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Macroscopic analyses and evaluation of environmental quality in urban springs of Divinópolis-MG

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Abstract. This study aimed to evaluate the environmental quality of the springs in the urban area of Divinópolis/MG, searching for identifying the main causes of negative impact, the level of interference and quantification of macroscopic parameter. Therefore, the environmental impact on the springs were evaluated from the interpretation of the Índice de Impacto Ambiental em Nascentes – IIAN (Index of Environmental Impact on Springs – IEIS). 22 springs were analyzed, being two of them were impossible to be evaluated due to burying. In general, the results showed that the springs found themselves in an advanced environmental degradation, being, most of them, in conservation classes as follows: “Bad” (n=12) and “very bad” (n=4). The other ones were considered “good” (n=1) and “reasonable” (n=3). None of them were considered “Great”. It was observed that the lack of protection in the springs area (n=20), the short distance from houses (n=18) and vegetation degradation (n=18) were the main checked parameters. Such results highlight the lack of environmental care and lack of inspection in these springs, making necessary a intervention in these sources, making its recovery and conservation possible.
Keywords: Macroscopic evaluation. Environmental impact. Water sources. Environmental quality.

Introduction

Water is a primordial element in maintaining the environmental balance, being one of the most important natural resources, indispensable to the physiological processes of organisms (PINTO et al, 2004; GOMES et al, 2005; FELIPPE, 2009). Currently, the use and exploitation of environmental resources improperly has resulted in degradation and pollution of water bodies. Frequently occurring, the loss of water quality is attributed to pollution caused by different anthropogenic fountain, such as domestic effluents, industrial effluents, urban and agricultural surface water flows, concomitantly with the physical and biological degradation of spring (FELIPPE et al, 2011; MALAQUIAS; CÂNDIDO, 2013).

The springs are the result of processes that involve from hydrogeological dynamics to geomorphological and anthropogenic aspects of the landscape. Conceptually, the spring is an environmental system in which the groundwater naturally emerges in a temporary or perennial way, integrating to the surface drainage network (FELIPPE, 2009; SPRINGER e STEVENS, 2009). Thus, the springs are responsible for surface waters, constituting an important system of maintenance of the hydrological and environmental balance of the hydrographic basins (FELIPPE e MAGALHÃES JÚNIOR, 2012).

The need to protect the springs is not focused on rural areas, but also on urban / metropolitan spaces. The places that have springs are considered by the current Forestry Code - Law nº 12.651 (BRAZIL, 2012), areas of environmental preservation, so that there must be preservation of the native vegetation at least 50 meters around the springs, in any topographic situation. Moura (1994) reported that the specific legislation does not guarantee the protection of the springs over time in Brazilian urban areas due to the lack of legal apparatus and the speculative and real estate interests of the urban space.

Among the cities of the center-west of Minas Gerais, Divinópolis stands out due to the high rates of population growth, urbanization and industrialization, currently having a population of 213,016 inhabitants (IBGE, 2010). The city's main source of water supply is the Itapecerica River, which flows into the Pará River, one of the main tributaries of the São Francisco River. However, the municipality has not cataloged its sources in the urban area, which may impact the flow of the Itapecerica River. However, according to Vilela et al. (2013), hospitals, food industries and part of the urban population still use water from springs and artesian wells, whose quality information is non-existent or outdated.

Due to the scarcity of information on the number, location and environmental conditions of the springs of the urban area of the municipality, this study aimed to identify the main springs, to perform the georeferencing and to analyze some parameters of environmental value in those springs. This information will be able to subsidize solutions with the public administration, as well as to promote the recovery and preservation of the springs, making the population aware of environmental education.

Methods

The study evaluated the environmental quality of 22 springs of the urban perimeter of Divinópolis - MG, through its macroscopic analysis. The municipality is located in the Center-West region of Minas Gerais and has an area of 716 km², equivalent to 0.12% of the state area, with an urban area of 192 km² and a population of 213,016 inhabitants, according to IBGE (2010). The municipality is bathed by the rivers Pará and Itapecerica, which cuts the city. The basin of the Pará River comprises the basin of the São Francisco River, of southern tropical regime, covering 16 municipalities, with an area of 234,347 km².

