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Environment

Importance of Macroscopic Environmental Analysis for spring preservation used for human consumption

Importância da Análise Macroscópica Ambiental para a preservação de nascentes usadas para consumo humano

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ABSTRACT

The lack and deterioration of the quality of water resources have made governments take educational measures and required society to rethink habits concerning the preservation and conservation of water quality. Thus, the present study aims to present the importance of spring preservation for water quality conservation as well as to develop a macroscopic environmental analysis of springs located in the state of Rio Grande do Sul, Brazil. Twenty springs were observed in two different periods of the year (May and November 2019), which had different economic activities: native forest – public domain; soybean, tobacco, and pig farming – private domain, in their surroundings. The study adopted five replications (different municipalities), and a macroscopic environmental analysis was carried out in each spring to classify them according to the extent of preservation. It was observed that most of the springs show “Good” and “Very good” preservation. However, it can be concluded that the economic activities developed in the surroundings do not interfere with spring preservation, and the methodology adopted is not recommended for the macroscopic environmental analysis in areas of native forest due to the characteristics considered.

Keywords: Conservation; Water quality; Permanent preservation area

RESUMO

A escassez e deterioração da qualidade dos recursos hídricos tem feito o governo tomar medidas educativas e a sociedade repensar seus hábitos para a preservação e conservação da qualidade das águas. Dessa forma, o presente estudo tem por objetivo apresentar a importância da preservação das nascentes para conservação da qualidade das águas, bem como desenvolver a avaliação macroscópica de impactos ambientais de nascentes localizadas no estado do Rio Grande do Sul, Brasil. Foram observadas

20 nascentes, em dois períodos do ano diferentes (maio e novembro de 2019), e que apresentavam atividades econômicas diferentes no seu entorno (mata nativa – domínio público, sojicultora, fumicultura e suinocultura – domínio particular) no seu entorno. O estudo adotou cinco repetições (municípios diferentes) e foram desenvolvidas análises macroscópicas de impactos ambientais em cada nascente (metodologia proposta por Gomes, Melo e Vale, 2005), com o intuito de classificá-las quanto ao seu grau de preservação. Foi percebido que a maioria das nascentes apresentam "boa" e "ótima" preservação. Contudo, conclui-se que as atividades econômicas desenvolvidas no entorno não interferem na preservação das nascentes e a metodologia adotada não é aconselhada para avaliação macroscópica de impactos ambientais em áreas de mata nativa, em virtude das características consideradas.

Palavras-chave: Conservação; Qualidade da água; Área de preservação permanente

1 INTRODUCTION

The increase in water demand for human, animal or industrial supply, combined with water crises and the deterioration of spring water quality, both surface and underground (Cruz et al., 2012), has alerted public bodies to develop educational campaigns aiming to preserve water quality, especially in communities far from large urban centers that are difficult to access (Hora et al., 2021).

Thus, isolated regions with precarious sanitation infrastructure are forced to seek alternative water collection systems and domestic sewage disposal (Cotta, Fachetti, & Andrade, 2021).

The Brazilian government is currently pushing through a proposal to amend the constitution (PEC 6/21) that includes drinking water on the fundamental rights list and guarantees of the Federal Constitution as the Brazilian Sanitation Information System (SNIS) stated that, in 2019, there were more than 30 million Brazilians who did not have access to the water supply network (SNIS, 2020).

This amendment is the result of Rio+20 that took place in 2015, where the United Nations considered drinking water and sanitation as one of the 17 Sustainable Development Goals (SDGs). Thus, SDG 6 ensures the availability and sustainable management of water and sanitation for all (United Nations Brasil, 2022).

There is a vast body of literature on water contamination in Brazil (Cotta, Fachetti, & Andrade, 2021; Gomes et al., 2019; Hora et al., 2021; Lazarotto et al., 2020; Meschede et al., 2018; Schleder et al., 2017; Schneider et al., 2021; Wiegand et al., 2021) that demonstrate the need for effective measures to be adopted to preserve resources and maintain water quality.

