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Temporal trends of the water quality of tributaries of the São Francisco River between Três Marias and Pirapora - MG

Tendências temporais da qualidade da água dos afluentes do rio São Francisco entre Três Marias e Pirapora - MG

Tendencias temporales de la calidad del agua de los afluentes del río São Francisco entre Três Marias y Pirapora – MG

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Abstract
Water is an essential natural resource for cell metabolism and the development of human society. Its availability, however, has been affected by the pollution to which it is subjected. In this question, there is the São Francisco watershed, which, although it has a unique economic and cultural role for the population of the semi-arid region, suffers the weight of anthropization, since it is exploited by agricultural activities and to drain urban and industrial effluents. To tell this, it is important to monitor the quality of its water and its tributaries, in order to implement an efficient management of this asset. That said, this research aims to evaluate the temporal trend of the behavior of the physicochemical attributes of water quality, between 2017 and 2021, in the stretch of the São Francisco river in Três Marias and in the tributaries Rio Abaeté, Formoso and De Janeiro. The data used for the analysis were produced by the Scientific Expedition Amigos das Águas and collected from the portal of the Water Supply and Sewage Service of Pirapora SAAE - MG. For statistical analysis, Sisvar was used, and the parameters evaluated were: aluminum, apparent color, iron, phosphate, nitrate, nitrite, sedimentable solids, suspended solids and pH, in accordance with CONAMA n° 357/2005. The criteria evaluated are within the established limits. However, it is recommended to include the criterion of thermotolerant coliforms, in order to better ensure the viability of the water resource.
Keywords: Abaeté River; Rio de Janeiro; Formoso River.

Resumo
A água é um recurso natural imprescindível ao metabolismo celular e ao desenvolvimento da sociedade humana. Sua disponibilidade, no entanto, tem sido afetada em função da poluição sobre a qual é submetida. Nesta questão, encontra-se a bacia hidrográfica do São Francisco, que embora possua papel econômico e cultural ímpar para a população do semi-árido, sofre o peso da antropização, já que é explorada pelas atividades agrícolas e para escoar efluentes urbanos e industriais. Para contar isso, é importante o monitoramento da qualidade de sua água e de seus afluentes, a fim de se implementar uma gestão eficiente deste bem. Isto posto, esta pesquisa tem como fim avaliar a tendência temporal do comportamento dos atributos físico-químicos de qualidade de água, entre 2017 e 2021, no trecho do rio São Francisco em Três Marias e nos afluentes Rio Abaeté, Formoso e De Janeiro. Os dados utilizados para a análise foram produzidos pela Expedição Científica Amigos das Águas e coletados do portal da Serviço de Abastecimento de água e Esgoto de Pirapora SAAE - MG. Para a análise estatística, utilizou-se o Sisvar, e os parâmetros avaliados: alumínio, cor aparente, ferro, fosfato, nitrato, nitrito, sólidos sedimentáveis, sólidos suspensos e pH, de acordo com o preconizado pela CONAMA n° 357/2005. Os critérios avaliados encontram-se dentro dos limites estabelecidos. No entanto, recomenda-se a inclusão do critério de coliformes termotolerantes, a fim de melhor se assegurar a viabilidade do recurso hídrico.
Palavras-chave: Rio Abaeté; Rio de Janeiro; Rio Formoso.

Resumen
El agua es un recurso natural esencial para el metabolismo celular y el desarrollo de la sociedad humana. Su disponibilidad, sin embargo, se ha visto afectada por la contaminación a la que está sometido. En esta cuestión, está la cuenca del São Francisco, que, si bien tiene un papel económico y cultural único para la población de la región semiárida, sufre el peso de la antropización, una vez que es explotada por actividades agrícolas y para drenar los efluentes de origen urbano e industrial. Para ello, es importante monitorear la calidad de sus aguas y sus afluentes, con el fin de implementar una gestión eficiente de este bien. Dicho esto, esta investigación tiene como objetivo evaluar la tendencia temporal del comportamiento de los atributos fisicoquímicos de la calidad del agua, entre 2017 y 2021, en el tramo del río São Francisco en Três Marias y en los afluentes Río Abaeté, Formoso y De Janeiro. Los datos utilizados para el análisis fueron producidos por la Expedición Científica Amigos das Águas y recolectados del sitio web del Servicio de Abastecimiento y Alcantarillado de Pirapora SAAE - MG. Para el análisis estadístico se utilizó Sisvar, y los parámetros evaluados fueron: aluminio, color aparente, hierro, fosfato, nitrato, nitrito, sólidos sedimentables, sólidos en suspensión y pH, de acuerdo con CONAMA n° 357/2005. Los criterios evaluados se encuentran dentro de los límites establecidos. Sin embargo, se recomienda incluir el criterio de coliformes termotolerantes, con el fin de asegurar mejor la viabilidad del recurso hídrico.
Palabras clave: Río Abaete; Rio de Janeiro; Río Formoso.

