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Research paper

Diagnosis of water quality in tributary streams of Rio Grande and Rio Paranaíba basins, in Pontal do Triângulo Mineiro, based on an environmental education activity

Diagnóstico da qualidade da água de mananciais tributários das bacias hidrográficas do Rio Grande e do Rio Paranaíba, no Pontal do Triângulo Mineiro, baseada em atividade de educação ambiental

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ABSTRACT: Several reports indicate that the integration with local communities is solving demands for the monitoring of stream water quality by volunteer teams. The aim of the present study is to report the results of environmental diagnosis of streams due to environmental education activities with populations from 3 municipalities in Pontal do Triângulo Mineiro. Workshops were held with the local communities of Carneirinho, Iturama and União de Minas. Water samples from 25 collection points in 10 streams were analyzed by physical parameters (temperature, turbidity, odor, oils, grease, and floating material), chemical (dissolved oxygen, nitrate, nitrite, ammonia, orthophosphate, and pH) and microbiological (concentration of total coliforms and *Escherichia coli*). The results revealed noncompliance with at least one legal parameter in 90% of the analysis, including situations with real risk to human health. The environmental education activities proved to be efficient both for diagnosing the water quality of various streams and consolidating a collective environmental awareness. Educational interventions, such as the proposed, are didactic instruments for environmental education and constitute a motivational action that awakens the feeling of belonging somewhere and the perception of co-responsibility for the local life quality and future planning to transform the reality of communities alongside the municipal public administration.
Keyords: Water Quality, Watercourses, Local Participation.

***RESUMO:** Há muitos registros de que a integração com as comunidades locais tem suprido as demandas do monitoramento da qualidade da água de mananciais por meio da análise físico-química e microbiológica por equipes voluntárias. O presente estudo tem por objetivo apresentar os resultados do trabalho envolvendo o diagnóstico ambiental de cursos d´água após a realização de atividade de educação ambiental com populações de 3 municípios do Pontal do Triângulo Mineiro. Foram feitas oficinas com as comunidades locais de Carneirinho, Iturama e União de Minas de forma que amostras de água de 25 pontos de coleta em 10 mananciais fossem analisadas por parâmetros físicos (temperatura, turbidez, odor, óleos, graxas e material flutuante), químicos (oxigênio dissolvido, nitrato, nitrito, amônia, ortofosfato e pH) e microbiológicos (concentração de coliformes totais e de Escherichia coli). Os resultados revelaram o não atendimento, a pelo menos 1 parâmetro legal, em 90% das análises, inclusive, com situações com risco real à saúde das populações humanas. As atividades de educação ambiental revelaram-se eficientes tanto para o diagnóstico da qualidade da água de diversos mananciais como também para construção e consolidação de uma consciência ambiental coletiva. Intervenções educacionais, como a proposta, além de serem instrumentos didáticos para a educação ambiental, também se constituem em ação motivacional que desperta a sensação de pertencimento ao lugar com a percepção da corresponsabilidade pela qualidade de vida local e seu planejamento futuro de forma a transformar a realidade das comunidades participantes inclusive, em conjunto com a gestão pública municipal.*
***Palavras-chave:** Características da Água, Cursos d´Água, Participação Local.*

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INTRODUCTION

Water quality of streams is multifactorial, highlighting not only the presence of riparian forests but also the intensity of water collection from streams and the release of properly treated domestic and industrial effluents into their waters, among many other factors (CÂNEPA; PEREIRA; LANNA, 2010).

River Basin Committees and state environmental agencies aim to monitor the water quality of main springs and a few specific tributaries (PHILIPPI JR.; SOBRAL, 2019; ANA, 2021). In any case, the environmental diagnosis of water resources is important for any municipality, regardless of its size or location in the drainage basin since the presence of water is fundamental for the growth and planning of any city and region.

The management of a municipality is also multifactorial, and the intensity of many aspects is dependent on the number of inhabitants (TUNDISI, 2014). However, some demands are constant and common to any municipality, such as education, safety, health, work, housing, and the environment (PHILIPPI JR.; ROMÉRIO; BRUNA, 2004). Considering that most of brazilian municipalities (80.3%) are small ones with less than 20,000 inhabitants, the management difficulties for these locations are relatively greater because they often lack several resources at the same time, not only manpower but also logistical as well as financial resources (FARIAS *et al.*, 2017).

The Pontal do Triângulo Mineiro region comprises 18 municipalities from the State of Minas Gerais and is divided into two geographic microregions. Most of the municipalities (15) have less than 20,000 inhabitants (IBGE, 2021).

