Geotemas, Pau dos Ferros, RN, Brasil
ISSN: 2236-255X, v. 13, 2023.

SOCIAL AND ENVIRONMENTAL PERCEPTION AND STATE OF PRESERVATION OF THE SPRINGS OF THE APODI-MOSSORÓ RIVER

Percepção socioambiental e estado de preservação das nascentes do rio Apodi-Mossoró

Percepción social y ambiental y estado de conservación de los nacimientos del Río Apodi-Mossoró

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Article History
Reveived: 19 april, 2023
Accepted: 06 august, 2023
Published: 03 october, 2023

ABSTRACT

Environmental degradation has contributed to a decrease in the volume of water in springs, thus compromising the provision of multiple uses and affecting the functions of watersheds. This study aims to carry out a macroscopic diagnosis of the perennial springs of the Apodi-Mossoró River Basin. The state of preservation was obtained through the macroscopic evaluation and was ranked as excellent, good, fair, poor and very poor in the perennial springs in the municipalities of Portalegre, Martins, Paraná, Luiz Gomes, São Miguel, Coronel João Pessoa and, finally, Doutor Severiano. In the basin, 18 perennial springs were studied. Finally, the environmental impacts were identified. 35% of the springs showed “very poor” degree of preservation and 35% showed “fair” degree of preservation, whereas only 6% of the studied springs showed “excellent” state of preservation. This study showed that the springs have several environmental impacts, including the presence of open sewers and deforestation. The main agents causing these impacts were the absence of a protective fence, easy access, presence of irregular disposal of solid and liquid waste, disorderly urbanization and soil compaction. For the restoration and environmental control of the springs, it is necessary to use measures to mitigate environmental damage, including: protective fence; environmental education programs; reforestation of PPAs; environmental sanitation; treatment of liquid waste, soil cover, among others.

Keywords: Environmental management; Hydrographic basin; Public policy.

RESUMO

A degradação ambiental tem contribuído para a diminuição do volume de água das nascentes, desta forma comprometendo o atendimento aos usos múltiplos e afetando as funções das bacias hidrográficas. Este trabalho objetiva realizar um diagnóstico macroscópico das nascentes perenes da Bacia Hidrográfica do Rio Apodi-Mossoró. O estado de preservação foi obtido por meio da avaliação macroscópica a qual foi ranqueado em ótimo, bom, razoável, ruim e péssimo nas nascentes perenes nos municípios de Portalegre, Martins, Paraná, Luiz Gomes, São Miguel, Coronel João Pessoa e, por fim, Doutor Severiano. Na bacia foram estudadas 18 nascentes perenes. Por fim, realizou-se identificação dos impactos ambientais. Quanto ao estado de preservação 35% apresentaram grau de preservação “razoável”, 35% das nascentes apresentam o grau de preservação “péssimo”, 18% “bom” e 6% “ruim” e “ótima”. Diante deste estudo, constata-se que as nascentes apresentam diversos impactos ambientais, entre eles a presença de esgotos a céu aberto e o desmatamento. Os principais agentes causadores destes impactos foram ausência de cerca de proteção, fácil acesso, presença da disposição irregular de resíduos sólidos e líquidos, urbanização desordenada e a compactação do solo. Para a recuperação e controle ambiental das nascentes faz-se necessário a utilização de medidas que venham a mitigar os danos ambientais dente elas: cerca de proteção; programas de educação ambiental; reflorestamento das APPs; saneamento ambiental; tratamento dos resíduos líquidos, cobertura do solo entre outras.

Palavras-chave: Gestão ambiental; Bacia hidrográfica; Políticas Públicas.

RESUMEN

La degradación ambiental ha contribuido a la disminución del volumen de agua en los manantiales, comprometiendo así la provisión de usos múltiples y afectando las funciones de las cuencas hidrográficas. Este trabajo tiene como objetivo realizar un diagnóstico macroscópico de los manantiales perennes de la cuenca del río Apodi - Mossoró. El estado de conservación se obtuvo a través de la evaluación macroscópica que fue calificada como excelente, buena, regular, mala y terrible en los manantiales perennes de los municipios de Portalegre, Martins, Paraná, Luiz Gomes, São Miguel, Coronel João Pessoa y, finalmente, Doctor Severiano. En la cuenca se estudiaron 18 manantiales perennes. Finalmente, se identificaron los impactos ambientales. En cuanto al estado de conservación, el 34% presentaba un grado de conservación “regular”, el 33% de los manantiales presentaba un grado de conservación “muy malo”, el 22% “bueno” y el 11% “malo”. A la vista de este estudio, parece que los manantiales tienen varios impactos ambientales, incluyendo la presencia de alcantarillas abiertas y la deforestación. Los principales agentes causantes de estos impactos fueron la ausencia de cerco protector, fácil acceso, presencia de disposición irregular de residuos sólidos y líquidos, urbanización desordenada y compactación del suelo. Para la recuperación y control ambiental de los manantiales, es necesario utilizar medidas que mitiguen el daño ambiental a los mismos: cerco de protección; programas de educación ambiental; reforestación de APPs; saneamiento ambiental; tratamiento de residuos líquidos, cobertura de suelos, entre otros.

Palabras clave: Gestión ambiental; Cuenca hidrográfica; Políticas públicas.

1 INTRODUCTION

Over the years, man's incessant search for the acquisition of wealth has been aggressively degrading the environment, causing pollution and contamination of soil and water bodies, without worrying about future generations (CUNHA, 2020).