The data were collected in the months of June and July 2015. The sources were selected according to their environmental relevance, and the location was obtained through information collected from residents and environmentalists. Figure 1 shows the spatialization of these springs.

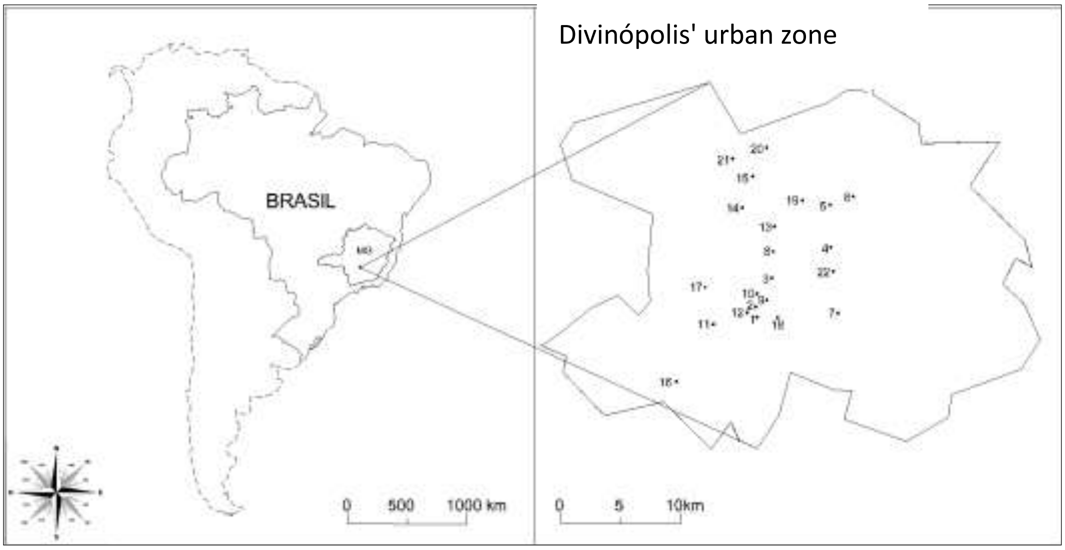

Figure 1. Spatial distribution of springs evaluated in the city of Divinópolis / MG. Source: Authors' organization.

The sources were evaluated by the Interpretation of the Environmental Impact Index in Nascentes - IIAN, presented by Gomes et al. (2005); Felippe (2009) and Felippe and Magalhães Júnior (2012). This method consists of analyzing the macroscopic parameters in the springs and comparing them to the standards for quantification, resulting in a summation of the points. By the score of each parameter evaluated (Table 1) it is possible to establish the level of conservation.. In this sense, the classification in good, medium or bad is converted into a score. The index is the result of the sum of the scores credited to each parameter. According to Felippe and Magalhães (2012), this qualitative method evaluates the degree of protection of the springs through a technique of sensorial (macroscopic) and comparative evaluation of key elements in the identification of environmental impacts on the quality of the springs.

Based on the parameters shown in Table 2, it was possible to categorize the springs into classes, according to the Degree of Preservation.

Garmin MAP 78 GPS Receiver (Global Positioning Systems) was also recorded locally (Table 3).

Table 1: Methodology of the macroscopic environmental impact index in springs.

Parameter	Qualification		
	Bad (1)	Medium(2)	Good (3)
Local protection	No protection	Protection (with access)	Protection (no access)
Proximity to residence	< 50 meters	50 to 100 meters	> 100 meters
Vegetation	Degraded or absent	Altered	Good condition
Water Color	Dark	Clean	Transparent
Odor of water	Strong	with odor	No odor
Trash around the spring	Very	Few	No trash
Foam	Very	Few	No foam
Oil	Very	Few	No oil
Floating materials	Very	Few	No material
Sewage in the spring	Visible	Probable	No sewage
Use by domestic animals	Presence	Traces only	No detection
Use by humans	Presence	Traces only	No detection
Type of insertion area	Absence	Private property	Parks or protected areas

Source: FELIPPE (2009) adapted from GOMES et al. (2005).