Several authors report that, in small municipalities of many regions of Brazil, the integration with local communities met the demands of monitoring the water quality in water courses and dams through physical-chemical and microbiological analysis by volunteer teams (HERMES *et al.*, 2004; FIGUEIREDO *et al.*, 2008; CAMPOS, 2015; FRANÇA; CALLISTO, 2015; SILVA, 2017 and MAIA, 2018).

Hermes *et al.* (2004) report that local participation allowed monitoring, including springs and streams in regions that are difficult to access.

The proposal to integrate environmental preservation and recovery actions with interventions of environmental education are also provided for in the National Environmental Education Policy (BRASIL, 1999). However, despite many programs, projects and reports, environmental education has not yet been consolidated in Brazil due to several reasons, including the size of the territory (MAIA, 2015). Jacobi (2003) and Campos (2015) emphasize that real change in behavior in relation to environmental education would happen through a continuous process where the interaction of new information with other pre-existing ones in the individual's cognitive structure ends up promoting learning.

Project-based environmental education, such as the one presented in this work, has the purpose to raise awareness in target communities about specific aspects of their regions and generate the perception of co-responsibility for the actions and results while also proposing action continuity.

The project "Knowing the urban watersheds" was developed by the Social and Environmental Studies and Research Group team of the UFTM-Iturama campus. The project was conducted throughout 2019 and early 2020 in four municipalities from Pontal do Triângulo Mineiro, in the State of Minas Gerais (Iturama, União de Minas, Limeira do Oeste and Carneirinho, including the district of São Sebastião do Pontal). The project encompassed several activities, with an emphasis on participative environmental mapping,

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application of the SWOT/FOFA matrix, and application of a rapid assessment protocol among participants from local communities (CASTELLO BRANCO JR. *et al.*, 2020, 2021).

The aim of the present work is to present the results of work involving the environmental diagnosis of streams based on environmental education activities with local communities in Pontal do Triângulo Mineiro, analyzing water quality by physical-chemical parameters and microbiological analysis, verifying its legal framework, and evaluating the anthropic influence on the quality of streams of the Rio Grande and Rio Paranaíba river basins.

MATERIAL AND METHODS

The municipalities of Iturama, União de Minas and Carneirinho and the district of São Sebastião do Pontal/ Carneirinho participated in the environmental education and environmental diagnosis activities (Figure 1A, 1B).

Twenty-five collection stations (EC) were defined along 10 streams in the target municipalities (Figures 1C-1F). These stations were defined from the participative environmental mapping described in Castello Branco Jr. *et al*. (2021).

Two water samples were collected from each collection station (EC). Glass collection flasks were used. Samples were collected by the community participants under the supervision of the project executing team. Samples were identified and packed in styrofoam thermal boxes for analysis at the project workshops' workplaces.

The physical analyzes were carried out in the field. A portable thermometer and adapted Secchi disk were used to measure water temperature and water turbidity while the perception of odor, oils, greases, and floating material was made by olfactory observation and naked eye by the community participants.

Chemical and microbiological analyses were carried out at the project workshop sites with the aid of an Alfakit® colorimetric kit to determine the parameters of dissolved oxygen, nitrate, nitrite, ammonia, orthophosphate, pH, and concentration of total coliforms and *Escherichia coli*. All the kit manufacturer's protocols were followed.

The results of the physical-chemical analysis of each collection station were tabulated on a blackboard (including the legal reference values) so that all participants could follow along, (CONAMA, 2005). There was also a discussion with the community to understand the meaning of the parameters and their results regarding the water quality of the evaluated stream.

An evaluation form was applied to the participants at the end of each workshop. The forms were filled out anonymously and voluntarily.

Since the results of the microbiological analysis required incubation in a field oven for 15 hours (according to the manufacturer's protocol), they were later passed on to the community leaders.

A final report, summarizing the actions and their results, was prepared, and presented to each local community and to the municipal government of each participating municipality.