Anthropic action has directly influenced the hydrological processes, as the water cannot infiltrate as a result of deforestation, which increases surface runoff and soil erosion, consequently reducing the recharge of aquifers, affecting the recharge of springs (PEREIRA, 2022). Thus, it is very important that there is an efficient management of water resources, seeking methodologies related to soil and water management, so that environmental impacts on them are minimized, as recommended in current legislation (CUNHA, 2020).

Land use and occupation at sites near springs have been causing major problems, including pollution and contamination of water, which accelerates the erosion process and consequently leads to siltation and burial of springs (SILVA et al., 2019). Erosion is mainly caused by incorrect soil management. Deforestation, disorderly use of land, lack of studies on agricultural suitability and absence of conservation practices are examples of issues (MONTEL et al., 2021).

Therefore, these practices may lead to extreme levels, such as the decrease of springs for supply and lowering of water table, thus contributing to water scarcity (SILVA et al., 2019).

From this perspective, Soares (2015) states that springs are extremely important both in the socio-environmental and in the hydrological spheres, as they promote the passage of groundwater to the surface, thus maintaining the flow of rivers and streams throughout the year. Therefore, their preservation is fundamental for the maintenance of ecosystems and life on the planet.

Law No. 12,651/2012, which governs the New Forest Code, provides for actions aimed at protecting native vegetation and ecosystems, classifying the springs as Permanent Preservation Areas – PPAs. This law establishes that, for the springs to be preserved, they must have at least a radius of 50 meters in their surroundings (Brasil, 2012).

In the semi-arid region, which constantly suffers from drought due to its climatic characteristics, the preservation of springs becomes fundamental. A study conducted by the National Agency for Water and Basic Sanitation - ANA reports that, between 2013 and 2016, 48 million people were affected by droughts (long-lasting) or dry spells (transient) in the

national territory. The year 2016 was considered to be the one with the greatest impact for the population, with 18 million inhabitants affected by water scarcity, and 84% of those impacted lived in the Northeast.

Between 2003 and 2016, droughts contributed for 2,783 municipalities to declare Emergency Situation or State of Public Calamity, of which 1,409 are located in the Northeast region (ANA, 2017).

Within this reality, it is possible to highlight the Apodi-Mossoró River Basin, which is the largest basin legitimately belonging to the Rio Grande do Norte state, being composed of 618 reservoirs, which reach a volume of 469,714,600 m3, corresponding to 27.4% and 10.7% of all the reservoirs and accumulated volumes of Rio Grande do Norte (IGARN, 2014).

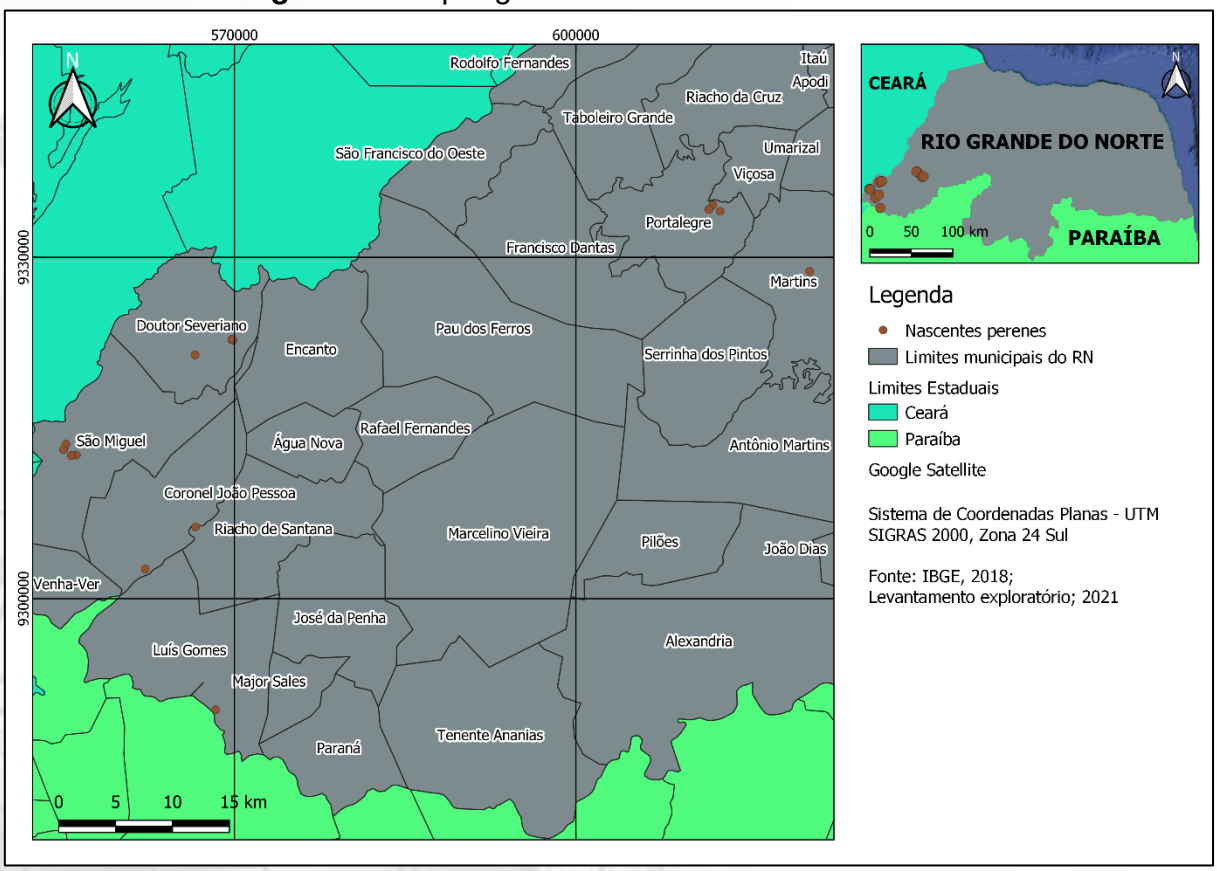
In view of their economic and social importance, the present study was conducted to study the environmental impacts on springs, using macroscopic aspects as the basis to diagnose the environmental impacts on the perennial springs belonging to the Apodi-Mossoró River Basin, through assessments in urban and rural scenarios, in order to observe the influence of urban expansion on the conservation of the springs.

