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# Water quality and risk assessment for the population of Pedro Versiani District, Minas Gerais, Brazil, over the years

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**Abstract:** Water can be a vector for the transmission of waterborne diseases, which may originate from excreta and living or dead animal Water can represent an important vehicle for the transmission of water diseases, which can originate from human and animal excreta, or even the presence of chemical substances harmful to living beings. The Todos os Santos River, one of the main rivers of the Mucuri basin, supplies water for daily use to the district of Pedro Versiani. It is of great socio-economic importance for the local population as a large part of this population consumes water from this river untreated. In view of the current scenario in which the Todos os Santos River is located and its importance for the district of Pedro Versiani, the objective of this study was to analyze the water quality of this river by evaluating the chemical, physicochemical, and microbiological parameters by using the water samples from this river in 2012, 2015, and 2018. It was observed that the parameters of coliforms and turbidity do not comply with the standards specified by the current legislation, as well as the concentrations of aluminum and iron. We conclude that the population living around this river is at risk of contracting diseases by consuming water from this river without treatment.

**Keywords:** daily water intake, Todos os Santos River, water river quality.

## Introduction

Water is one of the main natural resources in the world, and this resource is essential for the existence and maintenance of the natural ecosystems of the planet Earth. However, with the increase in urbanization, the global demand for water grows, bringing with it several sources of contamination, compromising the quality and availability of these resources (UN-WATER, 2018).

Many of the persistent contaminants in the aquatic environment have adverse and cumulative effects on a wide variety of organisms. High levels of some metals such as mercury, aluminum, cadmium, lead, nickel, copper, and manganese lead to significant bioaccumulation (exposure to and accumulation of the metals in the body) and biomagnification (passage of metals from one trophic level to another after bioaccumulation) throughout their biogeochemical cycles (ATSDR, 2018). Because of the presence of high levels of these metals in water bodies, they have become a primary source of contamination for living beings.

Although Brazil is privileged in terms of its natural resources, river distribution is not uniform in the country, exhibiting marked temporal and spatial variations that are an emerging challenge primarily in relation to the availability of fresh water for appropriate consumption (ANA, 2019). Therefore, to develop and plan actions that help in transforming the current socio-environmental challenges, it is extremely important to know which factors are in disagreement with the current standards and laws, and after this data is available, promote the dissemination of the impasses faced by the society so as raise awareness of the risks inherent to such problems.

Interdisciplinary studies that aim to monitor environmental issues are essential as these studies verify abnormalities and determine the presence of toxic substances that compromise the lives of many beings. To assess the quality standards of water resources in Brazil, Resolution no 357 of the National Council for the Environment (CONAMA) (BRASIL, 2005), which classifies surface water bodies, was established.

The Todos os Santos River (Mucuri Valley - Minas Gerais) exemplifies the condition of a critically polluted river, which, even undergoing a gradual contamination process, is used by riverside communities to water consume, agricultural activities, fishing and animal watering (SILVA et al, 2010). This river has its source in the city of Poté – Minas Gerais, it crosses the city of Teófilo Otoni – Minas Gerais, and goes towards the district of Pedro Versiani, whose community uses of its waters for various activities. The Todos os Santos flows into the Mucuri River, in the city of Carlos Chagas – Minas Gerais, carrying persistent contaminants to the aquatic environment (IGAM, 2017).

Once, the population of Pedro Versiani district used the Todos os Santos water in many activities, the objective of this study was to determine the concentration of toxic chemical elements using mass spectrometry techniques with inductively coupled plasma (ICP-MS) and to evaluate the physicochemical and mycrobiological parameters of water quality in the Todos os Santos River (Pedro Versiani district, Teófilo Otoni–Minas Gerais) according to the transition period classified by IGAM (Instituto Mineiro de Gestão das Águas) from April to June for 2012, 2015, and 2018, since domestic effluents are released from different regions along the bed of this river.

## Materials and Methods

### Sampling

Water samples were collected from the Todos os Santos River (Pedro Versiani district/Teófilo Otoni city/Minas Gerais State [17 ° 52 '(S), 41 ° 18' (W]) at 272.5 meters of altitude (Figure 1) in 3 years (2012, 2015, and 2018). An interval of 3 years between the sample collections was maintained. The samples were collected from April to June, climatologically classified as a transition period by IGAM (Instituto Mineiro de Gestão das Águas). The samples were collected according to the procedure adopted by Companhia Ambiental do Estado de São Paulo (CETESB, 2010). For sampling, 50 mL and 15 mL polypropylene flasks with a lid (Falcon) were used (type: metal free).