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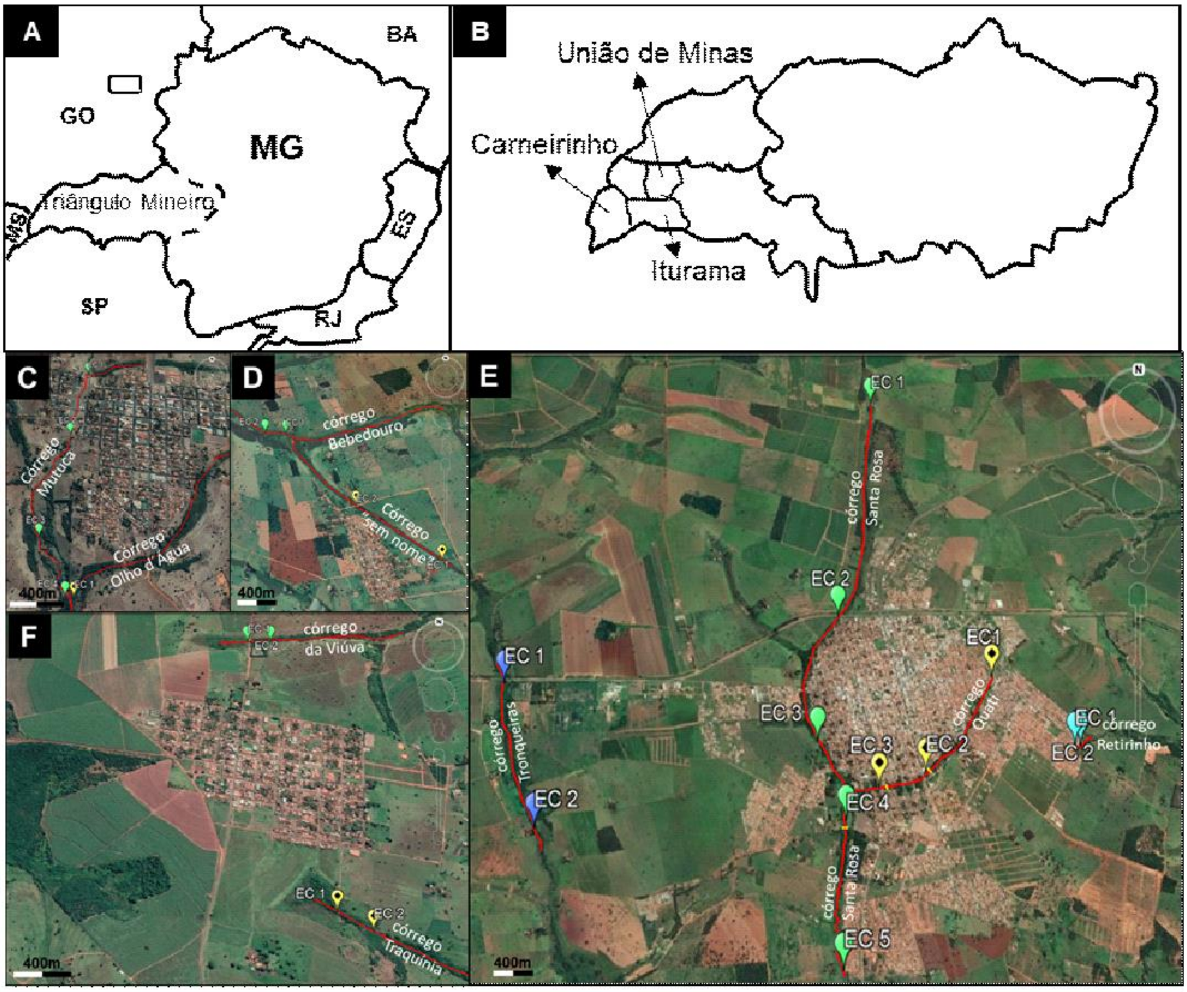
Figure 1. **A.** State of Minas Gerais and Triângulo Mineiro region; **B.** Detail of the Pontal do Triângulo Mineiro region and participating municipalities; **C.** Evaluated streams from Carneirinho county seat/ MG and water collection stations; **D.** Evaluated streams from the district of São Sebastião do Pontal/ Carneirinho/ MG and water collection stations; **E.** Evaluated streams from Iturama/ MG and water collection stations; **F.** Evaluated streams from União de Minas/ MG and water collection stations



Source: Google Earth© modified by the authors.

RESULTS AND DISCUSSION

Participation of local communities

One hundred and fourteen people from the communities of the target municipalities participated in the workshops in addition to the executing team. The 55 people participating in Iturama had the following distribution: 1.0% of young people between 15 and 19 years old; 95.0% of adults between 20 and 59 years old and 4.0% of elderly people over 59 years old. The 24 people in União de Minas were composed of 41.3% youth and 58.7% adults. The 20 people in Carneirinho county seat were 87.5% of adults and 12.5% of elderly and the 15 people in São Sebastião do Pontal/Carneirinho were 92.3% youth and 7.7% adults.

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In the workshops, the participants were surprised not only to see the possibility of carrying out the analysis themselves but also because they understood the meaning of the results and reached technical conclusions.

The demystification of water analysis was verified with the deconstruction of the idealized image of a laboratory with an unattainable structure and expensive equipment. It was demonstrated not only the planning to access the location of water sample collection, but also the scientific method involved in the collections, their records, and packaging, and the operational protocol of the analysis, and the reasoning of each parameter. The fact that a laboratory can be a normal classroom or even the school cafeteria, and that the glassware and necessary reagents can fit in a small plastic case were the most “disturbing” aspects, pointed out by the participants.

