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Analysis of the environmental integrity of water springs in rural areas

Análise da integridade ambiental de nascentes de água em área rural

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Abstract

The Brazilian legislation recognizes water springs and their surroundings as permanent preservation areas. In rural areas, many property owners do not follow the legislation, compromising their integrity and ecosystem functions. The objective of the study was to evaluate the environmental integrity of water springs in rural areas using the Environmental Impact Index of Springs and new indicators for planning, recovery, and preservation actions. The study was carried out in the northwest of the state of Rio Grande do Sul, Brazil, analyzing water springs with different use and conservation conditions. The Environmental Impact Index of Springs was evaluated and a detailed description of risks of pollution was carried out, called Characterization of the Surroundings of the Water Spring. The Environmental Impact Index of Springs shows that the preservation of springs in rural areas is compromised, mainly due to absence of vegetation, use by humans and animals, and easy accessibility. The Characterization of the Surroundings of the Water Spring pointed out that, even in the presence of vegetation, potential sources of contamination are found, showing the need for action plans to mitigate these effects. The joint use of these methodologies provides multidisciplinary and comprehensive subsidies to assess the integrity of these threatened ecosystems.

Keywords: Riparian Forest. Water Quality. IIAN. CENA. UN 2030 Agenda.

Resumo

A legislação brasileira reconhece as nascentes de água e entorno como área de preservação permanente. Em áreas rurais, muitos locais não seguem o disposto na legislação, comprometendo sua integridade e funções ecossistêmicas. O objetivo do estudo é avaliar a integridade ambiental de nascentes de água em área rural utilizando o Índice de Impacto Ambiental de Nascentes e novos indicadores para ações de planejamento, recuperação e preservação. O estudo foi realizado no noroeste do estado do RS, Brasil, analisando nascentes de água de diferentes estados de uso e conservação. Foi avaliado o Índice de Impacto Ambiental de Nascentes e uma descrição detalhada dos riscos de poluição, denominado de Caracterização do Entorno da Nascente de Água. O Índice de Impacto Ambiental de Nascentes mostra que o estado de preservação das nascentes em área rural é comprometida, principalmente pela ausência de vegetação, uso por humanos e animais e fácil acessibilidade. A Caracterização do Entorno da Nascente de Água aponta, que mesmo na presença de vegetação, potenciais fontes de contaminação são observados, mostrando a necessidade de planos de ações em mitigar estes efeitos. O emprego conjunto destas metodologias apresenta subsídios multidisciplinares e abrangentes para avaliar a integridade desses ecossistemas ameaçados.

Palavras-chave: Mata ciliar. Qualidade da água. IIAN. CENA. Agenda 2030.

Introduction

Water springs are characterized by natural outcrops of the water table forming a watercourse, whose primary functions is to form and maintain the perennially of streams, rivers, and lakes. In the balance of the hydrological cycle, water springs are fundamental for allowing the passage of groundwater to the surface of the earth. This water that emerges is essential for metabolic and biological processes, ensuring the maintenance of life and its biodiversity and various human activities (Calheiros et al., 2004; Romero, 2017). The Brazilian legislation recognizes water springs and their surroundings as permanent preservation areas (APP). The Law no. 12,651 of 2012 defines an APP as a protected area, covered or not by native vegetation, with the environmental function of preserving water resources, the landscape, geological stability, and biodiversity, facilitating the gene flow of fauna and flora, protect the soil, and ensure the well-being of human populations (Marciano, 2016; Galvan et al., 2020).

Despite their ecosystem importance, the integrity of water springs in agricultural areas has been compromised by human activities, including occupation of recharge areas; inappropriate land use practices; soil erosion; removal of native vegetation in preservation areas; improper waste disposal; and increase in impermeable areas (Honda & Durigan, 2017; Fonseca et al., 2019). Unprotected springs are impacted by pesticide and fertilizer residues carried by the wind and rainfall (Galvan et al., 2020). The roads close to water springs also allow access of people and animals and facilitate the transit of vehicles, causing compaction, erosion, and exposure of water springs to sediments or even its silting and/or obstruction. Therefore, actions that alter physical, chemical, and biological structure of these natural ecosystems affect the hydrological cycle balance and consequently the amount and quality of water supplied by the spring (Dos Santo et al., 2020; Yang et al., 2021).

