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Estudo da Biogeoquímica Fluvial nos Domínios do Parque Nacional do Descobrimento, Extremo Sul da Bahia

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R E S U M O

O presente estudo foi realizado nas microbacias hidrográficas do Parque Nacional do Descobrimento (PND). Foram estabelecidos sete pontos de amostragem nos principais rios e no campo, foram determinados os parâmetros físico-químicos (pH, condutividade elétrica, temperatura, potencial redox e concentração de oxigênio dissolvido). No laboratório, foram realizadas determinações de alcalinidade e as amostras foram fracionadas por filtração. Os filtros foram usados para determinar a concentração de partículas em suspensão (SPM) usando gravimetria. As concentrações de N-NH_4^+, N-NO_3^-, N-NO_2^-, P-PO_4^{-3} foram determinadas usando métodos colorimétricos. A qualidade da água nos rios analisados do DNP está de acordo com os parâmetros estabelecidos pela resolução. As razões N/P sugerem que os rios do PND têm razões típicas de rios naturais. A composição química fluvial no PND indica que as concentrações de P-PO_4^{-3} e NH_4 não estão associadas com o SPM e tendem a diminuir o pH, temperatura e concentração de oxigênio dissolvido (DO) nos cursos dos rios. Outro fator importante que controla a hidroquímica nos pontos estudados é o processo de oxi-redução, que controla o comportamento de diferentes formas químicas de N presentes no meio. A hidroquímica fluvial nos rios do PND também é controlada pelo sistema carbonato, considerando que a alcalinidade das águas fluviais está relacionada com a condutividade no meio e inversamente relacionada com o potencial redox. Os dados gerados neste estudo fornecem informações essenciais que podem ser utilizadas na gestão do Parque Nacional do Descobrimento.

Study of Fluvial Biogeochemistry in the Descobrimento National Park Domains, in the Southernmost Part of Bahia

Abstract

The present study was carried out in the hydrographic micro basins of the Descobrimento National Park (DNP). Seven sampling points were established on the main rivers and in the field, the physicochemical parameters (pH, electrical conductivity, temperature, redox potential, and dissolved oxygen concentration) were determined. In the laboratory, alkalinity determinations were carried out and samples were fractionated by filtration. The filters were used to determine the concentration of suspended particulate matter (SPM) using gravimetry. Concentrations of N-NH_4^+, N-NO_3^-, N-NO_2^-, P-PO_4^{-3} were determined using colorimetric methods. The water quality in the analyzed rivers of the DNP is in accordance with the parameters established by the resolution. The N/P ratios suggest that the rivers of the DNP have ratios typical of natural rivers. The fluvial chemical composition in the DNP indicates that the concentrations of P-PO_4^{-3} and NH_4 are not associated with the SPM and tend to decrease the pH, temperature, and dissolved oxygen (DO) concentration in the river courses. Another important factor controlling the hydrochemistry at the studied points is the oxi-reduction process, which controls the behavior of different chemical forms of N present in the medium. The fluvial hydrochemistry in the DNP rivers is also controlled by the carbonate system, considering that the alkalinity of the riverine waters is related to the conductivity in the medium and inversely related to the redox potential. The data generated in this study provide essential information that can be used by the management of the Descobrimento National Park.

Keywords: Hydrochemistry, River Water, Conservation Units.

Introduction

Watersheds play a key role in the hydrological cycle, influencing the biogeochemical processes that interconnect the environmental compartments (Fetter, 2014). The characterization of watersheds is of great relevance for understanding a variety of environmental issues, such as water resources management (Vörösmarty et al., 1998; Knecht et al., 2012; Brooks et al., 2012).

Drainage basins are systems that can be compartmentalized into different biogeochemical domains, according to the characteristics of the landscape (Sioli, 1975; Oliveira et al., 2019). From this perspective, biogeochemistry studies the different processes of mobilization, migration, transformation, and accumulation of chemical elements and/or molecules in landscapes, processes that suffer the interference of biotic and abiotic factors, including anthropic activity, which interact in the domains of a hydrographic basin (Christophersen et al., 1994; Griffiths and Mulholland, 2021).

Water is an important agent for mass transport and, considering its essentiality for ecosystems, we verified the importance of rivers in the environment, as they are the main route capable of connecting the phenomena that occur in the continental landscape, such as weathering and the cycling of nutrient with the oceans (Berner and Berner, 2012). Rivers are the main components of a hydrographic basin; they compose the basic organizational unit of continental waters (Teixeira, et al., 2007).