2 MATERIAL AND METHODS

Evaluation of the environmental impacts on springs belonging to the Apodi-Mossoró River Basin was carried out. The basin occupies an area of approximately 14,276 km2, which represents about 27% of the territory of the Rio Grande do Norte state (SILVA et al., 2018). According to the Institute of Water Management of Rio Grande do Norte – IGARN (2014), the Apodi-Mossoró River Basin is the largest basin in Rio Grande do Norte. The basin has 618 dams, which reach a volume of 469,714,600 m.

According to Köppen's climate classification, the predominant climate in the basin is BSw'h', which is characterized as very hot and semi-arid, with rainy season delayed to autumn. On the other hand, in the extreme southwest of the basin, where its springs are present, the classification is Aw, characterized by a rainy tropical climate (IGARN, 2014).

Figure 01 – Springs located in Rio Grande do Norte



Source: Created by the Authors (2020)

2.1 Macroscopic analysis

To identify the environmental impacts on the basin springs, qualitatively, a macroscopic evaluation was carried out according to the methodology proposed by Gomes et al. (2005). These authors were based on the Water Quality Assessment Guide (2004) and on the book called "*Educação Ambiental - Princípios e Prática*" (Environmental Education - Principles and Practice), written by Dias (1988).

The quantification of the Index of Environmental Impact on Springs (IEIS) used 14 parameters specified in Table 01, which were classified as very poor, poor, fair, good and excellent, and in each class a value was assigned according to the characteristics of the impacts, for bad (1), intermediate (2) and good (3)

Table 01 – Macroscopic quantification of the Index of Environmental Impact on Springs – IEIS.

Macroscopic parameter	Characteristics for quantification of Environmental Impact		
	Bad (1)	Intermediate (2)	Good (3)
Water color	Dark	Light	Transparent
Water odor	Strong smell	Weak smell	Absent
Waste inside springs	A lot	Little	Absent
Floating material	A lot	Little	Absent
Foam	A lot	Little	Absent
Oil	A lot	Little	Absent
Sewage in springs	Yes	Probable	Absent
Vegetation	Absent	Altered	Preserved
Use by animals	Presence	Only marks	Not detected
Use by humans	Presence	Only marks	Not detected
Protection	Without protection	With protection	With protection
Proximity to residence	More than 50m	From 50 to 100m	More than 100m
Type of surrounding area	Absent	Private property	Parks or PPAs
Accessibility	Easy	Difficult	No access

Source: Created by the Authors (2020)

The sum referring to each parameter allowed the springs to be classified according to the Environmental Quality Index (macroscopic analysis) as: excellent, good, fair, poor or very poor (Table 02).

Table 02 – Classification of the springs according to the sum of the parameters of the macroscopic analysis.

Class	Degree of Protection	Score
A	Excellent	37 – 39

B	Good	34 – 36
C	Fair	31 – 33
D	Poor	28 – 30
E	Very Poor	Below 28

Source: Created by the Authors (2020).

For a better visualization of the studied springs, Table 03 presents the municipalities and their respective springs.

Table 03 – Springs studied

Municipalities	Springs per municipality
Portalegre/RN	- *Nascente do Brejo* - *Nascente de Lavanderia Pública* - *Nascente da Bica*
Martins/RN	- *Nascente do Lamarão* - *Nascente de Dona Rita*
Luiz Gomes/RN	- *Nascente da Cacimba*
São Miguel/RN	- *Cacimba Luizinho de Azarias* - *Cacimba Terezinha Feliz* - *Cacimba da Prefeita* - *Cacimba Manoel Viera 1* - *Cacimba de Potó*
Coronel João Pessoa/RN	- *Nascente da Coite* - *Olho d'água da Mata Redonda*
Doutor Severiano/RN	- *Olho d'água dos Correa,* - *Nascente do Comprido,* - *Nascente da Castanhola* - *Olho d'água da Ingazeira*
Tenente Ananias/RN	- *Nascente Albuquerque*

Source: Created by the Authors (2020).

To assist in the validation of the data, on-site visits were carried out and photographic records were made. The study was conducted from June to October 2019.

3 RESULTS AND DISCUSSION

By studying the springs in the Apodi-Mossoró River Basin, rural and urban area, through macroscopic analysis, it was possible to identify some environmental impacts (Figure 02). Figure 02A shows the environmental impacts present in *Nascente da Bica*, where it is possible to observe the presence of solid and liquid waste, since it is located near the urban area, and in periods of rain, the water flows down by gravity, carrying this waste from the city to the spring.