1. Introduction

The water is a natural resource indispensable for the existence of life, since it is fundamental to the ocurrance of several biochemical (Zerwes et al., 2015; Peroni et al., 2021). For the human species, however, its role perpass the biological development and gain economical, social and cultural dimensions (Balduíno & Araújo, 2021; Carvalho et al., 2020).

Nevertheless, as societies develop, there is scarcity of this resource, especially, in function of its non-sustentable use, such as the polution that fresh and salt water are submitted (Balduíno & Araújo, 2021; Buzelli & Cunha-Santino, 2013). Part of this is a result of desordered development of economical activities in the urban perimiter, which makes that inequality and non-demographic planning contribute to improper disposal of domestic and industrial waste in rivers (Balduíno & Castro, 2021).

Other anthropic impacts on hydric resources derive from deforestation, mining, construction of dams, canals, irrigation systems and drainage systems, from transformations on land cover of hydrographical basins, depletion of groundwater and aquifers, and also from the discharge of chemical inputs of agriculture in the environment (Fernández-Luqueño et al., 2013). Those interferences reduce significantly the disponibility and quality of this resource for the population, which is worrying in a increasing demand scenario (Borges et al., 2022; Zerwes et al., 2015).

In the center of this question, are the heavy metals. They are stable contaminants and bioaccumulative which its high toxicity occur in function of the formation of organometallic complexes (Patel et al., 2017). In water samples, its concentrations depend on physical-chemical parameters of the environment, such as eletrical conductivity, pH, salinity, turbidity and total dissolved solids (Cengiz et al., 2017).

Futhermore, it is known that the concentrations of heavy metals in the upper courses of rivers are generally lower than the located downstream, due to effects of its accumulation in the lower course (Patel et al., 2017). This accumulation, which is a sensitive marker of alterations in the aquatic system, can be either associated to natural geological phenomenom, wheathering and erosion, or anthropic actions, use of fertilizers and perticides in agriculture activities, deposition of domestic or industrial waste and even burning of fossil fuels (Cengiz et al., 2017).

As a consequente of this process, the environmental exposition by heavy metals has received great emphasis, because affects millions of people in different parts of the world, specially, in South America, in function of its inexistent or weak legislation and aplication by governants (Fernández-Luqueño et al., 2013).

In Brazil, for example, the management of hydric resources has a relatively recent history, in which one of the initial legal frameworks was the Water Code of 1934. The Law 9.433/97, known as “Waters Act” incorporate the principle of multiple and integrated usage of hydric resources contemplating, simultaneously, quantitative and qualitative aspects of the assessment of Waters.

As a result, the anthropic impacts and the imminent risk of contamination of hydrographic basins by heavy metals afflicts the scientific community and propel researchs which objective is to preserve and protect hydric resources (Ribeiro, Trindade, Magalhães & Horn, 2009). Those basins, according to Barrella, Petrere, Smith, and Montag (2000) can be defined as sets of land drained by a river and its affluents, which its contour is delimited by higher parts of the terrain, the watersheds. In the basins, the waters from the rain flow superficially forming creeks and rivers or infiltrate in the soil originating springs and phreatic water. In the proportion that the water of creeks flow from the higher parts of the terrain, they join to other streams and increase their volume originating to the first rivers that will continue their course gaining volume from other tributaries, getting bigger, until draining into the ocean.

In Brazil, the hydrographic basin of the São Francisco River stands out, extending itself through the states of Minas Gerais, Goiás, Bahia, Pernambuco, Alagoas, Sergipe and the Federal District, occupying an area of drainage of 634.000km², approximately, 8% of the country territory. The course of the São Francisco River has an extension of 2.700 km crossing many states to its mouth, between Aracaju and Maceió, with an average flow of 3.360 m³/s (Trindade, 2010).

Although this basin presents historical, economical and especially cultural importante to the population of the semiarid, it commonly suffers from the onus of anthropization, since it is already vastly exploited by agricultural activity, (monocultures of pine, eucalyptus and grains) and for the outflow of urban and industrial effluents (processing of Zinc, Iron and Silicon) and, between other things, for the installation of hydropower plants (Ribeiro et al., 2009).