Table 2: Classification of sources for macroscopic impacts (final sum)

Class	Degree of Preservation	Final score
A	Great	37-39
B	Good	34-36
C	Acceptable	31-33
D	Bad	28-30
E	Poor	< 28

Source: FELIPPE (2009) adapted from GOMES et al. (2005).

Table 3: Geographic coordinates of the sources analyzed in the city of Divinópolis / MG.

Spring ID	Geographic coordinates
1	S20º10'12" - W44º54'27"
2	S20º10'37" - W44º54'44"
3	S20º9'98" - W44º54'07"
4	S20º8'77" - W44º52'62"
5	S20º7'50" - W44º52'38"
6	S20º7'38" - W44º52'4"
7	S20º10'16" - W44º52'28"
8	S20º8'52" - W44º53'59"
9	S20º9'56" - W44º54'14"
10	S20º9'53" - W44º54'22"
11	S20º10'30" - W44º55'27"
12	S20º10'14" - W44º54'37"
13	S20º8'19" - W44º53'58"
14	S20º7"53" - W44º54'45"
15	S20º7'12" - W44º54'29"
16	S20º11'49" - W44º56'29"
17	S20º9'40" - W44º55'38"
18	S20º9'28" - W44º54'2"
19	S20º7'44" - W44º53'18"
20	S20º6'32" - W44º54'9"
21	S20º6'48" - W44º54'58"
22	S20º9'19" - W44º52'34"

Source: Organization of authors.

Results and discussion

The data obtained from the application of the Nascent Environmental Impact Index (IIAN) were systematized in Table 4. Two of the 22 springs sampled (identified as 20 and 21), the environmental aspects could not be evaluated, since they were buried due to the real estate occupation, in the case, allotments.

Table 4: Quantification of macroscopic parameters observed in the sources evaluated in Divinópolis / MG

Parameters	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**22**
Local protection	2	1	1	1	1	2	2	1	2	2	1	1	1	1	1	1	1	1	1	1
Proximity to residence	2	2	1	1	1	2	3	1	3	2	1	1	1	1	1	2	1	1	1	1
Vegetation	3	1	1	1	1	3	1	1	2	2	1	1	2	1	1	2	1	1	1	1
Water color	3	3	3	3	2	3	2	3	1	2	2	2	3	1	1	3	3	2	2	3
Odor of water	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
Trash around the spring	3	2	1	2	3	1	1	3	3	1	3	1	3	1	3	2	3	3	3	3
Foam	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Oil	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Floating materials	3	3	3	3	3	3	3	3	3	3	3	3	3	1	3	3	3	3	3	3
Sewage in the spring	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	2	1	3	3	3
Use by domestic animals	3	3	2	3	3	2	3	3	3	3	2	2	3	1	3	3	3	3	2	3
Use by humans	1	1	1	1	1	1	2	1	2	2	3	3	1	3	3	2	3	1	2	1
Type of insertion area	2	2	1	1	2	2	2	1	2	1	1	2	2	2	2	2	2	2	2	1
TOTAL	34	30	26	28	29	31	31	29	27	30	29	28	29	20	30	31	30	29	29	29
Score	B	D	E	D	D	C	C	D	E	D	D	E	D	E	D	C	D	D	D	D

Source: Organization of authors

Based on the Environmental Impact Index, it was verified that 15 springs were unprotected (no enclosure) and 13 were within 50 meters of residences or establishments (Table 4). According to Gomes et al. (2005), anthropic interference in springs is verified to a greater degree when protection is ineffective and when there is greater proximity to residences or establishments, resulting in several negative environmental impacts, such as water contamination, presence of trash, degradation of vegetation, compaction and silting.

