Periódico Eletrônico

Fórum Ambiental da Alta Paulista

ISSN 1980-0827 – Volume 19, número 2, 2023

Impact of desilting by excavation on water quality in a water reservoir in the municipality of Fernandópolis, SP

Elise Baroni Ramos
Master's student in Environmental Sciences, Universidade Brasil, Brazil
elise_baroni@hotmail.com

Cleber Fernando Menegasso Mansano
Full Professor, Universidade Brasil, Brazil
cleber.mansano@ub.edu.br

Juliana Heloisa Pinê Américo-Pinheiro
Full Professor, Universidade Brasil, Brazil
juliana.pinheiro@ub.edu.br

Luiz Sergio Vanzela
Full Professor , Universidade Brasil, Brazil
luiz.vanzela@ub.edu.br

ABSTRACT

Desilting is an important job in restoring water reservoirs, but it disturbs the environment and has a potential impact on water resources. The objective of this work was to evaluate the impact of the desilting operation by excavation on the water quality of Córrego da Aldeia, Fernandópolis/SP. The experimental design was completely randomized in a 2x3x4 factorial scheme, in which the main factors were constituted by the runoff periods (with and without runoff), the secondary by the excavation periods (before, during and after excavation) and the tertiary by the points of monitoring (upstream points E1, E2 and E3 and downstream point S, in relation to the reservoir). Samples and analyzes of the physical, chemical and biological variables of the water were collected between July 2020 and March 2022. After that, analysis of variance of the isolated factors and their interaction was performed, followed by a mean comparison test. Through the results, it was observed that the work impacted the water quality in the concentration of ammonium and ammonia in 154.1% and 151.9%, respectively. The other qualitative water variables evaluated (water temperature, hydrogenionic potential, dissolved oxygen, electrical conductivity, total coliforms and *Escherichia coli*) were impacted due to climate and/or use and occupation of the soil around the collection points.

KEYWORDS: Silting. Dams. Water resources.

1 INTRODUCTION

The improper use and occupation of watersheds bring disastrous consequences to watercourses, including reservoirs known as dams. This is due to erosions, which carry the sediments to the bed of watercourses and from there are transported and retained in reservoirs, which have very low or practically zero flow (CARVALHO, 2008). This process is called siltation and can affect the quality and volume of water accumulated in dams.

While dams gradually fill with sediment over time, it is necessary to think about strategies to reduce or remove the deposition of this material. For this, there are a variety of desilting techniques that impair the functioning of the reservoir as little as possible (LEE; LAI; SUMI, 2022).

The work of desilting in a water reservoir consists of removing the accumulated sediments in its bed and on its sides, generally using equipment such as dredgers, to carry out the suction of the sedimented material, excavators, to widen the sides and trucks, for the transport of the sediments removed for final disposal. In this way, it is possible to increase the depth and surface area of the reservoir (GIUDICE et al., 2018).

In the municipality of Fernandópolis, located in the Northwest region of São Paulo State, there is a water reservoir for landscape and recreational purposes. Mainly due to the increasing urbanization in its drainage basin, this reservoir underwent a silting process, reducing its water surface by 81.9% from 1979 to 2020 (BUOSI, 2021).

Faced with this reality, the Municipality of Fernandópolis began, in December of 2020, the work of desilting 4.26 ha of water surface (CETESB, 2020a). The work will consist of two stages: excavation and dredging.

The excavation stage was completed in December 2021, and with that it was possible to monitor the water quality of Córrego da Aldeia before, during and after excavation, in order to evaluate the real impact of this temporary process on qualitative water variables.

2 OBJETIVE

To evaluate the impact of the silting operation by excavation on the water quality of Córrego da Aldeia, Fernandópolis/SP.

3 MATERIALS AND METHODS

3.1 Description of the study area

The water reservoir object of this study is located at the Córrego da Aldeia creek, in the municipality of Fernandópolis, in the Northwest of the State of São Paulo. The watershed of the Aldeia creek, up to the exit point of the reservoir dam, is 5.57 km^2, with a main bed of 2,214.78 m, being occupied mainly by grasses (50.7%), urbanized areas (35, 7%) and native forests (9.0%). According to São Paulo (1977), the framework of the water body is class 4 throughout its extension.