Another important deconstruction was the idea that transparent water is always clean. Regardless of the age group, it was verified how common this misconception of water quality was and how people are surprised by the truth.

Most important than the correct information, the personal evidence of the facts causes a real change of paradigms in the participants. França and Callisto (2015) and Silva (2017) report these same scenarios in their work in Minas Gerais and Rio Grande do Sul, respectively.

The paradigm shift also implies the perception of their co-responsibility with environmental issues in the municipality where they live. This co-responsibility is highlighted by several authors, as in the works of Jacobi (2003), Ferreira and Fonseca (2014), and Mota *et al*. (2020). According to Maia (2018), the participative community starts to have a broader view of the environment, in addition to creating a bond of commitment with the springs and streams.

Community participation was diverse, including teachers, rural producers, businesspeople, and councilors, as well as students. The perception of co-responsibility was common to all these groups, including those with the most immediate power of pressure to promote corrective and preventive actions with the streams of their municipalities. This popular participation is the basis for participative management and changes for better life quality in a region (PINTO et al., 2018; MOTA; OLIVEIRA; MEDINA et al., 2020).

Devolution of evaluation forms ranged from 37.5% to 43.0%, depending on the municipality. The long duration of the workshops (3 hr) compromised the devolution of the forms due to wear and tiredness among participants. The workshops were long due to procedures for the collection and analysis of samples, but also for travel to the streams and return to the worksite. Although they manifested themselves in the closing sessions, in each workshop, many revealed that they did not have time to fill in the forms due to the end time of the activity.

The answers analysis of the evaluation forms revealed that 48.0% of the respondents considered the contents covered in the workshops to be “very good”. Thirty-five percent considered it “good” and 17.0% considered it “regular”. Considering workshop covered aspects related to daily life, 74.0% considered it "good" or "very good" while 24.5% considered it regular and 1.5% noticed it not to be related to their daily life.

The organization of the workshops and the executing team performance were considered “very good” by 72.0% and 73.0% of the respondents, respectively; “good” by 24.5% and 24.8%, respectively, and “regular” by 3.5% and 2.2%. This evaluation guides us to keep the same formatting in future works.

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Another guiding aspect for future works is the way of publicizing the workshops. Schools were declared the biggest promoter of the actions (43.0%) while disclosure by colleagues/friends came in second place (21.5%). Ten percent of respondents stated that the workshops' disclosure was made at their work. These results indicate that the disclosure strategy among the leaders of each municipality was valid. Disclosure through social networks and radios was reported by 14.5% and 2.0% of respondents, respectively. Nine percent declared other ways in which they became aware of the workshops.

The verbal or written manifestation in the evaluation forms, suggests that the sensitization happened in most of the participants. However, behavior modifying awareness is not so simple to measure. Silva (2017) points out that the success of participatory actions is not necessarily due to the high rates of people involved in the process, but rather the number of those truly open to promoting the tasks.

In his work, in the municipality of Viamão/ RS, Silva (2017) highlights that the important thing is the quality with which the target community is reached, not worrying about affecting everyone, but those who are interested in listening, especially in locations where there was never guidance or learning in the participative context. Some authors report similar results in these same scenarios in different regions of Brazil (HERMES *et al*., 2004; GIRÃO; SOUSA; SILVA, 2010; FRANÇA; CALLISTO, 2015; PALMA, 2016; MAIA, 2018). In this context, 23.0% of the respondents of the evaluation form who declared their interest in the environmental area as the motivation for participating in the workshops, would constitute the main audience highlighted by Silva (2017). However, we consider that the 71.0% who declared curiosity and/or the search for new knowledge to be the motivation for their participation, also constituted an important part of the most receptive and interested public. The remaining 6% of the respondents stated different motivations.

An important aspect to be considered is the language used in local communities. The use of accessible, easy-to-understand language, neither too childish nor full of technicalities is essential for participants to be able to integrate new knowledge with what they already know. Silva (2017) warns of the need to explain concepts and reasoning in an informal language to allow dialogue and understanding and thus, positive contributions to participatory environmental education actions. In this context, 83.0% of the evaluation forms respondents considered that the clarification of the participants' doubts was "very good" or "good", while 14.5% considered the clarifications in a "regular" way. Two percent considered that the clarifications were “bad”.

Environmental Diagnosis

Figure 2 presents a map that allows a global visualization of the environmental diagnosis of the streams showing quality parameters in disagreement with the Brazilian current legislation, in each evaluated stream in each municipality.