In 18 springs the vegetation around was degraded or absent, with only two springs (1 and 6) in an adequate state of preservation (Table 1). According to Pinto et al. (2004); Paranhos Filho et al. (2005) and Primack and Rodrigues (2007), the vegetation surrounding the water resources exert important functions to the ecosystem, providing greater infiltration of rainwater in the soil, allowing the recharge in the groundwater and, consequently, the conservation of the perennial springs. According to Law No. 20,922 (MINAS GERAIS, 2013), the areas around the springs are Permanent Preservation Areas (APPs) and must be protected in a minimum radius of 50 meters, which has not been almost all the springs evaluated. Goulart and Callisto (2003); Sperling (2005) and Felippe (2009) reported that in the last decades, aquatic ecosystems have been negatively altered by the environmental impacts caused by human activity, since such interventions alter the processes of infiltration and percolation of the water in the soil. It should be noted that the municipality of Divinópolis, especially in the 80s, allowed the implantation of a large number of neighborhoods, without adequate infrastructure and lack of environmental control, which certainly negatively impacted many springs and streams of the urbanizable area of the municipality. Regarding water color (Table 4), half of the springs evaluated (n = 10) were transparent. According to Botelho et al. (2001) and Ricklefs (2010), it is a positive aesthetic parameter, since it favors the passage of light through the water, making possible the accomplishment of the photosynthesis of the existing aquatic vegetation. On the other hand, its absence usually results from the presence of particles of rocks, clay or by the decomposition of organic matter and added chemical elements. According to Sperling (2005) and FUNASA (2007), when these elements are the result of anthropic activities, there are chemical, physical and mainly biological contaminants that cause diseases and can release toxins.

Still, 19 springs had no odor (Table 4), which for Gomes et al. (2005) is a parameter that shows the non-decomposition of organic matter and the release of gases dissolved in water. FUNASA (2007) reported that it is common to find in urban centers the contamination of water by the domestic and / or industrial sewage, resulting in the formation of gases by the decomposition of the organic components.

The presence of litter was observed around nine springs (Table 4). According to Martelli (2013), in addition to the physical and biological contamination of the springs and surroundings, solid waste favors the appearance of parasitic organisms and vectors of diseases. In addition, they may contaminate the soil by percolation or surface runoff, which may reach the streams and rivers.

Foams and oils were not found in any of the springs evaluated. These elements are usually derived from sewage, from street flurries, or from the contact of water with garbage around the spring, evidencing many times the presence of pathogenic organisms (JAWETZ et al. 1998; FUNASA, 2007). Only in one spring had floating materials in the water (Table 4). According to Gomes et al. (2005), 'floating material' is any object coming from household waste or rainwater runoff, and may also be elements of organic origin such as leaves and branches. The presence of these elements occurs due to anthropic presence (establishments and transport routes) and the absence and / or inefficiency of the protection of the spring.

The presence of sewage was verified in two of the springs (Table 4). Corroborating with Gomes et al. (2005) and FUNASA (2007), this parameter influences the environmental and water quality, occurring mainly due to the lack of sanitation and health education, favoring conditions of proliferation of pathogenic organisms.

The presence of domestic animals in springs and / or trails was detected in six of the springs (Table 4). This aspect contributes to the reduction and the degradation of the vegetal cover, as well as it damages the recomposition and can also contaminate water by microorganisms of the gastrointestinal tract of these animals (JAWETZ et al., 1998). Associated to this, there is possibility of silting / burial of these springs, especially in function of the action of buffaloes, pigs and cattle.

The parameter "use by humans" was detected in 15 springs (Table 4). It was evidenced the presence of people in these areas, in addition to the presence of footprints, soil disturbance, the presence of wooden walkways to access water. According to Gomes et al. (2014), such interference negatively influences the preservation of these springs, which may favor chemical, physical and biological contamination, soil compaction, soil displacement, sedimentation, and degradation of vegetation by trampling and suppression of tree species. The same authors reported that fencing, planting of native trees, and monitoring in the areas of the springs are measures to be implemented, aiming to reduce the negative impacts due to the presence of animals and humans.