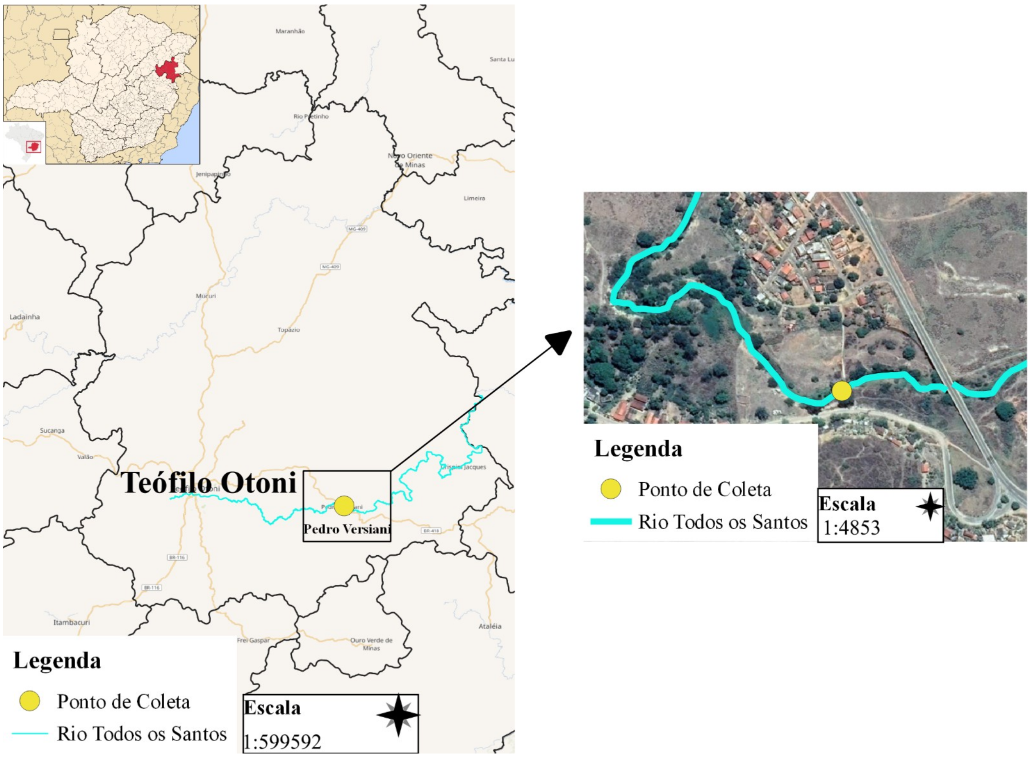

**Figure 1:** Identification of sample collection point in the district of Pedro Versiani, Teófilo Otoni/MG.

## Chemical and Physicochemical Analysis

Physicochemical parameters such as pH, dissolved oxygen (DO) concentration, temperature, turbidity, and electrical conductivity were analyzed at the Contaminant Analysis Laboratory of Institute of Science, Engineering and Technology of the Federal University of Jequitinhonha and Mucuri Valleys (ICET-UFVJM). The following equipment was used: pH-meter DM–22–Digimed; turbidimeter, model HI 98703 – Hanna Instruments; oximeter, model DM–4P – Digimed and conductivity meter, model CD–4303–Lutron, respectively according to the methodology adopted by Macedo (2003).

Furthermore, the concentrations of 19 chemical elements (aluminum, arsenic, barium, beryllium, cadmium, lead, copper, cobalt, chrome, iron, phosphorus, lithium, manganese, mercury, nickel, silver, selenium, uranium, and vanadium) were also determined according to the analytical method proposed by Lawrence et al (2006). For these analyses, a mass spectrometer with the inductively coupled plasma (ICP-MS) model (NECTON 300D, PerkinElmer) installed in the Analytical Instrumentation Laboratory of ICET- UFVJM in a Clean Room – Class 1000 was used. High-purity deionized water (resistivity 18.2 m Ω cm–1) obtained from the Milli-Q system (Millipore®) was used in all the experiments to prepare the calibration standards for quantifying the samples. High-purity nitric acid was also used after distillation at a lower temperature, than the boiling temperature by using the Kürner Analysentechnik quartz distiller to eliminate any possible impurity. Descriptive statistical analyses of the concentration values of the metals and semi-metals considered in this study and the physicochemical parameters were performed for subsequent comparison with the standards recommended by CONAMA (2005).