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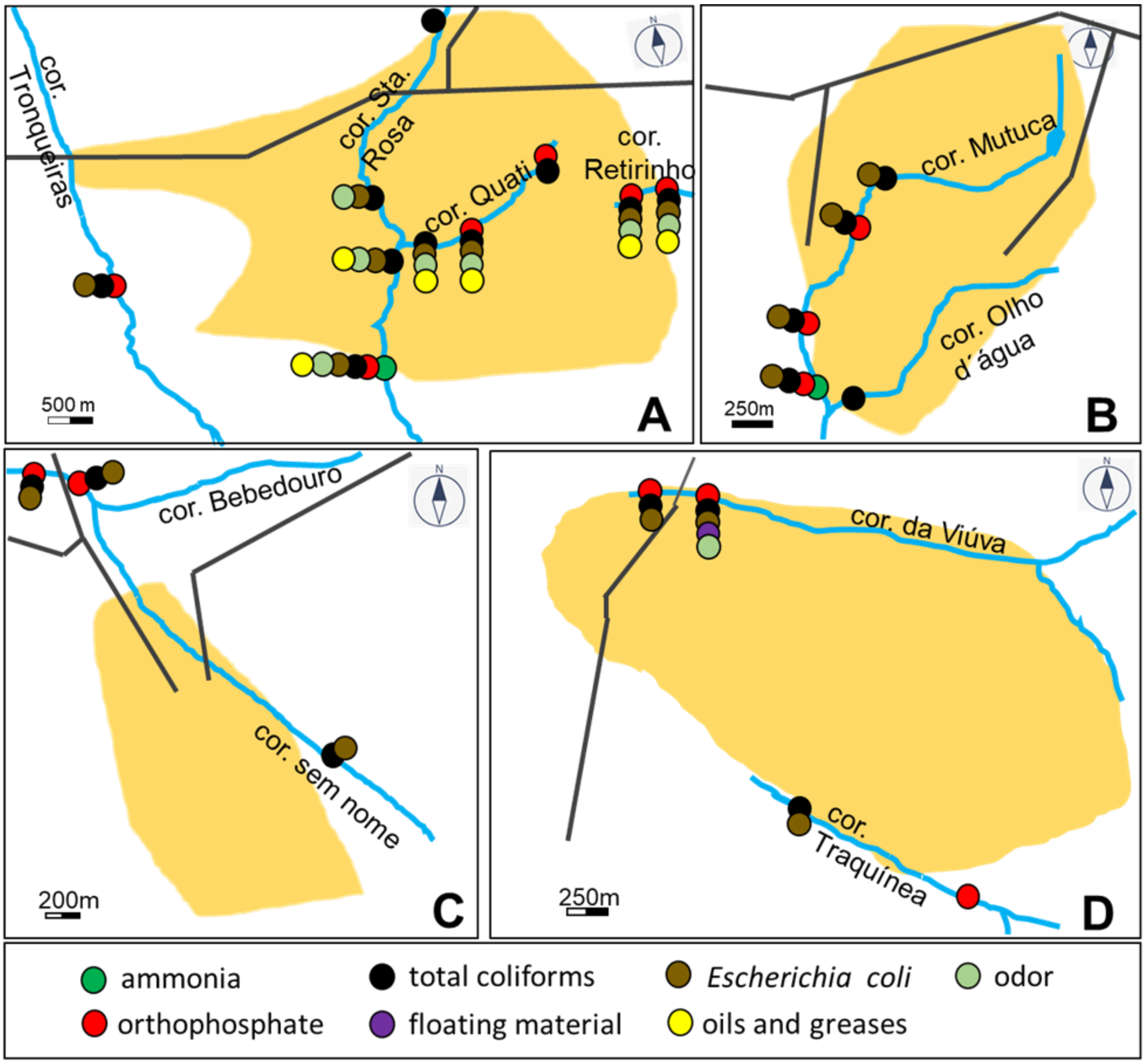
Figure 2. Map of the analysis of the streams' water quality, in the collection stations, in the evaluated municipalities, showing the parameters in disagreement with the Brazilian current legislation. **A.** Iturama/ MG; **B.** Carneirinho/ MG; **C.** São Sebastião do Pontal district/ Carneirinho/ MG; **D.** União de Minas/ MG



Tables 1, 2, and 3 shows the results of the physical-chemical and microbiological analysis of the water from the 25 collection stations.