According to Law nº 12.651 of May 25, 2012, the Brazilian Forest Code understands perennial spring as “a spring that flows naturally above ground throughout the year”, whereas it considers Permanent Preservation Area (PPA) as a “a protected area, covered by native vegetation or not, with the environmental function to preserve water resources, landscapes, geological stability and biodiversity, facilitating genetic flows of fauna and flora, protecting the soil, and ensuring human well-being” (Brazil, 2012).

Thus, Brazilian legislation requires the PPA to be enforced around watercourses (natural or artificial) (Brazil, 2012) to make it difficult for humans or animals to access, thus avoiding waste (solid or liquid) in the water body and, consequently, reducing water quality degradation.

As a result, the macroscopic environmental analysis assesses the spring system and points out areas where improvements are needed to protect them (Gomes, Melo, & Vale, 2005). The spring system, consisting of vegetation, soil, rocks and relief of the upstream and downstream areas of the water outcrop, are considered permanent PPAs and must be preserved, regardless of their location (Gomes, Melo, & Vale, 2005), within a minimum radius of 50m around each spring (Brazil, 2012).

Considering the above, the present study aims to present the importance of preserving springs for water quality conservation, as well as making a macroscopic assessment of the environmental impacts of springs located in the state of Rio Grande do Sul, Brazil.

2 MATERIAL AND METHODS

This study was divided into two parts. First, a literature review was carried out to show the importance of spring protection and preservation for the water quality conservation that emerges at these points. Second, a macroscopic environmental analysis was applied to springs located on rural properties that are used for human consumption and animal watering.

Two visits were made at two different times during the year – May and November 2019 – at the locations chosen for analysis. No environmental changes were observed at the points analyzed between the seasons. The macroscopic analysis was always carried out by the same researcher, thus preventing different analyses from occurring at the sampled points, aiming at standardizing the observed points.

Overall, 20 springs were studied and located in 16 different municipalities, distributed in two regions (Noroeste and Planalto) in the state of Rio Grande do Sul, (Brazil). Spring water located within the native forest area (public area) (in Derrubadas, Dois Irmãos das Missões, Iraí, Mato Castelhano and Sarandi); spring water located near the swine farming area (in Frederico Westphalen, Marau, Nova Boa Vista, Palmitinho and Vista Gaúcha) (perennial condition); spring water located near the soybean farming area (in Camargo, Derrubadas, Dois Irmãos das Missões, Sarandi and Taquaruçu do Sul) (annual) and spring water located near to the tobacco farming area (in Caiçara, Iraí, Liberato Salzano, Nova Alvorada and Tenente Portela). The locations of the municipalities can be found in Fig. 1, Seben et al. (2021).

The research adopted four different conditions of land use and occupation, namely: native forest (public domain properties) and pig, soybean and tobacco farming (private domain properties), in different municipalities, to compare the data and verify if the economic activities developed around the springs could, in some way, influence their preservation.

The methodology used to develop the macroscopic environmental analysis was initially proposed by Gomes, Melo and Vale (2005), and was adapted by Felippe and Magalhães (2012), Leal et al. (2017) and Pieroni et al. (2019). The authors mention that through characteristics, such as water color and odor; waste, floating materials, foam, oil, sewage; vegetation; animal use and human use and site protection/preservation (Table 1), the spring can be classified according to its degree of preservation. Therefore, improvements can be suggested to maintain water quality that, in the aforementioned study, the springs located on private properties are used both for human consumption and for animal watering and other domestic uses.

Table 1 – Quantification of characteristics to develop the macroscopic environmental analysis

Characteristics	**Score**		
	1	**2**	**3**
Water color	Dark	Light	Transparent
Odor	Strong smell	Weak smell	No smell
Waste	A lot	A little	No garbage
Floating materials	A lot	A little	No floating materials
Foam	A lot	A little	No foams
Oil	A lot	A little	No oil
Sewage	Domestic sewer	Surface flow	No sewer
Vegetation (preservation)	High degradation	Low degradation	Preserved
Animal use	Presence	Marks only	Not detected
Human use	Presence	Marks only	Not detected
Site protection	No protection	Access protection	No access protection
Proximity to residence	Less than 50m	Between 50 and 100m	More than 100m
Insertion area type	Absent	Private property	Parks or protected areas