Near the *Nascente de Dona Rita*, located in Martins/RN (Figure 02B), within the radius of approximately 150m, it was possible to notice the presence of ravines, probably formed by the flow of water. However, Figure 02C and 02D shows clay extraction and the presence of open sewage, respectively. Figure 02E and 02F shows an area that was deforested and later burned and a deforested mountain chain, respectively. This practice is common in the city of São Miguel/RN.

Figure 02 – Environmental impacts present in the Apodi-Mossoró River Basin

Source: Created by the Authors (2020).

Legend: A- Solid and liquid waste, Portalegre/RN; B- Soil loss (ravines), Martins/RN; C- Clay extraction, Luiz Gomes/RN; Open sewage, São Miguel/RN; E- Burned area, São Miguel/RN; F- Deforestation, Coronel João Pessoa/RN.

Santos et al. (2021) report that, because the springs are easily accessible, environmental degradation has caused major problems of precariousness and devastation. Due to the proximity of the springs to residences, the deterioration intensifies through the inadequate practice of land use, for instance with accumulation of garbage, open sewage, and the presence of domestic animals.

Table 04 describes the main environmental impacts identified close to the springs under study and some environmental restoration measures.

Table 04 – Main environmental impacts present in the springs of the Apodi-Mossoró River Basin and potential restoration and control measures.

Impact on Springs	General implication	Restoration and control measures
Absence of protective fence	Direct use of the spring by animals; compaction; contamination/pollution by animal feces and urine.	Protective fence
Easy accessibility	Use by animals and people; removal of native forest; compaction and siltation of springs; and pollution.	Protective fence; Environmental education programs;
Deforestation and paving	Reduction of aquifer recharge; soil erosion and impoverishment; flooding and siltation of springs and rivers; decrease in CO_2 stock; rising temperatures; loss of biodiversity.	Reforestation of PPAs; environmental education.
Constructions	Loss of biodiversity; reduction in infiltration; burial of springs; affected drainage.	Urbanization; Creation of the Master Plan of the Cities.

Solid waste	Contamination of soil, surface water and groundwater; damage to aquatic ecosystems.	Environmental education; reuse; recycling.
Compaction and absence of soil cover	Increased surface runoff; increased erosion and loss of the fertile soil layer; siltation of water bodies; change in the flow of liquids and gases.	Bioengineering; furrowing, sub-soiling; mulching.
Open sewage	Chemical and biological pollution; proliferation of bacteria, viruses and harmful microorganisms in general; eutrophication; spread of endemic diseases, among others.	Environmental Sanitation; treatment of liquid waste; environmental education.
Constant flow of people	Presence of solid waste	Environmental Education; isolation of the area.
Erosion	Generation of sediments and increase of features; damage to aquatic fauna; interruption of watercourses.	Reduction of surface runoff; reforestation; soil cover; dams.

Source: Created by the Authors (2020)

Similar results were obtained by Santos et al. (2021), who studied springs located in the Fontes neighborhood, in the municipality of Soledade/RS, and found that they are located near the residences, with presence of domestic animals, open sewage, presence of solid waste and attenuation of native species near the springs, among other environmental impacts.

The Ribeirão Anhumas Basin, the largest one among the contributors of the Atibaia River in the city of Campinas/SP, also suffers from deforestation, agriculture (monoculture), fires and urbanization (Garcia et al., 2019). Galvan et al. (2020) reported that 66.7% of the springs studied do not have protective fence.

3.1 Degree of preservation of the springs

In order to study the degree of preservation of the springs belonging to the Apodi-Mossoró River Basin, 18 perennial springs were selected (Figure 03). They are located in the municipalities of São Miguel/RN, Doutor Severiano/RN, Coronel João Pessoa/RN, Portalegre/RN and Martins/RN. The springs *Cacimba Luizinho de Azarias*, *Cacimba Terezinha Feliz*, *Cacimba da Prefeita*, *Cacimba Manoel Viera 1* and *Cacimba do Potó* showed a “very poor” degree of preservation, and all are present in the urban area of São Miguel/RN.

As the springs of São Miguel are located in the urban area and the municipality does not have a Master Plan, land use and occupation have occurred illegally, not respecting the PPAs. As a result, the scenario around the springs includes: paved streets, absence of forests (decreasing biodiversity and infiltration, besides contributing to extinction of species, decrease in CO2 stock and absence of water in the springs), open sewage (chemical and biological pollution and spread of diseases), presence of solid waste (soil and water contamination), absence of protective fence in some of the springs, uncovered soils and presence of erosion. These factors contributed to reducing the degree of preservation of the springs.

Nascente da Bica (Portalegre/RN), despite being located in an area of Conservation Unit, with sustainable use and classified in the category Area of Relevant Ecological Interest – AREI, showed a “poor” degree of preservation. This classification is due to the anthropization, since the spring is used as a tourist point of the region, with entrance portico, parking lot, access steps, and restaurant. Along with the anthropic impacts, it was possible to observe uncovered soils, erosion, presence of solid waste, deforested areas, among other environmental impacts.

As for the recharge zone, it is degraded, probably because the area upstream of the spring site is urbanized (SEMARH, 2018). These environmental impacts occur because the conservation unit (AREI) does not have a management plan, hence resulting in neglect by the population (MEDEIROS et al., 2018).

It was possible to find springs with a “fair” state of preservation in the municipalities of Doutor Severiano/RN (*Olho d'água dos Correa, Nascente do Comprido, Olho d’água da Ingazeira*), Coronel João Pessoa/RN (*Nascente da Coite*), Portalegre/RN (*Nascente do Brejo*), and Martins/RN (*Nascente de Dona Rita*). All springs classified with “fair” IEIS are located in the rural area, a factor that contributes to their degree of preservation.

