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Estimated dissolved oxygen in a river located in the south of Rio Grande do Sul

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Abstract

The present study aimed to estimate the dissolved oxygen concentrations in the Piratini River Watershed (in Brazilian Portuguese: BHRP), located in the northwest region of the State of Rio Grande do Sul. DO is a crucial parameter in assessing water quality, as it is essential for the maintenance of aquatic ecosystems. To estimate this, global linear regression models were applied, statistical tools capable of evaluating the effect that one or more variables exert on another. The analyzed data come from collections carried out by Environmental Protection Foundation (FEPAM) between the years 2005 and 2013, period that, due to the rigorous protocol followed and sampling periodicity, revealed a robust and consistent data set. For the selection of parameters, we sought those that had the smallest sampling failures in the historical data series, namely: Thermotolerant Coliforms, Total Phosphorus, Ammoniacal Nitrogen and Total Nitrogen, Turbidity, Total Solids and Hydrogenionic Potential. After applying the linear regressions, the best global models generated were able to explain 91.90% of the variations in dissolved oxygen in the BHRP, once all the analyzed parameters were incorporated, consolidating the applicability of the method. It is also conclude that, with the exception of Total Phosphorus, all training periods are within the limits tolerated by legislation.

Keywords: Linear Regression; Water Quality; Piratini River.

Estimativa do oxigênio dissolvido em um rio situado no sul do Rio Grande do Sul

Resumo

O presente estudo teve como objetivo estimar as concentrações de oxigênio dissolvido (OD) na Bacia Hidrográfica do Rio Piratini (BHRP), localizada na região noroeste do Estado do Rio Grande do Sul. O OD é um parâmetro crucial na avaliação da qualidade hídrica, pois é fundamental para a manutenção dos ecossistemas aquáticos. Para estima-lo, foram aplicados modelos de regressão linear global, ferramentas estatísticas capazes de avaliar o efeito que uma ou mais variáveis exercem sobre outra. Os dados analisados são provenientes de coletas

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realizadas pela Fundação Estadual de Proteção Ambiental (FEPAM) entre os anos de 2005 e 2013, período que devido ao rigoroso protocolo seguido e periodicidade amostral, forneceu um conjunto de dados robusto e consistente. Para a seleção dos parâmetros, buscou-se aqueles que apresentaram as menores falhas amostrais na série histórica de dados, a saber: Coliformes Termotolerantes, Fósforo Total, Nitrogênio Amoniacal e Total Nitrogênio, Turbidez, Sólidos Totais e Potencial Hidrogeniônico. Após a aplicação das regressões lineares, os melhores modelos globais gerados foram capazes de explicar até 91,90% das variações de oxigênio dissolvido no BHRP, uma vez que todos os parâmetros analisados foram incorporados, consolidando a aplicabilidade do método. Concluiu-se ainda, que com exceção do Fósforo Total, todos os parâmetros estudados encontram-se dentro dos limites tolerados pela legislação.

Palavras-chave: Regressão Linear; Qualidade da Água; Rio Piratini.

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1 Introduction

Water resources play a fundamental role in the maintenance of human life and ecosystems. Be that as it may, they are intensely impacted due to factors associated with human actions, exacerbated population growth, along with the various uses for which they are intended, such as human supply, animal watering, irrigation, industrial production and electricity generation (Mitrović *et al.,* 2019).

Such factors, associated with the release of effluents, without prior treatment and incorrect disposal of waste, cause changes in the natural characteristics of water bodies, compromising the availability of water in adequate quantity and quality (Uddin; Nash & Olbert, 2020). From this, the need arises for water quality monitoring, by the agencies responsible for water management, in order to make sure the population has water of a quality that is compatible with the use for which it is intended (Van Vliet *et al.,* 2021; Manoiu *et al.,* 2022), since the consumption of poor-quality water, that is, outside the pre-established potability standards, can harm human health, on top of affecting aquatic and terrestrial ecosystems (Drose *et al.,* 2020).

In this sense, National Environmental Council (CONAMA) Resolution No. 357/2005 complemented by N° 430/2011 categorizes and fits water bodies into classes according to their uses, establishing permission limits through physical, chemical and biological

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parameters, which must be monitored periodically (Brasil, 2005). Wherein, in order to generate a reliable database, frequent collections must be carried out at several sampling points, in addition to the performing of laboratory analysis of a large number of parameters, a factor that generates a vast amount of data (of complex interpretation) and thus demands financial and technical resources for: the collection, transport and storage of samples, training of professionals, field and IT infrastructure for data processing (Liao *et al.*, 2008; Maia; Silva & Libanio, 2019).

In this bias, to facilitate the monitoring and analysis of water quality data, according to Zhao *et al.* (2012), the use of statistical tools is essential, as it allows a global view of the environmental phenomena involved, whether natural or from human actions. To this end, global linear regression models are statistical techniques that make it possible to know the effect that one or more variables have on others (Morais *et al.*, 2020; Centeno, 2017), additionally to modeling the spatio-temporal relationships between the attributes of interest (Alves *et al.*, 2021).