## Microbiological Analysis

For analyzing the microbiological characteristics of the samples, the multiple tube technique was used to determine total and thermotolerant coliforms according to the Practical Manual for Water Analysis of the National Health Foundation (FUNASA, 2013). To determine total and thermotolerant coliforms, 1 mL of each sample was diluted in saline (0.85% NaCl), and a total of 6 serial dilutions were performed. For each dilution, 1 mL of the solution was inoculated into test tubes with the culture medium Lauril Triptose Sulfate (LST) broth contained an inverted Duhran tube, totaling three repetitions for each dilution. The tubes were incubated in a bacteriological culture incubator at 35°C for 48 h. After incubation, the tubes that showed a positive result, that is, turbidity of the culture medium and gas formation inside the Duhran tube, were inoculated in Brilliant Green Broth (VB) and EC broth to confirm total and thermotolerant coliforms, respectively. For this purpose, an aliquot was removed from each tube that was considered positive, and with the platinum loop, the positive culture was raised in tubes containing the culture media mentioned above, and then the tubes containing VB and EC were incubated at 35°C and 45°C for 48 h, respectively. The results were expressed as the most probable number per mL (NMP mL–1) and calculated using the NMP table provided by the Practical Water Analysis Manual (BLODGERT, 2003).

## Statistical Analysis

To statistically analyze the data obtained from sampling, the program System for Statistical Analysis version 2.0 was used. The statistical method used was an entirely randomized design (DIC) with Analysis of Variance (ANOVA) and the Tukey test at 5% level of significance.

## Estimated Daily Intake for Chemical Elements

The estimated daily intake for chemical elements (EDI) is a calculation that determines the risk of exposure to the riverside population in relation to the chemical elements studied when they ingest the water from the river under study. The formulae used for this calculation are given below:

$$EID1 = C \times L \qquad \text{(Equation 1)}$$

Where:

EID= Daily intake estimation for chemical elements (μg day–1)

C= Concentration of the chemical element analyzed (μg L–1)

L= Average water intake per day (L–1)

$EID2 = EID1/P$ (Equation 2)

Where:

EID2= Daily intake estimation for chemical elements (µg kg-1 day–1)

P= Average population weight (kg)

In Equation 1, an average intake of 2 liters of water per day was considered for this study (EFSA, 2018), and in Equation 2, an average population weight of 68 kg was considered (EFSA, 2018).

The values of the daily reference doses (maximum amount) were obtained from the United States Environmental Protection Agency (USEPA, 2018) daily tolerance table.

## Results and discussion

### Microbiological and Physicochemical Parameters

The water samples from the Todos os Santos River were subject to microbiological and physicochemical analyses to verify their contamination levels. The results were compared to the maximum values recommended by CONAMA Resolution 357/2005 for Class II rivers for water bodies intended for the following uses: domestic water supply after conventional treatment; protection of aquatic communities; primary contact recreation; irrigation of vegetables and fruits; agriculture and fishing activity.

Table 1 shows the maximum values allowed for each physicochemical parameters and thermotolerant coliforms according to the current legislation and their respective average results obtained in 2012, 2015, and 2018.

**Table 1.** Results of physicochemical and microbiological water quality parameters of Todos os Santos River in the district of Pedro Versiani – Teófilo Otoni city/Minas Gerais State.

| **Parameters** | **Concentration Year (2012)** | **Concentration Year (2015)** | **Concentration Year (2018)** | **M A A* Class 2** |
|---|---|---|---|---|
| Dissolved Oxygen (mg $L^{-1}$) | 6.95 ±0.70 a | 6.38 ±0.24 a | 6.27 ±0.19 a | >5.00 |
| pH | 7.09 ±0.34 a | 7.12 ±0.33 a | 6.40 ±0.37 a | 6.00a 9.00 |
| Temperature ( °C) | 24.40 ±0.14 ab | 20.12 ±2.95 a | 27.60 ±0.52 b | - |
| Turbidity (NTU) | 27.20 ±0.28 c | 16.30 ±2.47 a | 20.30 ±0.23 b | <100.00 |
| Conductivity (µS $cm^{-1}$) | 233.40 ±14.53 a | 207.60±12,02 a | 202.20 ±13.5 a | <100.00 |
| Thermotolerant coliforms (NMP $mL^{-1}$) | 445.00 ±8.00 c | 290.00 ±7.07 b | 93.00 ±8.00 a | <10.00 |

*M A A: Maximum Amount Allowed–CONAMA (2005). Similar lowercase letters in the same line indicate that the medium does not represent statistical differences by ANOVA at 5% significance.