3.2 Experimental design

The experimental design was completely randomized in a 2 x 3 x 4 factorial scheme, in which the main factors were constituted by the periods of surface runoff (PRun) (with and without runoff), the secondary by the periods of desilting (PDes) (before, during and after excavation) and the tertiary by the points of monitoring (Po) (upstream points E1, E2 and E3 and downstream point S, in relation to the reservoir).

3.3 Points of monitoring

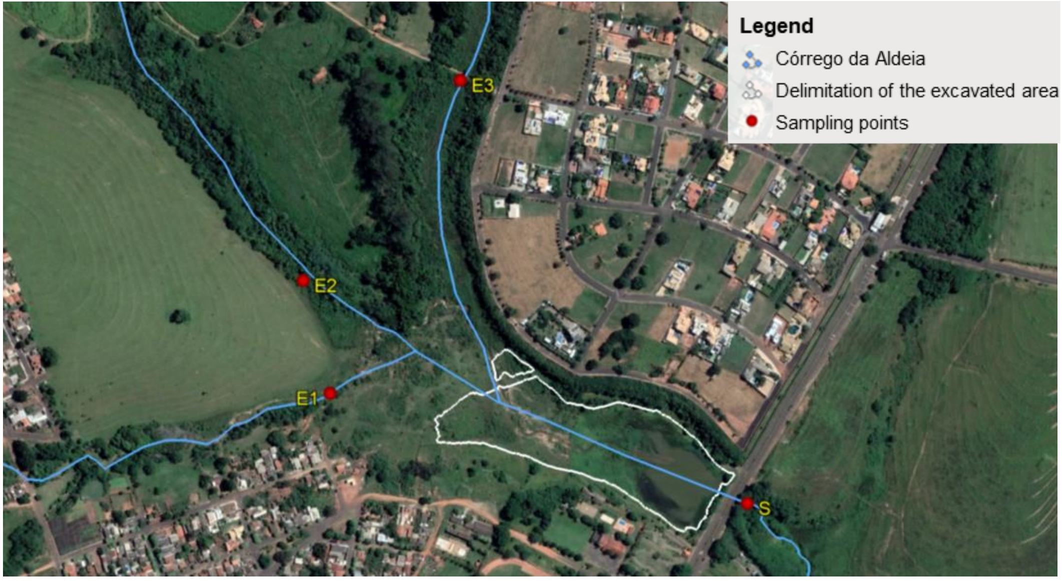
The points of monitoring (Po) were defined by location in relation to the reservoir, being located and characterized according to Table 1 and Figure 1.

Table 1 - Details of sampling points

Point of monitoring	Geographical coordinates	Characterization of the surroundings	Characterization of the contribution basin
Entry 1 (E1)	20°15'47.21" South 50°14'28.51" West	The site is degraded and with severe silting. It is a confinement area for horses and cattle, in addition to receiving rainwater and solid waste from the surrounding neighborhoods, as well as clandestine discharge of sewage.	• Area: 2,55 km² • Most of it occupied by: - Urbanized area (65%) - Grasses (27%)
Entry 2 (E2)	20°15'42.04" South 50°14'29.80" West	It is characterized by the scarcity of riparian forests and the advanced silting process, with a shallow and wide bed, almost entirely occupied by aquatic macrophytes. It is an area of cattle breeding and the animals use to drink water at the banks of the water reservoir.	• Area: 0,87 km² • Most of it occupied by: - Grasses (80%) - Native forests (17%)
Entry 3 (E3)	20°15'32.89" South 50°14'22.16" West	This point has a water mirror and greater depth than the others, with the presence of aquatic macrophytes. It has preserved riparian forest and is inhabited by animals, such as capybaras.	• Area: 1,62 km² • Most of it occupied by: - Urbanized area (51%) - Grasses (36%)
Exit (S)	20°15'52.27" South 50°14'08.19" West	The site is located after the energy dissipation of crossing the reservoir and has riparian forest preserved in this section, with a shallow and wide bed and with a lot of aquatic macrophytes.	• Area: 5,57 km² • Most of it occupied by: - Urbanized area (51%) - Grasses (36%)

Source: Own authorship (2022)

Figure 1 - Location of sampling points and delimitation of the excavated area



Source: Adapted from Google Earth Pro (2022)

3.4 Periods of surface runoff

The runoff period factor was defined from the surface runoff determined by the Curve Number Method, developed by the Soil Conservation Service (SCS) (PRUSKI; BRANDÃO; SILVA, 2004). With this method it is possible to estimate the volume of surface runoff by the basin area, based on precipitation data and other characteristics of the basin.