With the use of some indicators (for example, major dissolved elements, nutrients, and some physicochemical parameters) the spatial changes in the fluvial biogeochemistry can be used with the purpose of understanding and recognizing biogeochemical processes that coexist in a drainage basin, identifying areas that are sources of elements and regions that are natural biogeochemical barriers. As examples of biogeochemical barriers in riverine systems, we can mention macrophyte banks, marginal wetlands, and riparian forests (Jones and Holmes, 1996).

Biogeochemical barriers significantly affect the transport of some nutrients, such as Nitrogen (N) and Phosphorus (P), through the accumulation in biomass and by adsorption and denitrification processes (Vought et al., 1994; Jones and Holmes, 1996). As an example, we have the increase in sedimentation due to the physical effect of vegetation on water flow, forming a barrier where metallic pollutants will accumulate since these elements migrate in the landscape, preferentially associated with particulate material in suspension (Foster and Charlesworth, 1996).

Some biogeochemical studies of natural hydrographic basin and others that are under significant anthropic influence have been carried out in recent decades. Regardless of their scales, considering that the watercourses reflect the dynamics of this geographically delimited space, comprising its physical, chemical, and biological aspects and the interrelationships of the landscape components: soil, water, vegetation cover, soil use, atmosphere and anthropogenic alterations that occur in the drainage area (Jenkins et al., 1994; Mortatti, 1995; Ferraz et al., 2002; Bibian, 2007; Vendramini, 2009).

The physicochemical characteristics of river waters and their relationship with the geological, climatic, and anthropic characteristics present in the landscape have been widely used in several hydrographic basins, emphasizing the processes that shape and control the biogeochemistry in the drainage basin (Bibian, 2007).

Several works in the literature use the biogeochemistry of river waters as a tool in the study of hydrographic basins, relating them to geology, vegetation cover, hydrology and ichthyofauna (Brown, 1986; Cronan et al., 1987; Schofield and Driscoll, 1987; Martins, 1988). This variety of interrelationships in the study of watersheds elucidates the importance of studies with this kind of approach in a natural setting, and its potential as an indicator of the relationships between the physical, biotic, and anthropic environments. (Smart et al., 1998; Nakagawa and Iwatsubo, 2000; Jain, 2002).

The Descobrimento National Park (DNP) is in the hydrographic basin of Itanhém River, with the park area drained by a set of watercourses that form a small hydrographic basin. In this perspective, and considering the theoretical basis presented, the work intends to carry out a biogeochemical characterization of river waters in different sampling points in rivers of the DNP to evaluate which factors are influencing the chemical composition of river waters, and to rank, through a Principal Components Analysis, which are the controlling factors of fluvial hydrochemistry in the analyzed points. Based on this, the general objective of the research is to characterize the river waters in different rivers of the microbasins that cross the DNP, typifying the chemical composition of the waters in the different points studied, to identify the sources of chemical elements acting in the DNP and to provide data for the management of the conservation unit.

Materials and Methods

Study Area - The Descobrimento National Park (DNP) was created in April 1999 and covers an area of 21,129 hectares, being inserted in the Atlantic Forest biome, whose vegetation is characterized by dense ombrophilous forest that shelters a significant biodiversity. The DNP is in the southernmost region of Bahia and is characterized by Atlantic Forest Biome. The park area is drained by the river basins of Do Peixe River, Japara River, Japara Grande River, Jucuruçu River, Do Ouro River, Imbassuaba River and Cahy River. The Imbassuaba and Cahy River basins stand out as the most important in terms of territorial extension in the domains of the DNP. The DNP, along with other conservation units in the region, contributes to the microclimate, to the water balance and to the conservation of hydrographic microbasins. The region is characterized by a humid or super humid tropical climate, with no dry season, and the average temperature of the hottest month is above 18°C. The total rainfall in the driest month is more than 60 mm, with higher precipitation from March to August, exceeding the annual total of 1,500 mm. In the hottest months (January and February) the temperature is around 24 ºC to 25 ºC.

The sampling areas of the research project in the DNP were selected at different sampling points: three collection points on the Japara River (JP01, JP02, JP03), two collection points on the Cahy River (RC01, RC02), one collection point on the Do Sul River (RS01) which is close to the indigenous village Alegria Nova and a sampling point located at Só Não Vou Lagoon (LSNV), which is representative of the Imbassuaba River hydrographic basin (Figure 1). Two sampling campaigns were carried out, one in March 2022 and another campaign in May 2022. In the field, the points were recorded using GPS and georeferenced in QGIS software. The images (shapefile) were obtained from the Ministry of the Environment website to produce a map with the respective collection points.

