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Assessment of the Macroscopic Aspects of Córrego das Pedras Sub-basin, in Ouro Verde de Goiás, Goiás, Brazil

Maria Andréia dos Santos Jaime

Centro Universitário de Anápolis - UniEVANGÉLICA, Brazil

Abstract: Hydrographic Basins can be defined as natural geographic units adequate for establishing use and management plans, monitoring and assessing human interference in the environment. In order to mitigate the environmental impacts caused by anthropic activities, and consequently to protect the water resources, the Payment for Environmental Services (PSA – initials in Portuguese) program was created, which goals include providing of financial payment to rural producers who contribute to the protection and recovery of springs found within their properties, thus generating benefits for the Hydrographic Basin and for society. Within this scenario, the Ribeirão João Leite Water Producer Project (PPARJL – initials in Portuguese) in the state of Goiás, created by the National Water Agency is a program that aims to remunerate all the environmental services rendered in Hydrographic Basins of great strategic relevance, being an effective mechanism for encouraging the adoption of practices and management actions aimed at improving quality and quantity of water resources. In this perspective, an environmental diagnosis of the springs located at the rural properties that have adhered to the PPARJL was prepared, in the Córrego das Pedras Sub-Basin (Serra do Sapato Arcado micro-basins), in the municipality of Ouro Verde de Goiás, state of Goiás, through a macroscopic assessment (visual), assessing several macroscopic parameters to identify the IIAN (Index of Environmental Impact on the Springs) and determine their degree of preservation. It was observed that 43.75% of the assessed springs had a degree of protection classified as poor, 37.50% were acceptable, 6.25% were good and 12.50% were excellent. The parameters that had the greatest positive contribution in the calculation of the IIAN were the absence of waste, floating matter, foams, oils and sanitary pollution, in 100% of the springs these parameters were absent. The parameters that had the greatest negative interference in the calculation of the IIAN were the access of animals within the springs and in the APP (initials in Portuguese for Permanent Protection Area), due to the lack of protection in those areas.

Key words: water producer, environmental assessment, springs, Ouro Verde de Goiás

1. Introduction

It is impossible to deny the relevance of water resources for creation and maintenance of life on the planet. Water is an indispensable resource for sustaining life, evidencing social, ecological and economic importance [1].

The culture that water was an infinite resource used to prevail in humanity, however, its scarcity, resulting from several factors, such as increased demand, poor distribution management, pollution and degradation of water reserves has forced society to reconsider this conception and replace the perspective of abundance with the culture of finitude of this resource.

In view of this new reality of finitude and scarcity of the resource, in addition to its indispensability for life subsistence, the need arose to search for positive anthropic attitudes, capable of avoiding or mitigating the negative effects of human activities on water resources, mainly those that cause negative impacts directly on springs and consequently on the Hydrographic Basins.

In this context, the rural area deserves special attention, since the practice of agricultural activities, as a rule, causes suppression of natural vegetation in the surroundings of the springs, silting, erosion and contamination of the groundwater.

Corresponding author: Maria Andréia dos Santos Jaime, Master; research areas/interests: environmental sciences. E-mail: m_andreia_jaime@yahoo.com.br.

In order to curb the environmental impacts caused by these anthropic activities, and consequently, to protect the water resources, the Payment for Environmental Services (PSA) program was created, which goals include providing financial payment to rural producers who contribute to the protection and recovery of the springs found within their properties, thus generating benefits for the Hydrographic Basin and for society.

Hydrographic Basins can be defined as natural geographic units adequate for establishing use and management plans, monitoring and assessing human interference in the environment. They represent systemic units that allow the identification and understanding of the interconnections of energy flows and other factors involved in the production process, in order to make human activities compatible with environmental preservation [2].

There are several international PSA experiences related to water, Viega Neto (2008) [3] mentions some emblematic cases worth mentioning, such as the "Perrier-Vittel" PSA implemented in France; the "Corporação do Vale de Cauca" PSA implemented in Colombia, and the PSA implemented in New York for the recovery of the "Croton, Catskill and Delaware" Hydrographic Basins.

In Brazil, there are already ongoing projects at the national level, such as, for instance, the Water Conservation Project, in Extrema/Minas Gerais (MG); the Water Producer Project, in Espírito Santo (ES); the Pipiripau Project, in the Federal District (DF), the Oasis Project, in Apucarana/Paraná (PR); the Water and Forestry Producers Pilot Project – Guandu, in Rio de Janeiro (RJ); the Water Producer Project, in Balneário Camboriú/Santa Catarina (SC); the Living Water Source Program, in the municipality of Campo Alegre/Mato Grosso do Sul (MS); the Water and Soil Conservation Project, in the municipality of Rio Claro/Acre (AC); the Water Producer Program, in the municipality of Rio Verde/Goiás, and, finally, the Water Producer Program of Ribeirão João Leite, with a Pilot Project in the municipalities of Ouro Verde de Goiás and Nerópolis, both also located in the state of Goiás [4].

Within this outlook, the Ribeirão João Leite Water Producer Project (PPARJL), created by ANA (initials in Portuguese for National Water Agency), is a program that aims to remunerate all the environmental services rendered in Hydrographic Basins of great strategic relevance; it is an effective mechanism for encouraging the adoption of practices and management aimed at improving quality and quantity of water resources.

