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Research paper

# Analysis of water quality in Roda D'Água Brook, Uberaba River tributary, MG

## *Análise da qualidade da água do Córrego Roda D'Água, afluente do Rio Uberaba, MG*

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**ABSTRACT:** Water resources degradation reflexes the environmental crisis caused by both increased anthropic demands and population growth, which lead to changes in consumption habits, pollution generation and lack of basic sanitation. The cost to treat water for public supply and to recover water springs is high, with emphasis on the relevance of preserving and taking care of water-use procedures. The Water Quality Index (WQI), which assesses waterbodies' contamination, is the monitoring method adopted in Brazil. The aim of the present study is to assess the quality of water in Roda D'Água Brook, Uberaba City, Minas Gerais State, Brazil, based on WQI. It was done to diagnose this brook's environmental health. To do so, physical, chemical, and microbiological parameters were assessed. Results have shown that the WQI value recorded for the herein assessed brook is too low, and its water was classified as having very poor quality, since its WQI values were lower than 25 – this number is considered dissatisfactory. Thus, although there was no industrial waste in its water, feces discharge from livestock farms close to this waterbody can be blamed for the frame, given the presence of thermo-tolerant coliforms in the assessed water. Therefore, this water must be avoided for human consumption and for leisure activities; moreover, it is recommended to take migratory actions to reduce anthropic impacts, since the brook's content is used by the municipal government to water plants in the city. Thus, integrating policies associated with the accountable municipal bureaus are suggested and they must aim at guiding companies and local community, based on environmental policies that exceed the simple development and monitoring of projects focused on mitigating these water-spring issues.
**Keywords:** Water quality. Watercourses. WQI. Microbiology.

***RESUMO:*** *A degradação dos recursos hídricos reflete a crise ambiental causada pelo aumento das demandas antrópicas e crescimento populacional, acarretando mudança dos hábitos de consumo, geração de poluição e falta de saneamento básico. O custo do tratamento de água para abastecimento público e a recuperação de mananciais é elevado, ressaltando a importância da preservação e cuidados nas formas de utilização da água. Uma forma de monitoramento adotada no Brasil é o Índice de Qualidade da Água (IQA), que avalia a contaminação dos corpos hídricos. Esse trabalho avaliou a qualidade da água do córrego "Roda d'água", na cidade de Uberaba (MG), por meio do IQA, visando diagnosticar a saúde ambiental do córrego e, para isso, foram avaliados os parâmetros físicos, químicos e microbiológicos. Os resultados indicaram que o valor de IQA é muito baixo, classificando a água como péssima, com os valores (IQA) abaixo de 25, o que é considerado insatisfatório. Assim, apesar de não ter sido comprovada a presença de efluentes industriais, os despejos de fezes oriundos da agropecuária próximo ao corpo hídrico podem ser considerados um causador, visto a presença de coliformes termotolerantes. Sugere-se, portanto, evitar o consumo humano da água e atividades de recreação no córrego, além de recomendar-se ações mitigatórias a fim de diminuir os impactos antrópicos, já que seu conteúdo é utilizado pelo governo municipal da região para regar as plantas da cidade. Para isso, são sugeridas políticas integradoras associadas com órgãos municipais competentes, orientando empresas e comunidades locais por meio de políticas ambientais além da criação e fiscalização de projetos com a finalidade de mitigar esses problemas dos mananciais.*
***Palavras-chave****: Qualidade da água. Curso d'água. IQA. Microbiologia.*

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**INTRODUCTION**

Water is an essential resource for life maintenance, since it is broadly distributed worldwide (SELBORNE, 2001). This environmental resource is essential at all scopes, from biome conservation, economy, animal and vegetal consumption, to physical, chemical and biological processes (TUNDISI; TUNDISI, 2013; SANA et al., 2020).

Nowadays socio-environmental scenario turns the attention to freshwater quality into a priority, since this is an essential resource that is getting scarcer, overtime (SELBORNE, 2001; BUTZKE; PONTALTI, 2012; SOUSA et al., 2021). Although the importance of water has been broadly discussed, anthropic activities pollute it and make it inappropriate for consumption (BUTZKE; PONTALTI, 2012; IGAM, 2022).

