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Effect of two consecutive periods of drought on the limnology of three shallow reservoirs in an urban park

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ABSTRACT
Urban parks are used as spaces for leisure, socialization, and environmental preservation. Many parks have reservoirs in their perimeter, whose dry period can lead to a decrease in the water level, causing changes in the physicochemical variables that can provide deterioration of water quality. The objective of this work is to compare the effects of two consecutive dry periods (2019 and 2020) on the physicochemical variables of water in three shallow urban reservoirs. The collections were carried out in the park "Leda Campos Borges," located in the city of Frutal-MG, during the years 2019 and 2020. The inlet and outlet of water from each of the reservoirs were sampled. The means of the limnological data in each year of the collection were used to perform a principal component analysis (PCA) to verify the associations of the variables in the respective reservoirs with the years sampled. The Principal Component Analysis associated the variables total phosphorus, total nitrogen, dissolved oxygen, total dissolved solids, and electrical conductivity to R3-2020 and R1-2020. R2-2019 and R2-2020 are associated with the highest temperature values. R1-2019 is associated with the highest values of pH and turbidity. The worsening of the drought between 2019 and 2020 caused a decrease in water quality in reservoirs 1 and 3.

Keywords: Urban Parks, Physicochemical Variables, Principal component analysis.

1 INTRODUCTION

The unbridled and disorderly urban growth causes impacts such as the loss of biodiversity and natural resources and the degradation of the environment, providing changes in the microclimate and the hydrological balance. The construction of urban parks helps in reducing these impacts, aiming at the maintenance of biogeochemical and wildlife cycles, which are fundamental to maintaining the balance of the environment (RODRIGUES et al., 2017). Urban parks are important spaces for leisure, environmental preservation, and socialization of the population, constituting an environment of encounter with nature, rest, entertainment, and the search for a better quality of life (RODRIGUES;

SAINTS, 2018). Many of these parks have on their perimeter water reservoirs, which can function as water containment systems, recreational purposes, and landscaping. These aquatic systems can be impacted by point and diffuse sources of pollution and by the climate, factors that will influence water quality (GUEDES; COSTA, 2017).

The physicochemical variables of water are commonly used to monitor the water quality of reservoirs (SILVA; Smith, 2020). Among these variables are temperature, pH, electrical conductivity, turbidity, total dissolved solids, dissolved oxygen, nitrogen, and phosphorus. The pH is determined by the amount of bases and acids in the water, being influenced by the respiratory and photosynthetic processes of aquatic organisms and microorganisms. Turbidity indicates the presence of suspended materials in the water, which prevent the penetration of sunlight into the water column (LEIRA et al., 2017). Dissolved oxygen is important for aquatic life, being used in the respiratory processes and decomposition of organic matter. Total dissolved solids are used to infer the amount of solid substances dissolved in water, where high values may be related to the incorporation of allochthonous material, such as untreated waste (GOMES et al., 2017). Temperature influences the growth of aquatic organisms and biological activities; the higher the temperature, the greater the biological activity of the reservoir and the lower the solubility of gases. Electrical conductivity is used to predict the amount of ions dissolved in water and increases as dissolved salts intensify (SENA et al., 2020). Nitrogen can be found in different forms in aquatic environments (ammonia, nitrate, nitrite), aiding in the growth of microalgae and influencing the demand for dissolved oxygen. Phosphorus has a great influence on increasing the production of planktonic organisms, which can cause an imbalance in the ecosystem when found in large quantities. These nutrients are widely used to indicate eutrophication of the environment (SILVA et al., 2020).

Precipitation is a variable of great influence in water systems such as reservoirs, in qualitative and quantitative aspects, because regions of little or no incidence of rainfall can lead to a decrease in the water level of these reservoirs deteriorating their quality, with nutrient concentration (BEZERRA et al., 2017). Prolonged periods of drought, high temperature, and evapotranspiration can lead to physical-chemical imbalances (BATISTA et al., 2020).

The objective of this study was to compare the effects of two consecutive dry periods (2019 and 2020) on the physicochemical variables of water in three shallow urban reservoirs.

2 METHODOLOGY

The research was conducted in the Leda Campos Borges Park, popularly known as Parque dos Lagos, located in the city of Frutal-MG, at approximately 20º01'31"S and 48º55'26" W, with an average altitude of 531 m (Figure 1). The park has about 53,000 m2 of area, featuring two sports courts, a sand court, a walking track, toilets and a green area, with three reservoirs (R1, R2, and R3) arranged sequentially, supplied mainly by rainwater and urban drainage (Figure 1).

The climate of the region is subtropical Cwa (PEEL et al., 2007), with dry winter and rainy summer, presenting temperature and average annual precipitation of 23.8ºC and 1626.9 mm, respectively (FERREIRA, 2002).