Precipitation data were obtained from the automatic climatological station of the Integrated Center for Agrometeorological Information (CIIAGRO, 2022), located 6 km from the dam design, and the characterization of the basins was carried out *in situ* and using Google Earth images. For the runoff calculations, it was used the accumulated precipitation on the seven days prior to the monitoring dates.

After determining the surface runoff, a period without runoff was defined, when there was no accumulated surface runoff on the seven days prior to the monitoring date, while the periods with runoff were defined on the dates in which the accumulated runoff of seven days was greater than zero.

3.5 Excavation periods

The excavation periods factor was defined from the monitoring period in relation to the excavation service for desilting, as follows: (a) before - monitoring carried out before the start of excavation, (b) during - monitoring carried out throughout the entire period in which the work was being carried out and (c) after - monitoring carried out after the end of the excavation.

3.6 Analyzed variables and sampling

The water variables analyzed were the series of solids (concentration of total, suspended and dissolved solids) (mg L-1), water temperature (ºC), electrical conductivity of water at 25ºC (µS cm^{-1}), hydrogenionic potential, dissolved oxygen concentration (mg L^{-1}), total coliforms (CFU/100 mL), thermotolerant bacteria (*Escherichia coli*) (CFU/100 mL), ammonia and ammonium concentration (mg L^{-1}). Some variables were analyzed *in situ*, while others were sampled and analyzed in the laboratory (Table 2).

Table 2 - Details of the form and method of analysis of the water variables analyzed in the laboratory

Variable	**Method**	**Material e equipment**
Total solids (TS), dissolved solids (DS) and suspended solids (SS)	Gravimetric, analyzed in the laboratory	Scale, buchner funnel, vacuum pump, and drying oven
Electrical conductivity (EC)	Automatic reading, analyzed in the laboratory	Conductivity meter (MS Tecnopon®)
Total coliforms (TC) and thermotolerant bacteria (*E.coli*)	Quantitative analysis, analyzed in laboratory	Microbiological Kit of Colipaper® Cards and Microbiological Microgreenhouse (Alfakit® brand)
Hydrogenionic Potential (pH)	Automatic reading, analyzed *in situ*	Multiparameter photometer (HI83303-01 model, HANNA® brand)
Ammonia (NH_3) and ammonium (NH_4^+)	Photometry, analyzed *in situ*	
Dissolved oxygen (DO)	Automatic compensation, analyzed *in situ*	Multiparameter Meter (AK87 model, AKSO® brand)
Water temperature (T)		

Source: Own authorship (2022)

In all, 25 fortnightly/monthly sampling campaigns were carried out, divided into three campaigns between July and August 2020 (before the work started), nineteen campaigns from January to November 2021 (during the excavation) and three campaigns from January to March 2022 (after completion of the excavation stage). All collections were carried out in the morning, between 8 am and 11 am.

Samples were collected in 500 mL PVC bottles, packed in styrofoam with ice, for transport to the laboratory. In the case of bacteriological samples, they were collected directly from the stream, removing the excess from the cards, which were then placed in plastic bags and in Styrofoam with ice until they were taken to the laboratory.

3.7 Statistical Methodology

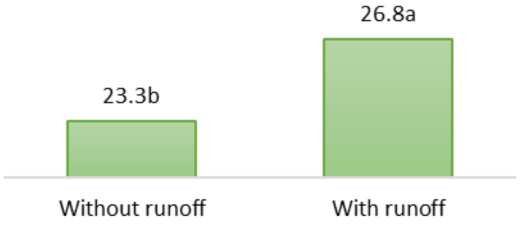
After obtaining data on the water variables, the analysis of variance of the isolated factors (PRun, PDes and Po) and the interraction factors (PRunxPo and PDesxPo) was carried out. In the case of probability of significance (p value) less than or equal to 0.05, the analyzes proceeded by the means comparison test by Scott and Knott (SCOTT; KNOTT, 1974), at the level of 5% of statistical significance. In all comparisons of means, the respective coefficients of variation (CV value) were presented.