Global models seek to identify associated factors to explain a response variable, also called dependent variable, using variables whose results are known, named independent variables (Amorim, 2022). Such models are tools widely used in data analysis in several areas of knowledge due to the promptness of expressing the relationship between variables through a mathematical equation (Montgomery; Vining & Peck, 2001), however they are still scarcely used in studies focused on quality of the water. Therefore, the present work aims to estimate dissolved oxygen through said global models, in the Piratini River Watershed.

2 Methodology

2.1 Characterization of the study area

The Piratini River Watershed (in Brazilian Portuguese: BHRP), located in the northwest region of the State of Rio Grande do Sul (Figure 1), between coordinates 31°30' to 34°35' South latitude and 53°31' to 55°15' West longitude (FEPAM, 2022), has a drainage area of approximately 4,700.47 km². It is considered one of the main tributaries of the São Gonçalo channel, joining Laguna dos Patos to Lagoa Mirim, and the main uses of this water resource are: agriculture and livestock, with emphasis on the cultivation of corn, soybeans, brewing barley, irrigated rice and fruit production (Telles, 2002).

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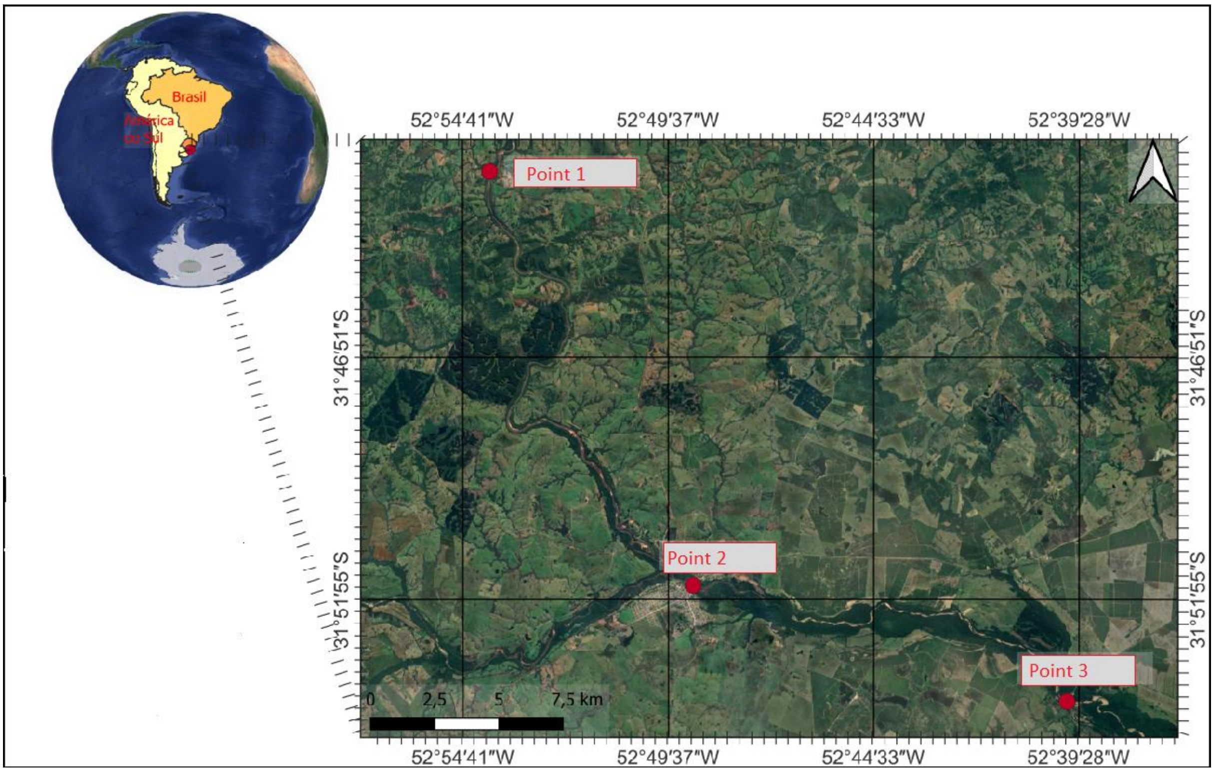
Figure 1: Characterization map of the study area



Source: Authors (2023)

2.2 Data collection

For this study, secondary data were used, granted by State Environmental Protection Foundation (FEPAM), from collections carried out every six months between 2005 and 2013.

Data from this period were used due to the consistency and integrity of this specific time series. During this interval, the project funded by FEPAM followed a rigorous collection and analysis protocol, resulting in a robust and reliable dataset.

After 2013, the project faced a pause in data collection and analysis, as a consequence, the data did not maintain the same consistency and quality observed previously, presenting significant sampling flaws that compromised the quality and comparability of the information.