Figure 1 - Satellite image of the Lagos park, with identification of the reservoirs (R1 – R3)

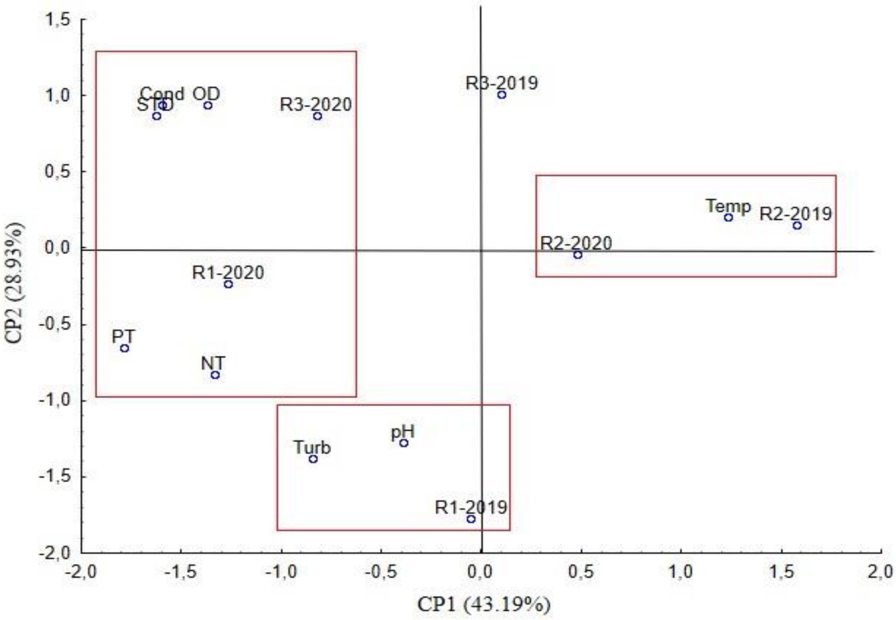
The collections occurred monthly during the dry season of two consecutive years (May to September 2019 and 2020). Two points were sampled in each reservoir, one at the water inlet and the other at the water outlet of each reservoir. The worsening drought in 2020 made it impossible to analyze the water in P3 in September 2020.

The variables temperature (Temp – ºC), pH, electrical conductivity (Cond – µS $^{cm-1}$), dissolved oxygen (DO – mg $^{L-1}$), total dissolved solids (STD – mg $^{L-1}$) and turbidity (Turb – UNT) were measured with a multiparametric probe HORIBA U-50 on site. For the quantification of total phosphorus (PT - µg $^{L-1}$) and total nitrogen (NT - µg L-1) samples were collected in 500 mL polyethylene vials and analyzed according to Golterman; Clymo; Ohnstad (1978) and Koroleff (1976). The interpretation of the results was performed by Principal Component Analysis (PCA), using the means of the limnological variables of the reservoirs in the years of sampling, to verify the associations of the variables in the respective reservoirs with the years sampled.

3 RESULTS AND DISCUSSION

The principal component analysis grouped 72.12% of the original variability of the data, with Main Component 1 (CP1) retaining 43.19% of the variability and Principal Component 2 (CP2) 28.93% (Figure 2). On the positive side of CP1, R2-2019 and R2-2020 were positioned, which are associated with higher temperature values with averages of 22.19 ºC in R2-2019 and 20.44 ºC in R2-2020, presenting an opposite relationship with the concentration of nitrogen and phosphorus in the water, that is, lower trophic condition than the other reservoirs. The worsening of the drought considerably decreased the level of the R2 reservoir, which made it impossible for the water to pass from R2 to R3. On the negative side of CP1, R3-2020 and R1-2020 were positioned, which are associated with higher values of PT, NT, OD, STD and Cond (Figure 2) with means in R3-2020 of 3.87 µg $^{L-1}$, 780.94 µg $^{L-1}$, 5.73 mg $^{L-1}$, 164.50 mg $^{L-1}$ and 255.90 µS $^{cm-1}$ respectively and in R1-2020 of 5.15 µg $^{L-1}$, 721.78 µg $^{L-1}$, 6.66 mg $^{L-1}$, 123.20 mg $^{L-1}$ and 189.90 µS $^{cm-1}$, respectively. Among these values, only OD is in higher values than that established by resolution 357 of CONAMA (BRAZIL, 2005) for class II fresh waters, which is 5 mg $^{L-1}$ (with the exception of the variable electrical conductivity that is not addressed in the aforementioned legislation), indicating that the environment is adequately oxygenated for the maintenance of aquatic life. The higher values of nutrients such as phosphorus and nitrogen in R3 in 2020 occur due to the incorporation of allochthonous material and by punctual discharges of clandestine sewage that occur in this reservoir, increasing the values of electrical conductivity and STD. These same high variables are related to R1 in 2020, which was no longer supplied with spring water due to drought, with a progressive decrease in the water level. In this environment are waterfowl such as ducks and geese that promote sediment turnover movement when swimming in shallow environments. Thus, the presence of these animals and the progressive drought influenced the elevation of the aforementioned variables and the association with R3 in this year of sampling. Also, the decrease in the water level in R1 promoted a lack of water supply in R2.

Figure 2 – Biplot graph of principal component analysis. R1 – R3/2019-2020 = Reservoirs-year; STD = Total Available Solids; Cond = Electrical Conductivity; Temp = Temperature; Turb = Turbidity; DO = dissolved oxygen; PT = Total Phosphorus; NT = Total Nitrogen.



R1-2019 was positioned on the negative side of CP2 (Figure 2), associated with higher values of pH (mean of 7.70) and turbidity (104.52 UNT), which demonstrates that in 2019 this reservoir was already impacted by drought, with an increase in particulate matter, which intensified in 2020. According to resolution 357 of CONAMA (BRAZIL, 2005) for class II fresh waters, turbidity values exceed the established 100 UNT.

4 FINAL CONSIDERATIONS

The worsening of the drought provided an increase in the variables electrical conductivity, dissolved oxygen, total dissolved solids, total nitrogen and total phosphorus in reservoir 1 and 3, however, all are within the established by resolution 357 of CONAMA (BRAZIL, 2005) for class II fresh waters.

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