4 RESULTS AND DISCUSSION

4.1 Water temperature

The greatest mean of water temperature was observed in the period when there was runoff (26.8°C), being 14.7% greater than the period without runoff (Figure 2). The water temperature fluctuates with seasonal variations and in the study region of this work, there is a tendency for T to increase in periods with accumulated rain, as it coincides with the period of warmer days.

Figure 2 - Means of water temperature (ºC) as a function of the PSR factor (CV=17.25)



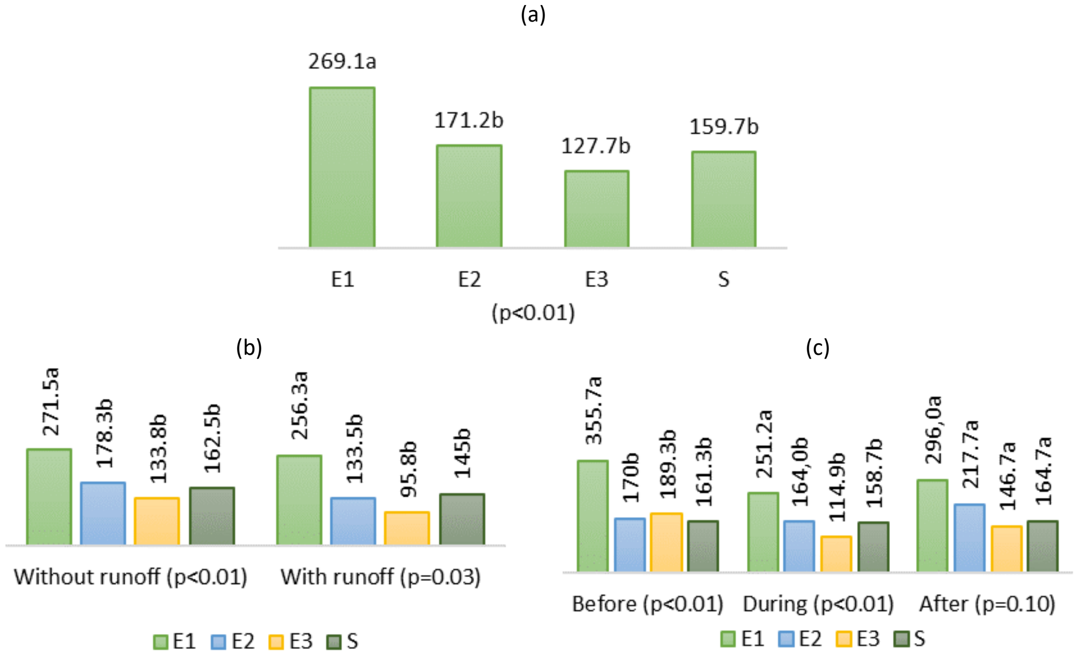
($p<0.01$)

Means followed by the same letter do not differ at $p<0.05$
Source: Own authorship (2022)

4.2 Total solids

Analyzing the isolated points of monitoring factor, at point E1 the greatest mean concentration of total solids was observed (269.1 mgL-1), being 76% greater than the mean of the other points (E2, E3 and S) (Figure 3a). The greatest values relate to the upstream point where the water body is more silted.

Figure 3 - Means of total solids concentration (mg L^{-1}) as a function of the Po factor (a), the interaction between the PRunxPo factors (b) and the interaction between the PDesxPo factors (c) (CV=43.37)



Means followed by the same letter do not differ at $p<0.05$
Source: Own authorship (2022)

Statistically significant differences were observed in the interaction between runoff periods and points (Figure 3b), where the average of point E1 remained greater than the other points (E2, E3 and S) in periods without and with surface runoff.

In the breakdown of points within the periods of desilting (Figure 3c), there was statistical significance in the moments before and during excavation, with point E1 having the greatest means. In the period after excavation, there was no statistically significant difference between means.