Activities, such as water use in industrial and domestic activities, among others, have higher or lower negative impact on the environmental quality of water resources (SARDINHA et al., 2008; SANTOS; SANTOS, 2019; NASCIMENTO et al., 2020; IGAM, 2022). Another factor linked to it lies on uncontrolled population growth that, by rising water consumption level, worsens waterbodies' pollution (MENDONÇA; GONÇALVES; RIGUE, 2020). Concerning contamination status has been the consequence of such environmental pressures, mainly because of discharge of both inorganic waste and elements MADRUGA et al., 2008; YAMAGUCHI; CORTEZ; OTTONI, 2013; NUNES et al. 2021) that, besides directly interfering with ecosystems' functioning, can also compromise human health due to the presence of pathogenic microorganisms in the environments (SANTOS; GUIMARÃES; SANTOS, 2017).

Given such environmental issues, back in 1970, the National Sanitation Foundation created the Water Quality Index (WQI) in the United States. This methodology, which takes into consideration water physical, chemical and biological parameters, was first adopted in Brazil by São Paulo State Environmental Company, also known as CETESB, five years after its creation (1975). Later, it was extended to the other states in the country. Nowadays, this quality-evaluation methodology became one of the main parameters to analyze the quality of waterbodies (ANA, 2022).

Each one of the following parameters: dissolved oxygen, thermo-tolerant coliforms, hydrogen potential, biochemical oxygen demand, total organic carbon, water temperature, total phosphorus, turbidity and total residue, has considerably acceptable level (ANA, 2022; IGAM, 2022). WQI is used to analyze and to allow the mitigation of factors accountable for contamination (ANA, 2022).

Microbiological analysis is another tool that has contributed to identify quality of water. It regards the presence of microorganisms in water, such as total and thermo-tolerant coliforms, whether pathogenic or not (YAMAGUCHI; CORTEZ; OTTONI, 2013; REIS; BEVILACQUA; CARMO, 2014; SANTOS; GUIMARÃES; SANTOS, 2017; MASCARENHAS et al., 2021).

By having in mind environmental issues correlated to waterbodies and to the relevance of assessing water quality, the aim of the present study was to analyze the quality of water in Roda D'Água Brook micro-basin, which is a tributary of Uberaba River. This brook is in the borders of Federal University of Triângulo Mineiro (UFTM), Univerdecidade campus, based on microbiological and physical-chemical variables.

According to the Operational Company of Development, Sanitation and Urban Actions, also known as CODAU, which accounts for services related to basic sanitation in Uberaba City, this tributary is classified as parameter II, based on CONAMA Resolution 357/05. Therefore, it is destined to domestic supply, after its treatment. It is responsible for

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supplying water tank trucks aimed at water distribution in municipal public parks, as well as at irrigation, dust control, streets' cleaning, population water supply purposes, among others.

Thus, Roda D'Água Brook was chosen as study target to better understand its quality, since there is no documented study about this location. Nevertheless, assumingly, clandestine waste is discharged in this location by small industries, as well as it is used for leisure purposes – these activities are performed in a non-ecological way -, a fact that reinforces the need of making the population aware of the quality of water that supplies Uberaba City.

## MATERIAL AND METHODS

### Sampling

Samples were collected in Uberaba City – MG, Southeastern Brazil, on the borders of Federal University of Triângulo Mineiro – UFTM (**Figure 1**).

The collection procedure was performed in 2022. Three sites in the herein assessed brook were sampled, and it totaled three triplicates, in each collection point: Point 1, at coordinates 19° 42' 56" S 47° 57' 26" W, in the upstream region; Point 2, at coordinates 19° 43' 11" S 47° 57' 19" W, in the backyard of Institute of Technological and Exact Sciences (ICTE); and Point 3, at coordinates 19° 43' 13" S; 47° 57' 19" W, in the downstream region.

According to the present authors' analysis for the conduction of the current research, Point 1 is featured as waterbody among water rapids and pools in much of its bed. Brook sides present partly preserved riparian forest and mid-sized vegetation with fully closed canopy. Brook bed features small- to mid-sized rock pebbles, steams and exposed roots. Point 2 shows grass species around it; it is separated from Point 3 by a paved road. Finally, Point 3 presents a small line of riparian forest with closed canopy, water rapids and pools. Anthropic action in the region is linked to livestock farming and to recreational use, based on open trails in its surroundings.