Collections were carried out by FEPAM according to the methodology described by the Environmental Company of the State of São Paulo, additionally, the analytical methods and sample preservation follow the procedures defined by APHA (2005). The parameters analyzed in this study were: Thermotolerant Coliforms (TC), Total Phosphorus (TP), Ammoniacal Nitrogen (NH_3), Total Nitrogen (TN), Dissolved Oxygen (DO), Potential Hydrogen (pH), Total Solids (TS) and Turbidity (TH).

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2.3 Classical statistics

In other to appraise the behavior of the distribution of the studied data, an exploratory analysis was carried out while using descriptive statistics, calculating measures of position (arithmetic mean and median), of dispersion (standard deviation, variance and coefficient of variation) and of distribution format (asymmetry and kurtosis coefficients), and later on the analyzed data were transformed according to the methodology of Centeno *et al.* (2020), henceforth presenting a normal distribution with mean and standard deviation values of 0.50 and 0.25, respectively.

2.4 Global linear regression models

To estimate the Dissolved Oxygen in the BHRP, the Global Simple and Multiple Linear Regression Models were put to use, where, based on the variables studied, all possible combinations were tested and, from there, global models were generated. According to the objective of the study to estimate its presence, the dissolved oxygen was used as the dependent variable, taking into account its importance for the maintenance of aquatic life and influence in determining the levels of pollution of water bodies (Sperling, 2018), while the independent variables selected were those that presented a more reliable database, that is, with the lowest number of sample failures, to ensure the accuracy of the global models obtained.

After defining the variables to be used, the data were divided into two sets, where 75% of the data were used to construct the linear regressions and 25% to validate the global models generated. The identification of the most satisfactory global model was based on Pearson's coefficient of determination (R^2), which ranges from 0 to 1, and the closer to 1, the more accurate the model obtained (Pala, 2019).

3 Results and Discussion

Table 1 presents the basic statistics applied to the variables studied, in order to assess the behavior of data distribution.

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Table 1: Basic statistics referring to data obtained at sampling points in the BHRP

	DO	TC	TP	NH_3	TN	pH	TS	TH
Mean	6.98	73.40	0.41	0.10	1.75	6.66	116.64	17.53
Median	7.20	82.20	0.13	0.10	0.64	6.70	118.00	17.50
Mode	7.30	116.60	0.09	0.10	0.68	6.80	133.00	21.70
Standard Deviation	2.42	38.62	0.73	0.05	3.34	0.24	27.91	4.36
Minimum	5.20	18.30	0.06	0.02	0.50	6.30	65.00	8.20
Maximum	10.60	130.00	2.51	0.17	11.50	7.30	160.00	23.40
Variance	5.865	1491.53	0.54	0.002	11.16	0.06	778.99	19.05
Coefficient of Variation	34.69	52.61	52.61	177.70	49.14	190.60	3.65	23.93
Count	27	27	27	27	27	27	27	27

DO= Dissolved Oxygen; TC= Thermotolerant Coliforms; TP= Total Phosphorus; NH_3= Ammoniacal Nitrogen; TN= Total Nitrogen; TH= Temperature; TS= Total Solids; pH= Hydrogenionic Potential.

Source: Authors (2023)

According to Table 1, the mean value obtained for the levels of dissolved oxygen in the BHRP was 6.98 mg/L O_2, that is, above the minimum limit established by CONAMA Resolution N°. 357/2005 and N° 430/2011, which is 5 mg/L O_2 for class II freshwater. In this context, values above 5 mg/L O_2 of dissolved oxygen suggest that, although there are anthropic actions and the release of effluents, the self-purification capacity of the water body was not exceeded, allowing the maintenance of aquatic life (Costa *et al.*, 2021).

The thermotolerant coliform count is also in accordance with the limit allowed by legislation, which must not exceed 1.000 thermotolerant coliforms in 100 mL, in at least 80% of the samples (Brasil, 2005).

Regarding temperature, there are no values established by CONAMA Resolution 357/2005 complemented by 430/2011, although, elevations in temperature can increase the rate of chemical and biological reactions, by the same token reducing the solubility of gases such as dissolved oxygen, as well as generating a bad smell, in cases where there is the presence of gases with unpleasant odors (Sperling, 2018). Therefore, it can be said that the average temperature around 17°C contributes positively to the water quality in the BHRP.

Total Phosphorus, in turn, presented a mean of 0.413 mg/L P, exceeding the maximum limit of 0.1 mg/L P (Brasil, 2005). Values above the established limits point to the occurrence

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of the eutrophication phenomenon, intensified by the input of phosphorus from human activities such as livestock, domestic effluent discharge and soil transport (Rocha & Lima Neto, 2020).

Santos *et al.* (2023), carried out a qualitative analysis of surface water in BHRP, where they obtained higher concentrations of Total Phosphorus in monitoring points located in urban perimeters and in regions of predominantly agricultural land use and occupation, linking such results to the disposal of effluents urban areas and the runoff of fertilizers applied to nearby agricultural areas.