Adapted from: Gomes, Melo and Vale (2005)

After observing and scoring the characteristics in Table 1, the Spring Environmental Impact Index should be applied and the springs should be classified according to their degree of preservation. The springs can be classified as: Class “A” – “Very good” degree of preservation (score between 37 and 39 points); Class “B” –“Good” degree of preservation (score between 34 and 36 points); Class “C” – “Fair degree of preservation (score between 31 and 33 points); Class “D” – “Poor” degree of preservation (score between 28 and 30 points); and Class “E” – “Very poor” degree of preservation (score below 28 points) (Gomes, Melo, & Vale, 2005). This score is obtained from the sum of the points quantified in the macroscopic analysis (Table 1).

In addition, Figureics (Stacked Columns) were constructed using the Microsoft Excel program, aiming to represent the percentage of the degree of preservation springs for each land use and occupation and the attributed to each macroscopic parameter.

3 RESULTS

Among the water sources studied in the present work, those that obtained the best macroscopic environmental classification - Class “A”, matching a “Very good” degree of preservation, were the water sources located in rural properties with the following economic activities: 2 in soybean farming areas, 1 in tobacco farming area and 1 in pig farming (Table 2).

The waters classified as Class “B”, with a “Good” degree of preservation, are the water sources located on rural properties with the following characteristics: 1 in soybean farming area, 4 in tobacco farming and 4 in pig farming (Table 2).

There were 4 springs that were classified as - Class “C”, with a “Fair” degree of preservation, which were located in public areas of native forest and a private rural property with soybean cultivation (Table 2).

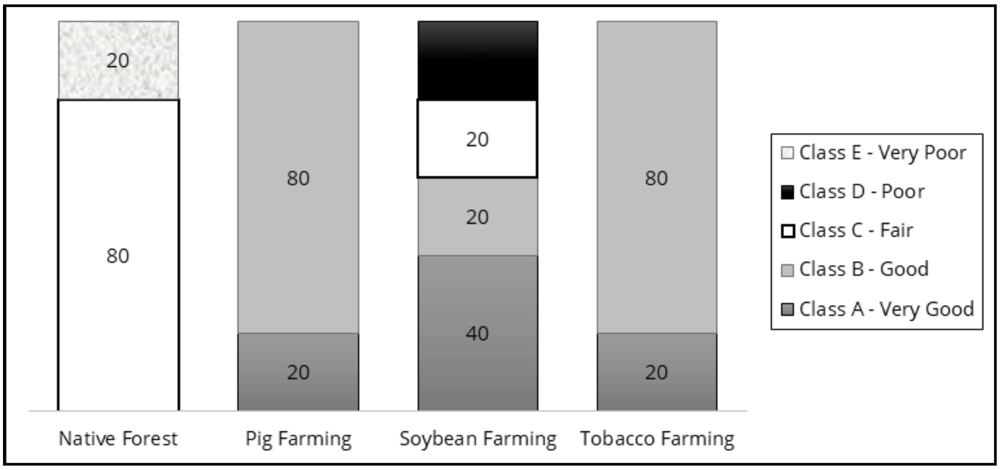
The only property studied that obtained classification - Class “D”, with a “Poor” degree of preservation was the source of a repetition located in the rural property with a soybean crop (Table 2). Moreover, in the “E” classification, meaning a “Very Poor” degree of preservation, a spring located on a public property of native forest was characterized (Table 2).