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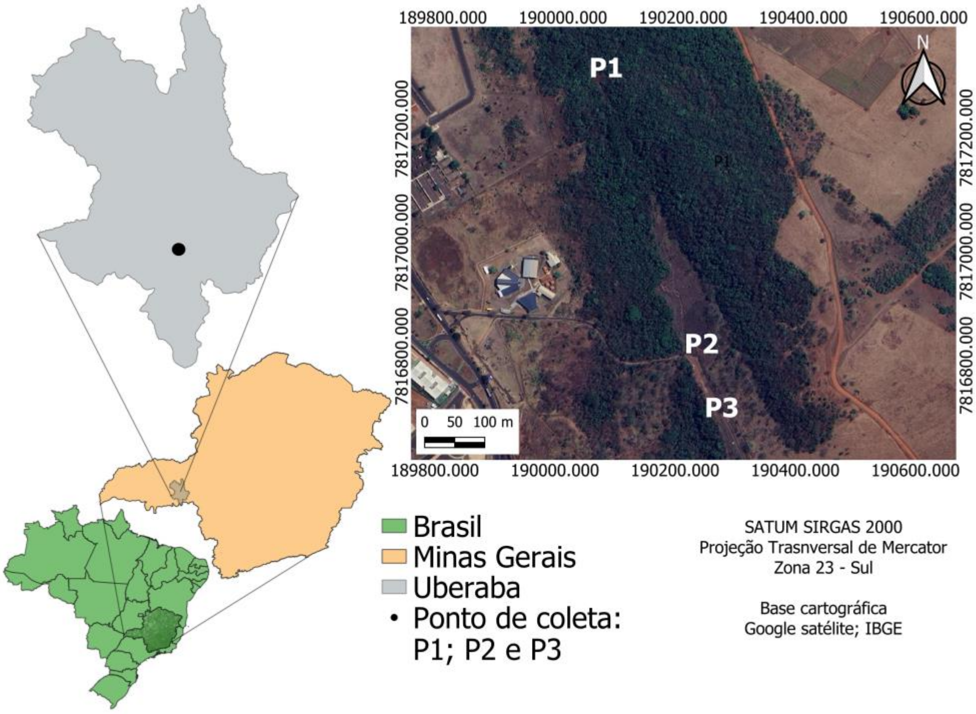
**Figure 1.** Map with the location of Uberaba County, Minas Gerais State, Southeastern Brazil. Sampled perimeter of Roda D'Água Brook, urban zone in Univerdecidade neighborhood.




## Physical-chemical analysis

Sample collections were performed on April 27 and on May 04, 2022 – two collections were carried out in each point. These samples were collected by inserting 2L plastic bottles in the brook to capture water. The bottles were previously sanitized and, subsequently, acclimatized to the herein analyzed brook. It was done to ensure result reliability. Three repetitions of each point were collected in 50mL Falcon Tubes for microbiological analysis purpose; then, they were taken to the laboratory for triplicate analyses.

The physical-chemical and microbiological analyses were carried out in the chemistry and microbiology laboratory of Federal University of Triângulo Mineiro. The following items were analyzed: thermo-tolerant coliforms, hydrogen ion potential (pH), biochemical oxygen demand (BOD), total organic carbon (TOC), temperature, total phosphorus, turbidity, and total waste. Results were compared to CONAMA 357/05 parameters (BRASIL, 2005) and the introduced methods were adopted to conduct physical-chemical and microbiological analyses.

WQI calculation was carried out according to recommendations by Minas Gerais Water Management Institute (IGAM), based on the weighed product of the nine parameters, through equation 1:

$$IQA = \prod_{i=1}^{n} q_i^{w_i} \qquad (1)$$

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Where, WQI = Water Quality Index (it ranges from 0 to 100); $q_i$ = quality of the i[th] parameter (data gathered from the quality graphic by analyzing concentration or measurement – it ranges from 0 to 100); $w_i$ = weight corresponding to the fix $q_i$, depending on its relevance for quality global compliance (it ranges from 0 to 1).

**Table 1** shows the classification levels adopted to assess the collection points.

**Tabela 1.** WQI classification levels

| Faixas de IQA | Avaliação da Qualidade da Água |
|---|---|
| 91-100 | Excellent |
| 71-90 | Good |
| 51-70 | Reasonable |
| 26-50 | Poor |
| 0-25 | Very poor |

Source: BRASIL, 2005.