For the parameters Ammoniacal Nitrogen (NH_3) and Total Nitrogen (TN), CONAMA Resolution 357/2005 complemented by 430/2011 establishes concentrations that vary according to pH. BHRP falls within the range of pH ≤ 7.5, which tolerates up to 3.7mg/L N. The hydrogenic potential (pH) represents the amount of H+ protons, and through it it is possible to measure the concentration of acidity or alkalinity of an aquatic environment (Santos; Santos & Silva, 2018). The BHRP waters were within the range of 6.0 to 9.0, established by CONAMA 357/2005 complemented by 430/2011. Table 2 presents the global models generated through linear regressions, after applying all possible combinations, according to the parameters evaluated.

Table 2: Global models generated for estimating Dissolved Oxygen at sample points belonging to the BHRP

MODEL 1	R^2
DO= 0.568*TC + 0.181	0.105
DO= 0.742*TP + 0.052	0.152
DO= 0.905*NH_3 - 0.052	0.275
DO= 0.473*TN + 0.180	0.059
DO= 0.380*TH + 0.256	0.068
DO= 0.755*TS + 0.081	**0.414**
DO= - 0.019*pH + 0.405	0.003

DO= Dissolved Oxygen; TC= Thermotolerant Coliforms; TP= Total Phosphorus; NH_3= Ammoniacal Nitrogen; TN= Total Nitrogen; TH= Temperature; TS= Total Solids; pH= Hydrogenionic Potential.

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Continued Table 2

MODEL 2	R^2
DO= 0.566*TC + 0.740*TP - 0.166	0.266
DO= 0.545*TC + 0.891*NH_3 - 0.256	0.372
DO= 0.602*TC + 0.5228*TN - 0.07	0.177
DO= 0.470*TC + 0.252*TH + 0.122	0.132
DO= 0599*TC - 0.036*pH + 0.178	0.118
DO= 0.413*TC + 0.714*TS - 0.061	0.469
DO= 0.972*TP + 1.077*NH_3 - 0.593	0.527
DO= 0.770*TP + 0.516*TN - 0.201	0.222
DO= 0.654*TP + 0.236*TH + 0.004	0.177
DO= 1.028*TP + 0.882*TS - 0.454	**0.695**
DO= 0.744*TP - 0.021*pH + 0.057	0.157
DO= 0.854*NH_3 + 0.264*TN - 0.150	0.292
DO= 0.907*NH_3 + 0.384*TH - 0.200	0.344
DO= 0.533*NH_3 + 0.603*TS - 0.121	0.492
DO= 0.905*NH_3 - 0.000*pH - 0.052	0.275
DO= 0.382*TN + 0.319*TH + 0.101	0.104
DO= 0.282*TN + 0.728*TS - 0.039	0.434
DO= 0.487*TN - 0.026*pH + 0.180	0.065
DO= 0.146*TH + 0.724*TS + 0.0380	0.423
DO= 0.430*TH - 0.043*pH + 0.247	0.084
DO= 0.759*TS + 0.008*pH + 0.078	0.415

DO= Dissolved Oxygen; TC= Thermotolerant Coliforms; TP= Total Phosphorus; NH_3= Ammoniacal Nitrogen; TN= Total Nitrogen; TH= Temperature; TS= Total Solids; pH= Hydrogenionic Potential.

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Continued Table 2

MODEL 3	R^2
DO= 0.538*TC + 0.967*TP + 1.062*NH_3 - 0792	0.621
DO= 0.603*TC + 0.771*TP + 0.565*TN - 0.458	0.341
DO= 0.535*TC + 0.711*TP + 0.079*TH - 0.170	0.260
DO= 0.382*TC + 1.014*TP + 0.843*TS - 0.579	0.742
DO= 0.598*TC + 0.744*TP - 0.038*pH - 0.170	0.271
DO= 0.976*TP + 1.024*NH_3 + 0.278*TN - 0.699	0.546
DO= 0.900*TP + 1.065*NH_3 + 0.187*TH - 0.625	0.542
DO= 1.112*TP + 0.668*NH_3 + 0.702*TS - 0.752	**0.817**
DO= 0.972*TP + 1.077*NH_3 + 0.000*pH - 0.594	0.527
DO= 0.877*NH_3 + 0.157*TN + 0.358*TH - 0.248	0.350
DO= 0.501*NH_3 + 0.195*TN + 0593*TS - 0.192	0.502
DO= 0.851*NH_3 + 0.268*TN - 0.005*pH - 0.149	0.293
DO= 0.256*TN + 0.111*TH + 0.707*TS - 0.060	0.440
DO= 0.392*TN + 0.370*TH - 0.0458pH + 0.088	0.123
DO= 0.149*TH + 0.723*TS - 0.002*pH + 0.038	0.423