One of the factors responsible for the "fair" classification was the absence of sewage in the springs, the non-use or minimal use by humans and the fact that they are distant from the residences, contributing to this result. However, a deforested area was also found near the springs of the municipalities of Coronel João Pessoa/RN and Doutor Severiano/RN (*Olho d'água dos Correa*). In *Nascente do Brejo*, located in Portalegre/RN, it was possible to detect uncovered soils, presence of erosion, and removal of native forest for planting grass and some fruit crops.

In *Nascente de Dona Rita*, Martins/RN, on the other hand, for being located far from any village and at a site with difficult access, there was no presence of animals or humans, which contributed to its classification. According to reports, the water is no longer consumed by the community due to poor quality, and one of the environmental impacts visible on the site is the partial replacement of native vegetation with planted vegetation (grass) for agricultural and livestock farming purposes.

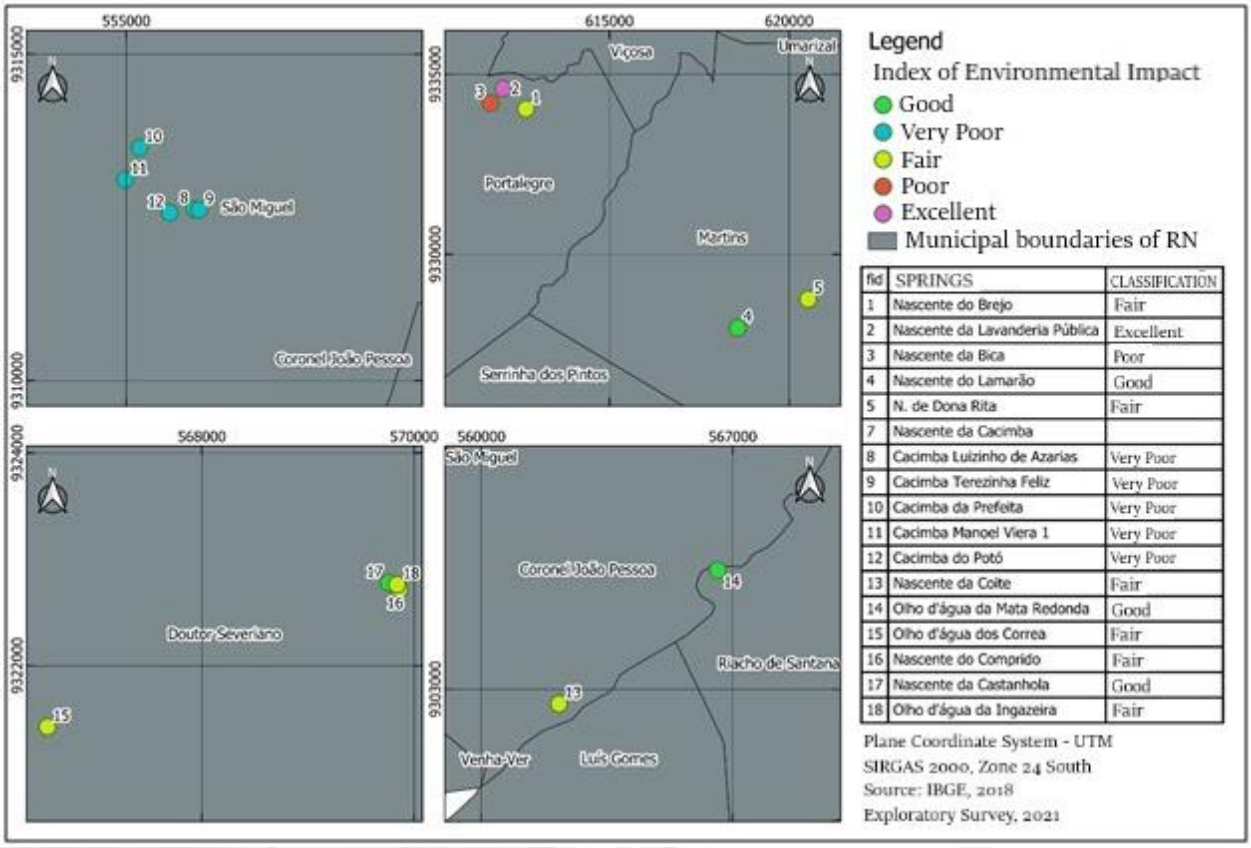
The springs with "good" degree of preservation were three, located in the municipalities of Portalegre/RN (*Nascente da Lavanderia Pública*), Martins/RN (*Nascente do Lamarão*), Coronel João Pessoa/RN (*Olho d'água da Mata Redonda*), and Doutor Severiano/RN (*Nascente da Castanhola*). It is worth pointing out that none of the springs studied in the municipalities belonging to the Apodi-Mossoró River Basin obtained an "excellent" degree of protection.

Nascente da Lavanderia Pública (Portalegre/RN) has been in disuse for more than 10 years, which contributes to its classification. In *Nascente do Lamarão* (Martins/RN), factors such as protective fence approximately 150 m away from the spring, absence of domestic effluents and slightly altered vegetation were fundamental for its degree of preservation.

The factors that contributed to the degree of preservation of *Olho d'água da Mata Redonda* (Coronel João Pessoa/RN) were its location in the rural area, difficult access (access through closed forest), slightly altered natural vegetation, soils with good vegetation cover, as well as no use by animals or humans.

