Determination of the water quality index in two rural properties in the Municipality of Guatambu-SC

Determinação do índice de qualidade da água em duas propriedades rurais no Município de Guatambu-SC

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ABSTRACT
Knowing the quality of water resources is fundamental to guarantee its different functions in the environment. In this sense, this study highlighted the relationship between land use and occupation with water quality, since the objective was to assess water quality in two rural properties in the municipality of Guatambu in the state of Santa Catarina, Brazil. Five points for analysis and their geographic coordinates were demarcated in each property using the Global Positioning System (GPS) and inserted into the Quantum GIS (QGIS) software for spatial assessment. For the water quality analysis of each point, the following parameters were determined: pH, electrical conductivity, dissolved oxygen, color, turbidity, alkalinity, chlorides and biochemical oxygen demand. According to these results, the Bascarán surface water quality index ($SWQI_B$) was estimated. As demonstrated by the results, both properties presented an $SWQI_B$ ranging from “medium” to “good”. However, when comparing the points intended for human consumption with the Brazilian Decree 2,914 of December 2011, it was found that the color and turbidity parameters were in disagreement in some cases. However, these two parameters can easily vary. In addition, it was noted that points classified with $SWQI_B$ "good" have a better protection area when compared to points classified with $SWQI_B$ "medium".

Keywords: Water quality, Bascarán index, Physicochemical parameters.

RESUMO
Conhecer a qualidade dos recursos hídricos é fundamental para garantir as suas diversas funções no ambiente. Nesse sentido, este estudo destacou as relações entre o uso e ocupação do solo com a qualidade da água, uma vez que o objetivo foi avaliar a qualidade da água em duas propriedades rurais no município de Guatambu no estado de Santa Catarina, Brasil. Cinco pontos para análise e suas referidas coordenadas geográficas foram demarcados em cada propriedade através de Global Positioning System (GPS) e inseridos no software Quantum GIS (QGIS) para a uma avaliação espacial. Para a análise da qualidade da água de cada ponto foram determinados os seguintes parâmetros: pH, condutividade elétrica, oxigênio dissolvido, cor, turbidez, alcalinidade, cloretos e demanda bioquímica de oxigênio. Com estes resultados, estimou-se o índice de qualidade das águas superficiais de Bascarán ($IQAS_B$). Conforme demonstrado pelos resultados, ambas as propriedades apresentaram um $IQAS_B$ variando de “médio” à “bom”. Entretanto, ao comparar os pontos destinados ao consumo humano com a Portaria 2.914 de dezembro de 2011, verificou-se que os parâmetros cor e turbidez estavam em desacordo em alguns casos. No entanto, estes dois parâmetros podem facilmente sofrer variações. Além disso, foi constatado que os pontos classificados com $IQAS_B$ “bom” possuem melhor área de proteção quando comparados aos pontos classificados com IQA_B “médio”.

Palavras-chave: Qualidade da água, Índice de Bascarán, Parâmetros físico-químicos.

1 INTRODUCTION

Urbanization and industrialization have caused an increase of water pollution. In developing countries, this problem is even greater, as the water and sanitation infrastructure is unable to meet population growth[1]. Currently, around 2.2 billion people do not have access to safe managed water services worldwide[2]. Therefore, the evaluation of water resources and the management of their quality is essential for a sustainable community to be reached.

In agriculture, the excessive chemicals usage, such as fertilizers and pesticides, and the improper disposal of wastewater are some anthropic activities that significantly reduce water quality[3,4]. In addition, runoff is largely affected by land use, resulting in impacts on water bodies. Therefore, it emphasizes the need for studies that assist in the qualitative monitoring of these resources[5].

In this sense, the evaluation of water quality can be performed through its physical, chemical and biological parameters. However, in order to perform a good environmental diagnosis, it is also necessary to apply technologies that allow a spatial view of the entire system. A commonly used tool is Geographic Information Systems (GIS)[6,7]. This technology has been the target of increasing use in environmental planning with strong adherence to the management of water resources[8,9].