Ribeirão João Leite Hydrographic Basin (Fig. 1) was chosen for implementing the PPARJL, focusing on the recovery and conservation of springs, because it feeds a large water reservoir that supplies the municipality of Goiânia, state of Goiás and part of its metropolitan region and because it has been degraded by anthropic actions, besides the fact that there are conflicts of interest related to the use of water at those places. The Basin comprises part of seven municipalities: Goiânia, Anápolis, Teresópolis de Goiás, Campo Limpo de Goiás, Goianápolis, Nerópolis and Ouro Verde de Goiás; however, initially the program will only be implemented in two pilot units: in Córrego Bandeira Sub-Basin, located in Nerópolis, and in Córrego das Pedras Sub-Basin (Serra do Sapato Arcado micro-basins) located in Ouro Verde de Goiás, GO. These municipalities were chosen because they are considered the birthplaces of the springs, in the Basin [5].

The success of implementing programs aimed at water and soil conservation/recovery in the Hydrographic Basins mainly depends on the participation of rural landowners in the region, thus being relevant to know those producers' connection with the environment wherein they are inserted.

Hence, the *in loco* knowledge of the region associated with the study of the environmental characteristics of the landscape and the impacts on the soil, resulting from anthropic activities, are important in defining the strategies for environmental recovery of degraded areas.

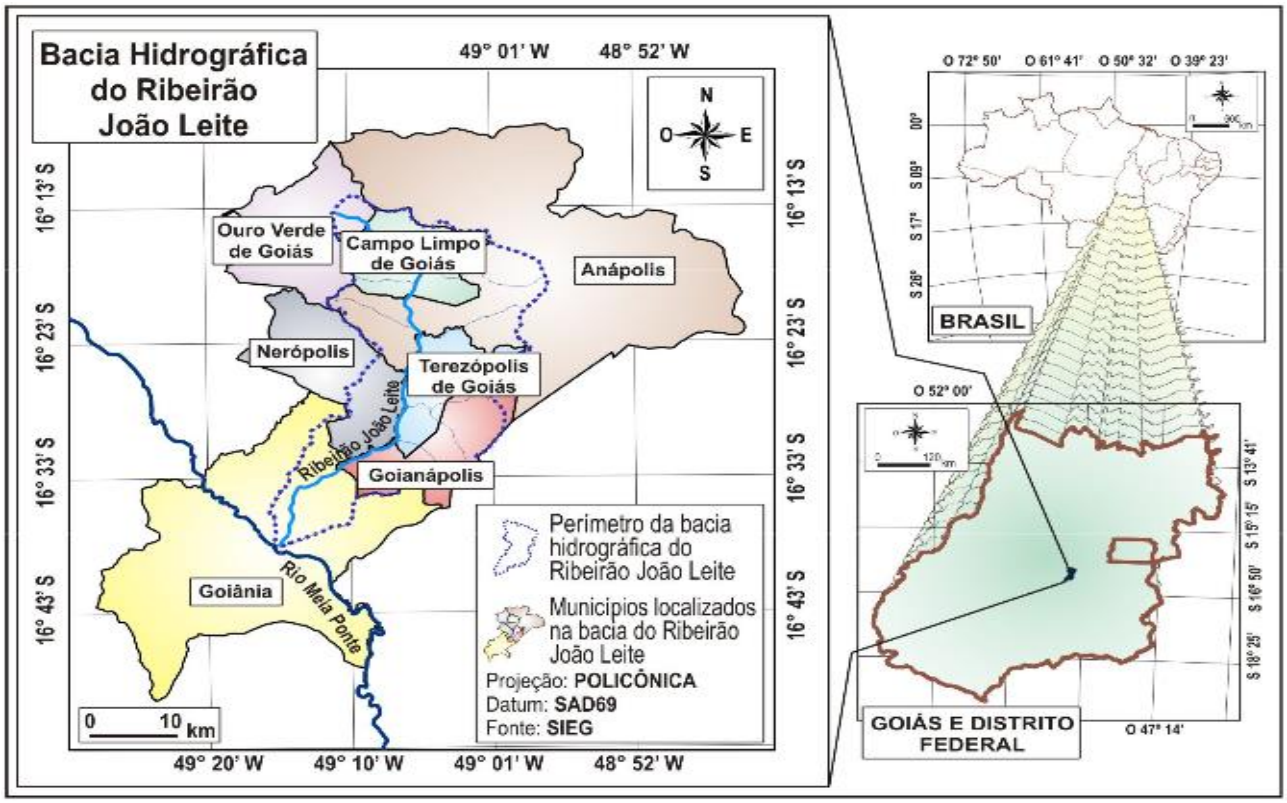

Fig. 1 Location map of the municipalities that comprise Ribeirão João Leite Hydrographic Basin, in the state of Goiás [2].

Several tools can be used to obtain this information, like preparation of environmental diagnoses, for instance. Gomes (2015) [6] confirms the importance and the need for preparing environmental diagnoses for the success of the proposal and implementation of projects aimed at the recovery and preservation of springs. Following this same line of reasoning, Oliveira et al. (2010) [5] states that "studies on the conservation status of springs and the structure of their riparian forests are extremely important to substantiate programs aimed for the restoration of those ecosystems".

In this perspective, an environmental diagnosis was prepared, assessing the springs of the rural properties that joined the PPARJL, in Córrego das Pedras Sub-Basin (Serra do Sapato Arcado micro-basins), in the municipality of Ouro Verde de Goiás, GO.

To identify the environmental impacts of Córrego da Pedras Sub-Basin springs (Serra do Sapato Arcado micro-basins), a visual macroscopic assessment was carried out. The macroscopic assessment of the springs is a simple, practical, didactic methodology with satisfactory results, which aims to verify in a qualitative and visual manner the degree of conservation of the springs, based on the identification of the actual negative environmental impacts, in order to mitigate them [7].

A similar assessment was made by Leal et al. (2016) [8], when presenting the characterization of Córrego Itanguá Basin springs, in Capão Bonito, SP, whereby he concluded that the macroscopic assessment used in his research proved to be efficient as a qualitative visual analysis of the condition of the springs and as a supplier of information to support actions aimed for water conservation in Capão Bonito National Forest, SP.