The physicochemical parameters are important indicators of pollution and can either confirm the contamination process or serve as a preliminary basis for future analyses. DO concentration, for example, is important for assessing the ability of a water body to perform its biological activity because the higher is the load of organic matter; the greater are the number of decomposing microorganisms and the oxygen consumption (SPERLING, 2014). For the years analyzed, there were no significant changes in the DO indices, and for all the samples, the DO concentration values were within limits specified by CONAMA (2005).

In relation to pH, the mean values were of 7.09 in 2012, 7.12 in 2015, and 6.4 in 2018, did not present significant statistical differences between the years evaluated, and they are within the recommended limits specified by CONAMA (2005), reflecting a neutral environment.

Turbidity presents the degree of suspended solid particles in water, confirming the presence of organic and inorganic materials. The results were 27.20 NTU in 2012, 16.30 NTU in 2015, and 20.30 NTU in 2018, which are in accordance with the standards established by CONAMA (2005). Although the results are in accordance with CONAMA, turbidity values are high when compared to the limits set by the Ministry of Health Ordinance n. 2.914/2011 (MS, 2011), which predicts potability patterns of 5 NTU. In general, the turbidity of water is associated with silt, clay, inorganic and organic matter, colored compounds and microorganisms (ROOHUL et al, 2012; LOUCIF et al, 2020).

The electrical conductivity values exceeded 100 µS cm–1 (maximum acceptable value) for all years analyzed (233.40; 207.60; 202.20 µS cm–1). CONAMA (2005) does not provide standards for electrical conductivity, but according to CETESB (2011), which also regulates water quality standards in Brazil, values for electrical conductivity of over 100 µS cm–1 indicate impacted environments. A change in this parameter confirms the release of effluents into the Todos os Santos River, as the electrical conductivity of the water increases as more soluble solids are added. High values may indicate corrosive characteristics of water (CETESB, 2011) apart from indicating a higher level of ions present in this river.

The thermotolerant coliforms parameter shows us the estimated amount of this type of coliforms found in these waters. It is an important indicator of domestic pollution as the presence of this bacterium reveals that the river and its surrounding environment are contaminated with fecal matter (FERNANDEZ-CASSI et al, 2016). From 2012 to 2018, there was a significant reduction in this parameter, from 445.00 to 93.00 NMP $mL^{-1}$, which can be justified by the installation of the Sewage Treatment Station in the region, that has contributed to the reduction in the spread of harmful microorganisms through human excreta. However, when comparing these values with the limits specified by law, the established value is 10 NMP $mL^{-1}$, and for all the years analyzed, the observed values were above the stipulated value, indicating that a considerable amount of effort is required for the reduction and classification of the river in Class II category. The parameter thermotolerant coliforms are for designating water quality and hygienic conditions to human use, and the results in disagreement within the legislation may be used to consider the water unacceptable for human use, once these bacteria are pathogens responsible for various infections, mainly in immune deficient patients (MWANAMOKI et al, 2014; FERNANDEZ-CASSI et al, 2016).

Bianchi et al (2019) also evaluated the quality of water consumed by human communities in Brazil. In this case, the authors monitor the water quality of three rivers of the Sinos River Basin, Southern Brazil, and they found that the physicochemical and microbiological parameters are in disagreement with the Brazilian environmental normative in all sites of collection. Leme et al (2018) evaluated the quality of three rivers (water supply and fishing): Rio Pequeno, Rio Grande and Bororé that presented contamination by Escheria coli and heterotrophic bacteria, being these rivers considered unacceptable for human use in their untreated state and for fishing. Medeiros, Lima and Guimarães (2016) took into account the exposure to urban and industrial pollutants in the municipalities of Abaetetuba and Barcarena in Pará. The waters used for human consumption in the Maranhão Community, where there was no contamination by industrial pollutants, presented adequate quality, whereas the waters of Vila do Conde, close to industrial activity sites, showed unacceptable quality for consumption. The main parameters affected were pH and nitrate, with values up to 25 times higher than allowed by legislation.