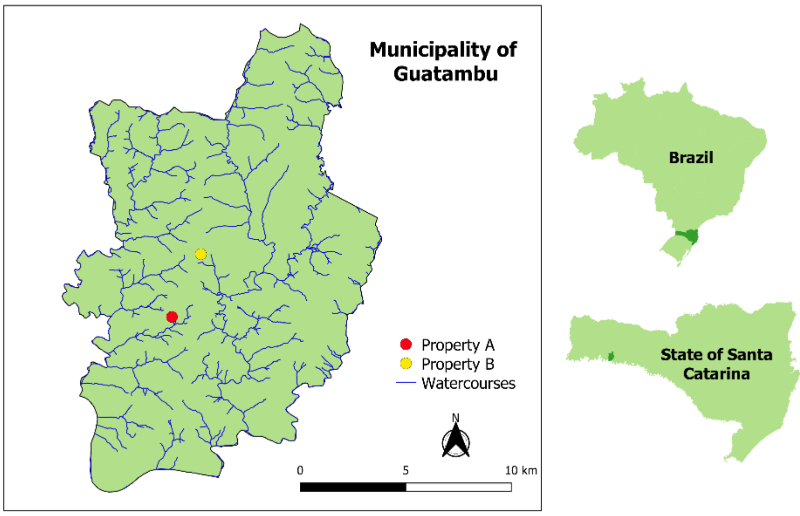
Accordingly, the objective of this study was to analyze the water quality of two rural properties in the municipality of Guatambu to estimate a qualitative classification index. For this estimate, the following parameters were evaluated: electrical conductivity (EC), pH, dissolved oxygen (DO), color, turbidity, alkalinity, chlorides and biochemical oxygen demand (BOD).

2 MATERIAL E METHODS

2.1 STUDY AREAS

The study area was the municipality of Guatambu, located in the west of the state of Santa Catarina (SC), Brazil, as shown in Figure 1. The city has successfully developed the family farming model and for this reason the most intense agricultural activities in the municipality are poultry, dairy cattle and pig farming, as well as the planting of soybeans and corn. In rural properties, it is common to have wells or sources of water intake for human and animal consumption. The location of these water source points is often problematic, since they are close to livestock and plantation areas. During the cultivation of crops, chemical fertilizers and animal waste are used, which can seriously contribute to degrade water quality.

Figure 1. Location of the study areas.



Source: Authors.

2.2 SAMPLING POINTS

The two rural properties were named herein as property A and B. In each of them, 5 collection points were established to assess the water quality, which were identified as A1, A2, A3, A4, A5, B1, B2, B3, B4 and B5 and had the geographic coordinates determined with the aid of a Global Positioning System (GPS). The definition of the sampling points considered water springs, places where the water is used for human consumption and places for the watering of animals. Both properties were delimited in satellite images kindly provided by the Association of Municipalities in the West of Santa Catarina (AMOSC) using the Quantum Gis software (QGIS).

2.3 SAMPLING

The water samples were collected following the procedures reported in the practical water analyses manual of the National Health Foundation (FUNASA)[10]. Polyethylene bottles with, properly sterilized and with a volume of 500 mL, were used for sampling. For each point, three completely filled and properly identified bottles were used. Immediately after collection, the samples were stored in a dark and refrigerated atmosphere. The meteorological conditions of the 24 hours preceding the collection were also considered, since the occurrence of rain, for example, can alter some analyzed parameters.

2.4 PHYSICOCHEMICAL ANALYSES

The analyses were performed less than 24 hours before the time of collection. The parameters analyzed were: EC, pH, DO, color, turbidity, alkalinity, chlorides and BOD. The values of pH, EC, DO, color and turbidity were determined in duplicates by pH meter, conductivity meter, oximeter, colorimeter and turbidimeter, respectively. All devices used in these analyses were previously calibrated. The quantification of alkalinity and chlorides was performed according to the specific procedures reported by the National Health Foundation (FUNASA)[11]. BOD was indirectly determined by the DO concentration, which was quantified shortly after collection and 5 days later; during this period the samples remained stored at 20 ° C and protected from light.