For *Nascente da Castanhola* (Doutor Severiano/RN), the factors that were decisive for its degree of preservation were the absence of sewage, water odor, foams, oils, use by humans and its location, about 100 m away from residences.

Figure 03 – Index of Environmental Impact on the springs of Apodi-Mossoró River Basin



fid	SPRINGS	CLASSIFICATION
1	Nascente do Brejo	Fair
2	Nascente da Lavanderia Pública	Excellent
3	Nascente da Bica	Poor
4	Nascente do Lamarão	Good
5	N. de Dona Rita	Fair
7	Nascente da Cacimba	
8	Cacimba Luizinho de Azarias	Very Poor
9	Cacimba Terezinha Feliz	Very Poor
10	Cacimba da Prefeita	Very Poor
11	Cacimba Manoel Viera 1	Very Poor
12	Cacimba do Potó	Very Poor
13	Nascente da Coite	Fair
14	Olho d'água da Mata Redonda	Good
15	Olho d'água dos Correa	Fair
16	Nascente do Comprido	Fair
17	Nascente da Castanhola	Good
18	Olho d'água da Ingazeira	Fair

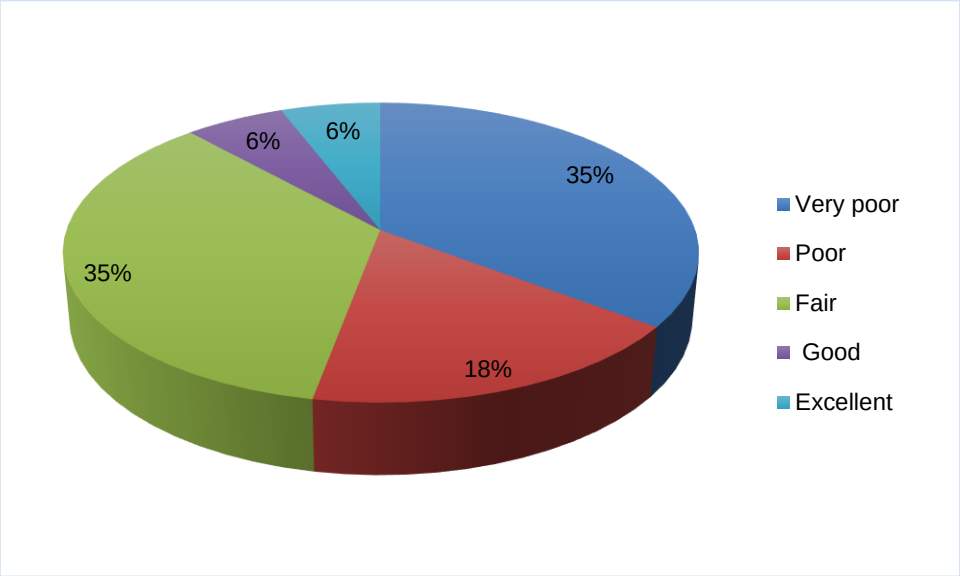
Plane Coordinate System - UTM
SIRGAS 2000, Zone 24 South
Source: IBGE, 2018
Exploratory Survey, 2021

Source: Created by the Authors (2020).

For a better visualization of the degree of preservation of the springs belonging to the Apodi-Mossoró River Basin, Graphic 01 presents the Index of Environmental Impact on the Springs – IEIS. 35% of the springs showed "very poor" degree of preservation and 35% showed "fair" degree of preservation, whereas only 6% of the studied springs showed "excellent" state of preservation.

Nascente do Brejo, Nascente de Dona Rita, Nascente da Coite, Nascente do Comprido, Olho d'água dos Correa and Olho d'água da Ingazeira showed a "fair" degree of preservation. This classification was due to the use and occupation of the land. *Nascente do Brejo*, for example, shows high degradation within the radius of 50 meters, because much of the native forest has been removed for planting grass and some fruit crops. The soil, in some places, has no vegetation cover, which contributes to the occurrence of erosion and ravines near the spring. Presence of solid residues was also detected in this spring.

Graphic 01 – Index of Environmental Impact on Springs - IEIS



Source: Created by the Authors (2020)

However, the presence of a protective fence, area of difficult access, light color and absence of odor in the water, soil with good vegetation cover and no features of erosion are characteristics that contributed to the "fair" classification of the springs.

Regarding the "very poor" degree of preservation of the springs, obtained for *Cacimba Luizinho de Azarias, Cacimba Terezinha Feliz, Cacimba da Prefeita, Cacimba Manoel Viera 1* and *Cacimba do Potó*, all located in the urban area of the municipality of São Miguel/RN, it is due to the use and occupation of the land, since these springs are located in the city. The environmental impacts observed include: disappearance of biodiversity – fauna and flora, caused by ecological imbalance; decrease in infiltration rate, due to the absence of forests; open sewage; presence of solid waste; among others.

A similar reality was observed by Silveira et al. (2019), who found that 78.57% of the springs near the urban area of the municipality of Umbaúba/SE have "very poor" IEIS, 14.28% have "poor" IEIS and 7.14% have "fair" IEIS.

On the other hand, Neres (2014) studied the springs of the municipalities of Martins/RN and Portalegre/RN and observed that 75% of them showed a "poor" degree of preservation, 25% showed a "very poor" degree of preservation and none of them was classified as with "excellent", "good" or "fair" degree of preservation.