To overcome this situation, the monitoring of the quality of superficial waters is extremely important to the efficient management of hydric resources, because its results enables a better knowledge of the situation of the quality of waters and of the main alterations occurred through time, allowing to detect spatial and temporal tendencies (Oliveira, Soares, Barroso, Dantas & Oliveira, 2019; Soares, Pinto, Barbosa & Oliveira, 2018, Carvalho et al., 2020). In addition, it contibutes to the identification of more critical stretches and for the determination of preventive and corrective actions to be taken (Soares et al., 2018).

The resolution of the National Council of Environment, CONAMA 357/2005, is a legal instrument which orientates the classification of bodies of water and environmental guidelines to its framework, as well as estabilishes conditions and standards of releasing of its effluents. And as an effect of this Resolution, it is considered the environmental impact that any alteration of the physical, chemical and bilogical properties of the environment, caused by any form of matter or energy resulted by human activities that, directly or undirectly, affects health, safety or well-being of the population (Brasil, 2005).

In view of that, the objective of this work is to evaluate the temporal tendency of the behavior of physical-chemical attributes of the quality of water between the years 2017 and 2021 in the stretch of the São Francisco river in Três Marias and in the affluents Abaeté, Formoso and De Janeiro rivers.

2. Methodology

2.1 Local and study data

The data base utilized in this research was elaborated from data extracted from the portal of the Service of Water Suply and Sewer of Pirapora SAAE - MG. The water samples for analysis were collected in the São Francisco River in Três Marias – MG and in the affluents, in the sub-basins of Abaeté River, Formoso River, located at the right side of the river, and in the sub-basins of De Janeiro River, at the left side margin (Ribeiro et al., 2012). Between the years 2017 and 2021, were utilized secondary data from the project Scientific Expedition Friends of the Waters, that covers the São Francisco River from Três Marias/MG to Pirapora/MG, a stretch of approximately 150 kilometers.

2.2 Samples and parameters evaluated

The physical-chemical parameters evaluated were: aluminum, apparent color, iron, phosphate, nitrate, nitrit,

sedimentable solids, suspensed solids and pH, thermotolerants coliforms, as proposed by CONAMA 357/2005 that provides about the classification of bodies of water and environmental guidelines for its framework (Brasil, 2005).

2.3 Statistical evaluations

The statistical evaluations were realized in Sisvar software having the data submitted to evaluation of the variance in the effect of time (temporal analysis) compared by Scott-Knott Test at the nominal level of 5% (Ferreira, 2000).

3. Results and Discussion

The obtained results in the variance evaluation can be observed in the following tables for the respective locations sampled in the São Francisco River - Três Marias (Table 1).

Table 1 - Analysis of variance for secondary data of superficial hydric samples of the São Francisco River - Três Marias, 2017 to 2021. The same letters in the same line do not differ in by the Scott-Knott test at 0,05 or 5%.

Parameter	Unit	Recomendation CONAMA 357	Rate	2017	2018	2019	2020	2021
Aluminum	mg/L	0,1	0,102	0,10 a	0,10 a	-	0,131 a	0,08 a
Apparent color	uH	100	5,35	3,3 a	4,1 a	-	10,1 a	3,9 a
Iron	mg/L	0,3	0,22	-	0,3 a	-	0,07 a	0,31 a
Phosphate	mg/L	-	0,17	-	-	-	0,17	-
Nitrate	mg/L	10	0,753	0,6 a	0,8 a	0,88 a	-	0,734 a
Nitrite	mg/L	1	0,10025	0,002 a	-	0,03 a	0,347 a	0,022 a
Sedimentable solids	mg/L	-	0,01	-	-	-	-	0,01
Suspensed solids	mg/L	-	2,5	-	-	-	3 a	2 a
Turbidity	uT	100	11,53	-	5,67 a	-	3,58 a	2,28 a
pH	-	6,0 - 9,0	7,72	8,06 a	7,17 a	-	7,03 a	8,63 a

Source: Authors.

There was no statistical differences between the years for the evaluated parameters sampled at São Francisco River - Três Marias (Table 1). Although adressing 5 years of data, some parameters are not shown in the respective representative fields (-). For the Aluminum, the data presented with a rate (0,102 mg/L) close to recommended values by CONAMA 357 (0,1 mg/L). All the other parameters analysed are below or in the proposed range of the resolution and did not demonstrate significant differences to the Scott-Knott test.