Springs can be defined as the outcrop of the underground water that will give rise to a source of accumulation water, or water courses [9]. They are the main source of quality water for rural communities,

where most of the times it is pure, crystalline, healthy and does not require treatment to be consumed. The springs are also responsible for supplying rivers and lakes, forming important water reserves, which is the most precious element of life on earth, meeting the basic needs of human beings, such as health, food production and maintenance of natural ecosystems [10].

The springs, also called mines, sources of water, water spouts are superficial manifestations of underground water, according to Valente; in the words of Gomes (2005) [11], they give rise to water courses, and most of them are located in mountainous regions and in headwater basins, which are small basins located at the edges of larger basins, almost always located in areas of greater declivity. According to the description presented by Mota and Aquino (2003) *apud* Vaz and Orlando (2012), springs play an essential role in maintaining the quality, quantity and in guaranteeing permanence of water in streams, brooks and rivers.

The diagnosis of the riparian forest was also carried out through a macroscopic visual assessment. The literature presents differences on the concept of riparian forest: there are authors who consider it as a synonym for gallery forest, lowland forest, vegetation or riparian woodland; and there are others who consider it as a type of forest vegetation, distinguishing it from gallery forest. Santos et al. (2017) [12], confirm that the riparian forests are types of plant cover, located on the banks of rivers, streams, lakes, water spouts (mines and springs) and other water bodies. And in terms of their importance, they claim that the riparian forests provide soil stability and control of erosion processes, acting as filters, retaining the arrival of nutrients, pesticides, pollutants and sediments that would be carried on to water courses, causing silting of rivers and changing the physical, chemical, biological characteristics, as well as the quantity and quality of the water bodies.

This research has adopted as a criterion the position that uses the term riparian forest, gallery forest, lowland forest and riparian woodland as synonyms; accordingly, the expression "riparian forest" will be used to refer to plant formation located on the banks of rivers, streams, lakes, dams and springs.

Concerning their importance, Ferreira et al. (2009) [13] point out that riparian forests have one of the most important functions in the environment, namely, maintenance of water quality, retaining waste, creating corridors for movement of the fauna, as well as plant dispersion and maintenance of the aquatic ecosystem. Other important roles played by riparian vegetation are its ability to recharge aquifers, conservation of the good water quality in the property as refuge for the wildlife, and maintenance of biodiversity [14].

2. Description of the Study Focus Area

The study focus area is Córrego das Pedras Sub-Basin (Serra do Sapato Arcado micro-basins), in Ouro Verde de Goiás, GO (Fig. 2). The history of this City began with the foundation of Fazenda Boa Vista do Matão, in the 19th Century. Municipal Law no. 75, dated 07/12/1948, created the district named Matão, which was subordinate to the Municipality of Anápolis. Later on, it was raised to the category of municipality, being named Ouro Verde de Goiás, by State Law no. 4.592, dated 10/01/1963, separating from Anápolis (IBGE 2017). This municipality has an estimated population of 3.971 dwellers, with a demographic density of 19.32 inhabitants/km², with a territorial unit of 208.769 Km² (IBGE 2017).

The springs of Ribeirão João Leite are located in the municipality of Ouro Verde de Goiás, in Serra do Sapato Arcado, at an altitude of 870m, the Northern divider of the waters drained in this Hydrographic Sub-Basin [15].

3. Material and Methods

The research carried out was exploratory and descriptive, with a quantitative and qualitative approach, based on bibliographic references, documents,

bibliographic surveys, semi-structured interviews, photographic records, audios and field study.