MODEL 4	R^2
DO= 0.561*TC + 0.972*TP + 0.999*NH3 + 0.330*TN - 0.925	0.648
DO= 0.525*TC + 0.955*TP + 1.061*NH3 + 0.033*TH - 0.793	0.621
DO= 0.405*TC + 1.010*TP + 0.683*NH3 + 0.657*TS - 0.891	**0.869**
DO= 0.551*TC + 0.967*TP + 1.053*NH3 - 0.016*pH - 0.788	0.624
DO= 0.919*TP + 1.023*NH3 + 0.234*TN + 0.145*TH - 0.707	0.555
DO= 1.113*TP + 0.636*NH3 + 0.200*TN + 0.692*TS - 0.825	0.827
DO= 0.976*TP + 1.021*NH3 * 0.282*TN - 0.005*pH - 0.700	0.546

DO= Dissolved Oxygen; TC= Thermotolerant Coliforms; TP= Total Phosphorus; NH_3= Ammoniacal Nitrogen; TN= Total Nitrogen; TH= Temperature; TS= Total Solids; pH= Hydrogenionic Potential.

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Continued Table 2

MODEL 4	R^2
DO= 0.539*NH_3 + 0.146*TN + 0.182*TH + 0.550*TS - 0.239	0.515
DO= 0.861*NH_3 + 0.167*TN + 0.386*TH - 0.025*pH - 0.249	0.355
DO= 0.257*TN + 0.117*TH + 0.704*TS - 0.004*pH - 0.061	0.440
MODEL 5	R^2
DO= 0.579*TC + 0.989*TP + 0.999*NH_3 + 0.345*TN - 0.045*TH - 0.930	0.649
DO= 0.425*TC + 1.100*TP + 0.645*NH_3 + 0.244*TN + 0.642*TS - 0.987	**0.884**
DO= 0.582*TC + 0.971*TP + 0.981*NH_3 + 0.348*TN - 0.023*pH - 0.927	0.653
DO= 1.181*TP + 0.612*NH_3 + 0.241*TN - 0.151*TH + 0.735*TS - 0824	0.835
DO= 0.913*TP + 1.01*NH_3 + 0.238*TN + 0.161*TH - 0.013*pH - 0.704	0.556
MODEL 6	R^2
DO= 0.541*TC + 1.240*TP + 0.599*NH_3 + 0.344*TN - 0.322*TH + 0.719*TS - 1.030	**0.917**
DO= 0.590*TC + 0.979*TP + 0.982*NH_3 + 0.355*TN - 0.021*TH - 0.022*pH - 0.930	0.653
DO= 1.200*TP + 0.619*NH_3 + 0.232*TN - 0.189*TH + 0.756*TS + 0.024*pH	0.840
MODEL 7	R^2
DO= 0.532*TC + 1.251*TP + 0.602*NH_3 + 0.338*TN - 0.343*TH + 0.732*TS + 0.015*pH - 1.03	**0.919**

DO= Dissolved Oxygen; TC= Thermotolerant Coliforms; TP= Total Phosphorus; NH_3= Ammoniacal Nitrogen; TN= Total Nitrogen; TH= Temperature; TS= Total Solids; pH= Hydrogenionic Potential.
Source: Authors (2023)

Analyzing the models found, it is clear that when using only one or two water quality parameters, no satisfactory results were found to estimate dissolved oxygen, a circumstance which explains only 41.40% of the DO while using the total solids variable alone. On the other hand, once added, the parameter total phosphorus explains 69.50% of the DO variations.

Meanwhile, when adding the variable NH_3, a significant increase in the coefficient of determination R^2 was observed, which became 0.817 and which gradually increased as more variables were added, having its best result when the seven variables in question were used, namely: Thermotolerant Coliforms, Total Phosphorus, Ammoniacal Nitrogen, Total Nitrogen,

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Temperature, Total Solids and pH, all together making it possible to explain 91.90% of the Dissolved Oxygen concentrations in the BHRP.

The difference between models 6 and 7, of 0,2%, is not significant, and therefore be considered as the best model for estimating DO concentrations, the one that presents fewer variables, that is, the model 6. This is due to the fact that, by incorporating a smaller number of parameters to be monitored, it is possible to optimize time to perform sampling and analysis, as well as technical and financial resources.

It is worth noting that in all combinations that presented the best determination coefficients (R^2), the parameter Total Solids (TS) is present. This situation is due to the fact that, according to Sperling (2018), with the exception of dissolved gases, all impurities present in the water directly influence the solids load, which may have a high organic load, and it's decomposition can lead to a depletion of dissolved oxygen levels in the water body in question (CETESB, 2017). Therefore, the other parameters analyzed are present in the water bodies in the form of solids, in suspension or dissolved, according to their physical characteristics (Silva, 2012).

Total Phosphorus (TP), in turn, is found naturally in water bodies through the dissolution of compounds in the soil and decomposition of organic matter, or even anthropically, through the release of domestic and industrial effluents and animal excretions (Lemes, 2021). It is a fundamental nutrient for the development of aquatic ecosystems, nonetheless, in high concentrations it can cause the exacerbated growth of algae, causing the phenomenon called eutrophication (Sperling, 2018). According to Baldissera, Zampiere and Bampi (2011), phosphorus is the main nutrient responsible for the growth of microorganisms in charge of the decomposition of organic matter, factor which correlates it to dissolved oxygen, considering that as such organic matter is decomposed, DO concentrations tend to increase.