In this scenario, environmental monitoring of water springs using efficient methodologies that allow the diagnosis of preservation conditions is essential. The Spring Environmental Impact Index (IIAN), developed by Gomes et al. (2005), is a tool used for this monitoring, considered a simple, practical, didactic technique, with quick response and results. It consists of visual analysis of pre-defined macroscopic parameters for the identification of environmental impacts and their consequences on the quality of springs (Da Silveira et al., 2019; Pieroni et al., 2019).

The characterization of the spring preservation degree in the IIAN is the result of indicators referring to characteristics of sensorial perception, water color and odor; presence of contaminants such as foam, oil, and sewage; conservation of plant protection (degraded, altered, or preserved); use by humans and animals; its accessibility; and others. In general, it is an assessment tool that portrays environmental conditions at the time of the visual analysis (Da Silveira et al., 2019). However, water springs are complex aquatic ecosystems and the use indicators that point out the interaction with its surroundings in a more comprehensive way is essential, as it more precisely reflects the environmental conditions on a longer time scale. In this context, go beyond this assessment, with indicators that analyze the type of outcrop and artificial protection and potential sources of contamination on the water resource and surroundings is important.

The objective of the study was to evaluate the environmental integrity of water springs in rural areas using the Environmental Impact Index of Springs and propose new indicators to qualify the characterization of the water springs and its surroundings, for planning, recovery, and preservation actions.

Material and Methods

The study was carried out in the northwest region of the state of Rio Grande do Sul, in the municipalities of Ijuí and Bozano, next to the Ijuí river basin. There are small hydroelectric plants (PCH's) in the study micro-region, which exploit the hydroelectric potential of the Ijuí river. Water springs were selected by visiting rural properties, locate, and identify springs that form and contribute to watercourses that maintain water availability in the Ijuí River. Six types of springs with representativeness of the most found forms in this region were identified, according to the land use and occupation and its surroundings. Springs were selected in an agricultural area, in a fish pond, in a native forest protected by drainage, in a livestock area, in a reforested area with concrete protection, and in a reforested area with protection by drainage, with the three conservation conditions of the surrounding vegetation (preserved, disturbed, and degraded).

A macroscopic evaluation was carried out to identify the environmental impacts of the water springs, using the Environmental Impact Index of Springs (IIAN) proposed by Gomes et al. (2005), which aims to qualitatively verify the protection degree of springs. The IIAN was applied during field visits in August 2021.

The IIAN methodology was divided into three stages: i) understanding of the method and interpretation of parameters; ii) on-site visits to water springs with application of the method and; iii) classification of water springs based on the results by the method. Thirteen evaluation criteria were analyzed in loco, and graded according to the preservation degree of the water spring. The parameters were classified as good, average, and bad, using the values 3, 2, and 1, respectively. The sum of each variable allowed the classification of the preservation degree according to the controlled score into the classes A (excellent), B (good), C (reasonable), D (bad), and E (terrible) (Table 1) (Silveira et al., 2019).

Parameters	Qualification points of water springs		
	1 (bad)	2 (average)	3 (good)
Water color	Dark	Clear	Transparent
Water odor	Strong smell	Weak smell/ Odor	Absent
Waste in the surroundings	Many	Little	Absent
Floating Materials	Many	Little	Absent
Foams	Many	Little	Absent
Oils	Many	Little	Absent
Sewer at the water spring	Visible	Likely	Absent
Vegetation	Degraded	Changed	Preserved
Use by humans	Constant	Sporadic	Absent
Use by animals	Constant	Sporadic	Absent
Site protection / Accessibility	Easy access / No protection	With protection (with easy access)	With protection (no access)
Type of area	Absent	Private propriety	Parks or protected areas
Proximity to households	Less than 50 meters	Between 50 – 100 meters	More than 100 meters
Final score[a]	**Qualification of the preservation degree of water springs**		
	Class	Preservation degree	
Between 37 to 39 points	A	Excellent	
34 to 36 points	B	Good	
31 to 33 points	C	Reasonable	
28 to 30 points	D	Bad	
Below 28 points	E	Terrible	

Table 1 - Parameters used in the macroscopic evaluation of water springs by the IIAN method
([a]) grade for observed parameters (sum of points obtained in the quantification of macroscopic analysis). IIAN = Index of Environmental Impact of Water Springs
Source: adapted from Gomes et al. (2005)

Criteria were defined to determine the scores of the evaluated macroscopic parameters that determine the preservation degree to minimize the subjectivity of the method, according to the methodology used by Reis et al., 2021.

After classifying the water springs according to the IIAN, a qualitative description of these environments was performed, called Characterization of the Surroundings of the Water Springs (CENA) (Table 2). In loco surveys were carried out throughout the study period, considering the following parameters: type of outcrop, flow, formation posterior to the water springs, protective structure, riparian forest, activities in the surroundings, and potential sources of contamination.