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Table 1. Result of the water quality analysis at the collection stations (EC) of the Olho d´água and Mutuca streams, in the municipality of Carneirinho/MG, and in the “sem nome” and Bebedouro streams, in the district of São Sebastião do Pontal, municipality Carneirinho/ MG and legal water quality parameters (CONAMA Resolution nº 357/2005)

Parâmeter (unit)	Carneirinho (seat)					São Sebastião do Pontal				CONAMA Resolution nº 357/ 2005
	Olho d´água	Mutuca				“sem nome”		Bebedouro		
	EC1	EC1	EC2	EC3	EC4	EC1	EC2	EC1	EC2	
Dissolved oxygen (mg/L)	6.0	8.0	9.0	7.5	5.0	7.0	6.0	6.5	5.0	≥ 5.0
Ammonia (mg/ L)	0.1	0.17	0.25	0.25	>3.0	0.1	0.1	0.25	2.0	≤ 2.0(pH= 8.0)
Nitrate (mg/ L)	0.2	0.7	2.5	1.0	0.7	0.1	0.3	0.0	2.0	≤ 10.0
Nitrite (mg/ L)	0.01	0.02	0.02	0.02	0.05	0.03	0.0	0.0	0.1	≤ 1.0
Orthophosphate (mg/L)	0.0	1.0	1.75	3.0	3.0	0.0	0.0	1.0	0.75	≤ 0.1
pH	7.0	8.0	8.0	8.0	8.0	6.5	6.0	7.0	7.0	6.0 – 9.0
Turbidity (NTU)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	≤ 100.0
Temperature (°C)	24.0	25.0	23.0	25.0	26.0	28.0	28.0	28.0	26.0	Parameter not covered
Oils and greases	absent	absent	absent	absent	absent	absent	absent	absent	absent	Virtually absent
Floating material	absent	absent	absent	absent	absent	absent	absent	absent	absent	Virtually absent
Odor	absent	absent	absent	absent	absent	absent	absent	absent	absent	Virtually absent
CFU *E. coli* ($x10^3$) /100mL	0.0	3.7	5.8	4.0	5.0	4.4	anp	2.2	14.5	Parameter not covered
CFU tot. coliforms ($x10^3$) /100 mL	1.1	6.6	8.9	8.1	5.1	12.5	anp	5.9	15.9	≤ 1.0

anp = analysis not performed

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Table 2. Result of the water quality analysis at the collection stations (EC) in Quati, Retirinho and Tronqueiras streams in the municipality of Iturama/MG and legal water quality parameters (CONAMA Resolution nº 357/2005)

Parameter (unit)	**Quati stream**			**Retirinho stream**		**Tronqueira stream**		**CONAMA Resolution nº 357/2005**
	EC1	**EC2**	**EC3**	**EC1**	**EC2**	**EC1**	**EC2**	
Dissolved oxygen (mg/L)	8.5	7.0	7.5	7.0	6.0	6.0	5.0	≥ 5.0
Ammonia (mg/ L)	1.0	3.0	2.0	3.0	0.35	0.0	2.5	≤ 3.7 (pH ≤ 7.5)
Nitrate (mg/ L)	0.1	>2.5	>2.5	1.75	>2.5	0.0	1.0	≤ 10.0
Nitrite (mg/ L)	0.03	0.4	0.5	0.2	0.3	0.0	0.25	≤ 1.0
Orthophosphate (mg/ L)	0.75	0.75	0.0	0.75	0.75	0.0	1.75	≤ 0.1
pH	6.75	7.5	7.5	7.5	8.0	7.0	7.5	6.0 – 9.0
Turbidity (NTU)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	≤ 100.0
Temperature (°C)	24.0	23.0	23.0	24.0	24.0	23.0	23.0	Parameter not covered
Oils and greases	absent	present	present	present	absent	absent	absent	Virtually absent
Floating material	absent	absent	absent	absent	absent	absent	absent	Virtually absent
Odor	absent	present	present	present	present	absent	absent	Virtually absent
CFU *E. coli* ($x10^3$) / 100mL	1.3	8.3	13.1	7.8	2.0	0.3	3.7	Parameter not covered
CFU tot. coliforms ($x10^3$) /100mL	3.3	cn	17.3	8.5	3.3	0.7	7.0	≤ 1.0

cn=CFU countless number

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Table 3. Result of the water quality analysis at collection stations (EC) in Santa Rosa stream, in the municipality of Iturama/ MG, in Viúva and Traquínea streams, in the municipality of União de Minas/ MG and legal water quality parameters (CONAMA Resolution nº 357/2005)