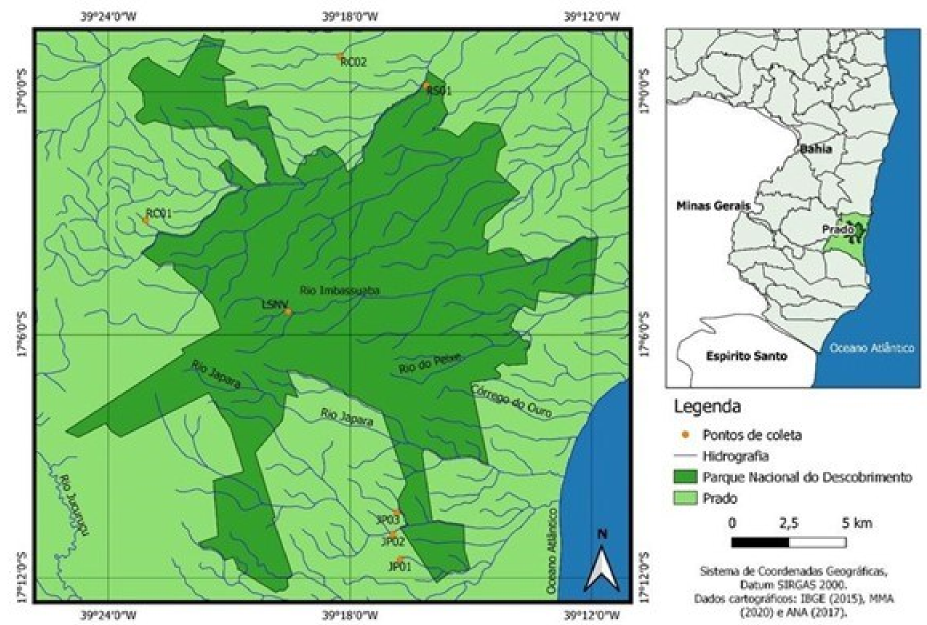

Figure 1. Map of the study area (Descobrimento National Park) highlighting the hydrographic network and the sampling points studied in the present investigation: JP01 – Japara River, JP02 – Japara River, JP03 – Japara River; RC01 – Cahy River, RC02 – Cahy River, RS01 – Do Sul River and LSNV – Só Não Vou Lagoon. Source: The authors.

According to Strahler's methodology for hierarchizing rivers in the hydrographic basin, the park's rivers are first-order rivers, whose characteristics are rivers with headwaters and low flow, and by second-order rivers formed from other first-order rivers. This is a justification for the conservation unit to assume the protective role of water sources, which are responsible for supplying and draining water in the region.

Experimental Section - The surface water samples were collected in two sampling campaigns carried out in March/2022 and May/2022, in the central portion of the river channel. Although seasonality in the region is not so perceptible, the samplings were carried out in March during the less rainy season, and in May, which is when the period of more frequent rainfall in the region begins. In the May/2022 sampling campaign, it is important to highlight that we were unable to access one of the collection points due to heavy rains that compromised entrance to the RC01 sampling point (Cahy River).

At the time of collection, measurements of the physicochemical parameters were performed using a multiparameter probe (pH, electrical conductivity, temperature, redox potential, dissolved oxygen) model HI9829 from Hanna Instruments, which was previously calibrated with a calibration solution.

The collected samples were placed in polypropylene bottles previously sterilized with a 2% Detertec solution and washed vigorously with deionized water. At the time of collection, the flasks were previously rinsed with the respective water samples. To be transported to the laboratory, the samples collected in the field were stored in thermal box with ice.

In laboratory 1 at UFSB (Paulo Freire *Campus*), the samples were filtered using vacuum filtration systems. In the filtration process, approximately 250 ml of each water sample was filtered through cellulose acetate filters (0.45 µm porosity) to fractionate the samples into: dissolved fraction and particulate fraction. The filtered samples were frozen until chemical analysis. Before the filtration procedure, the filters were previously prepared by drying in an oven at a temperature of 60 °C for 3 hours. Afterwards, these filters were placed in the desiccator for a period of time, until the moment of weighing. The filter mass was recorded on the analytical balance and recorded in a laboratory notebook. Then, the filters were used in the sample filtration process. At the end, the filters went back to the drying process in an oven and desiccator until the moment of a new mass verification after filtration on the analytical balance. The method described above is the determination of SPM (Suspended Particulate Matter) using the gravimetric method (Strickland e Parsons, 1972).

In the laboratory, the alkalinities of the water samples were analyzed using the titration method (Gran, 1952). The water samples were submitted to chemical analysis, using the UV-visible spectrophotometry technique, to determine the concentrations of ($N\text{-}NH_4^+$, $N\text{-}NO_3^-$, $N\text{-}NO_2$, $P\text{-}PO_4^{-3}$) by means of a model FEMTO CIRRUS 80 spectrophotometer using reagents, wavelengths, and specific calibration curves for each determination (Carmouze, 1994).