As for the origin of the outcrop, the water spring can be: “localized”, when it presents water flow in a single point of the terrain, or “diffuse”, when the water flow occurs in several points of the soil surface. Regarding the type of flow, water springs are considered as: “perennial” when the flow is continuous, occurring throughout the year; “intermittent or temporary” when there is flow only in the rainy season, which can last from a few weeks to months; “ephemeral” when arising in direct response to rainfall with water flows only for a few days or hours (Calheiros, 2007; Leal et al., 2017).

Considering the protection of the spring water outcrop to ensure quality for use, it was evaluated whether there is a physical protection structure and the type of protection used: concrete structure that protects the water outcrop from sources of contamination and entry of sediments or whether the water springs is drained, seeking its preservation and conservation. The economic activity carried out on the property and in the water spring surroundings, was analyzed to understand potential anthropogenic impacts that affect the integrity of the water spring. Finally, potential sources of contamination were listed, including “pesticides”: insecticides, fungicides, herbicides; “fertilizers”: nitrogenous, potassium, phosphate, mixed and lime; “domestic effluents”: liquid waste from different types of water use in households; “livestock activity residues”: animal waste (cattle, horses, pigs, poultry, sheep); and fish farming residues. This method, which the authors called CENA (Characterization of the Surroundings of the Water Spring), is detailed in Table 2.

Qualitative Parameters	Levels of Qualitative Assessment Parameters		
Outcrop origin	One-off	Diffuse	
Flow type	Permanent	Ephemeral	Intermittent
Formation after the water spring	Water course	Weir	Drained source
Protective structure	Concrete	Drainage	Does not have
Vegetation in the surroundings	Presence	Absence	

Activities in the surroundings	Livestock	Agriculture	Pisciculture	Native forest	Reforested area
Potential sources of contamination	Pesticides	Fertilizers	Domestic effluents	Livestock waste	

Table 2 - Parameters for characterizing the surroundings of the water spring (CENA)
Source: authors themselves (2021)

Results and Discussion

Considering the macroscopic parameters and preservation degree of the water springs (Table 1), Table 3 shows the result of the classification by the IIAN method.

Macroscopic Parameters	Water springs					
	Agricultural area	Weir	Native forest with drainage protection*	Livestock area	Reforested area with concrete protection **	Reforested area with drainage protection*
Water color	3	2	3	3	3	3
Water odor	3	3	3	3	3	3
Waste in the surroundings	3	3	3	3	3	3
Floating Materials	3	2	3	3	3	3
Foams	3	3	3	3	3	3
Oils	3	3	3	3	3	3
Sewer at the water spring	3	3	3	3	3	3
Vegetation	1	2	3	1	2	3
Use by humans	1	1	1	1	1	1
Use by animals	3	1	3	1	3	3
Site protection / Accessibility	1	1	2	1	2	2
Type of area	2	2	2	2	2	2
Proximity to households	3	2	3	2	3	2
Total	32	28	35	29	34	34
Class	Reasonable	Bad	Good	Bad	Good	Good

Tabela 3 - Environmental impact index of water springs by the IIAN method
IIAN - Environmental Impact Index of Springs. Water spring in an agricultural area: without fragment of vegetation in the surroundings; conservation status: degraded. Water spring inside the dam: fragment of surrounding vegetation; conservation status: degraded. Water spring in the native forest: native forest and physical protection by drainage; conservation status: preserved. Water spring in a livestock area: without fragment of vegetation in the surroundings with protection by buried concrete pipes with an upper hole; conservation status: degraded. Water spring in a fragment of reforested area with concrete protection: disturbed conservation condition. Water spring in a reforested area with drainage protection: preserved conservation condition.
Source: authors themselves (2021)