2.5 SURFACE WATER QUALITY INDEX

According to the analyses of the parameters aforementioned, it was possible to estimate the surface water quality index (SWQI) of each rural property. The calculation was performed using the Bascarán method ($SWQI_B$), as reported in other works[12–15] by Equation 1

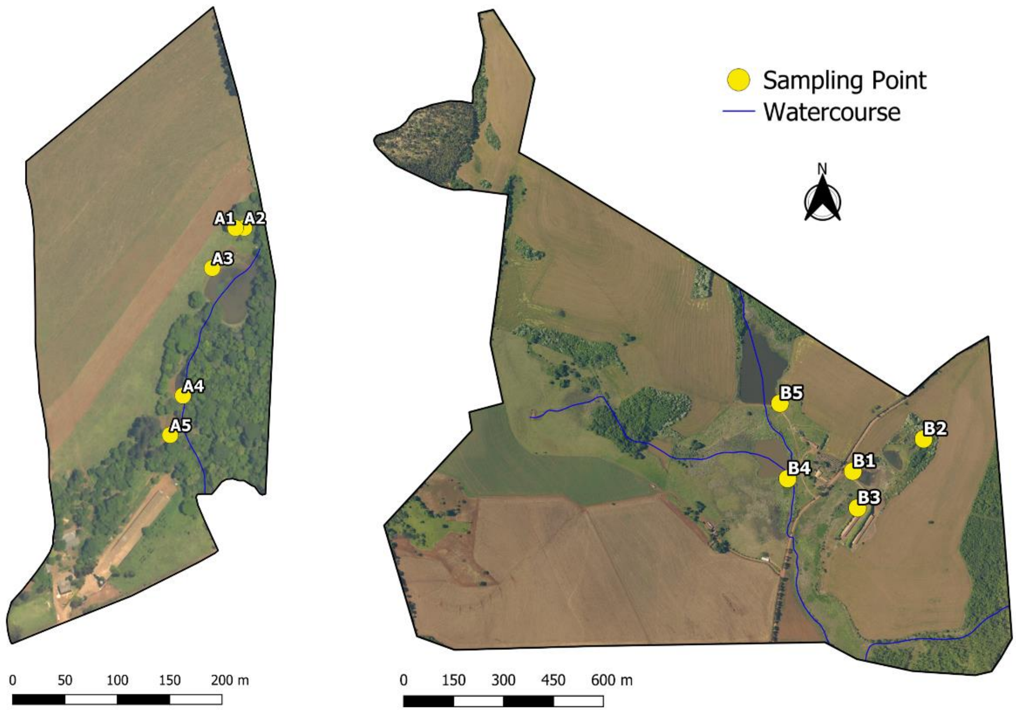
$$SWQI_B = K * \frac{\sum C_i * P_i}{\sum P_i} \quad (1)$$

where *Ci* and *Pi* are the percentage and weight, respectively, which are tabulated according to the determined value of each parameter[15]. *K* is an adjustment constant according to the visual aspect of the waters, attributed through the following scale: 1.0 for clear waters without apparent contamination; 0.75 for slightly colored waters, foams and/or slight unnatural apparent turbidity; 0.50 for waters with a contaminated appearance and with a strong odor and 0.25 for dark waters with fermentations and odors. Depending on the value of the $SWQI_B$, which can vary from 0 to 100, the evaluated water can be classified qualitatively as very bad, bad, medium, good or excellent[13,15].

3 RESULTS AND DISCUSSION

Properties A and B have areas of 10.2 and 194.9 hectares, respectively. Figure 2 shows the sampling points at both locations. The points A1 and A2 comprise two water springs used for human consumption, while the water spring located at point A3 only contributes to supplying the adjacent reservoir. At points A4 and A5 are the other two reservoirs on the property used for animals watering. In relation to property B, points B2 and B3 represent water springs used for animals watering, while the water spring in point B4 is intended for human consumption. Points B1 and B5 are reservoirs, and the latter is utilized for fish farming.

Figure 2. Sampling points on property A (left) and property B (right).



Source: Authors.

The results of the parameters analyzed at properties A and B are shown in Table 1 and Table 2, respectively. The pH values for both properties indicate acidic waters.