Cardoso and Almeida (2022) corroborate the statement above, by relating satisfactory levels of DO with high concentrations of phosphorus in a study on the environmental degradation of water bodies in the municipality of Paraíso do Tocantins.

Likewise, nitrogen is also considered an essential nutrient for the development of aquatic life and algae growth, and when present in high concentrations it contributes to eutrophication (Oliver; Ribeiro, 2014). Said nutrient has a direct relationship with the consumption of dissolved oxygen during the processes of conversion of the ammoniacal form to nitrite and from this to nitrate (Carvalho *et al.*, 2016).

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With regard to Thermotolerant Coliforms (TC), this is a fundamental microbiological parameter to assess the patterns of potability of water resources, given that contamination by bacteria of the coliform group represents an indication of transmission of waterborne diseases (Gurgel; Silva, 2020). Thus, there is an indirect correlation between dissolved oxygen and thermotolerant coliforms since the presence of TC in a water body is linked to the release of effluents without previous treatment and human and/or animal waste (Arcos; Silva; Cunha, 2020; Sperling, 2018).

Once more according to Baldissera, Zampieri and Bampi (2011), the inappropriate use of soil in agricultural practices that end up leaving it exposed, coupled with the devastation of riparian forest, contributes to the dragging of unprotected soil towards the rivers, favoring the increase in turbidity, due to soil particles and suspended organic materials. This fact can lead to reduced photosynthesis in the aquatic environment, as well as low levels of DO.

The hydrogenic potential (pH) has no direct relationship with risks to public health, as a rule, it has an influence on the maintenance of ecosystems and physiology of aquatic species, as well as dissolved oxygen (Alves *et al.*, 2019).

Regarding the use of global linear regression models to estimate the presence of dissolved oxygen in this study, it was found that they presented satisfactory results, besides what was expected according to the literature.

Adôrno, Santos and Jesus (2013), in a study to assess the environmental quality of the Subaé River headwaters in Feira de Santana-BA, used global linear regression models as a statistical tool for association of physical and chemical variables, where they concluded that, among the analyzed parameters, dissolved oxygen was the one that best represented the quality of the environment.

In order to model a new IQA equation for Arroio Moreira/Fragata, Santos, Valentini and Vieira (2021) explained 84.2% of the variations in the IQA (Water Quality Index) using global linear regression models. Lastly, Ferreira, Nepomuceno and Diniz (2017), applied global linear regression models to verify the relationship between true color and absorbance at a wavelength of 254 nm in treated water samples, and obtained results above 70%.

4 Conclusions

Taking into consideration the results obtained, with the application of global linear regression models, it was possible to conclude that they presented satisfactory results when the variables that have correlation with dissolved oxygen are incorporated. When estimating

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their concentrations in BHRP, the variables that had the greatest influence were: Thermotolerant Coliforms, Total Phosphorus, Ammoniacal and Total Nitrogen, Turbidity and Total Solids.

Another finding points out that except for the Total Phosphorus parameter, which exceeded the tolerance limits established by CONAMA Resolution 357/2005 complemented by 430/2011, every other parameter analyzed remains in accordance with the aforementioned legislation.

It is suggested for future studies, the spatial analysis of anthropic interference exerted in the BHRP, in addition to the improvement in the use of global models for environmental monitoring, all due to how easy it is to understand and apply them.

References

Adôrno, Erivaldo; Santos, Elinaldo Sacramento Dos; Jesus, Taise Bomfim De. SIG e regressão linear para avaliação ambiental das nascentes do Rio Subaé em Feira de Santana-BA. **Boletim Goiano de Geografia,** Goiânia, v. 33, n. 2, p. 63-80. 2013. Disponível em https://revistas.ufg.br/index.php/bgg/article/view/25557. Acesso em 10 out. 2022.

Alves, Aaron de Sousa et al. Qualidade da água residuária aplicada a cultura da bananeira/Quality of wastewater applied to banana tree culture. **Brazilian Journal of Animal and Environmental Research**, [S.L.], v. 4, n. 1, p. 511-531. 2021. Disponível em https://ojs.brazilianjournals.com.br/ojs/index.php/BJAER/article/view/24117 . Acesso em 12 out 2022.

Alves, Wellmo dos Santos et al. Análise das relações entre uso do solo e qualidade da água do Lago Bonsucesso, em Jataí, Estado de Goiás, Brasil. **Revista Brasileira de Geografia Física**, [s. l], v. 12, n. 1, p. 326-342. 2019.

American Public Health Association – APHA. S**tandard methods for the examination of water and wastewater**. 21. ed. Washington: American Public Health Association. APHA/AWWA/WEF. 2005.