Other studies on water quality in Brazil focus on the analysis of different hydrographic basins. Among these studies, Garcia (2013) evaluated the water quality of the Paraíba do Sul River in the city of Lorena - São Paulo; Moretto et al, (2012) studied the Rio Pardo Hydrographic Basin, Rio Grande do Sul; Pinto et al, (2009) studied the water quality of Ribeirão Lavrinha, in the Alto Rio Grande region - Minas Gerais; Avellar, Castro and Hadad (2008) the Ribeirão São João, in the São eFrancisco River Basin - Minas Gerais; and Donadio et al, (2005) verified the different water quality standards in the Córrego Rico hydrographic Basin in the cities of Taquaritinga and Guariba - São Paulo, among other works.

In all the studies mentioned above, water quality parameters were found in disagreement with the legislation, which may pose risks to the health of the population dependent on these hydrographic basins, making water quality monitoring studies of great importance.

## Chemical Parameters

Table 2 shows the results of the 19 chemical elements analyzed from Pedro Versiani District in the years of 2012, 2015 and 2018. The values of these elements presented concentrations below to the established by CONAMA 357/05 for most of them. But, aluminum and iron levels were found to be high in the samples analyzed for all years.

**Table 2.** Determination of 19 chemical elements in the water samples from Todos os Santos River in Pedro Versiani – Teófilo Otoni/Minas Gerais in the years of 2012, 2015 and 2018.

| **Elements** | **Concentration ±SD** Year (2012)** | **Concentration ±SD** Year (2015)** | **Concentration ±SD** Year (2018)** | **M A A*** |
|---|---|---|---|---|
| Aluminum | 203.41 ±0.83 a | 250.00 ±8.00 b | 276.00 ±3.42 c | 100.0 μg L–1 Al |
| Arsenic | <DL*** a | <DL*** a | <DL*** a | 10.0 μg L–1 As |
| Barium | 40.62 ±2,14 c | 31.00 ±0.48 a | 36.70 ±1.56 b | 700.0 μg L–1 Ba |
| Beryllium | <DL*** a | <DL*** a | <DL*** a | 40.0 μg L–1 Be |
| Cadmium | <DL*** a | <DL*** a | <DL*** a | 1.0 μg L–1 Cd |
| Lead | <DL*** a | 2.58 ±0.03 b | 3.42 ±0.02 c | 10.0 μg L–1 Pb |
| Copper | <DL*** a | <DL*** a | <DL*** a | 9.0 μg L–1 Cu |
| Cobalt | <DL*** a | <DL*** a | <DL*** a | 50.0 μg L–1 Co |
| Chrome | <DL*** a | 2.60 ±0.13 b | 3.20 ±0.14 c | 50.0 μg L–1 Cr |
| Iron | 2063.86 ±17.06 c | 602.00 ±8,80 b | 504.08 ±5.56 a | 300.0 μg L–1 Fe |
| Phosphor | 0.38 ±0.22 a | 0.23 ±0.07 a | 0.25 ±0.12 a | 20.0 μg L–1 P |
| Lithium | <DL*** a | 1.85 0.01 c | 0.76±0.01 b | 2500.0 μg L-1Li |
| Manganese | 60.33 ± 1.93 c | 0.58 ± 0.03 a | 50.36±2.35 b | 100.0 μg L-1Mn |
| Mercury | <DL*** a | <DL*** a | <DL*** a | 0.2 μg L-1Hg |
| Níckel | <DL*** a | <DL*** a | <DL*** a | 25,0 μg L-1Ni |
| Silver | <DL*** a | 0,518± 0,08 c | 0,20±0,06 b | 10,0 μg L-1Ag |
| Selenium | 3,09 ± 1,77 b | <DL*** a | <DL*** a | 10,0 μg L-1Se |
| Uranium | <DL*** a | <DL*** a | <DL*** a | 20,0 μg L-1U |
| Vanadium | <DL*** a | 5,53 ± 0,04 b | 5,87 ±0,01 b | 100,0 μg L-1V |

*M A A: Maximum Amount Allowed – CONAMA (2005), **SD: Standard Deviation, ***DL: Below Detection. Lowercase letters equal in the same line indicate that the media does not represent statistical differences by ANOVA at 5% significance.