Generally, the normal pH range for surface water is between 6.5 and 8.5, but a reduction of around 5.2 is expected for waters in contact with atmospheric carbon dioxide (CO_2)[16]. In addition, another factor that influences the pH of these waters is the acidic soils leaching and the decomposition of organic matter present when producing organic acids[17]. The EC values of the points sampled on property B were similar. In property A, points A3 and A4 showed a higher EC compared to the others, although this increase is still in line with the range of values for this parameter in surface waters (10 to 100 µS · cm-1)[18]. Thus, the low EC values reported herein indicate that there is not an high amount of dissolved salts, because the stronger the flow of the electric current, the greater the conductivity[19].

Table 1. Physicochemical analyses of the sampled points on property A.

Parameter	Sampling Point				
	A1	**A2**	**A3**	**A4**	**A5**
pH	5.04	5.13	6.00	5.45	6.25
Electrical Conductivity ($\mu S \cdot cm^{-1}$)	25.65	23.85	48.85	41.50	36.50
Colour (HU)	16.15	10.80	377.10	134.15	685.35
Turbidity (NTU)	8.5	2.5	43.5	15.5	86.5
Alkalinity ($mg \cdot L^{-1}$ $CaCO_3$)	14.30	12.35	23.72	16.40	20.11
Chloride ($mg \cdot L^{-1}$)	7.42	8.59	6.40	9.56	7.60
Dissolved Oxygen ($mg \cdot L^{-1}$)	6.52	6.07	7.26	6.57	7.28
Biological Oxygen Demand ($mg \cdot L^{-1}$)	0.28	0.17	0.49	0.44	0.56

Table 2. Physicochemical analyses of the sampled points on property B.

Parameter	Sampling Point				
	B1	**B2**	**B3**	**B4**	**B5**
pH	6.51	5.21	5.09	6.07	6.26
Electrical Conductivity ($\mu S \cdot cm^{-1}$)	12.40	20.81	20.14	22.81	26.00
Colour (HU)	89.95	11.10	14.65	76.80	220.75
Turbidity (NTU)	13.0	1.5	5.0	6.0	27.0
Alkalinity ($mg \cdot L^{-1}$ $CaCO_3$)	16.01	15.81	13.27	18.06	18.59
Chloride ($mg \cdot L^{-1}$)	9.86	7.08	8.58	5.54	6.02
Dissolved Oxygen ($mg \cdot L^{-1}$)	7.42	6.69	6.79	6.57	7.00
Biological Oxygen Demand ($mg \cdot L^{-1}$)	0.71	0.19	0.26	0.43	0.40

The color values were clearly different for the points analyzed in the two properties. The color reflects the amount of colloidal material that water has, i.e., dissolved substances[20]. For property A, it is interesting to note that the water springs A1 and A2 are properly protected with vegetation and there is no access for animals at these points. On the contrary, points A3, A4 and A5 do not have adequate vegetation, and the last two are reservoirs for watering animals. Some studies have also reported changes in the physical-chemical characteristics of well water due to the combined effect of evaporation and accumulation of feces and urine of herbivores[21,22]. All of these factors contribute directly to degrade the aesthetic characteristics of the water and, consequently, to its potability. Similarly, in property B, the points with the least color are those where the protective vegetation is preserved (B2 and B3).

The amount of suspension matter is represented by the turbidity, which, as well as the color, is also influenced by the local preservation practices. The lack of vegetation allows the development of erosive processes. In addition, in places with little vegetation, precipitation contributes to the transport of substances to water resources through runoff and percolation. Thus, it is important to maintain a natural protection barrier[22].