The data obtained in the analyzes described above were statistically worked through a similarity analysis and principal component analysis (PCA), adopted as a tool for ranking hydrochemical data and verifying the controlling factors of fluvial biogeochemistry at the points studied.

Results and discussion

The physicochemical parameters evaluated in this present study are shown in Table 1 (March/2022 campaign) and Table 2 (May/2022 campaign). The mean pH values were 6.99 and standard deviation 0.53. The average water temperature was 25.85 °C and standard deviation 3.00. The average electrical conductivity at the sampling points was 56.52 µS/cm with a standard deviation equal to 10.15. The mean redox potential values in the river waters were 68.15 mV and standard deviation equal to 28.10. The mean concentration of dissolved oxygen was 6.18 mg/L and standard deviation equal to 0.98. The mean concentration of suspended particulate matter (SPM) in the DNP rivers was 0.023 mg/L with a standard deviation equal to 0.015. The mean alkalinity of river waters was 17.14 mg/L of $CaCO_3$ with a standard deviation equal to 6.50.

The pH (hydrogenionic potential) in aquatic environments is related to the concentration of free protons present in solution (Carmouze, 1994), being influenced by the amount of decomposing material, where the greater availability of organic matter justifies lower pH values, considering that the decomposition of this material releases many acids, such as humic acids. This process may be occurring in the water column, where the pH values are lower in relation to the other sampling points analyzed.

Table 1. Physicochemical data from water samples collected at different sampling points of the Descobrimento National Park (DNP) in the March/2022 Campaign.

	pH	Temperature (°C)	Condutivity (µS/cm)	Eh (mV)	DO (mg/L)	SPM (mg/L)	Alkalinity (mg/L $CaCO_3$)
JP01	6,9	26,9	81,5	68,0	7,16	0,034	21,6
JP02	7,3	25,2	65,9	9,0	6,62	0,029	13,3
JP03	7,1	29,3	56,0	56,0	6,18	0,022	24,3
RC01	6,9	30,5	50,4	63,0	6,88	0,026	27,0
RC02	7,9	27,7	65,7	52,0	7,12	0,029	21,0
RS01	7,8	24,8	52,7	102,0	7,45	0,030	11,3
LSNV	7,0	30,5	48,6	92,0	7,35	0,062	6,0

Table 2. Physicochemical data from water samples collected at different sampling points of the Descobrimento National Park (DNP) in the May/2022 Campaign.

	pH	Temperature (°C)	Condutivity (µS/cm)	Eh (mV)	DO (mg/L)	SPM (mg/L)	Alkalinity (mg/L $CaCO_3$)
JP01	6,0	24,8	47,9	115,0	4,9	0,007	9,0
JP02	6,6	21,9	49,7	70,0	4,7	0,028	10,3
JP03	6,7	24,7	57,4	53,0	5,0	0,011	20,3
RC01	-	-	-	-	-	-	-
RC02	7,0	23,3	60,1	57,0	5,2	0,006	17,3
RS01	6,2	21,4	42,8	99,0	5,7	0,011	22,0
LSNV	6,9	24,6	55,6	50,0	5,8	0,004	19,3

Note: In this sampling campaign, it was not possible to collect at point RC01. It was a week of heavy rain and access to the collection point was compromised.

The electrical conductivity parameter is related to the amount of ions present in the fluvial channel, which produce an electric current. We can say that the higher the concentration of ions present in solution, the higher the conductivity of the medium. In the March/22 samplings, the highest conductivity was found in the Japara River (JP01) and during the May/22 campaign in the RC02 point (Cahy River).

Dissolved oxygen (DO) concentrations are considered an important hydrochemical parameter, bearing in mind that most organisms need this chemical element for respiration. The concentration of DO in the medium depends on the water temperature, as this parameter is related to the solubility of gases, as well as atmospheric pressure and the relationship between salinity and conductivity of the medium. There are two sources of oxygen for aquatic systems, namely the atmosphere and photosynthetic processes.

In addition to physicochemical parameters, there are other elements present in river channels that are essential to understanding the hydrochemical behavior of the systems. Nitrogen is often a limiting element (Clair et al., 1994), and is in some cases chemically related to carbon. This is an element found in an aquatic ecosystem in the most diverse chemical forms, and most of these chemical forms are soluble, and therefore mobile. The input of nitrogen into river systems is mainly related to atmospheric input and biological activity in the basin (Vitousek et al., 1997).

The nitrate concentrations are shown in Figure 2. The $N\text{-}NO_3^-$ concentrations were evaluated at different sampling points in the two sampling campaigns, and the mean concentration at the sampling points was 0.034 mg/L and standard deviation equal to 0,03. The highest concentrations were found in the Japara River (JP01). Comparing the data with the parameters established in Conama Resolution 357, the concentrations are within the established and acceptable parameters.