## RESULTS AND DISCUSSION

After data gathering, the recorded results have pointed out evaluation evidence related to Roda D'Água Brook's environmental health. They will be discussed over the present section.

Overall, temperature remained stable according to environments in tropical regions (mean temperature of 24 °C) (JUNK et al., 2020). According to Ribeiro et al (2019), mean thermal regimen in Uberaba region, MG, ranges from 20 °C to 24 °C, and this finding corroborates the presented data (Table 1). There was temperature drop in June/July, only; this drop was expected, since these are the coldest months of the year. Therefore, data have reinforced the average expected for the annual pattern (RIBEIRO et al., 2019).

Vasconcellos et al (2006) highlight the surface runoff observed in the rainiest periods. It contributes to change water microbiological quality due to human and animal excreta dragging, which tends to take pathogens to waterbodies.

The presence of these pathogens can be explained by the fact that Point 1 in an open water spring and by the presence of livestock farms in its surroundings. These animals' feces get combined to other organic matters, such as leaves and branches, and it contributes to the very low WQI value recorded for this point, as shown in **Table 2**.

**Table 2.** WQI values based on means recorded in weeks 1 and 2

| Sampling point | IQA |
|---|---|
| 1 | 14,01 |
| 2 | 14,05 |
| 3 | 14,01 |

Roda D'Água Brook was considered inappropriate for human and animal consumption in all analyzed collection points because they presented 2,300 MPN/m thermo-tolerant coliforms. This number exceeds the limit set to it (1,000 per 100/mL), according to CONAMA Resolution 357/2005. The Research by Pinto et al (2009) about quality of water presented results that have corroborated the explanation that correlates

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livestock farming to pollutant results; it also stated that contamination with coliforms is linked to livestock activities.

CONAMA 357/2005 does not provide on the concentration limit to TOC parameter, but this analysis was carried out to set the amount of dissolved carbon in samples of the herein assessed brook. According to results in **Table 3**, analysis carried out based on TOC pointed out low amount of dissolved carbon in the brook, and it highlights low organic matter concentration in it. Thus, it is possible inferring that dissolved oxygen levels are high, because DO and TOC recorded inversely proportional values (BRASIL, 2005).

**Table 3.** Analyzed physical-chemical parameters

| Physico-chemical and microbiological parameters | Week 1 (2022/27/04) | | | Week 2 (2022/04/05) | | |
|---|---|---|---|---|---|---|
| | P 1 | P 2 | P 3 | P 1 | P 2 | P 3 |
| Temperature | 24,03 | 24,03 | 24,33 | 22,39 | 22,51 | 22,15 |
| pH | 6,10 | 6,10 | 6,16 | 6,09 | 6,15 | 6,08 |
| Electrical conductivity (µS.cm$^{-1}$) | 30 | 30 | 31 | 36 | 31 | 32 |
| ORP | 335,00 | 335,00 | 332,00 | 517,00 | 332,00 | 463,67 |
| Turbidity (UNT) | 6,66 | 6,67 | 9,17 | 14,79 | 9,16 | 14,30 |
| Phosphorus (mg.L$^{-1}$) | 0,02 | 0,02 | 0,01 | 0,01 | 0,01 | 0,01 |
| TOC (mg.L$^{-1}$) | 4,46 | 2,91 | 5,39 | 2,64 | 1,75 | 1,50 |
| Inorganics (mg.L$^{-1}$) | 3,27 | 3,29 | 4,54 | 4,07 | 3,56 | 3,40 |
| TDS (mg.L$^{-1}$) | 0,19 | 0,19 | 0,20 | 0,02 | 0,20 | 0,02 |
| Thermo-tolerant coliforms (NMP.mL$^{-1}$) | 2.300 | 2.300 | 2.300 | 2.300 | 2.300 | 2.300 |
| Color e odor | no | no | no | no | no | No |
| Salinity (%) | 0 | 0 | 0 | 0 | 0 | 0 |

pH: Hydrogen Potential; ORP: oxidation/reduction potential; TOC: total organic carbon (mg.L); STD: total dissolved solids (µg/L).