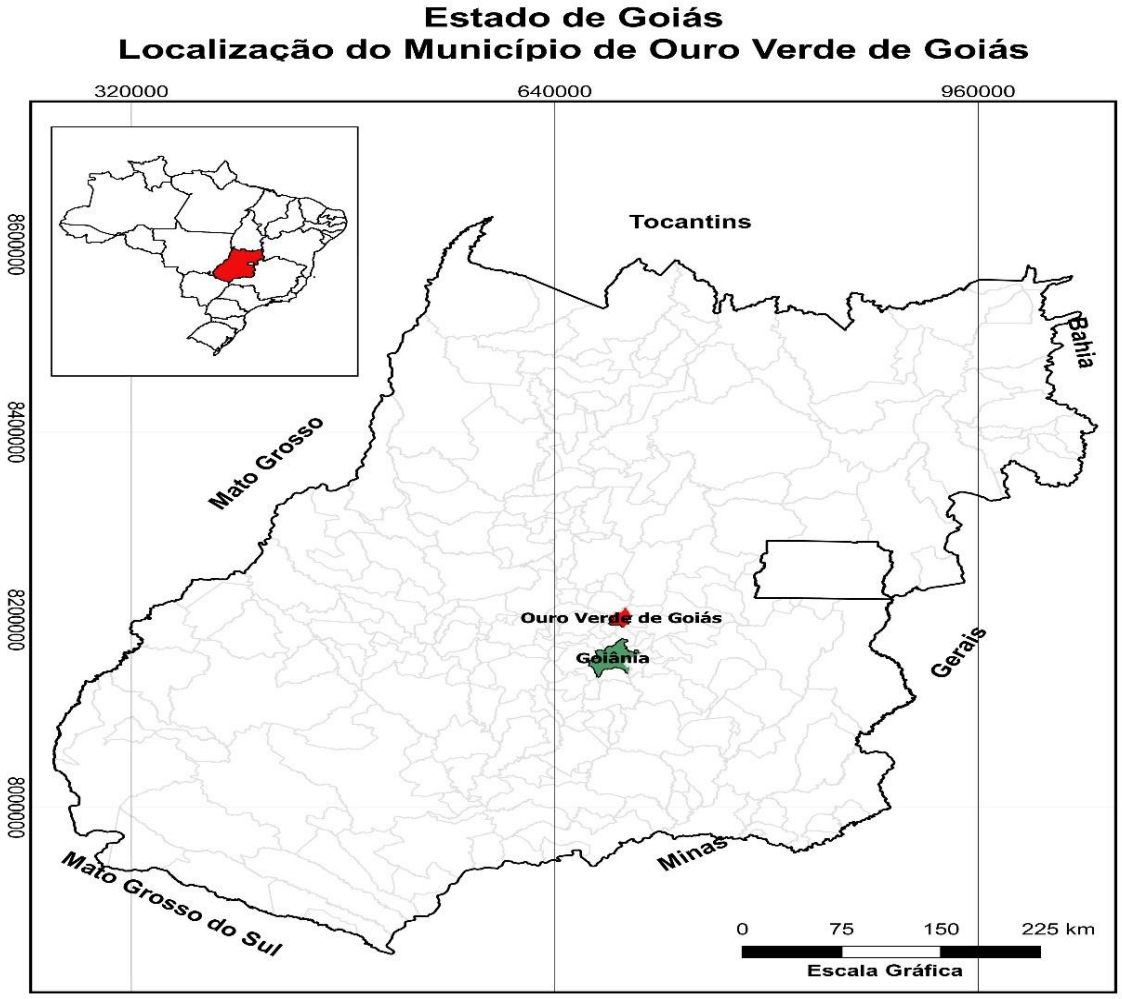

Fig. 2 Location of the municipality wherein the research was carried out.

Along the path to the springs, the landscape and the macroscopic parameters used for development of the research were observed, which were recorded with a 14.1 MPX SONY Cybershot model digital camera.

The research universe covered one hundred percent (100%) of the rural properties that joined the PPARJL, in Córrego das Pedras Sub-Basin (Serra do Sapato Arcado micro-basins), in the municipality of Ouro Verde de Goiás, GO, totaling fifteen (15) properties; the properties were identified in the research by letter "P", followed by numbers 1 to 15 and they located at the coordinates indicated in Table 1.

To identify the environmental impacts of Córrego da Pedras Sub-Basin springs (Serra do Sapato Arcado micro-basins), a visual macroscopic assessment was carried out, in order to diagnose the conservation degree of the springs and their surroundings, focusing on the observation of the landscape and degree of anthropic degradation. The soil use and occupancy study was used as auxiliary tool. The environmental impacts were assessed based on the interpretation of the Index on Environmental Impact on the Springs — IIAN, presented by Gomes et al. (2005) [11] and Felippe e Magalhães Junior (2012) [7], who used the Water Quality Assessment Guide (2004) and the Classification of the degree of impact on the spring (2004) as the grounds for that assessment. The IIAN results from the sum of the scores reached in each parameter.

The eleven (11) parameters (Table 2) used in the analysis were chosen taking into account the objectives proposed for this research, and received the classification of bad, medium and good, with the respective assignment of value 1 for the bad feature, 2 for the medium feature and 3 for the good feature. Thus, the score ranges from 11 points — when all the parameters are considered bad — to 33 points — in case all the parameters are good [7, 11].

Table 1 Coordinates of the fifteen (15) properties studied, located in Córrego das Pedras Sub-Basin, (Serra do Sapato Arcado micro-basins), Ouro Verde de Goiás, GO.

P	COORDINATES
P.1	UTM 22 SOUTH – DATUM WGS84- X (E) 696835; Y(N) 8206448
P.2	UTM 22 SOUTH – DATUM WGS84- X(E) 696647; Y(N) 8203640
P.3	UTM 22 SOUTH – DATUM WGS84- X(E) 695837; Y(N) 8203910
P.4	UTM 22 SOUTH – DATUM WGS84- X(E) 697127; Y(N) 8206600
P.5	UTM 22 SOUTH – DATUM WGS84- X(E) 696803; Y(N) 8203530
P.6	UTM 22 SOUTH – DATUM WGS84- X(E) 697395; Y(N) 8204244
P.7	UTM 22 SOUTH – DATUM WGS84- X(E) 696756; Y(N) 8203528
P.8	UTM 22 SOUTH – DATUM WGS84- X(E) 697926; Y(N) 8205855
P.9	UTM 22 SOUTH – DATUM WGS84- X(E) 695989; Y(N) 8206035
P.10	UTM 22 SOUTH – DATUM WGS84- X(E) 696288; Y(N) 8204297
P.11	UTM 22 SOUTH – DATUM WGS84- X(E) 694136 ; Y(N) 8204707
P.12	UTM 22 SOUTH – DATUM WGS84- X(E) 695002; Y(N) 8204223
P.13	UTM 22 SOUTH – DATUM WGS84- X(E) 696610; Y(N) 8205781
P.14	UTM 22 SOUTH – DATUM WGS84- X(E) 696404; Y(N) 8204683
P.15	UTM 22 SOUTH – DATUM WGS84- X(E) 697821; Y(N) 8203831

Table 2 Macroscopic parameters and score [10].