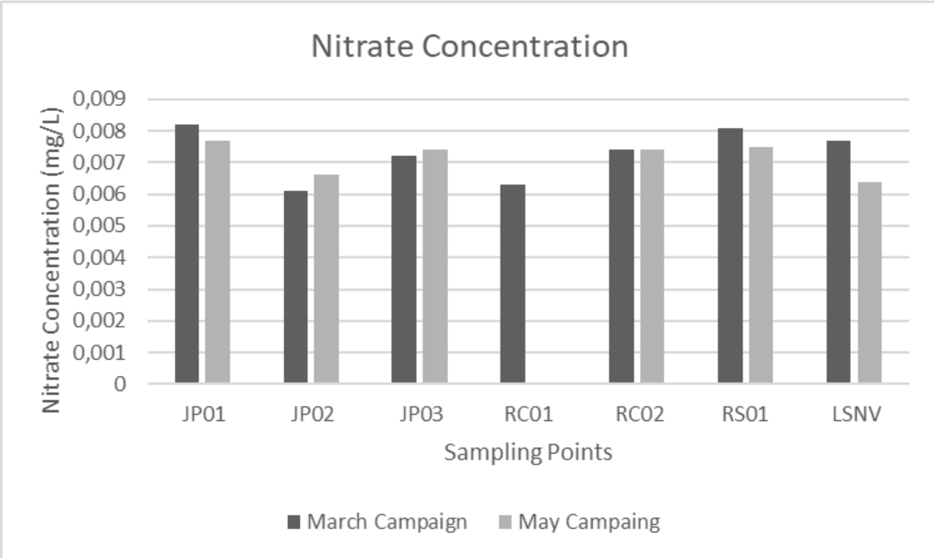

Figure 2. Comparative chart of nitrate concentrations among the different sampling points and in the sampling campaigns of March and May/2022.

Nitrite ($N\text{-}NO_2^-$) concentrations are shown in Figure 3, with a mean concentration of nitrite equal to 0.049 mg/L and standard deviation equal to 0.018. The highest concentrations were found in the Japara River. Comparing the data with the parameters established in Conama Resolution 357, the concentrations are within the established and acceptable parameters.

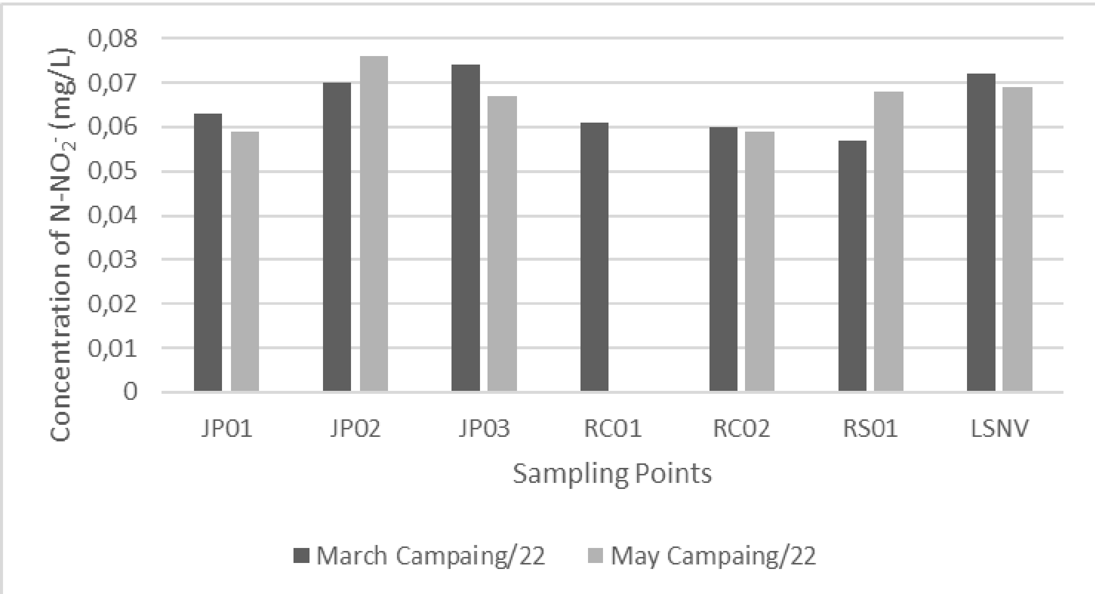

Figure 3. Comparative chart of nitrite concentrations among the different sampling points and in the sampling campaigns of March and May/2022.