Arcos, Adriano Nobre; Silva, Jonismar Souza Da; Cunha, Hillândia Brandão Da. Grupo coliforme fecal como indicador de balneabilidade em praia de água doce no rio Negro, Amazonas. **Research, Society and Development**, [s. l], v. 9, n. 7, p. 1-17. 2020.

Baldissera, Ivan Tadeu; Zampieri, Sergio Luiz; Bampi, Daiana. Monitoramento da qualidade da água na microbacia Tarumanzinho em Águas Frias, SC, Brasil. **Revista de Ciências Ambientais**, Canoas, v. 5, n. 4, p. 5-14. 2011.

Cardoso, Maria Marielly Araújo; Almeida, Rejane Freitas Benevides. Degradação ambiental e qualidade da água de rios urbanos: o caso dos corpos d'água de Paraíso do Tocantins, TO, Brasil. **Revista Sítio Novo**, Palmas, v. 6, n. 3, p. 28-47. 2022.

Revista Gestão & Sustentabilidade
ISSN 2596-142X

Carvalho, Aurean de Paula et al. Avaliação da poluição em rios utilizando índices de qualidade da água: um estudo de caso no ribeirão São João em Porto Nacional –TO. **Geociências**, São Paulo, v. 35, n. 3, p. 472-484. 2016.

Centeno, Luana Nunes. **Proposta metodológica para a construção de índices de qualidade da água na bacia hidrográfica Piratini-São Gonçalo- Mangueira, RS.** 188f. Dissertação (Mestrado) - Programa de Pós-Graduação em Recursos Hídricos, Engenharia de Recursos Hídricos, Universidade Federal de Pelotas, Pelotas. 2017. Disponível em: https://guaiaca.ufpel.edu.br/handle/prefix/3692?show=full . Acesso em 10 jun. 2022.

CETESB-Companhia de Tecnologia de Saneamento Básico do Estado de São Paulo. Publicações e Relatórios. **Significado ambiental e sanitário das variáveis de qualidade.** 2017. Disponível em: https://cetesb.sp.gov.br/aguas-interiores/wp-content/uploads/sites/12/2017/11/Ap%C3%AAndice-E-Significado-Ambiental-e-Sanit%C3%A1rio-das-Vari%C3%A1veis-de-Qualidade-2016.pdf . Acesso 09 out. 2022

CONAMA – Conselho Nacional do Meio Ambiente. Resolução CONAMA N° 357, DE 17 DE MARÇO DE 2005. **Diário Oficial da República Federativa do Brasil**. Brasília, DF. 2005. Disponível em: https://www.icmbio.gov.br/cepsul/images/stories/legislacao/Resolucao/2005/res_conama_357_2005_classificacao_corpos_agua_rtfcda_altrd_res_393_2007_397_2008_410_2009_430_2011.pdf . Acesso em 01 set. 2022.

Costa, Vinicius Moura et al. Estudo da autodepuração em um trecho do Rio Sorocaba, SP - Brasil. **In: Meio ambiente, sustentabilidade e tecnologia, 1. Recursos hídricos.** Belo Horizonte: Poisson. v. 5, p. 25-28. 2021. Disponível em: https://www.meioambientepocos.com.br/ANAIS%202020/363%20Estudo%20da%20autodepura%C3%A7%C3%A3o%20em%20um%20trecho%20do%20rio%20Sorocaba,%20SP%20-%20Brasil.pdf . Acesso 03 fev. 2022.

Drose, Andressa et al. Utilização de Métodos Estatísticos Multivariados no Monitoramento de Qualidade da Água da Lagoa Mirim. **Meio Ambiente (Brasil)**, [s. l], v. 2, n. 4, p. 58-67. 2020.

FEPAM, **Fundação Estadual de Proteção Ambiental Henrique Luiz Roessler** – RS. 2020. Disponível em: http://www.fepam.rs.gov.br/. Acesso em: 03 maio. 2022.

Ferreira, Weruska Brasileiro; Nepomuceno, Thiago Cabral; Diniz, Tarciana Ramos. Utilização de regressão linear para verificar a relação entre cor verdadeira e absorbância no comprimento de onda 254nm. **Anais II CONAPESC**. Campina Grande: Realize Editora. 2017.

Gurgel, Raiana Silveira; Silva, Lirna Salvioni Da; Silva, Luciete Almeida. Investigação de coliformes totais e Escherichia coli em água de consumo da comunidade Lago do limão, Município de Iranduba –AM. **Brazilian Applied Science Review**, Curitiba, v. 4, n. 4, p. 2512-2529. 2020. Disponível em: https://ojs.brazilianjournals.com.br/ojs/index.php/BASR/article/view/14024/11728 . Acesso em 02 mar. 2022.

Lemes, Cryslara de Souza. **Avaliação da qualidade da água do Ribeirão Sampaio em Pires do Rio - GO antes e após o lançamento de efluente de abatedouro avícola**. 54 f. Dissertação (Mestrado) - Curso de Pós-Graduação em Conservação de Recursos Naturais, Instituto Federal Goiano, Urutaí. 2021.