Parameters	Bad (1 point)	Medium (2 points)	Good (3 points)
Vegetation	Degraded	Disturbed	Preserved
Protection	Absence	Presence, with access	Presence, without access
Waste	A lot	Few	Absence
Animal Access	Presence	Evidence	Absence
APP Protection	Absence	Less than 50 m	More than 50 m
Floating Matter	A lot	Few	Absence
Foams	A lot	Few	Absence
Oil	A lot	Few	Absence
Sanitary Pollution	Presence	Evidence	Absence
Anthropic Use	Presence	Evidence	Absence
Spring proximity to houses/livestock breeding	Less than 50m	More than 50m	Non-observed

The following parameters were observed in the macroscopic analysis of the springs:

- Vegetation (preservation): Pinto et al. (2004) [16] classifies the springs according to the degree of vegetation preservation as preserved (when there is at least 50 m of natural vegetation and not evidencing signs of disturbance or degradation), disturbed (when there is not 50 m of natural vegetation in their surroundings, but they are in a good conservation condition, although being partially occupied by pasture or agriculture),

and degraded (when there is a high degree of disturbance, little vegetation, compacted soil).

- Protection (fence): existence of some type of protection around the spring.
- Presence of waste around the spring.
- Direct access of animals in the APP: evidence of use by animals, presence of footprints, feces, burrows, skeletons.
- APP (50 m radius surrounding the spring).
- Floating matter: presence of objects on the water surface.
- Foams: presence on the water surface.
- Oils: presence on the water surface.
- Evidence of sanitary pollution: observation of flows from houses or corrals or yet other livestock breeding, falling into the APP of the spring.
- Anthropic use: evidence of use of the spring by humans (pipeline, diversions, animal watering).

Springs proximity with houses or livestock breeding (less than 50 m: observed, more than 50 m: not observed).

After summing up the points obtained in each parameter, the springs were classified in terms of the degree of protection (Table 3), as Class A (excellent: 31 to 33 points), Class B (good: 28 to 30 points), Class C (acceptable: 25 to 27 points) and Class E (awful: below 22 points) [7, 11].

Table 3 Classification of the springs in terms of the degree of preservation, according to the IIAN.

Class	Degree of preservation	Final Score
A	Excellent	31 to 33
B	Good	28 to 30
C	Acceptable	25 to 27
D	Bad	22 to 24
E	Awful	Below 21

4. Results and Discussions

Property P.01 has a 7.20 ha total area, divided as follows: 0.09 ha of APP; 1.39 ha of legal reserve; 5.22 ha of productive area, used for cassava, banana and yam farming; and 0.50 ha of area used for internal roads, main house and yard.

The survey observed that the riparian forest around the spring is protected by a fence, the APP has less than50 m protection radius and plant cover around the spring is in good condition, however, part of the fence has fallen apart, serving as access to the cattle, there were recent marks of trampling, although no animals were seen at the time of the assessment. The presence of animals in the surroundings of springs is detrimental, since it causes water contamination, due to their feces and urine and results into compacting of the soil. No waste, floating matter, foam or oil was found, nor evidence of sanitary pollution in the assessed spring, which is positive. It was found that a mini well was built in the riparian forest, with approximately one (1) square meter, where a small water tank was placed to irrigate the crops, characterizing a negative anthropic intervention. The APP is not close to any house or livestock breeding. The APP does not have a firebreak system; the internal road was not built applying soil conservation techniques; and at the place where cassava is grown, there are no terraces or rainwater containment techniques. After scoring the parameters, the assessed spring reached IIAN 27, falling into the “C” class, which has an acceptable degree of preservation.

Property P.02 has a 4.89 ha total area, divided as follows: 0.04 ha of APP; 0.16 ha of legal reserve; 4.09 ha of productive area, used for yam farming, with a small vegetable garden and pasture; and 0.60 ha of area for internal roads, main house and yard.

The spring is located in an area with anthropogenic vegetation, formed by brachiaria grass, with the presence of animals; it has no fence or plant cover; and in its surroundings there is no riparian forest. No waste, floating matter, foam or oil was found, nor evidence of sanitary pollution in the assessed spring, which is positive, the spring is more than 50 m distant from the house; the APP does not have a firebreak system; the internal road was not built applying soil conservation techniques; and at the cultivated place, there are no

terraces or rainwater containment techniques. After scoring the parameters, the assessed spring reached IIAN 22, falling into the "D" class, which has a poor degree of preservation.

Property P.03, has a 15.26 ha total area, divided as follows: 0.27 ha of APP; 3.05 ha of legal reserve; 11.54 ha of productive area, used exclusively for pasture; and 0.40 ha of area for internal roads, main house and yard.

The spring is located in an anthropized area, formed by brachiaria grass, with the presence of animals, at the time of the assessment; it has no fence or natural plant cover; and in its surroundings there is an unprotected water course, in the open air and devoid of riparian forest, which is used for the animal watering, the spring is more than 50 m distant from the house. Although there was no waste, floating matter, foam or oil, nor evidence of sanitary pollution in the assessed spring, which is positive, the APP does not have a firebreak system; there is no terracing in areas intended for pasture or rainwater containment techniques; and the internal road was not built applying soil conservation techniques. After scoring the parameters, the assessed spring reached IIAN 22, falling into the "D" class, which has a poor degree of preservation.

Property P.04 has a 79.55 ha total area, divided as follows: 2.98 ha of APP; 16.37 ha of legal reserve; 58.64 ha of productive area, used for guariroba farming and pasture; and 1.56 ha of area used for internal roads, main house and yard, and for the farm caretaker's house. Its main economic activity is livestock and guariroba farming.