Nascente da Bica, Portalegre/RN, was the only spring that showed "poor" degree of preservation, a classification due to the removal of native forest, paving in some stretches,

uncovered soils, loss of soil (erosion), and constant flow of people. In addition to that, for being located very close to the city, in periods of rain, the water carries solid and liquid waste by gravity from the city to the spring.

Finally, “good” and “excellent” degrees of preservation were observed for *Nascente do Lamarão, Nascente da Castanhola and Nascente da Lavanderia Pública*, which show characteristics such as slightly altered natural vegetation, conserved soil, with vegetation cover, which contributes to low erosion, as well as solid waste in small amount and absence of odor, oils and sewage.

In their study, Leal et al. (2017) observed that 13% of the springs had “excellent” IEIS, 80% had “good” IEIS and only 7% had “fair” state of conservation.

4 CONCLUSIONS

The springs that had a “good” degree of preservation, for maintaining the natural vegetation slightly altered, and “fair” degree of preservation, due to the land use and occupation in the surrounding areas, are located in the municipalities of Portalegre/RN, Martins/RN, Coronel João Pessoa/RN and Doutor Severiano/RN. *Nascente da Bica* (Portalegre/RN) was classified with a “poor” degree of preservation, and one of the reasons is the removal of native forest. All the springs located in the urban area of São Miguel/RN showed a “very poor” degree of preservation. One of the main reasons for this classification is the fact that they are located in urban areas and, although tourist activities are not exploited in the area, there is no environmental planning.

Regarding the main agents causing environmental impacts, the following issues were identified: absence of protective fence, easy access, deforestation, presence of solid and liquid waste, urbanization, compaction and absence of soil cover.

It is observed, however, that although good quality water is fundamental for a healthy life and sustenance of families living near these springs, in addition to the economic self-sufficiency of the rural property, and that it is the duty of the State to establish policies for the identification and preservation of these springs, there is no such care, because the present study showed that the analyzed springs have several environmental impacts, such as open sewage and deforestation of secondary vegetation, harming their preservation.

The process of restoration and conservation of the springs is slow, but it is possible with some strategies and preservation actions that consist of building protective fence, promoting Environmental Education programs, reforesting the PPAs, controlling

urbanization, creating the master plan of the cities, isolating the area, reducing surface runoff, increasing soil cover and dams, as well as applying an efficient environmental management strategy, which includes compliance with environmental laws, rational use of water, waste management, valorization of green areas, fight against pollution, among others.

REFERENCES

ANA. **Relatório da ANA apresenta situação das águas do Brasil no contexto de crise hídrica.** 2017. Disponível em: <http://www3.ana.gov.br/portal/ANA/noticias/relatorio-da-ana-apresenta-situacao-das-aguas-do-brasil-no-contexto-de-crise-hidrica>. Acesso em: 27 mai. 2019.

BRASIL. Dispõe sobre a proteção da vegetação nativa. **Novo Código Florestal Lei Nº 12.651, de 25 de Maio de 2012.** Brasília, 2012. 36 p. Disponível em: <https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm>. Acesso em: 20 fev. 2022.

CUNHA, V. T. **Percepção socioambiental e estado de preservação das nascentes do Rio Apodi-Mossoró**. Mossoró: UFERSA. p. 94, 2020. Dissertação. Disponível em: <https://repositorio.ufersa.edu.br/bitstream/prefix/8806/1/VanessaTC_DISSERT.pdf>. Acesso em: 20 fev. 2022

GALVAN, K. A.; MEDEIROS, R. C., MARTINS NETO, R. P. LIBERALESSO, T., GOLOMBIESKI, J. I. ZANELLA, R. Análise ambiental macroscópica e a qualidade da água de nascentes na bacia do Rio São Domingos/SC, Brasil. **Revista Ibero-Americana de Ciências Ambientais,** Nova Mutum, v.11 - n.1, p. 165- 176, 2020. Disponível em: <https://www.sustenere.co/index.php/rica/article/view/CBPC2179-6858.2020.001.0016>. Acesso em: 20 mai. 2022

GARCIA, J. M.; MANTOVANI, P.; GOMES, R. C.; Longo, R. M.; DEMANBORO, A. C.; BETTINE, S. do C. Degradação ambiental e qualidade da água em nascentes de rios urbanos. **Sociedade e Natureza**, v.30, p. 228-254, 2019. Disponível em: <https://www.scielo.br/j/sn/a/DvNMBqxxQbSvQ4xhtQv36Ts/?format=pdf&lang=pt>. Acesso em: 20 fev. 2022

GHANEM, M.; AHMAD, W.; SAWAFTAH, F.; KEILAN, Y. Socio - Economic - Environmental Impact on Spring water in Western Ramallah Catchments. **The Canadian Journal for Middle East Studies**, v. 2, p. 78- 92, 2017. Disponível em: <C:/Users/vanes/Downloads/SocioeconomicPaper2017.pdf> Acesso em: 20 fev. 2023

GOMES, P. M.; MELO, C.; VALE, V. S. Avaliação dos impactos ambientais em nascentes na cidade de Uberlândia/MG: análise macroscópica. **Revista Sociedade & Natureza**, v. 17, n. 32, p. 103-120, 2005. Disponível em: <https://seer.ufu.br/index.php/sociedadenatureza/article/view/9169/5638>.Acesso em: 20 mai. 2020.

