access than river 1, and also serves environmental and ecotourism activities. River 2 was analyzed around the water collection point for treatment.

In Brazil, several factors such as the great diversity found in the country, as well as the few studies that explore the use of macroinvertebrates as bioindicators, are among the difficulties in using these animals for the biomonitoring of aquatic ecosystems (DOCILE; FIGUEIRÓ, 2013).Therefore, it is expected that this work will contribute with more information about the role of macroinvertebrates in the water quality monitoring process, as well the improvement of the knowledge of the aquatic fauna within the Pedra Branca State Park.

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