Revista Gestão & Sustentabilidade
ISSN 2596-142X

Liao, S. W., et al. Identification of pollution of Tapeng Lagoon from neighbouring rivers using multivariate statistical method. **Journal of Environmental Management**, v. 88, n. 2, p. 286-292. 2008.

Manoiu, V. M; et al. Water Quality and Water Pollution in Time of COVID-19: Positive and Negative Repercussions. **Water.** v. 14 n. 1124. p. 1-17. 2022.

Mitrović, Tatjana et al. Virtual water quality monitoring at inactive monitoring sites using Monte Carlo optimized artificial neural networks: A case study of Danube River (Serbia). **Science Of The Total Environment**, [s. l], v. 654, p. 1000-1009. 2019.

Montgomery, D. C.; Vining, G. G.; Peck, E. A. **Introduction to Linear Regression Analysis.** 3. ed., New York: John Wiley & Sons, 641 p. 2001.

Morais, Elder Olinto de et al. Aplicação de modelos de regressão linear e não linear para estimativa de volume de biomassa e estoque de carbono. **Brazilian Journal Of Development**, Curitiba, v. 6, n. 7, p. 45621-45632. 2020. Disponível em: https://ojs.brazilianjournals.com.br/ojs/index.php/BRJD/article/view/13041 . Acesso em 02 mar. 2022.

Oliver, Sofia Lizarral de; Ribeiro, Helena. Variabilidade climática e qualidade da água do Reservatório Guarapiranga. **Estudos Avançados**, [s. l], v. 28, n. 82, p. 95-128. 2014. Disponível em: https://www.revistas.usp.br/eav/article/view/88921 . Acesso em 03 mar. 2022.

PALA, Luiz Otávio de Oliveira. **Revisitando a estimação do Coeficiente de Determinação.** 112 f. Dissertação (Mestrado) - Programa de Pós-Graduação em Estatística Aplicada e Biometria, Universidade Federal de Alfenas, Mg, Alfenas. 2019.

Rocha, Maria De Jesus Delmiro Da; Lima Neto, Iran Eduardo. Relação entre fósforo total e vazão afluente nos principais reservatórios rurais do estado do Ceará no semiárido brasileiro. **Revista Aidis, de Ingeniería y Ciencias Ambientales: Investigación, Desarrollo y Práctica.** [s. l], v. 13, n. 3, p. 715-730. 2020. Disponível em: https://www.revistas.unam.mx/index.php/aidis/article/view/68153 . Acesso em 05 mar. 2022.

Santos, Gabriel Borges Dos; Valentini, Marlon Heitor Kunst; Vieira, Bruno Müller. Análise de regressão linear aplicada à modelagem de uma nova equação para o monitoramento de qualidade da Água: estudo de caso do Arroio Moreira/Fragata. **Ambientale,** Alagoas, v. 13, n. 1, p. 13-27. 2021. Disponível em: https://periodicosuneal.emnuvens.com.br/ambientale/article/view/262 . Acesso em 05 mar. 2022.

Santos, Gabriel Borges dos *et al*. Análise qualitativa das águas superficiais da Bacia Hidrográfica do Rio Piratini - RS. **Boletim Geográfico do Rio Grande do Sul**, Porto Alegre, n. 41, p. 9-33, 2023.

Santos, Nathália Bandeira Carvalho Dos; Santos, Rayza Helen Graciano Dos; Silva, Ronaldo Faustino da. Aplicação da Análise Multivariada e da Resolução CONAMA 357/2005 para Análise da Qualidade de Água em Rios de Pernambuco. **Revista Brasileira de Geografia Física**, [s. l], v. 11, n. 5, p. 1859-187. 2018.

Silva, Luana Monteiro da. E**studo da correlação entre o oxigênio dissolvido e a matéria orgânica em diferentes ambientes aquáticos da região Amazônica.** 108 f. Dissertação (Mestrado) - Programa de Pós graduação em Química, Universidade Federal do Amazonas, Manaus. 2012.

Revista Gestão & Sustentabilidade
ISSN 2596-142X

Telles, Rossana Madruga. I**nundações Urbanas nos municípios de Pedro Osório e Cerrito-RS.** 74 f. Dissertação (Mestrado) - Programa de Pós Graduação em Geografia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Porto Alegre.2002.

Uddin, Md. Galal; Nash, Stephen; Olbert, Agnieszka I. A review of water quality index models and their use for assessing surface water quality. **Elsevier Ltda,** [s. l], p. 1-21, v. 17. 2020.

Van Vliet, M T.H; et al. Global water scarcity including surface water quality and expansions of clean water technologies. **Environ. Res. Lett.** v. 16. p. 1-12, 26. 2021.

Von Sperling, M. **Introdução a qualidade das águas e tratamento de esgotos**. Minas Gerais: UFMG. 472 p. 1 v. 2018.

Zhao, Y et al. Assessment of water quality in Baiyangdian Lake using multivariate statistical techniques. **Procedia Environmental Sciences,** v. 13, p. 1213-1226. 2012.