Parameter (unit)	Iturama					União de Minas				CONAMA Resolution nº 357/ 2005
	Santa Rosa stream					Viúva stream		Traquínea stream		
	EC1	EC2	EC3	EC4	EC5	EC1	EC2	EC1	EC2	
Dissolved oxygen (mg/L)	8.00	9.0	7.5	5.5	6.5	7.0	6.0	6.5	7.5	≥ 5.0
Ammonia (mg/ L)	0.0	0.0	0.25	1.0	>3.0	0.1	> 3.0	0.0	0.1	≤ 2.0 (pH=8.0)
Nitrate (mg/ L)	0.0	0.0	0.0	2.5	0.7	< 0.1	0.3	0.6	0.85	≤ 10.0
Nitrite (mg/ L)	0.0	0.0	0.01	0.1	0.05	< 0.01	0.02	0.0	0.0	≤ 1.0
Orthophosphate (mg/ L)	0.0	0.0	0.5	0.5	1.0	0.75	3.0	0.0	0.75	≤ 0.1
pH	7.0	6.5	7.0	7.25	7.5	6.25	7.5	6.75	7.75	6.0 – 9.0
Turbidity (NTU)	100.0	100.0	100.0	75.0	60.0	100.0	100.0	anp	anp	≤ 100.0
Temperature (°C)	23.0	22.0	23.0	24.0	26.0	18.0	20.0	24.0	24.0	Parameter not covered
Oils and greases	absent	absent	absent	present	present	absent	absent	absent	absent	Virtually absent
Floating material	absent	absent	absent	present	present	absent	present	absent	absent	Virtually absent
Odor	absent	absent	present	present	present	absent	present	absent	absent	Virtually absent
CFU *E. coli* ($x10^3$) / 100mL	0.0	0.1	4.6	8.5	10.4	4.4	14.5	2.2	anp	Parameter not covered
CFU tot. coliforms ($x10^3$) /100 mL	1.7	0.9	9.0	cn	cn	12.5	15.9	5.9	anp	≤ 1.0

anp = analysis not performed; cn = CFU countless number (CFU= colony forming units)

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The analysis of the tables 1 to 3 reveals parameters frequently in disagreement with the legal limits, especially orthophosphate, oils, and greases, floating material, and odor in the water, in addition to the concentration of *Escherichia coli* enterobacteria.

Orthophosphate reveals the total phosphates available in the water for biological processes. Its origin can be geological, agricultural (by fertilizers and pesticides), and/or by releases of domestic, animal, and industrial sewage. In domestic sewage, there is a high concentration of phosphates which can lead to eutrophication of streams' water. The greater the eutrophication the better conditions for algae multiplication which can cause a reduction in the availability of dissolved oxygen in the water (GOMES FILHO, 2013). This chemical parameter may be present up to the legal limit equal to 0.1 ppm (mg/L). Orthophosphate was frequently found above the legal parameters, reaching a value equal to 30 times above.

The odor in water has its origin associated with both the presence of chemical substances or dissolved gases, as well as the presence of some microorganisms such as algae and bacteria. Organic matter in large quantities and with volatile compounds also generates a characteristic odor (BRASI, 2014).

It should be noted that oils and greases from the streets are easily carried by rainwater to the rainwater drainage network reaching urban streams (SECRON; GIORDANO; BARBOSA FILHO, 2010).

Odor, oils, grease, and floating material must be virtually absent in any water sample in accordance with Brazilian current legislation (CONAMA, 2005).

All parameters mentioned may indicate contamination in natural waters. However, the parameter that confirms the contamination by feces and, eventually, by domestic sewage is the presence of *E. coli* enterobacteria. The fecal origin of *E. coli* is unquestionable as well as its ubiquitous nature is unlikely, validating it as an indicator organism of contamination in natural and treated waters (BRASIL, 2014).

These and other parameters are defined in CONAMA Resolutions nº 357/2005 and nº 430/2011. The microbiological parameter of *E. coli* concentration is provided for in CONAMA Resolution nº 274/2000 to characterize the waters as excellent for human consumption, very good, satisfactory, or inappropriate.

The analysis of stream water results will be presented individually, by municipality.

In Carneirinho, a municipality with about 9,500 inhabitants, the concentration of orthophosphate was always above the legal limit in the Mutuca stream. In EC1, orthophosphate concentration was 10 times above the legal parameter, reaching 30 times in EC3 and EC4 (Table 1). The municipal sewage treatment plant releases effluent between EC2 and EC3 (Figure 1C). The concentration of *E. coli* in the Mutuca stream characterized water unfit for human consumption (value bigger than $2.0x10^3$ CFU/100mL of water - CONAMA, 2000) (Table 1).

There was no noncompliance with legal parameters in the Olho d´Água stream, in Carneirinho.

There was also a non-conformity of the *E. coli* parameter characterizing “sem nome” stream water as inappropriate (Table 1) in the district of São Sebastião do Pontal (Figure 1D). In the Bebedouro stream (Figure 1D), in addition to unfit water due to the non-conformity of the *E. coli* parameter (Table 1), the concentration of orthophosphate was also above the legal limits.

In the Quati stream, in Iturama, the largest municipality in the region with around 36,000 inhabitants, the concentration of orthophosphate was 7.5 times higher than the legal

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limit at 100 m from its spring (EC1) (Figure 1E). The concentration of orthophosphate reduced along the 900 m separating EC2 from EC3 (Table 2). The presence of oils and greases and a strong odor of sewage were also verified in this stream.