Inorganic traces were also analyzed in the herein assessed brook. They presented mean concentration of 3.69 mg.L$^{-1}$. This value pointed towards toxicity, carcinogenicity and to other adverse health factors. Oliveira; Silva and Tavares (2020) state that results presenting high amounts of inorganics can be explained by the presence of minerals that may have several impairing chemical elements, such as arsenic, barium and chromium.

With respect to salinity, all locations and sampled repetitions recorded value equal to zero (0). This finding confirmed one of indicators for freshwater environments, where salinity was lower than, or equal to, 0.5% and reached maximum variation of 0.7°C among the sampled samples (BRASIL, 2005).

Electrical conductivity of water was also analyzed. It depends on ionic concentration in water and is defined based on water ability to conduct electric current (FEITOSA et al., 2008). Values recorded for this parameter were relatively constant and low. This finding can be explained by temperature increase (from 0 °C to 30 °C), which can also lead to solubility increase (ANA, 2005). Conductivity can be also associated with industrial waste and/or waste discharged by thermo-electric power plants – both sectors have strong activity close to the herein assessed region (PIRATOBA et al., 2017).

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Moreover, results have shown electric-conductivity content of 30 µS.cm$^{-1}$ in the first week and from 31 µS.cm$^{-1}$ to 36 µS.cm$^{-1}$ in the second week - CONAMA Resolution 357/2005 does not set a limit value. According to Von Sperling (2007), conductivity contents ranged from 10 to 100 µS.cm$^{-1}$; limits were wider for industrial waste. Thus, the herein recorded results are within the recommended limit.

Hydrogen potential values (pH) presented light acidity in all assessed points (**Table 3**). However, all of them were within the limits provided on CONAMA Resolution 357/2005 – the following values were adopted as metric: 6 and 9. By definition, according to Esteves (1998), these values are observed in continental environments; however, pH values range from 6 to 8. This same author points out low pH values in environments with high concentrations of dissolved organic acids of allochthonous and autochthonous origin, as well as in Amazonian regions, on the coast and in peat bog waterbodies. Besides these allochthonous and autochthonous factors, the presence of vegetation (phytoplankton) and fish (small to mid-sized) can generate inorganic compounds (sulfuric, nitric, oxalic, acetic, carbonic acid) with higher activity for zooplankton and fish. Accordingly, pH values recorded for the herein assessed brook have shown that this waterbody did not suffer with any relevant alkaline or acidic interference capable of significantly changing the pH value. However, it also shines light on the dynamics based on the composition/structure of each environment.

Turbidity in shallow environments (3m, for example) is a parameter that, whenever at high levels, oftentimes points out the presence of both suspended particles and colloids deriving from mud, excess of organic matter and from other organisms that cause waterbody transparency reduction (fish reduce vegetal biomass, for example) due to ingestion of organic matter and sediment revolving (ESTEVES, 1998). Point 1, in the second week, was the one accounting for the highest nephelometric turbidity unit: 14,795 NTU. This value does not indicate a potential problem, since the limit for freshwater environments goes all the way up to 40 NTU, based on CONAMA Resolution 357/2005.

## CONCLUSION

The assessed data have shown that Roda D'Água Brook suffers with impact on its quality due to high coliform concentrations, although it presents little changes in the other parameters. WQI application has shown that its water does not match the 'good class'; in other words, it is inappropriate for human and animal consumption, based on CONAMA 357/05. Thus, WQI value pointed out numbers lower than 25, which are considered dissatisfactory. It is worth highlighting that, although the tributary does not present recurrent industrial waste discharge, there is frequent disposal of feces from animals bred in livestock farms close to this waterbody. This fact can be explained by the presence of thermo-tolerant coliforms in its water, which are considered responsible for the water's low quality.

The recorded results point out that water in Roda D'Água Brook can pose risk to human health, because, although its physical-chemical parameters are following the enforced legislation, microbiological analyses have evidenced the presence of infectious agents that can cause illnesses, such as diarrhea and urinary infections.

Thus, it is important highlighting the need of conducting further studies about Roda D'Água Brook, as well as of constantly monitoring it and of subjecting it to adequate treatment. To do so, it is important developing integrating policies associated with responsible municipal bureaus to guide and inspect companies and the local community. It

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is also essential developing projects to mitigate these water springs' issues and to promote environmental education to make the population aware of them. Only after applying these measures that this waterbody may be considered appropriate for consumption and for use on food-plant crops.

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