The mean concentration of ammonia (NH_3) in the points of the DNP rivers was 0.059 mg/L and standard deviation equal to 0.061. The data are shown in Figure 4. The highest concentrations were found at Point JP01, located on the Japara River. Comparing with the concentrations established by CONAMA 357 resolution, the concentrations of all points are within the parameters.

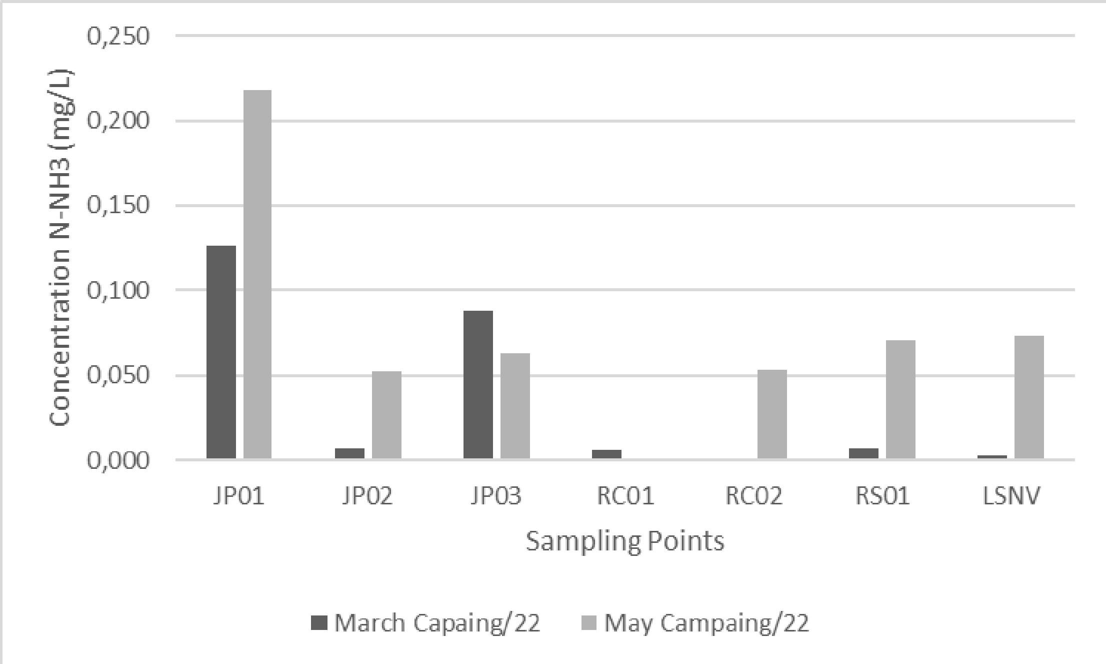

Figure 4. Comparative chart of ammonia concentrations among the different sampling points and in the sampling campaigns of March and May/2022.

Phosphorus (P) is a limiting nutrient for the primary production that occurs in aquatic environments and is found in both organic and inorganic forms (Berner and Berner, 2012). The mean concentration of phosphorus in the form of orthophosphate ($P\text{-}PO_4^{-3}$) was equal to 0.007 and standard deviation equal to 0.0006. The highest concentration of orthophosphate was found during sampling in the rainy season at point RC02 (Cahy River). The orthophosphate data are shown in Figure 5. Comparing with the orthophosphate standards established by CONAMA 357 resolution, the concentrations of all points are within the parameters.

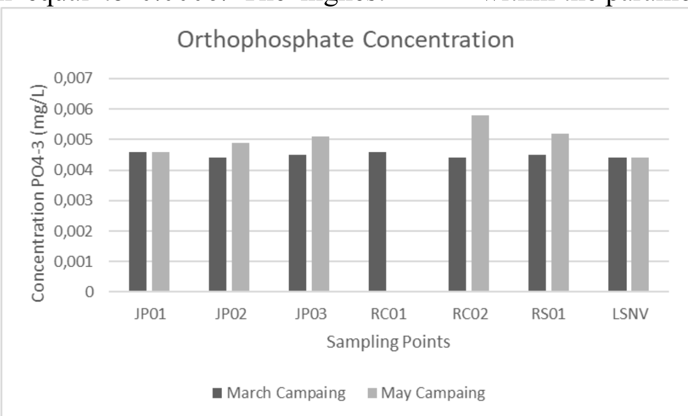

Figure 5. Comparative chart of orthophosphate concentrations among the different sampling points and in the sampling campaigns of March and May/2022.