Table 2 – Classification of water sources in the State of Rio Grande do Sul considering different uses and land occupation (native forests and pig, soybean and tobacco farming) according to the Macroscopic Environmental Analysis

Repetitions	**Land use and occupation conditions**	**Water color**	**Odor**	**Waste**	**Floating materials**	**Foam**	**Oil**	**Sewage**	**Vegetation (preservation)**	**Animal use**	**Human use**	**Site protection**	**Proximity to residence**	**Insertion area type**	**Sum**	**Classification**
1	Native Forest	2	3	3	3	3	3	3	3	1	1	1	3	3	32	C
	Pig Farming	3	3	3	3	3	3	3	2	3	3	3	2	2	36	B
	Soybean Farming	2	3	3	3	3	3	3	1	3	3	1	2	2	32	C
	Tobacco Farming	3	3	3	3	3	3	3	2	3	3	3	2	2	36	B
2	Native Forest	2	3	1	2	3	3	3	1	1	1	1	2	3	26	E
	Pig Farming	3	3	2	3	3	3	3	3	1	3	2	3	2	34	B
	Soybean Farming	3	3	3	3	3	3	3	3	3	3	3	3	2	38	A
	Tobacco Farming	3	3	3	3	3	3	3	3	3	3	3	3	2	38	A
3	Native Forest	2	3	3	3	3	3	3	3	1	1	1	3	3	32	C
	Pig Farming	3	3	3	3	3	3	3	2	3	3	3	1	2	35	B
	Soybean Farming	3	3	3	3	3	3	3	2	2	3	3	3	2	36	B
	Tobacco Farming	3	3	1	3	3	3	3	1	3	3	3	3	2	34	B
4	Native Forest	3	3	3	3	3	3	3	3	1	1	1	3	3	33	C
	Pig Farming	3	3	3	3	3	3	3	3	3	3	3	3	2	38	A
	Soybean Farming	2	3	3	3	3	3	3	1	1	1	1	3	2	29	D
	Tobacco Farming	3	3	3	3	3	3	3	1	2	3	3	3	2	35	B
5	Native Forest	2	3	3	3	3	3	3	3	1	1	1	3	3	32	C
	Pig Farming	3	3	3	3	3	3	2	2	3	3	2	3	2	35	B
	Soybean Farming	3	3	3	3	3	3	3	2	3	3	3	3	2	37	A
	Tobacco Farming	3	3	3	3	3	3	3	1	3	3	3	2	2	35	B

Figure 1 shows that the economic activity of soybean development was the one that presented the greatest variety of classification regarding the degree of environmental preservation. It also shows the largest number of springs with the best degree of preservation (40% of the springs are in class “A”; 20% class “B”; 20% class “C”; and 20% class “D”). The economic activities of growing tobacco and pig farming showed the same degrees of preservation (20% of the springs are in class “A” and 80% are in class “B”). The areas of native forest showed the worst results in the macroscopic analysis of the environmental impacts to verify the classification regarding the degree of preservation as the data obtained were 80% of the springs classified in class “C” degree of preservation and 20% in class “E”.

Figure 1 - Number of springs according to the land use and occupation and degree of preservation