The assessed spring, which is considered by DEMA as the main one in the Ribeirão João Leite Hydrographic Basin, has a protection fence around it, with an area larger than 50 m in radius and preserved natural plant cover (Fig. 4). The APP is not close to any house or livestock breeding. The owners started efforts for reforesting the riparian forest of this spring in 2003 (Fig. 3), after guidance issued by DEMA, and currently there is evidence that the riparian forest is restored and

Fig. 3 Registration of the beginning of the restoration work on the riparian forest, in 2003, at property P.4, in Córrego das Pedras (Serra do Sapato Arcado micro-basins) in Ouro Verde de Goiás, GO. (A) surrounding of the spring, covered with brachiaria grass. (B) mastic piles used in the fencing. (C) seedlings that have been planted. (D) surrounding of the spring with minor erosions caused by livestock trampling. (E) banana seedlings planted to contain erosion. (F) evolution of seedling growth.

Fig. 4 Registration of the riparian forest, in 2017, and the surrounding of the spring, with indications of recovery at property P.4. (A) evidence of de-compacted soil, vegetation recovered. (B and C) growth of bushes within the riparian forest. (D) fruit trees that were planted within the riparian forest. (E) area close to the spring, soaked soil. (F) presence of ferns typical of preserved areas. (G) water flow within the riparian forest.

the spring is protected (Fig. 4). In the tree trunks of the riparian forest, which is also fenced, it is possible to observe the presence of lichens, a certain indicator of good air quality. The APP has firebreak system to prevent fire, and it is noteworthy the abundance of water in the area (Fig. 4G). PPARJL's work in this area will be limited to fencing the water course upstream the riparian forest. No waste, floating matter, foam or oil, nor evidence of sanitary pollution in the assessed spring. There are terraces and contour lines to contain rainwater, the roads were not built applying soil conservation techniques. After scoring the parameters, the assessed spring reached IIAN 33, falling into the "A" class, which has an excellent degree of preservation.

Property P.05 has a 70.48 ha total area, divided as follows: 1.73 ha of APP; 1.48 ha of legal reserve; 66.26 ha of productive area, where part of the land is used for citrus farming and the rest for livestock; and 1.01 ha of area used for internal roads, main house and yard. This property has previously benefited from environmental preservation work, carried out by the owner, on his own, consisting of fencing of some springs, but there are still unprotected springs.

The assessed spring has no natural plant cover (it is covered with brachiaria grass) and there is no riparian forest in its surroundings. At the time of the assessment, the spring had no flow, but there were traces of previous flow, in view of the animal trampling marks. Near the spring, there is a water course, not protected

Fig. 5 (A) Registration of the surroundings of the spring, at property P.04, in 2003. Spring without the presence of riparian forest. (B) Photo from 2017, spring protected and surrounded by a large riparian forest.

by fences, within the pasture area, which is used for the animal watering. The APP is not close to any house or livestock breeding. No waste, floating matter, foam or oil was found, nor evidence of sanitary pollution in the assessed spring, which is positive, the APP has no firebreak system; the internal road was not built applying soil conservation techniques; and there are no terraces or contour lines to contain rainwater and erosion at the sites assigned for citrus farming and livestock. After scoring the parameters, the assessed spring reached IIAN 24, falling into the "D" class, which has a poor degree of preservation.

Property P.06 has a 38.09 ha total area, divided as follows: 1.22 ha of APP; 1.81 ha of legal reserve; 33.96 ha of productive area, used for banana farming and pasture; and 1.10 ha of area used for internal roads, main house, yard, and a dam. Its main economic activity is livestock breeding and banana farming. This property has previously benefited from environmental preservation works, carried out by the owner, on her own, consisting of the fencing of some springs, but there are still unprotected springs.

The surrounding of the assessed spring has a part with riparian forest, not fenced, and another part without riparian forest and covered with brachiaria grass, with the presence of erosion. No waste, floating matter, foam or oil was found, nor evidence of sanitary pollution in the assessed spring, which is positive. The APP is not close to any house or livestock breeding, the APP has no firebreak system; there is no terracing in the productive areas to contain rainwater; the internal road was not built applying soil conservation techniques. After scoring the parameters, the assessed spring reached IIAN 26, falling into the "C" class, which has an acceptable degree of preservation.

Property P.07 has a 1.9 ha total area, divided as follows: 0.13 ha of APP; 0.38 ha of legal reserve; 1.22 ha of productive area, which includes an orchard and pasture; and 0.17 ha of area used for internal roads, main house and yard. The property is used for leisure, without any type of economic activity. The APP does not have a firebreak system, and the road was not built using soil conservation techniques. At the back of the property there is a large water course (stream). The owners, on their own, made an effort to contain the erosion that was compromising the water course and the springs that surround the APP. The riparian forest is not protected by a fence, but the plant cover around the analyzed spring is in good condition. However, despite the owners' attempts to contain the erosion, their efforts were not enough, since there are buried springs and others on the verge of being buried. No waste, floating matter, foam or oil was found, nor evidence of sanitary pollution in the assessed spring, which is positive, but the internal road was not built applying soil conservation techniques. After scoring the parameters, the assessed spring reached IIAN 24, falling into the "D" class, which has a bad degree of preservation.

Property P.08 has a 145.85 ha total area, divided as follows: 10.59 ha of APP; 7.57 ha of legal reserve; 127.11 ha of productive area, with a portion of 11.16 ha used for cassava farming, and another one, of 115.95 ha used for pasture; and an area of 0.58 ha used for internal roads, main house, yard and dam. It has six (6) springs, which need to be recovered. No waste, floating matter, foam or oil was found, nor evidence of sanitary pollution in the assessed spring, which is positive, the APP does not have a firebreak system; and the internal road was not built applying soil conservation techniques. The spring is not fenced, which, in the specific case, is not actually detrimental, since it is located inside a grotto with difficult access, whose obstacle naturally protects it from the presence of bovine and equine cattle, thereby resulting into preservation of the riparian forest and native vegetation. After scoring the parameters, the assessed spring reached IIAN 32, falling into the "A" class, which has an excellent degree of preservation.