The obtained results in the variance evaluation can be observed in the following tables for the respective locations sampled in the Abaeté River (Table 2).

Table 2 - Analysis of variance for secondary data of superficial hydric samples of the Abaeté River, 2017 to 2021. The same letters in the same line do not differ in by the Scott-Knott test at 0,05 or 5%.

Parameter	Unit	Recomendation CONAMA 357	Rate	2017	2018	2019	2020	2021
Aluminum	mg/L	0,1	0,08075	0,1 a	0,1 a	-	0,063 a	0,06 a
Apparent color	uH	100	12,45	14,50 a	18,9 a	-	10,10 a	6,3 a
Iron	mg/L	0,3	0,27	-	0,3 a	-	0,28 a	0,23 a
Phosphate	mg/L	-	0,09	-	-	-	0,09	-
Nitrate	mg/L	10	0,6205	0,50 a	1,4 a	0,52 a	-	0,062 a
Nitrite	mg/L	1	0,17625	0,003 a	-	0,03 a	0,192 a	0,48 a
Sedimentable solids	mg/L	-	-	-	-	-	-	-
Suspensed solids	mg/L	-	2,5	-	-	-	3 a	2 a
Turbidity	uT	100	16,82	-	46,8 b	-	2,24 a	1,42 a
pH	-	6,0 - 9,0	7,82	8,09 a	8,11 a	-	7,06 a	8,03 a

Source: Authors.

Statistical analysis between the years for the evaluated parameters sampled at Abeté River (Table 2). Although adressing 5 years of data, some parameters are not shown in the respective representative fields (-). The Sedimentable solids parameter was not obtained for any year in the data available.

The Turbidity (uT) parameter demonstrated significant differences between the years with notorius peak in 2018 (46,8 b) in contrast with the recent years of data 2020 (2,24 a) and 2021 (1,42 a). Although, both the data and the rate are below the recommended values by CONAMA 357 (100 uT) and do not demonstrate significant differences to the Scott-Knott test. All the other parameters analysed are below or in the proposed range of CONAMA 357 and did not demonstrate significant differences to the Scott-Knott test between the years, including its averages.

The obtained results in the variance evaluation can be observed in the following tables for the respective locations sampled in the De Janeiro River (Tabela 3).

Tabela 3 - Analysis of variance for secondary data of superficial hydric samples of the De Janeiro River, 2017 to 2021. The same letters in the same line do not differ in by the Scott-Knott test at 0,05 or 5%.

Parameter	Unit	Recomendation CONAMA 357	Rate	2017	2018	2019	2020	2021
Aluminum	mg/L	0,1	0,091	0,10 a	0,10 a	-	0,098 a	0,066 a
Apparent color	uH	100	9,925	8,40 a	9,20 a	-	15,0 a	7,10 a
Iron	mg/L	0,3	0,41	-	0,30 a	-	0,61 a	0,33 a
Phosphate	mg/L	-	0,04	-	-	-	0,04	-
Nitrate	mg/L	10	0,459	0,70 a	0,80 a	0,20 a	-	0,136 a
Nitrite	mg/L	1	0,141	0,006 a	-	0,030 a	0,166 a	0,362 a
Sedimentable solids	mg/L	-	-	-	-	-	-	-
Suspensed solids	mg/L	-	4,0	-	-	-	5,0 a	3,0 a
Turbidity	uT	100	9,55	-	25,0 a	-	2,25 a	1,42 a
pH	-	6,0 - 9,0	7,68	8,19 a	7,22 a	-	7,20 a	8,14 a

Source: Authors.

There was no statistical difference between the years for the evaluated parameters at De Janeiro River (Table 3). Although adressing 5 years of data, some parameters are not shown in the respective representative fields (-). The Sedimentable solids parameter was not obtained for any year in the data available. All the other parameters analysed are below or in the proposed range of CONAMA 357 and did not demonstrate significant differences to the Scott-Knott test between the years, including its averages.

The obtained results in the variance evaluation can be observed in the following tables for the respective locations sampled in the Formoso Stream (Table 4).

Tabela 4 - Analysis of variance for secondary data of superficial hydric samples of the Formoso Stream, 2017 to 2021. The same letters in the same line do not differ in by the Scott-Knott test at 0,05 or 5%.