High levels of these elements in the human body cause adverse effects. Aluminum is a neurotoxic metal (ASTDR, 2018) that accumulates in various tissues, including bones, brain, and other organs of the human body. The main signs and symptoms of intoxication are hypochromic and microcytic anemia, acute neurotoxicity (agitation, mental confusion, and convulsion), kidney failure, encephalopathy, and aluminum-related bone disease (osteomalacia and adynamic bone disease). Since it is predominantly excreted through the urine, aluminum toxicity is of high importance in patients with chronic kidney disease. There is also the possibility that aluminum may play an important role in the development of Alzheimer’s disease (FREITAS, 2001; ATSDR, 2018).

Iron, in the human body, plays several important roles such as oxygen transport and storage, energy-release reactions in the electron transport chain, a cofactor for some enzymatic reactions, hemoglobin production, etc. Its deficiency can cause anemia, and in excess quantities, it accumulates mainly in the liver, pancreas, and heart, which can increase the incidence of heart problems, diabetes, liver cirrhosis, hemochromatosis, and other liver complications, as humans have limited capacity to excrete excess iron (SIQUEIRA et al, 2009).

The increasing of toxic metals in soils and waters is generally associated with the release of industrial effluents, urban waste and domestic sewage (MACEDO, 2004; ROCHA; AZEVEDO, 2015). But in the case of these water samples from the Pedro Versiani district, it should also be remembered that these elements may come from weathering and soil transport, since the city of Teófilo Otoni has a predominance of red-yellow latosols that are composed of highly weathered minerals, in which the presence of iron and aluminum oxides is common (PALMIER; LARACH, 2004). The fact that this water are contaminated with high concentrations of aluminum and iron and that is used for the consumption of humans and animals, makes it even more necessary to carry out environmental sanitation and adequate water treatment for this region.

## Estimated Daily Intake for Chemical Elements

Human exposure to toxic metals through drinking water is considered as an important pathway for heavy metal exposure (ALIDADI et al., 2019). Based on this, the values of Estimated Daily Intake (EDI) for all chemical elements analyzed in the water samples from Pedro Versiani District collected in the years of 2012, 2015, and 2018 are presented in Table 3.

Table 3. Values of Estimated Daily Intake for the chemical elements studied to assess the risk of exposure of the riverside population.

| **Elements** | **Concentration ±SD** Year (2012)** | **Concentration ±SD** Year (2015)** | **Concentration ±SD** Year (2018)** | **M A A*** |
|---|---|---|---|---|
| Aluminum | 203.41 ±0.83 a | 250.00 ±8.00 b | 276.00 ±3.42 c | 100.0 µg L–1 Al |
| Arsenic | <DL*** a | <DL*** a | <DL*** a | 10.0 µg L–1 As |
| Barium | 40.62 ±2,14 c | 31.00 ±0.48 a | 36.70 ±1.56 b | 700.0 µg L–1 Ba |
| Beryllium | <DL*** a | <DL*** a | <DL*** a | 40.0 µg L–1 Be |
| Cadmium | <DL*** a | <DL*** a | <DL*** a | 1.0 µg L–1 Cd |
| Lead | <DL*** a | 2.58 ±0.03 b | 3.42 ±0.02 c | 10.0 µg L–1 Pb |
| Copper | <DL*** a | <DL*** a | <DL*** a | 9.0 µg L–1 Cu |
| Cobalt | <DL*** a | <DL*** a | <DL*** a | 50.0 µg L–1 Co |
| Chrome | <DL*** a | 2.60 ±0.13 b | 3.20 ±0.14 c | 50.0 µg L–1 Cr |
| Iron | 2063.86 ±17.06 c | 602.00 ±8,80 b | 504.08 ±5.56 a | 300.0 µg L–1 Fe |
| Phosphor | 0.38 ±0.22 a | 0.23 ±0.07 a | 0.25 ±0.12 a | 20.0 µg L–1 P |
| Lithium | <DL*** a | 1.85 0.01 c | 0.76±0.01 b | 2500.0 µg L-1Li |
| Manganese | 60.33 ± 1.93 c | 0.58 ± 0.03 a | 50.36±2.35 b | 100.0 µg L-1Mn |
| Mercury | <DL*** a | <DL*** a | <DL*** a | 0.2 µg L-1Hg |
| Níckel | <DL*** a | <DL*** a | <DL*** a | 25,0 µg L-1Ni |
| Silver | <DL*** a | 0,518± 0,08 c | 0,20±0,06 b | 10,0 µg L-1Ag |
| Selenium | 3,09 ± 1,77 b | <DL*** a | <DL*** a | 10,0 µg L-1Se |
| Uranium | <DL*** a | <DL*** a | <DL*** a | 20,0 µg L-1U |
| Vanadium | <DL*** a | 5,53 ± 0,04 b | 5,87 ±0,01 b | 100,0 µg L-1V |