Table 3 compares the average values of the present study with average values of other Brazilian rivers. The pH values are like the average values found in the Imbé River. The electrical conductivity values of the DNP waters are like the average values found in the Muriaé River and the concentrations of dissolved oxygen in the DNP waters are lower than the other rivers used as a comparison. The SPM concentrations are lower compared to data from other rivers used for comparison. The concentrations of the different chemical species of N (N-NO_2^-, N-NO_3^- and N-NH_3) and P-PO_4^{-3} are lower in the DNP rivers. The alkalinity values are like the average alkalinity determined for the waters of the Paraíba do Sul River.

Table 3. Comparative data of different hydrochemical parameters of Brazilian rivers

	Rio Paraíba do Sul (1)	Rio Pomba (2)	Rio dois Rios (3)	Rio Muriaé (4)	Rio Imbé (5)	Médias PND (6)
pH	7,19	7,51	7,5	7,29	6,5	6,99
Condut	67,0	75,0	84,0	56,0	40,0	56,5
OD	8,1	8,5	8,8	8,7	8,2	6,2
MPS	5,00	7,00	7,00	3,00	18,00	0,02
Nitrito	0,22	0,31	0,38	1,50	3,80	0,05
Nitrato	41,00	31,00	55,00	0,25	5,80	0,03
Amônia	0,40	1,10	0,50	39,00	9,65	0,06
Fosfato	0,600	0,920	1,360	1,490	3,850	0,007
Alcalinidade	18,10	10,80	26,80	21,20	0,24	17,14
Período	seco	seco	seco	seco	seco	seco/chuvoso

Table references: (1) (2) (3) (4) Silva, 2000; (5) Santos, 2003; (6) DNP data generated in this study.

The data obtained from the analyzes of the sampling campaigns were used to create a Cluster diagram. The diagram was constructed considering 13 hydrochemical variables analyzed at different points and sampling campaigns. According to the analysis, it is possible to separate the data into three distinct groups: i) one group of points have their hydrochemistry influenced by the controlling factors that predominate during the dry season (base flow), ii) one group has the hydrochemistry influenced primarily by the processes acting during the rainy season, such as surface and subsurface flows. And there is iii) a third intermediate group that is classified separately. The Cluster diagram is shown in Figure 6.

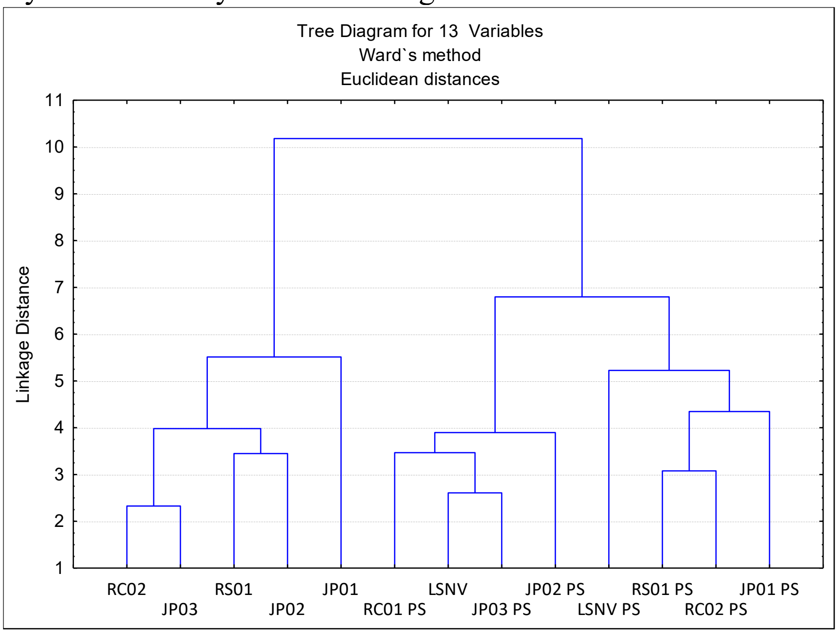

Figure 6. Cluster diagram prepared for the 13 hydrochemical variables, in the sampling campaigns and collection points.

The variation of fluvial hydrochemistry is related to the changes occurring in the landscape regarding its elementary prism, which involves lithological, pedological, geomorphological changes and changes in land use. Considering these aspects, a principal component analysis (PCA) was performed to rank the controlling factors of biogeochemistry at the studied points in the DNP. Factor analysis (Tables 4 and 5) of principal components was used as a tool in the investigation of a group of data, related to sampling campaigns carried out at different times of the year at different sampling points, distributed in micro-watersheds that cross the DNP.

Table 4. Principal Component Analysis (PCA) data indicating eigenvalues, percentage variance, cumulative eigenvalues, and cumulative percentage.