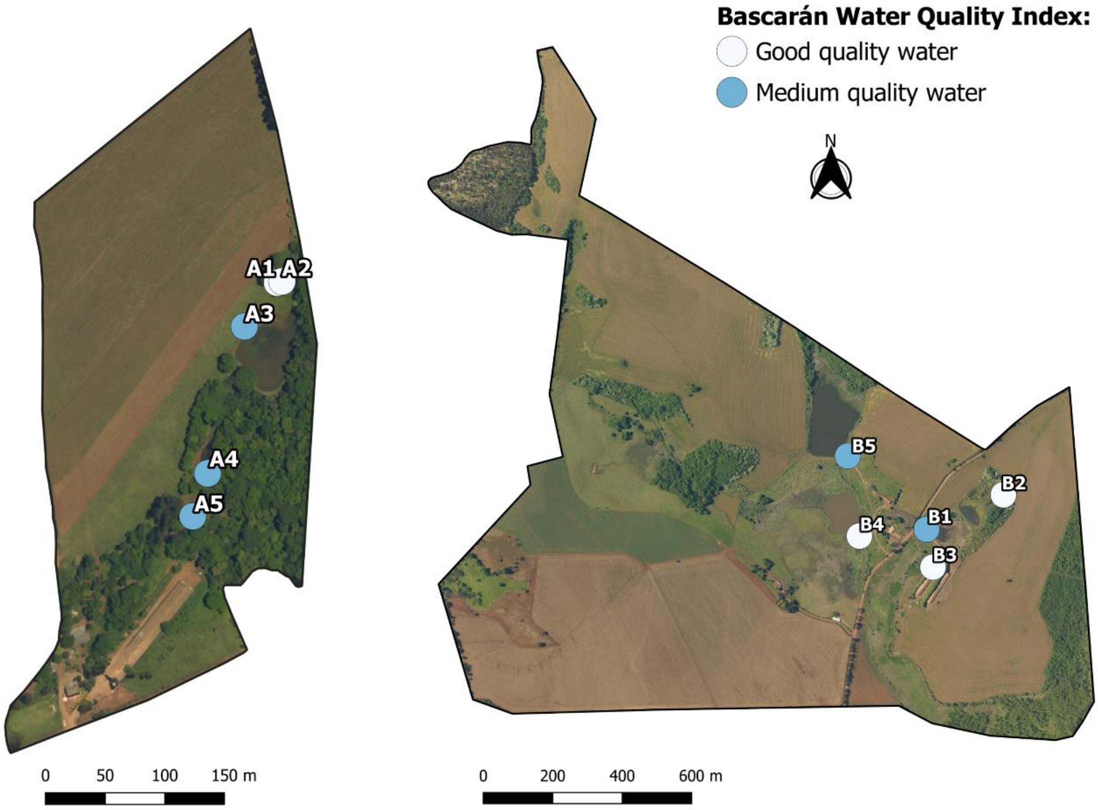
Both alkalinity and chlorides showed low values in both properties. Alkalinity reflects the buffering capacity of water, that is, resistance to changes in pH[11]. Waters with low alkalinity value are called "soft"[12]. Low chloride values are beneficial, since high concentrations of these ions can prevent water consumption due to the salty taste[11]. Moreover, high concentrations of chloride can be harmful to aquatic organisms and can increase the mobility of other compounds, such as metals[23].

Regarding the low BOD values found at all points, they reflected the DO concentration, which remained between 6.0 and 7.5 $mg \cdot L^{-1}$, considered satisfactory. In another study, when evaluating the main tributaries of a hydrographic basin, the authors also found similar behavior[12].

Those points whose water is used for human consumption (A1, A2 and B4), the values determined herein were compared with Brazilian Ordinance n° 2,914/2011, which provides the control and surveillance procedures for the water quality for human consumption and its potability standard[24]. Accordingly, it was found that some parameters were in disagreement. The apparent color and turbidity must have a maximum value of 15 HU and 5 NTU, respectively. However, regarding the points analyzed, only one had values within the limits of the aforementioned Ordinance, although it is important to point out that both color and turbidity can easily change. In relation to the pH of these points, only one was in the recommended range (6.0 to 9.5); the others slightly below. Thus, none of those water springs was in full agreement with the legislation for consumption.

The $SWQI_B$ was determined according to the parameters evaluated. The adjustment constant K was defined according to the visual aspect of the waters: 1.0 for points A1, A2, A4, B2, B3 and B4 (clear waters without apparent contamination) and 0.75 for points A3, A5, B1 and B5 (slightly colored waters, foams and/or slight unnatural apparent turbidity). Figure 3 presents the analyzed points and their respective classifications. In this way, the $SWQI_B$ can provide an easy way to communicate an estimate of the quality of water resources.