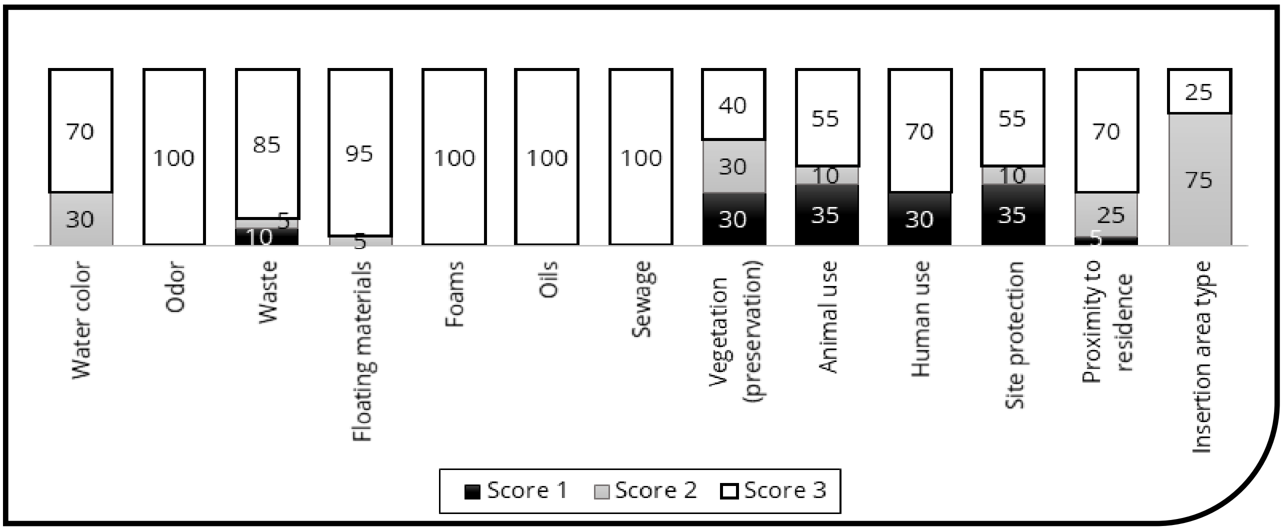
Values in %

Regarding the characteristics considered during the macroscopic environmental analysis (Table 1), it can be observed that the variables odor, foam, oil and sewage are those that were not found in any of the sources studied (Figure 2). Similarly, the springs in which no animal use was detected represent 55% (11/20) and springs for human use account for 70% (14/20) (Figure 2).

Waste (85% - 17/20) and floating materials (95% - 19/20) (Figure 2) were also characteristics that had little presence in the springs. Regarding the water color, 70% of the analyzed springs showed a transparent color (14/20) (Figure 2). Another characteristic that presented good results was related to the proximity of the springs to the residences, and, in this regard, 70% of the springs (14/20) were more than 100 m distant (Figure 2).

However, the vegetation around the springs, aiming at preservation, was a characteristic that was rarely found (Figure 2), as only 40% (8/20) of the sampled points are places that have this characteristic.

Figure 2 – Percentage of the parameters analyzed in the Macroscopic Environmental Analysis



Values in %

4 DISCUSSION

Due to a lack of water and the deterioration of surface water quality, groundwater has represented an alternative for communities with little access to basic sanitation, since they are less susceptible to contamination due to difficult access (Seben et al, 2021).

Springs represent aquifer water points that rise to the surface of the ground. Its occurrence depends on characteristics such as: rock porosity, soil permeability, hydrogeomorphology slope of the surface and precipitation (Taloor et al., 2020).

A study carried out in springs located in Argentina detected high organic loads and the presence of microorganisms in spring water, which characterizes contamination by effluents (Cruz et al., 2012). The values of the indicators in this study varied according to the regions (agricultural and non-agricultural), seasons of the year, rainy seasons and soil characteristics (such as permeability and porosity).

Schneider et al. (2021) found that Brazilian shallow waters (Rio Grande do Sul - Brazil) showed greater contamination, among the indicators analyzed, when compared to waters with greater depth due to the ease of access, sediment transport, waste and rainwater, through runoff, and protection around the site.

Galvan et al. (2020) analyzed springs used for human consumption, located in rural properties in Santa Catarina, Brazil, and found that they were unfit for human consumption given the physical, chemical, microbiological and pesticide indicators analyzed. The authors point out the proximity to residences and agricultural areas and the lack of minimum permanent preservation, required by law, as the main motivators for the results found.

Other springs located in the state of Rio Grande do Sul, Brazil, studied by Lazarotto et al. (2020), proved to be unsuitable for human consumption as total coliform microorganisms and Escherichia coli in the water was found due to the lack of local protection and the vegetation degradation in the surroundings, mainly caused by the inappropriate land use and occupation.

Jeronymo, Silva and Fonseca (2021) emphasize the importance of maintaining preservation areas, as they maintain the biodiversity of local and traditional cultures, in addition to socio-environmental sustainability.

In general, the springs studied here, which are located on private properties, are used for human consumption. The economic activities in their surroundings present “Good” or “Very Good” macroscopic environmental analysis for environmental impacts. Only two springs with soybean economic activity were classified as “Fair” and “Poor” due to the lack of protection in masonry and vegetation, and the ease with which animals and humans have access.