Property P.09 has a 25.54 ha total area, divided as follows: 1.29 ha of APP; 2.58 ha of legal reserve; 21.22 ha of productive area, used for mango farming and

pasture; and 0.45 ha used for a dam, internal roads, main house and yard. The property has already benefited from environmental preservation works, previously carried out, consisting of fencing of the springs, done by the owner, on his own. Part of the riparian forest is fenced, but there is evidence of access by animals. The APP is fenced by a radius larger than 50 m, but natural vegetation is being invaded by the presence of brachiaria grass. No waste, floating matter, foam or oil was found, nor evidence of sanitary pollution in the assessed spring, which is positive, the APP does not have a firebreak system; and the internal road was not built applying soil conservation techniques. After scoring the parameters, the assessed spring reached IIAN 29, falling into the "B" class, which has a good degree of preservation.

Property P.10 has an 18.30 ha total area, divided as follows: 0.12 ha of APP; 2.32 ha of legal reserve; 15.50 ha of productive area, used for cassava farming and pasture; and 0.36 ha of area used for a dam, internal roads, main house and yard. The property is leased to third parties, who explore agricultural activities (cassava and corn crops) and livestock at the site. Part of the riparian forest of the assessed spring is fenced, by a radius smaller than 50 m, the fence is in poor conservation condition, with fallen props and wires, allowing the access of animals, no waste, floating matter, foam or oil was found, nor evidence of sanitary pollution in the assessed spring; the APP does not have a firebreak system; the internal road was not built applying soil conservation techniques; there is evidence of deforestation of part of the riparian forest. After scoring the parameters, the assessed spring reached IIAN 24, falling into the "D" class, which has a poor degree of preservation.

Property P.11 has a 38.29 ha total area, divided as follows: 0.59 ha of APP; 0.74 ha of legal reserve; 36.11 ha of productive area, used exclusively for livestock activities; and 0.85 ha of area used for a large dam, internal roads, main house and yard. The property has four (4) springs, where restoration and preservation works will be implemented. Part of the riparian forest is fenced by a radius smaller than 50 m, and its natural vegetation is being invaded by the presence of brachiaria grass; the APP is less than 50 m distant from the house; no waste, floating matter, foam or oil was found, nor evidence of sanitary pollution; the APP does not have a firebreak system; the internal road was not built applying soil conservation techniques. After scoring the parameters, the assessed spring reached IIAN 26, falling into the "C" class, which has an acceptable degree of preservation.

Property P.12 has a 184.00 ha total area, divided as follows: 7.26 ha of APP; 14.15 ha of legal reserve; 2.50 ha of swamp; 157.29 ha of productive area, used for cassava, banana, and eucalyptus farming, vegetable garden and pasture; and 2.80 ha of area used for internal roads, main house and yard. The property has previously benefited from environmental preservation works, consisting of building rainwater collection basins, opening of contour lines, and fencing of some springs, done by the owner, on his own. Among the rural properties visited by the researcher, this is the one with the larger number of springs and abundance of water, which emerges everywhere, even in the holes that were dug by PPARJL to fence the unprotected springs. Part of the APP is fenced by a radius smaller than 50 m, the assessed spring is located in the part of the APP that is unprotected and devoid of natural vegetation, no waste, floating matter, foam or oil was found, nor evidence of sanitary pollution; and the APP has firebreak system at some places, which is positive; its natural plant cover is being invaded by brachiaria grass; there are six (6) unprotected springs (PPARJL has already started to fence them); there are parts of the APP without firebreak system; the internal roads were not built applying soil conservation techniques. After scoring the parameters, the assessed spring reached IIAN 27, falling into the "C" class, which has an acceptable degree of preservation.

Property P.13 has a 45.85 ha total area, divided as follows: 1.66 ha of APP; 12.28 ha of legal reserve;

31.71 ha of productive area, used for banana farming and pasture; and 0.20 ha of area used for internal roads, main house and yard. Its three (3) springs were assessed, which, for purposes of distinction, were named spring 1, spring 2 and spring 3. Spring 1 and 3 have remnants of riparian forest, they are not protected by fences, there are signs of access of animals and the APP is not protected. Spring 2 is devoid of riparian forest and natural vegetation, it is buried by trampling of cattle. No waste, floating matter, foam or oil was found, nor evidence of sanitary pollution in the three assessed springs. A large water course inside the property has gone dry; the APP does not have a firebreak system; and internal roads were not built using soil conservation techniques. After scoring the parameters of springs 1 and 3, both reached IIAN 26, falling into the "C" class, which has an acceptable degree of preservation and spring 2 reached IIAN 23, falling into the "D" class, which has a poor degree of preservation.

Property P.14 has a 51.90 ha total area, divided as follows: 4.49 ha of APP; 12.04 ha of legal reserve; 33.77 ha of productive area, used exclusively for pasture; and 1.60 ha of area for internal roads, main house and yard. The property has several springs that have been protected and has previously benefited from environmental preservation works, done by the owner, on her own, comprised of fencing of some springs, opening contour levels in the pastures. Although there was no waste, floating matter, foam or oil, nor evidence of sanitary pollution in the assessed spring, their soil is very compacted by trampling of animals, which in addition to leaving their feces around and inside them, are also directly responsible for their silting and for the erosion found in their respective areas. The APP is not protected and there is a small remnant of riparian forest and natural plant cover in its surroundings; the APP does not have firebreak system in some parts; and the internal road was not built applying soil conservation techniques. After scoring the parameters, the assessed spring reached IIAN 25, falling into the "D" class, which has a poor degree of preservation.