Parameter	Unit	Recomendation CONAMA 357	Rate	2017	2018	2019	2020	2021
Aluminum	mg/L	0,1	0,0995	0,10 a	0,10 a	-	0,076 a	0,122 a
Apparent color	uH	100	17,5	15,40 a	14,3 a	-	20,80 a	19,50 a
Iron	mg/L	0,3	0,54	-	0,30 a	-	0,62 a	0,72 a
Phosphate	mg/L	-	0,20	-	-	-	0,20 a	-
Nitrate	mg/L	10	0,54	0,50 a	1,10 a	0,42 a	-	0,14 a
Nitrite	mg/L	1	0,11975	0,008 a	-	0,03 a	0,181 a	0,260 a
Sedimentable solids	mg/L	-	-	-	-	-	-	-
Suspensed solids	mg/L	-	2,5	-	-	-	2 a	3 a
Turbidity	uT	100	7,43	-	13,40 a	-	4,07 a	4,84 a
pH	-	6,0 - 9,0	7,91	8,10 a	7,64 a	-	7,52 a	8,40 a

Source: Authors.

There was no statistical difference between the years for the evaluated parameters at Formoso Stream (Table 4). Although adressing 5 years of data, some parameters are not shown in the respective representative fields (-). The Sedimentable solids parameter was not obtained for any year in the data available. All the other parameters analysed are below or in the proposed range of CONAMA 357 and did not demonstrate significant differences to the Scott-Knott test between the years, including its averages.

The evaluation and monitoring of the quality of water, exercised by the entities responsible for the catchment of water, as to its vigilance, are important tools to the guarantee of the protection of the health of consumers. Diverse factors can compromise the quality of springs of water, as an example, waste of industrial activity. In this study were evaluated the aluminum, iron, phosphate, nitrate and nitrites, total dissolved solids, turbidity and hydrogenionic potential.

With a grayish-white coloration, the aluminum (Al) is a metal that it is not found freely in nature, but only in combined configurations, such as oxides and hydroxides, or, in soluble forms, such as sulphates, nitrates and chlorates (Silva et al., 2012). In waters, it can be introduced from the biogeochemical processes, from weathering of rocks or by anthropic action (Figueirêdo, 2004). In this environment, it is complexed and influenced by many factors, such as pH, temperature and the presence of organic matter or binders such as fluoride and sulphates. (Figueirêdo, 2004). In conditions with a pH below 4, for example, it is found predominantly in the form of ion Al^{3+}, once in pH above neutral, the dissolved form of Al(OH) is the predominant (Freitas, 2021).

Even being one of the most abundant elements, the risks of frequent exposition of human beings to sources of aluminum are still scarcely known. Healthy organisms have barriers to reduce the absortion of this micronutrient when ingested (Silva et al., 2012). In mammals, for example, its gastrointestinal absortion is low, as its salts can be turned into aluminum phosphate, that is insoluble in the digestive tract (Dantas et al., 2007).

Studies, however, have related the intoxication by this metal to the risk of developing dementia, of osteomalacia, hyperparathyroidism, anemia, hepato-toxicity, premature ageing, hair loss, cerebral sclerosis etc. (Russ et al., 2020; Klein, 2019; Pascalicchio, 2002).

The iron is the second metal found in higher abundance at the earth crust, representing aproximately 5% of its mass. In the molecular form, it is rarely found in nature, as its ionic forms, Fe^{+2} e Fe^{+3}, combine with compounds rich in oxygen and sulphur forming oxides, hydroxides, carbonates and sulphetes (Proshad et al., 2017). It is present in almost every underground waters (Freitas, 2021). In hydric bodies, it can have geogenic origin, when occurs the lixiviation of granite, doleritic, lateritic rocks and ferruginous leaflets of the matrix rock, or by anthropic action, when dumping indiscriminately industrial or domestic effluents, which organic matter also facilitates its decrease to the form Fe^{2+} (Patel et al., 2017). Normally, the yellowish coloration of the affluents functions as an indicative of the presence of iron in the environment (Proshad et al., 2017).

In the human species, its accumulation, with the similarity of cooper, has been associeted with neurodegenaration in the Wilson's Disease, besides its free form, specially Fe^{2+}, being highly toxic in function of its capacity of triggering the Fenton's reaction and, therefore, the formation of free radicals, lipid peroxidation and cellular death (Butterworth, 2010). In the aquatic fauna, studies with Alosa immaculate Bennet of Danúbio river, in Siberia, report the bioaccumulation of this element in muscles, livers and gills (Visnjic-jeftic et al., 2010).