Figure 3. Bascarán water quality index for properties A (left) and B (right).



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The $SWQI_B$ values varied between 57 and approximately 90 for the ten points assessed. Through the spatial evaluation of the land use and occupation, it was possible to verify that those points classified with $SWQI_B$ "good" have greater preservation compared to those classified with "medium" quality. Still, out of the five points labeled “medium” quality, four have free access to animals, which directly interferes on water quality, as mentioned previously. Therefore, these results emphasize the strong relation between the quality of water resources and the forms of land use.

4 CONCLUSION

This study showed satisfactory results regarding the water quality of the rural properties analyzed in the municipality of Guatambu-SC, since the $SWQI_B$ classified the points of analysis as “medium” or “good”. However, the results also showed that, due to the anthropic influence existing in some analyzed points, some parameters (color, turbidity and pH) were in disagreement with the Brazilian potability reference for human consumption. The most influencing factor was land use, since the protection area was not always effective. This contributes to leach many substances used in agriculture, which may be responsible for the variations in the values of some parameters, directly influencing the water quality. Thus, the vegetation recovery at the sampling points is recommended. Additionally, the correct management and planning of the land use in the property can also contribute significantly to the protection and improvement of water resources.

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REFERENCES

1. Ighalo JO, Adeniyi AG. A comprehensive review of water quality monitoring and assessment in Nigeria. *Chemosphere*. 2020;260:127569. doi:https://doi.org/10.1016/j.chemosphere.2020.127569

2. Bhushan B. Design ofwater harvesting towers and projections for water collection from fog and condensation. *Phil Trans R Soc A*. 2020;378. doi:10.1007/978-3-030-42132-8_6

3. Mello K de, Valente RA, Randhir TO, Vettorazzi CA. Impacts of tropical forest cover on water quality in agricultural watersheds in southeastern Brazil. *Ecol Indic*. 2018;93:1293-1301. doi:https://doi.org/10.1016/j.ecolind.2018.06.030

4. Ustaoğlu F, Tepe Y, Taş B. Assessment of stream quality and health risk in a subtropical Turkey river system: A combined approach using statistical analysis and water quality index. *Ecol Indic*. 2020;113:105815. doi:https://doi.org/10.1016/j.ecolind.2019.105815

5. Dias P da S, Pereira EM, Machado NR, et al. Levantamento da qualidade da água em ambiente fluvial: Estudo de caso em nascente do córrego Siriema, Jandaia do Sul/PR. *Brazilian J Dev*. 2020;6(3):13967-13976. doi:10.34117/bjdv6n3-313

6. Jankowski P. Towards participatory geographic information systems for community-based environmental decision making. *J Environ Manage*. 2009;90(6):1966-1971. doi:https://doi.org/10.1016/j.jenvman.2007.08.028

7. Sobral M do C, Lopes H, Candeias AL, Melo G, Gunkel G. Geotecnologias na gestão de reservatórios: Uma revisão e uma proposta de integração. *Eng Sanit e Ambient*. 2017;22(5):841-852. doi:10.1590/S1413-41522017111054

8. Mohammadi AA, Yaghmaeian K, Hossein F, et al. Temporal and spatial variation of chemical parameter concentration in drinking water resources of Bandar-e Gaz City using geographic information system. *Desalin Water Treat*. 2017;68(January):170-176. doi:10.5004/dwt.2017.20341

9. Khosravi R, Eslami H, Almodaresi SA, et al. Use of geographic information system and water quality index to assess groundwater quality for drinking purpose in Birjand city, Iran. *Desalin Water Treat*. 2017;67(April):74-83. doi:10.5004/dwt.2017.20458

10. Fundação Nacional de Saúde. *Manual Prático de Análise de Água*.; 2009. http://www.funasa.gov.br/site/wp-content/files_mf/eng_analAgua.pdf