In the Retirinho stream (Figure 1E), the orthophosphate concentration equal to 7.5 times the legal limit, in both collection stations, also proves contamination by the release of sewage from the pumping station overflow (Table 2). A strong sewage odor was also observed in this stream.

In the Tronqueiras stream (Figure 1E), there was effluent release between EC1 and EC2, since the orthophosphate concentration was equal to 17.5 times higher than the legal limit (Table 2). This situation is worrisome since the collection of water for public supply in the municipality of Iturama is carried out in the stretch between EC1 and EC2.

In the Santa Rosa stream (Figure 1E), also in Iturama, there was no presence of phosphate until EC2, about 3,300m from its spring. However, between EC2 and EC3, there were large releases through rainwater drainage pipes, even with no rain precipitation. The orthophosphate concentration in EC3 was five times higher than the legal limit (Table 3). After receiving water from its tributary, Quati stream, the phosphate concentration remained at this value (0.5 ppm) in the EC4. The phosphate concentration was ten times higher than the legal limit (1.0 ppm) after 1,000m of the treated effluent released from the municipal sewage treatment plant, in EC5 (Table 3).

It was detected the presence of odor, floating material (non-natural foams), oils, and greases in EC4 and EC5 in Santa Rosa stream. These parameters should be virtually absent in Class 2 streams, as all the streams evaluated in the present work.

The *E. coli* bacterium was not detected at Santa Rosa stream spring (EC1). However, it was already verified in EC2, within the urban area. According to CONAMA Resolution nº 274/2000, stream water with *E. coli* up to the concentration of 200 colony forming units (CFU)/100 mL of water is considered excellent. This condition was verified up to EC2 in Santa Rosa stream. However, *E. coli* concentrations were found far above the limit for satisfactory water (up to 800 CFU/100 mL water) from EC3 even within the category of unfit water (CONAMA, 2000).

In União de Minas, a municipality with about 5,000 inhabitants, the concentration of orthophosphate was 7.5 times higher than the legal limit in EC1 in the Viúva stream (Figure 1F), about 150 meters from its spring. At EC2, about 160 m downstream from EC1, the orthophosphate concentration was equal to 30 times the legal limit (Table 3). The orthophosphate in EC1 would be of agricultural origin since this stream is in an agropastoral matrix approximately 550 m away from the urban area (Figure 1F). On the other hand, EC2 was located 50 meters below the released effluent of the municipal sewage treatment plant and thus, it is assumed that the orthophosphate detected in EC2 originates from municipal domestic sewage. It was also verified the presence of an unpleasant odor of sewage and foam in this stream.

Although no concentration of orthophosphate was detected in EC1, its concentration was equal to 7.5 times higher than the legal limit at 200 meters downstream (EC2) (Table 3) in the Traquínea stream, in União de Minas (Figure 1F). There was a release of domestic sewage by the overflow of the sewage pumping station located in the vicinity of the stream Traquínea. High concentrations of *E. coli* were also detected, reaching a maximum value of 14,500 CFU/100 mL of water, thus proving contamination by domestic sewage.

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Parameters outside the legal standards are frequently reported in several studies. França and Callisto (2015) reported several situations like this In Minas Gerais, in the metropolitan region of Belo Horizonte, in a stretch of the São Francisco River basin. Likewise, cases have also been reported in the State of São Paulo (CAMARGO FILHO *et a*l., 2009; CAMPOS, 2015), in Rio Grande do Sul (SILVA, 2017), in the Federal District region (PALMA, 2016; WERNECK, 2018) and in the brazilian northeastern semi-arid (FIGUEIREDO *et al*., 2008; GIRÃO; SOUSA; SILVA, 2010). In all these cases, there was always the participation of the local population in the evaluations.

CONCLUSIONS

The results confirmed, at least, one parameter of water quality out of legal limits in 90% of the evaluated streams, revealing situations of risk to the health of human populations.

The participation of local communities in environmental education actions allowed the diagnosis of water quality in streams, generating both technical-scientific knowledge about some hydrographic sub-basins of Pontal do Triângulo Mineiro, as well as collaborating for the construction of a collective environmental conscience.

Educational interventions, such as the proposal, in addition to being didactic instruments for environmental education, also constitute a motivational activity that stimulates the feeling of belonging to the place with the perception of co-responsibility for the local life quality as well as the planning of the community's future. The approach proved to win over young people and adults, from different educational levels and social classes, helping to strengthen citizenship and empower the local community. This was possible through the generated and democratized knowledge to the community, including the participation of municipal public management.

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