Regarding the characteristics water color, odor, residues, floating materials, oils, and sewage, although the water springs are in different environments, they showed great similarity, having the same score, exception water color and floating materials for the spring in the weir. In the vegetation analysis, the differentiation of water springs was already foreseen, due to characteristics of selection of representation of types of water springs in this rural environment. Water springs in the agricultural and livestock areas do not have surrounding vegetation, and were considered degraded. The water springs in the weir and in the reforested area with concrete protection were classified as altered vegetation, as they have a fragment of vegetation in the surroundings. The water springs in the native forest and in the reforested area protected by drainage stood out for their preserved vegetation, due to the characteristics of the riparian forest in these two different environments. Considering the criterion of use by humans, all springs showed constant use, graded as “1” (Table 3). Regarding the use by animals, the water springs in agricultural areas, native forest, reforested area with concrete protection, and reforested area with drainage protection were graded as “3” due to the absence of animals. The water springs in the weir and livestock areas were graded as “1” because they present constant use of the environment and water by animals. The accessibility was also differentiated in two types, water springs in the agricultural, weir, and livestock areas were easily accessible, without presence of barriers that would hinder access and movement of people and/or animals, and was graded as “1”. Water springs in the native forest, reforested area with concrete protection, and reforested area with drainage protection were graded as “2” by presenting some type of physical barrier/protection that would hinder the movement of people and/or animals, but still presented easy access.

Regarding the type of area, all water springs had the same grade, as they are in private properties (Table 3). Considering the proximity to households, water springs in the agricultural area, native forest, and reforested area with concrete protection were more than 100 meters away, graded as “3”, and springs in the weir and livestock areas were between 50 to 100 meters from the properties, graded as “2”. In general, considering the IIAN Method, the water spring in the agricultural area was classified as “Reasonable” regarding its preservation degree; water springs in the weir and livestock areas were classified as “Bad”; and the water springs in the native forest, reforested area with concrete protection, and reforested area with drainage protection were classified as “Good”. The Characterization of the Surroundings of the Water Springs, as called by the authors of CENA, is presented in Table 4. Considering the origin of the outcrop, there was a difference between the water springs in the different environments. Water springs in the agricultural area and native forest showed a diffuse outcrop and the water springs in the weir, livestock, reforested area with concrete protection, and reforested area with protection by drainage showed localized outcrop.

Parameters	Water springs					
	Agricultural area	Weir	Native forest with drainage protection*	Livestock area	Reforested area with concrete protection **	Reforested area with drainage protection*
	Outcrop origin					
One-off		X		X	X	X
Diffuse	X		X			
	Flow type					
Permanent	X	X	X	X	X	X
Ephemeral						
Intermittent						
	Formation after the water spring					
Water course	X			X	X	
Weir		X				
Drained source			X			X
	Protective structure					
Concrete				X	X	
Drainage			X			X
Does not have	X	X				
	Vegetation in the surroundings					
Presence		X	X		X	X
Absence	X			X		
	Activities in the surroundings					
Livestock				X		
Agriculture	X					
Pisciculture		X				
Native forest			X			
Reforested area					X	X
	Potential sources of contamination					
Pesticides	X	X	X	X	X	X
Fertilizers	X	X	X	X	X	X
Livestock waste		X	X	X	X	
Domestic effluents			X			

Tabela 4 - Characterization of the surroundings of the water spring (CENA)
Source: authors themselves (2021)

Regarding the type of flow, all water springs were characterized as perennial. Differences were found regarding the formation after the spring water outcrop, depending on their environments. The springs in the agricultural area, livestock area, and reforested area with concrete protection formed small watercourses and the water spring in the weir formed an artificial water reservoir (weir). The springs in the native forest and reforested area with drainage protection showed drained water flows, a physical intervention next to the outcrop to accumulate water for use on the property, which also has a protective effect on the outcrop.

The evaluation of presence of physical structures around the outcrop showed that springs in the agricultural area and in the dam did not had physical protection structures; springs in the native forest and reforested area with drainage protection had drained outcrops; and springs in the livestock and reforested area with concrete protection had concrete protection around the outcrop, allowing the accumulation of water and physical protection from possible sources of contamination and siltation. Regarding the activities carried out around the springs, there was great differences in the type of environment: agricultural area with intensive agriculture development; weir, with fish farming activity; native forest; livestock area with bovine breeding; reforested area with concrete protection; reforested area with drainage protection. The evaluation of possible sources of contamination in the surroundings showed similarity in potential risks of water contamination by pesticides and fertilizers. The risk of exposure to waste from animal husbandry was found for the springs in the dam, native forest, livestock, and reforested area with concrete protection. Regarding possible contamination by effluent of sanitary origin, a potential risk was found for the source in the native forest due to its proximity to the bed of a stream, in upper grounds in part of the course, although within the native forest.

In the quantification of the macroscopic parameters, only the water spring in the weir did not show transparent water. This non-transparency is explained by the water outcrop submerged in the weir, with sedimented organic materials that affect the water color. The water of all springs presented no odor, indicating no presence of decomposing organic materials or domestic effluents.