*DI1: Daily Intake (mg dia–1), *DI2: Daily Intake (µg kg–1dia–1). Maximum amount, Year * (µg L–1).

The EDI for the 19 elements are below the maximum amount recommended value according to USEPA (2015), even for Al and Fe that was found in concentrations above to those established by the legislation. However, it is estimated that drinking water is responsible for only a portion of the total intake of chemical elements by the population. In this case, the risks cannot be ruled out since such elements (Al and Fe) can be found in other sources such as fruits, vegetables, and other foods in general, and consuming polluted water would increase the daily intake limit of these metals under study.

Similar to our findings, daily intake of 17 metals via drinking water were investigated in six cities in Japan, and the authors described that for all cases, the drinking water did not contribute very much to essential metal intake (OHNO et al., 2010). Also, twenty samples throughout Ganjiang River in India were used to determine the daily intake of Zn, Cu, V, Ni, Cr, Pb, Co, Tl and As, and all studied elements was below unit, indicating that the water samples are basically clean and can be used as habitat for aquatic life and for adult and children ingestion (ZHANG et al., 2017). However, the authors suggested that the inhabitants of the samples sites might be subject to mixed trace elements being required to pay more attention for the daily intake of water and other sources of these mixed elements, especially when used for children.

Other study about daily intake of copper, zinc and arsenic in drinking water by population of Shangai/China showed on average 0.01%, 1.1% and 1.5% of the provisional maximum tolerable daily intake set by FAO/WHO Committee, suggesting that ingestion of these metals in drinking water were associated with a non-significant potential threat to human health for the general population of Shangai (XU et al., 2006).

## Conclusion

By performing physicochemical analyses and determining the levels of toxic metals, we found that the waters of the Todos os Santos River do not conform to the quality standards established by the CONAMA resolution 357 of 2005. The values for electrical conductivity parameter and thermotolerant coliforms remained in disagreement with those specified by CETESB (2011) in all the samples analyzed. Aluminum and iron levels were above the maximum permitted limits. Some toxic metals can be bioaccumulated in the tissues of fish and terrestrial animals that ingest the water of this river, and therefore, the ingestion of foods can present the risk of indirect contamination by toxic metals. Agricultural crops irrigated by these waters also present themselves as a source of contamination, as metals have the potential to adsorb on the surface of these foods. Regarding the EDI, the water for human consumption in the Todos os Santos River in Pedro Versiani is at the limit for Al and Fe. We, therefore, suggest that the population living around this river is susceptible to acquiring or developing diseases resulting from consuming the contaminated water of this river either directly or indirectly.

# Qualidade da água e avaliação de risco da população do Distrito de Pedro Versiani, Minas Gerais, Brasil, ao longo dos anos

**Resumo:** A água pode ainda representar um importante veículo de transmissão de doenças hídricas, que podem ser originadas de excretas humanas e de animais, ou mesmo pela presença de substâncias químicas nocivas aos seres vivos. O rio Todos os Santos, como um dos principais rios da bacia do Mucuri, abastece o distrito de Pedro Versiani, onde este possui uma grande importância social e econômica para a população local, sendo que boa parte desta população faz o consumo destas águas sem nenhum tipo de tratamento. Diante do atual cenário em que se encontra o rio Todos os Santos e da sua importância para o distrito de Pedro Versiani, o presente trabalho teve por finalidade analisar a qualidade da água do rio, avaliando parâmetros físico-químicos, químicos e microbiológicos de 2012, 2015 e 2018. Observou-se que os parâmetros analisados de coliformes e condutividade encontraram em desconformidade com a legislação vigente, assim como as concentrações de alumínio e ferro. Concluiu-se que a população se encontra em risco de contrair doenças oriundas do meio hídrico através do consumo dessa água sem tratamento.

**Palavras-chave: estimativa de ingestão diária, rio Todos os Santos, qualidade da água.**

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