The phosphorus is a micronutrient indispensable to biological processes, because participate in the constituition of molecules of ATP, DNA e RNA. Its presence in hydric courses can be related specially to the presence and discard of domestic, industrial or agricultural effluents that are rich in organic matter (Balduíno & Araújo, 2021). Large quantities of this material and of organic matter in decomposition promotes the process of eutrofization of courses of water, that reduces the disponibility of oxygen in the environment, impacting the aquatic ecosystem, and restricting the use of water for daily necessities (Lourenço et al., 2022; Fu & He, 2015).

In water, the high number of molecules of nitrate can indicate the utilization of animal faeces as fertilizant in culture of

plants, the use of artificial fertilizants or even the indiscriminate usage of agricultural pesticides by farming industry (Lourenço et al., 2022; Zerwes et al., 2015; Soares et al., 2018).

Although the resoltion of n° 357/2005 of CONAMA considers Total Dissolved Solids a parameter of quality of water, which the limit value is 500 $mg.L^{-1}$, the analysis of SAAE-Pirapora takes in consideration two distincts measures, Total Solids and Dissolved Solids, but complemmentary to the normative of the council. This parameter can present alteration in raining seasons, in function of the lixiviation of soil or by anthropic action of man, sometimes for the disposal of residual water and in other situations by agricultural activity. For being, generally, dissolved salts, a higher quantity of solids can indicate an increase in eletrical conductivity of the environment, of the indices of hardness and alterations in taste (Garcia et al., 2018; Zerwes et al., 2015). In elevated quantities, the solids also promoted the turbidity of water, its increase in temperature, as the suspended particles absorb more heat, and the restriction of the photsynthetic activity and, as a consequence, the significative reduction of the quantity of oxygen dissolved, what affects negatively the aquatic ecosystems.

Correia et al., (2008) defines turbidity as a measure of the difficulty a beam of light encounters when crossing a given amount of water. This attenuation is caused by solid matter in suspension, such as silt, clay, colloids and organic matter, which absorb and scatter light in such a way that the greater the spreading, higher will be the turbidity (Garcia et al., 2018; Correia et al., 2008). Alterations in this parameter commonly derive from agricultural activities that weakens the structure of soil promoting accelerated erosion and carriage of this sediments to courses fo water (Ribeiro et al., 2009).

The hydrogenic potential is the parameter influenced by many other factors such as gases, dissolved solids, hardness, alkalinity and temperature and for the presence of pollutants or organic matter in decomposition (Balduíno & Araújo, 2021; Silva et al., 2018). Elevated values of pH are associated to the presence of bicarbonates and carbonates and to long periods of drought. It has an direct impact in the equilibrium of aquatic life. When talking about waters of supply, its control is indispensable, once it can indicates the corrosion of structures and, subsequently, adition of contaminants such as iron and lead to the environment (Garcia et al., 2018).

In relation to bacteriological analysis, the same were not realized, the expedition did not considered to the quantification of thermotolerants coliforms. The CONAMA n° 357/2005 resolution, in accordance to the resolution of n° 274/2000, although, defines that the classification of waters type II, that are destined to recreation of primary contact, such as swimming, aquatic ski and diving, in the likeness of the rivers here evaluated, can be classified as proper or improper according to, between other factors, the quantity of thermotolerants coliforms, *Escherichia coli* or *Enterococos* per 100 mililiters of water. Samples superior to 2500 fecal coliforms (thermotolerants) or 2000 *Escherichia coli* or 400 *Enterococos* per 100 mililiters are indicatives of improper water (Brasil, 2000, 2005). This analysis is fundamental to the evaluation of the sanitary conditions of the environment, as those micro-organisms are indicators of fecal pollution and release of untreated domestic effluents (Garcia et al., 2018; Soares et al., 2018; Daronco, Bárta, Silva, Colet & Stumm, 2020). Without evaluation and proper treatment, this water represents risk of contamination and transmission of diseasesn representing risk to the collective health (Silva et al., 2018).

4. Conclusion

The data evaluated in this research are within the parameters established by current legislation. In addition, monitoring the water quality of the tributaries of the São Francisco River is of fundamental importance for establishing follow-up and intervention programs in its basin, as it allows better detection of diffuse sources of pollution.

In order to expand this process and ensure better water quality, future research should take into account different tributaries of the São Francisco River and include, in their analyses, the verification of thermotolerant coliforms, since they represent a significant risk to health human and the environment.

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