Property P.15 has an 80.05 ha total area, divided as follows: 13.15 ha of APP; 5.89 ha of legal reserve; 60.20 ha of productive area, used for banana, orange, vegetable farming and pasture; and 0.81 ha of area used for internal roads, main house and yard. As there are no springs on this property, the PPARL will only implement works for fencing the water course that passes inside it. The APP does not have a firebreak system, and the internal road does not have soil conservation techniques.

Fig. 6 globally registers the area analyzed in the research, the riparian forests and the surroundings of the springs, showing the positive and negative anthropic aspects.

Fig. 7 represents the sum of the IIAN final score calculated for each spring and the final classification of its degree of preservation, according to Table 3b.

5. Final Considerations

The research observed that 43.75% of the assessed springs have a degree of protection classified as bad, 37.50% as acceptable, 6.25% as good and 12.50% as excellent. Most springs had a poor degree of protection. The parameters that had the greatest positive contribution in calculation of the IIAN were the absence of waste, floating matter, foams, oils and sanitary pollution, in 100% of the springs these parameters were absent. On the other hand, the parameters that had the greatest negative interference in calculation of the IIAN were the access of animals within the springs and in the APP, due to the lack of protection in those areas. Most properties do not have firebreak systems in the APP's; the internal roads were not built applying soil conservation techniques; and in places where farming activities are developed, there are no terraces or contour lines for rainwater containment. The data from the environmental diagnosis show that although the landowners of the region are sensitive to the environmental affairs and have good intentions, they do not have the technical knowledge to effectively

Fig. 6 Registration of springs and riparian forest assessed in the Córrego das Pedras Sub-Basin, Ouro Verde de Goiás, state of Goiás. (A) Surrounding of the spring on Property P.14. (B) watercourse that went dry on Property P.14. (C) Riparian forest on Property P.08. (D) spring assessed on Property P.08. (E) spring assessed on Property P.13. (F) spring assessed on Property P.06. (G) spring assessed on Property P.09. (H) spring assessed on Property P.13. (I) spring assessed on Property P.13. (J) stream bed recovered on Property P.07. (k) spring assessed on Property P.07. (L) unprotected water course on Property P.05. (M) riparian forest on Property P.06. (N) surrounding of the spring on Property P.02. (O) surrounding of the spring on Property P.02. (P) riparian forest on Property P.10 with the presence of animals. (Q) surrounding of the spring on Property P.06. (R) Unprotected water course on Property P.02. (S) surrounding of the spring on Property P.12. (T) spring course of Property P.12. (U) spring devoid of riparian forest on Property P.03. (V) unprotected water course on Property P.03. (X) practice of negative anthropic activities in the spring on Property P.01. (X.1) riparian forest on Property P.04. (X2) water flow within the riparian forest on Property P.04. (X3) riparian forest of the assessed spring on Property P.01. (X4) surrounding of the spring on Property P.11. (X5) surrounding of the spring on Property P.14.

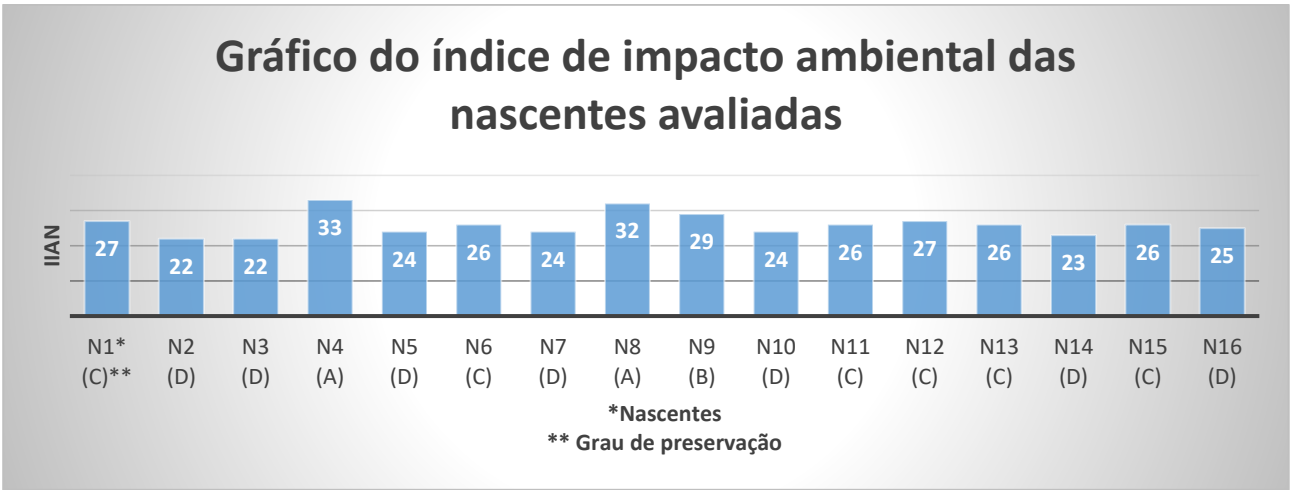

Fig. 7 Graph on the index of environmental impact on the assessed springs.

* Springs,** Degree of preservation

put in place activities aimed at the conservation and protection of water resources; nor do they have a comprehensive view of the Water Producer Program.

In view of these conclusions, the suggestion is for the government authorities and private entities interested in implementing PSA programs in rural properties to adopt as a prerequisite, the offering of activities related to Environmental Education, which is the appropriate educational action to provide knowledge, clarification of concepts in adequate language, and development of skills/capabilities needed for the proper conservation of the environment.

Another suggestion is the creation of Hydrographic Basin committees in all Hydrographic Sub-Basins subjected to implementing of PSA programs, since an environmental management space is required, at the local level, capable of being a link between rural producers, the private sector and government agencies.

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