The six water springs were used by humans, showing the strong interaction between rural properties and their water springs, with direct movement of people around the spring in the reforested area with concrete protection and development of economic activities around the springs in the agricultural and livestock areas. The springs in the native forest and reforested area with drainage protection were protected by drainage, not being used for watering animals or direct movement of animals. The spring in the agricultural area was far from households, which explains the absence of animals. The spring in the reforested area with concrete protection had a concrete protection and the surrounding area was fenced, restricting the access of animals. The spring in the weir was within a fish farming. The same situation was found for the spring in the livestock area, used to watering animals with the water that overflows from the protection through a concrete tube in the ground. Pieroni et al.

(2019) researched springs in the Corrego Ibitinga watershed, in Rio Claro, São Paulo, Brazil, and concluded that the use by humans and animals affect the conservation conditions of springs, directly interfering with water availability and quality, aggravating the effect of other impacts described by the IIAN method. Watercourses are formed from outcrops of springs and this flow can be directed to form a weir or be drained for conservation and/or recovery of springs, improving the water quality for human consumption, a procedure known as drained source (Rheinheimer, 2010; Romero, 2017).

The classification of water springs according to the Environmental Impact Index of Springs (IIAN method) showed that springs in the native forest, reforested area with concrete protection and reforested area with protection by drainage were in good preservation conditions. The native forest was important for the spring in the native forest, although it is two meters close to a road with circulation of vehicles. The spring in the reforested area with concrete protection was in a fragment of reforested vegetation and its preservation was maintained, despite the constant movement of people and easy access. The spring in the reforested area protected by drainage was close to a household and crops and in constant use by humans, but its preservation was not affected, possibly because it is in a forest preserved for over fifteen years and protected by drainage. The spring in the weir showed poor preservation conditions, with an outcrop submerged in a dam with fish farming and constant contact by humans and animals and absence of protection on one side. The spring in the livestock area also showed poor conservation conditions, mainly because it is in an area of dairy and beef cattle, without vegetation in the surroundings and constant use by humans. These springs could be even more compromises if there were no protection with concrete tubes, protecting the outcrop from erosion, burial, or even obstruction. The spring in the agricultural area showed reasonable preservation conditions, despite being in an area of intensive grain production, without presence of vegetation in its surroundings and protection.

The analysis of the Environmental Impact Index of the springs by the IIAN method is localized, portrays the environmental conditions at the time of evaluation, and shows changes recently occurred by visual characteristics of the water. Parameters such as "vegetation", "use" and "accessibility" reflect the effects that anthropogenic activities in rural areas have on the environment (Da Silveira et al., 2019). Riparian vegetation has important functions in water springs, contributing to retention of sediments, filtering, protection, containment of erosion processes, maintenance of water quality, and protection of biodiversity (Roberti et al., 2008; De Campos Macedo et al., 2020). The effects of vegetation around springs determines their existence; the lack of vegetation reduces infiltration conditions and favors surface runoff, causing silting of the outcrop, reduction in the contribution of the flow to surface watercourses, and even obstruction of the water spring over time (França et al., 2020).

The characterization of water springs in rural areas by the CENA method, combined with the preservation degree of the springs, enables a more comprehensive analysis regarding environmental integrity. The spring in agricultural crops presented a "reasonable" preservation degree by the IIAN method and by the CENA method, characterized by being diffuse, with permanent outcrop forming a watercourse along the crop. As it is not close to the property, the water has potential sources of contamination by inputs used for soybean, wheat, and other crops. As there is no vegetation in the surroundings, the source is vulnerable to erosion processes and soil contamination by pesticide and fertilizer residues (Khatri & Tyagi, 2015). This process may lead to silting and even obstruction of the water outcrop of the main spring and other smaller springs that make up the diffuse outcrop. Along the watercourse from the spring, the vegetative growth of some species was evident, which proves the contribution of nutrients to the spring (Oliveira et al., 2020). In view of these observations, it was evidenced that the integrity of the water spring is compromised.

The spring in the weir, presented a poor preservation degree by the IIAN method, however it is characterized by being localized by the CENA method, with permanent outcrop forming the weir used for the fish farm for local consumption. Therefore, the main potential source of contamination comes from the fish farming, followed by animal feces and residues of pesticides and fertilizers due to the presence of only one fragment of vegetation upstream of the outcrop site, with agricultural production in this area.