When analyzing shallow wells located in the state of Rio Grande do Sul, Brazil, Lazarotto et al. (2020) obtained the "Fair" (2/3) and "Poor" (1/3) degrees of preservation as a macroscopic analysis. Analyzing macroscopically springs located in different cities of the same state, Schneider et al. (2021) observed that 13% (4/30) of them are classified as "Very good". Another 37% (11/30) of the springs are classified as having a "Good" degree of preservation. Moreover, 50% (15/30) of the springs have a "Fair" or "Poor" macroscopic environmental analysis.

In turn, Galvan et al. (2020) macroscopically analyzed springs located in the state of Santa Catarina, Brazil, and found that only two springs (2/9) had preserved banks, another three (3/9) had natural revegetation in the surroundings and the others, representing more than 44% (4/9) of the springs studied, showed high environmental degradation, thus influencing the water quality of these springs.

In the state of Minas Gerais, Brazil, from the 177 perennial springs analyzed, more than 60% (107/177) had low degradation, 25% (44/177) had high degradation and less than 15% (26/177) were preserved (Pinto, Roma, & Balieiro, 2012). After analyzing 16 springs also located in Minas Gerais, Brazil, Gomes, Melo and Vale (2005) found high environmental degradation due to the lack of protection and proximity to homes. The study carried out by Oliveira et al. (2013), in the same previous state, found springs with large amounts of floating materials and waste near the springs.

In the state of Paraná, Brazil, 63% (5/8) of the springs studied were in poor conservation conditions (França Junior, & Villa, 2013).

In a study carried out in the Capão Bonito National Forest and in rural properties in the state of São Paulo, Brazil, Leal et al. (2017) did not find any impact that could change water quality, even in springs where there was easy access for animals and humans. On the other hand, the study carried out by Pieroni *et al*. (2019), also in the state of São Paulo, Brazil, observed changes in the water color in 18% of the samples, which was due to the erosive processes in the surroundings and the lack of vegetation protection and isolation of the area.

On the other hand, the springs that are located in public areas of native forest, in this article, present extensive areas of vegetation in their surroundings, exceeding 140 ha (hectares). However, regarding the macroscopic analysis, these springs were classified as “C” and “E”, which are lower scores due to the characteristics of: water color, ease with which animals can access and lack of protection in masonry (there was only plant protection). One of these springs still had waste in its surroundings, which also affected the score. It is worth mentioning that for humans to have access to these native forest areas that were studied, authorization had to be requested from the competent public agency responsible for preserving the site, to later have access to it.

Pinto, Roma and Balieiro (2012) consider that the ease of access for animals and humans negatively affects spring preservation as it favors negative impacts, such as: waste (solid, liquid, manure), soil compaction by cattle, planting crops, erosion, gullies and deforestation. A similar fact was observed by Gomes, Melo and Vale (2005) who noticed that the proximity of the springs to the residences, as well as the absence of protection, both in masonry and vegetation, were determining factors for environmental impacts in the surroundings of the springs.

Regarding compliance with Brazilian legislation in the preservation area around the springs (50 m of PPA around the springs) (BRAZIL, 2012), only the areas of public domain (native forest areas) were classified in the legislation.

5 CONCLUSIONS

Concerning the macroscopic environmental analysis, the studied springs are generally classified as “Good” in terms of preservation. This fact indicates that this preservation must be maintained, while the rural landowners of the other springs, which received lower classifications, were advised to take corrective actions in the surroundings of these places.

The study showed that the economic activities developed around the springs do not interfere with the degree of environmental preservation for the analysis performed.

The springs located in private rural properties do not comply with the applicable Brazilian legislation for the minimum radius of Permanent Preservation Areas in their surroundings, recommended by the current Brazilian legislation. This fact, in addition to negatively affectively the quality of these waters, may interfere with the quantity of local water resources.

Finally, the study also concluded that the macroscopic environmental analysis that was used in this research is not advisable for native forest areas due to the fact that they are easily accessible by humans and animals and because of water color, resulting in factors due to the lack of protection in masonry, even if they present extensive areas of vegetation protection in the surroundings (even if they are above the minimum limit required by Brazilian legislation).

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