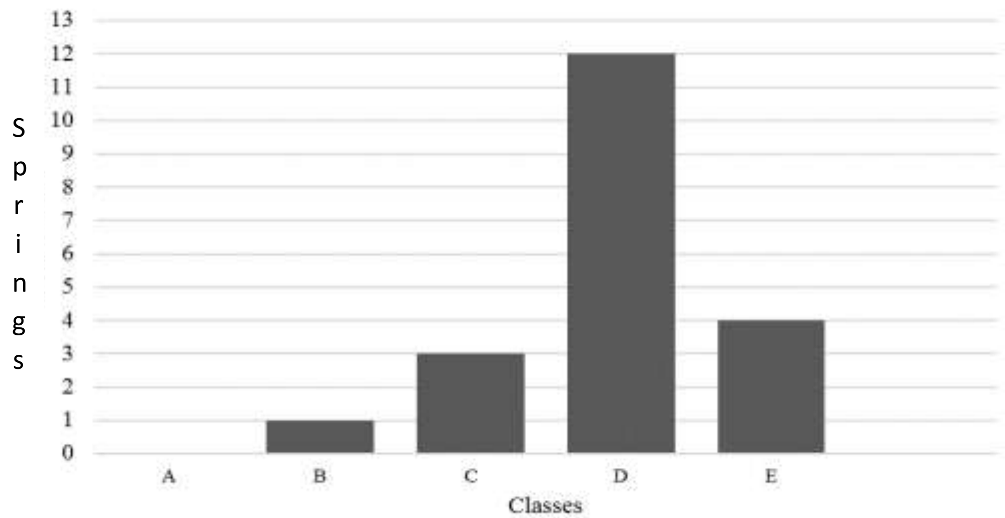

Figure 2: Number of springs in each class of degree of preservation, evaluated in the urban perimeter of the city of Divinópolis - MG. Classes: A = Great; B = Good; C = Acceptable; D = Bad; E = poor .

Regarding the parameter "type of area of insertion", 14 were located in private properties, and the others are in public areas, but none were in Conservation Units. According to Belizário (2015), the springs located in urban space suffer greater anthropogenic degradation, with the possibility of even disappearing and affect the whole water system of the basin. Thus, creating protected areas in the cities contributes to the reduction of the unrestrained population advance on these resources. Similar results were observed by Malaquias and Cândido (2013). The authors evaluated 54 springs in the municipality of Betim - MG, 14 of which were located in private properties and the others in public property, but none were in Conservation Units.

After scoring, the classes obtained were expressed in Figure 2. No springs were classified as "great" (Class A). One was classified as "good" (class B), three were "acceptable" (Class C), 12 were "bad" (Class D) and four had "poor" status. The low quality of the springs observed in this study are part of a generalized picture of degradation and neglect observed in other mining cities, which presented similar or worse situations, such as in Lavras (Pinto et al., 2004), Uberlândia (GOMES et al. 2005) and Betim (MALAQUIAS and CÂNDIDO, 2013).

Final considerations

In general, the results showed that the springs were in an advanced stage of environmental degradation, being classified as "Bad" and "Poor" and none being classified as "Great". Although there are regulations and licensing processes for urban expansion, one can perceive the environmental disregard by the city hall. As a rule, economic interest has supplanted the importance of these springs, which was evidenced by the high degradation and two being buried due to the implantation of lots.

Knowledge about the environmental conditions of the springs and their cataloging are essential actions for the protection of these water resources, once the implementation of these protection strategies result in better quality. It is necessary that the conservation of these watersheds be widely disseminated in the community and should be considered, through planning and urban management, priority areas for preservation, conservation and recovery.

Finally, the results of this work serve as a basis for the government to be able to adopt preservation, recovery and interdiction measures in cases where people collect water and use it for in natura consumption. It is important to remember that this study did not evaluate all the sources of the urban area of the municipality. Therefore, more studies are needed to get a better analysis of the causes and consequences of the impacts found.

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