11. Fundação Nacional de Saúde. *Manual de Controle Da Qualidade Da Água Para Técnicos Que Trabalham Em ETAS*. Vol 1 ed.; 2014. http://www.funasa.gov.br/site/wp-content/files_mf/manualcont_quali_agua_tecnicos_trab_emetas.pdf

12. Coradi PC, Pereira-ramirez O, Fia R. Qualidade Da Água Superficial Da Bacia Hidrográfica Da Lagoa Mirim. *Qual Da Água Superf Da Bacia Hidrográfica Da Lagoa Mirim*. 2009;3(1):53-64. doi:10.18316/114

13. de Oliveira ARM, Borges AC, Matos AT, Nascimento M. Viability of the use of minimum water quality indices: A comparison of methods. *Eng Agric*. 2018;38(4):616-623. doi:10.1590/1809-4430-Eng.Agric.v38n4p616-623/2018

14. Menezes JM, Sabino H, Cristo V, et al. Anuário do Instituto de Geociências - UFRJ Comparação entre os Índices de Qualidade de Água Cetesb e Bascarán Comparison between the Water Quality Indexes Cetesb and Bascarán dependentes da água para o seu funcionamento . reduziram significativamente a a . 2018;41:194-202.

15. Rizzi N. Índices de Qualidade de Água. Sanare - Revista Técnica da Sanepar. Published 2001. Accessed October 14, 2020. http://www.sanepar.com.br/sanepar/sanare/v15/indqualaguapag11.html

16. Oram B. The pH of water. Water Research Center. Published 2020. Accessed October 19, 2020. https://water-research.net/index.php/ph

17. Alves ICC, El-Robrini M, de Lourdes Souza Santos M, de Moura Monteiro S, Barbosa LPF, Guimarães JTF. Surface water's quality and trophic status assessment in the Arari River (Marajo Island, Northern Brazil). *Acta Amaz*. 2012;42(1):115-124.

18. Piratoba ARA, Ribeiro HMC, Morales GP, Gonçalves WG e. Caracterização de parâmetros de qualidade da água na área portuária de Barcarena, PA, Brasil. *Ambient Água - An Interdiscip J Appl Sci*. 2014;9(3):445-458. doi:10.4136/1980-993X

19. Arulnangai R, Mohamed Sihabudeen M, Vivekanand PA, Kamaraj P. Influence of physico chemical parameters on potability of ground water in ariyalur area of Tamil Nadu, India. *Mater Today Proc*. Published online 2020. doi:https://doi.org/10.1016/j.matpr.2020.07.033

20. Hoko Z. An assessment of the water quality of drinking water in rural districts in Zimbabwe. The case of Gokwe South, Nkayi, Lupane, and Mwenezi districts. *Phys Chem Earth*. 2005;30(11-16 SPEC. ISS.):859-866. doi:10.1016/j.pce.2005.08.031

21. Ferry N, Cordonnier M, Hulot FD, et al. Heterogeneity of water physico-chemical characteristics in artificially pumped waterholes: do African herbivores drink at the same locations and does it lead to interference competition? *J Arid Environ*. 2020;173:104014. doi:https://doi.org/10.1016/j.jaridenv.2019.104014

22. Msiteli-Shumba S, Kativu S, Utete B, Makuwe E, Hulot FD. Driving factors of temporary and permanent shallow lakes in and around hwange national park, zimbabwe. *Water SA*. 2018;44(2):269-282. doi:10.4314/wsa.v44i2.12

23. Stets EG, Lee CJ, Lytle DA, Schock MR. Increasing chloride in rivers of the conterminous U.S. and linkages to potential corrosivity and lead action level exceedances in drinking water. *Sci Total Environ*. 2018;613-614:1498-1509. doi:https://doi.org/10.1016/j.scitotenv.2017.07.119

24. Ministério da Saúde. *Portaria N°29.914, de 12 de Dezembro de 2011 - Dispõe Sobre Os Procedimentos de Controle e de Vigilância Da Qualidade Da Água Para Consumo Humano e Seu Padrão de Potabilidade*.; 2011:1-10. https://bvsms.saude.gov.br/bvs/saudelegis/gm/2011/prt2914_12_12_2011.html