IGARN, Instituto de Gestão das Águas do Rio Grande do Norte**. Bacia Apodi/Mossoró**. 2014. Disponível em: <http://adcon.rn.gov.br/ACERVO/IGARN/DOC/DOC000000000028892.PDF>. Acesso em: 02 nov. 2018

LEAL, M. S.; TONELLO, K. C.; DIAS, H. C. T.; MINGOTI, R. Caracterização hidro ambiental de nascentes. **Revista Ambiente & Água**, v. 12, n. 1, p.1-9, abr. 2017. Disponível em: <https://www.scielo.br/j/ambiagua/a/SdCmZSRf6NjVktjxN8cVLft/abstract/?lang=pt>. Acesso em: 10 mar. 2022.

MONTEL, L. V.; MAIA, C. S. L.; CRUZ, V. D.; SOUZA, J. D. S. D. Erosão do solo e os danos a agricultura e ao meio ambiente**. Revista Multidisciplinar de Educação e Meio Ambiente**, Papicu/CE, v.2, n.3, 2021. Disponível em: <https://doi.org/10.51189/rema/1701>. Acesso em: 10 mai. 2023

MEDEIROS, S. R. M.; CARVALHO, R. G.; SANTOS, G. B. S.; NASCIMENTO, L.; MEDEIROS, F. H. F.; BARBOSA, A. H. S. Uso público da Área de Relevante Interesse Ecológico Mata da Bica/Portalegre (RN): potencialidades e limitações. **Revista Brasileira de Ecoturismo**, São Paulo, v.11, n.2, pp.221-249, mai/jul 2018. Disponível em: <https://periodicos.unifesp.br/index.php/ecoturismo/article/view/6673/4259>. Acesso em: 10 jun. 2023

NERES, S. C. T. **Nascentes da região serrana de Martins e Portalegre, Rio Grande do Norte: aspectos hidrodinâmicos e macroscópicos como subsídio à conservação**. Mossoró: UERN. p.167, 2014. Dissertação. Disponível em: <https://www.uern.br/controledepaginas/mestrado-dissertacoes defendidas/arquivos/2212dis_suellen.pdf>. Acesso em: 05 jan. 2022

PEREIRA, J.O. de L. **Geomorfologia fluvial e ação antrópica no município de Prata-PB**: Estudo do trecho do Riacho Acauã. Campina Grande – PB: UFCG. p. 20, 2022. Graduação. Disponível em: <http://dspace.sti.ufcg.edu.br:8080/xmlui/bitstream/handle/riufcg/25070/JEFERSON%20OLDAIR%20DE%20LIMA%20PEREIRA%20%20TCC%20ARTIGO%20LICENCIATURA%20EM%20GEOGRAFIA%20CH%202022.pdf?sequence=1&isAllowed=y>. Acesso em: 10 jun. 2023

SANTOS, L. B. dos., SANTOS, E. de O. dos., SCHWANTZ, P. I., BOHRER, R. E. G., PRESTES, M. M. B., LARA, D. M. de. Análise ambiental de nascentes do bairro Fontes no município de Soledade (RS), Brasil. **Rev Agro Amb**, v. 14, n. 2. p. 1-19, 2021. Disponível em: <https://periodicos.unicesumar.edu.br/index.php/rama/article/view/8771>.Acesso em: 07 mai. 2023

SEMARH. Secretaria do Meio Ambiente e Recursos Hídricos. **Diagnóstico das Nascentes da Bacia Hidrográfica do rio Apodi-Mossoró**. Natal, 2018. p 201.

SILVA, L. B. da; MEZZOMO, M. D. M.; GONÇALVES, M. S. Diagnóstico Geoambiental em Nascentes: estudo de caso em Campo Mourão – Paraná. **Revista Acta Geográfica**, v. 13, n. 31, p.52-65, 2019. Disponível em: <https://revista.ufrr.br/actageo/issue/view/263>. Access on:15 abr. 2022

SILVA, J. J. da. LEMOS FILHO, L. C. de A. BATISTA, R. O. **Diagnóstico do saneamento Básico em Governador Dixsept Rosado-RN e os impactos no Rio Apodi-Mossoró**. UFERSA, p. 13, 2018. Disponível em: <https://repositorio.ufersa.edu.br/bitstream/prefix/4237/2/JohnatnJS_ART.pdf>. Acesso em: 02 dez. 2020

SILVEIRA, R. da; SANTOS, J. E. B. dos; SOUZA, A. C. Study of the environmental conditions of springs near the urban area of the city of Umbaúba/Se: macroscopic view. Braz. **J. of Develop,** 5, n. 7, p. 9119-9126 jul. 2019. Disponível em: <https://ojs.brazilianjournals.com.br/ojs/index.php/BRJD/article/view/2343/2358> Acesso em: 07 mai. 2023

SILVA, L. B. da; MEZZOMO, M. D. M.; GONÇALVES, M. S. Diagnóstico Geoambiental em Nascentes: estudo de caso em Campo Mourão – Paraná. **Revista Acta Geográfica**, Boa Vista, v. 13, n. 31, p.52-65, 2019. Disponível em: <https://revista.ufrr.br/actageo/article/view/4577/2612>. Acesso em: 07 mai. 2023.

SOARES, A. B**. Análise da problemática socioambiental de nascentes urbanas no município de Garanhuns –PE**. Natal: UFRN. p. 163, 2015. Dissertação. Disponível em: <https://repositorio.ufrn.br/bitstream/123456789/19780/1/AntonioBenevidesSoares_DISSERT.pdf>. Acesso em: 07 mai. 2023

SOARES, A. B; TROLEIS, A. L. Impactos ambientais na qualidade da água da nascente pau amarelo em Garanhuns-PE. **Revista de Geografia**, Recife, v. 34, n. 3, 2017.

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