Factors	Eigenvalues	% Total Variance	Cumulative eigenvalues	Cumulative %
1	3,70	33,6	3,70	33,61
2	2,22	20,2	5,92	53,8
3	1,73	15,7	7,65	69,5

Table 5. Presentation of Principal Component Analysis (PCA) factors and their respective positive and negative correlations.

	Factor 1	Factor 2	Factor 3
pH	**0,71**	-0,02	-0,46
Temperature	**0,73**	0,03	-0,10
Condutivity	0,25	0,15	**-0,72**
Eh	-0,12	**0,68**	**0,66**
D.O.	**0,89**	0,24	-0,21
PSM	**0,87**	0,00	0,31
Alkalinity	-0,15	-0,09	**-0,71**
Phosphate	**-0,70**	0,10	-0,12
Nitrite	0,04	**-0,74**	0,38
Nitrate	0,08	**0,89**	0,14
Ammonia	**-0,60**	0,41	0,20

For this purpose, 3 main factors were extracted, which explain 70% of the variance observed in this data set. Factor 1 explains 33.6% of all variances, and is related to the positive correlations between pH, temperature, DO and PSM and to the negative correlations between phosphate and ammonia. This factor, in other words, indicates that $P\text{-}PO_4^{-3}$ and NH_3 are not associated with PSM and tend to decrease pH, temperature and dissolved oxygen concentration in the water column. Factor 2, on the other hand, explains about 20.2% and indicates that the oxi-reduction process of the medium is responsible for controlling the behavior of the different nitrogen species in the form of NO_3^- and NO_2^-. Factor 3 explains 15.7% of the observed variance and suggests that the carbonate system (alkalinity) is positively associated with electrical conductivity and inversely related to the oxi-reduction potential of the medium.

Changes in land use directly influence the dynamics of chemical species in aquatic environments (Figueiredo and Ovalle, 1998; Chaogui, Wagner and Fohrer, 2021). Therefore, changes occurring in the structure of the elemental prism of a given landscape (whatever the environmental compartment) will be responsible for hydrochemical responses in aquatic ecosystems. From this perspective, the N/P ratio can be used as an indicator of the type of land use in an environmental scenario, pointing out probable influences that are affecting the biogeochemical behavior in a water body. To establish comparative parameters for river systems, Meybeck (1993) proposed N/P ratio values for river systems with different degrees of impact. These data are presented in Table 6. In order to verify these ratios for the DNP waters, the N/P ratios were calculated based on the chemical analyzes performed in the present study (Table 7). The calculated ratios indicate that the DNP rivers have typical ratios of small and large natural rivers.

Table 6. Ratio between nitrogen (N) and phosphorous (P) concentrations in different river environments, according to Meybeck (1993).

Pollution Degree	Ratio N/P
Small and large natural rivers	10-100
Small and large polluted rivers	1,0-10
Small polluted rivers and highly polluted	0,1-1,0
Larger rivers in urbanized areas	10-100

Source: Meybeck, 1993.

Table 7. N/P ratios calculated for the sampling points studied in Descobrimento National Park

	Dry season	Rainy Season
JP01	42,9	61,9
JP02	18,9	27,5
JP03	37,7	26,9
RC01	16,0	-
RC02	15,5	20,6
RS01	16,1	28,1
LSNV	18,8	33,7

Conclusions

Based on the data generated by the research, we can say that the water quality in the rivers Japara River, Cahy River, Do Sul River and Só Não Vou Lagoon (Imbassuaba River), in the analyzed stretches, is good and it is within the parameters established by the resolution in force. Based on the calculated N/P ratios for the studied rivers, it is possible to say that the data suggest that the DNP rivers have typical ratios of small and large natural rivers.

The data suggest that some points, whose hydrochemical behavior was studied, have their biogeochemistry influenced by processes that are preponderant during the dry season, such as the base flow. Another group is influenced by controlling factors typical of the rainy season, such as sub-surface and surface flows. And there is a third group of points with intermediate characteristics, whose chemical composition is influenced by both processes.

The chemical composition in the DNP rivers indicates that the concentrations of $P\text{-}PO_4^{-3}$ and NH_3 are not associated with suspended particulate matter (SPM) and tend to decrease the pH, temperature, and dissolved oxygen (DO) concentration in the river courses. Another important factor for controlling hydrochemicals at the sites studied is the oxi-reduction process, which controls the behavior of the different forms of N present in the medium, such as NO_2^- and NO_3^-. The fluvial hydrochemistry in these DNP rivers is also controlled by the carbonate system since the alkalinity of the water is related to the conductivity of the medium and inversely related to the redox potential.

The present study was the beginning of a work to monitor watercourses in hydrographic microbasins located in the Descobrimento National Park (DNP), where analytical methodologies were optimized. In addition, the data provide essential information that can be used for DNP management.

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