In view of the characteristics presented, the spring in the weir shows a risk in terms of compromising the integrity of the water spring. The spring in the native forest and in the native forest and protected by drainage presented good preservation conditions according to the IIAN method. The CENA method showed that the spring is characterized by being diffuse, with a permanent main outcrop and has drainage protection; however, the masonry structure is under poor conditions. After the occurrence of more intense rainfall, the water appears cloudy, indicating drainage failures with possible contamination. Therefore, possible polluting sources inherent to the surroundings of the native forest were identified, mainly residues of pesticides and fertilizers, residues from livestock activity, and traces of sanitary effluent. The evidences that characterized the spring in the native forest showed a risk of compromising the integrity of the water spring.

The water spring in the livestock area presented poor preservation conditions according to the IIAN method, due to absence of vegetation, use by humans and animals, and easy access. According to the CENA method, it is characterized by being localized, with a permanent outcrop and protection by concrete tubes from the point where the water emerges from the rock, with an upper opening that allows the water to leak to the surroundings. The water has sensorially perceptible mineral characteristics and shows potential sources of contamination by residues of pesticides/fertilizers and cattle farming activities, such as animal waste. The outcrop is inside tubes, but part of the water spills over to the sides of the protection, contributing to the formation of a wet area around it. The water that overflows serve to watering animals, with an imminent risk of contamination and carrying of materials from the upstream areas during rainfalls. The surrounding area is composed of natural pastures with a low density of cattle, and a protection of the outcrop with concrete pipes, which may not significantly affect water quality, but may compromise other ecosystem services, such as biodiversity (De Mello et al., 2020). Similar conditions were reported by Roberti et al. (2008), who found presence of forest-livestock system in spring areas. Calheiros et al. (2004) expressed concern about animal waste that can compromise the quality of surface and underground water, as it contains organic compounds of high energy content, with macro and micronutrients. In addition, they offer risks of contamination to humans and animals by pathogenic agents (Khatri & Tyagi, 2015). Another worrying factor is bovine diseases, such as tuberculosis, brucellosis, and foot-and-mouth disease, which can contaminate humans, using water as a vehicle (Roberti et al., 2008). Therefore, animals should be kept far from water springs because, eve when they have no access to the water, their waste can contaminate the surroundings, especially during rainy periods. Thus, it appears that there is a risk of compromising the environmental integrity of this spring.

The water spring in a fragment of reforested area with concrete protection presented good preservation conditions by the IIAN method and was characterized as localized by the CENA method, with outcrop at the base, in the downhill area, and has concrete (brick/cement) protection. Around the fragment of reforested vegetation, there is a weir upstream with a submerged source, with no vegetation in the surroundings and presence of erosion processes on the sides of the weir. Agricultural and livestock activities predominate on the land at the upper level near the weir and spring. Evidences of changes in spring flow due to the opening of the water reservoir in the weir was found, indicating an interconnection between the two water springs. Thus, potential sources of water contamination were listed, such as pesticide/fertilizer residues and waste from livestock activities. Thus, it appears that the presence of concrete protection around the outcrop is essential to protect the water spring from possible sources of contamination and silting and obstruction processes. However, due to the conditions presented in this water spring, there is a risk of compromising its environmental integrity.

The water spring in the reforested area with drainage protection presented good preservation conditions by the IIAN method and was classified as localized by the CENA method, with permanent outcrop protected by drainage and a potential source of water contamination from pesticide/fertilizer residues. The spring is drained at the base of a sloping area, with vegetation reforested for over fifteen years, contoured by a level curve to contain erosion processes and consequent dragging of soil and contaminants to the surroundings of the spring. Depending on the origin of the water table that supplies the water outcrop at the spring, contamination by waste percolation may occur. In the characterization analysis of its surroundings, it does not show evidence of a compromised site.

Final Considerations

The preservation conditions of springs in the agricultural area are compromised by several factors, mainly by the absence of vegetation, use by humans and animals, and accessibility. The impact of anthropogenic activities on the preservation degree of water springs is intensified when there is no vegetation in the surroundings.

The Brazilian environmental legislation considers the surroundings of water springs as an area of permanent preservation, guaranteeing environmental integrity and maintaining its ecosystem function. Four of the six water springs studied have protection with a physical structures, confirming the perception of farmers in caring for the source.

The use of the Environmental Impact Index of Springs (IIAN) together with the Characterization of the Surroundings of Water Springs (CENA) provide multidisciplinary and comprehensive subsidies to assess the integrity of these threatened ecosystems. Only one of the six water springs had preserved integrity; the others, despite the presence of native and/or reforested area in the surroundings, presented potential sources of contamination, showing the need for action plans to mitigate these effects.

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