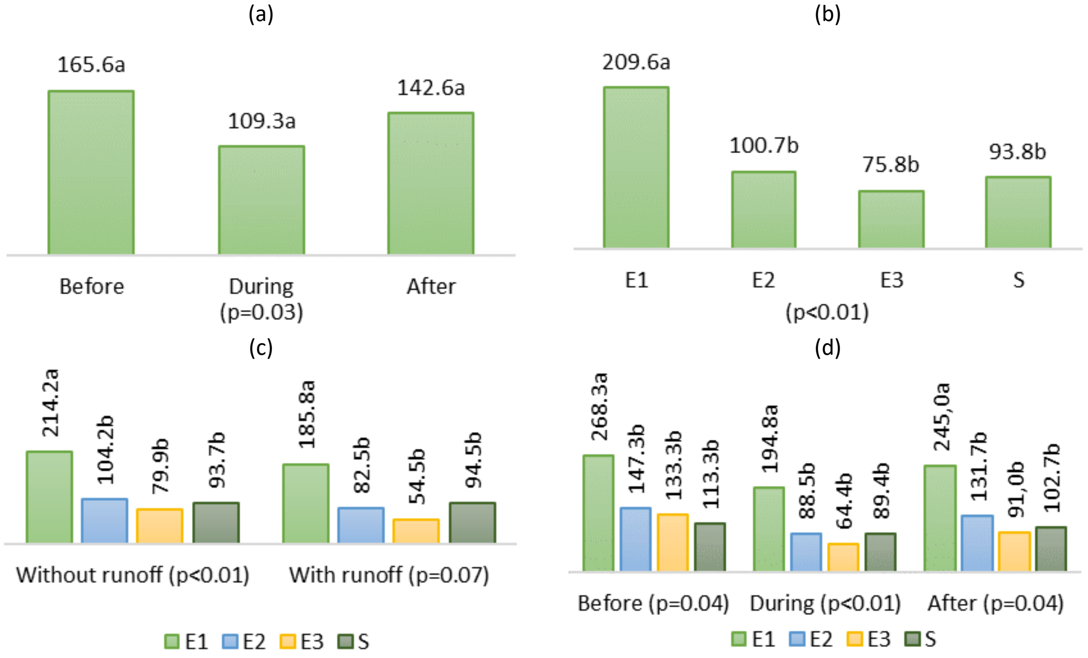
It is not possible to associate the results obtained with current legislation, as CONAMA Resolution No. 357 (BRASIL, 2005) does not have an established limit for TS in class 4 water bodies. High TS values are usually related to heavier rainfall, which allows the transport of sediment to the waterbed, however, the high urbanization close to watercourses also increases the mean concentration of solids (ALVES *et al.*, 2021), which explains the high concentration of TS found at point E1.

4.3 Dissolved solids

In the isolated periods of desilting factor, no statistical significance was observed, and the mean concentration observed in the three instants was 139,1 mgL^{-1} (Figure 4a). According to CONAMA Resolution nº 357 (BRASIL, 2005), class 4 fresh waters do not have a maximum DS concentration limit, however, with the mean concentrations observed in the water (≤ 500 mgL^{1}), this section of the Aldeia creek could be classified as class 1.

In Figure 4b, the means concentration of dissolved solids can be seen as a function of the isolated points factor. Following the pattern of total solids, the greatest value was observed at point E1, being 132.6% greater than the mean of points E2, E3 and S (90,1 mgL^{-1}).

Figure 4 - Means of dissolved solids concentration (mg L^{-1}) as a function of the PDes factor (a), the Po factor (b), the interaction between the PRunxPo factors (c) and the interaction between the PDesxPo factors (d) (CV=60.08)



Means followed by the same letter do not differ at p<0.05
Source: Own authorship (2022)

In the interaction between runoff periods and points of moonitoring factor (Figure 4c), again the mean DS concentration at point E1 remained greater than the other points (E2, E3 and

S) in both periods. The less rainy period holds greater values of dissolved solids, as there is a greater drag of materials present in the bed of the watercourse, making the solids more present. In the period with more rainfall, the concentration tends to decrease, since the solids are diluted in a greater volume of water (ALENCAR *et al.*, 2019).

The breakdown of the points within the periods of desilting showed a statistically significant difference in the three instants, with the means of point E1, respectively, 104.3%, 141.3% and 125.9% greater than the means between points E2, E3 and S (Figure 4d). The pattern remained the same in the three moments of the work, therefore, without influence of the excavation in the concentration of dissolved solids, being possible to associate the values found with the discharge of solids, mainly in the point E1.

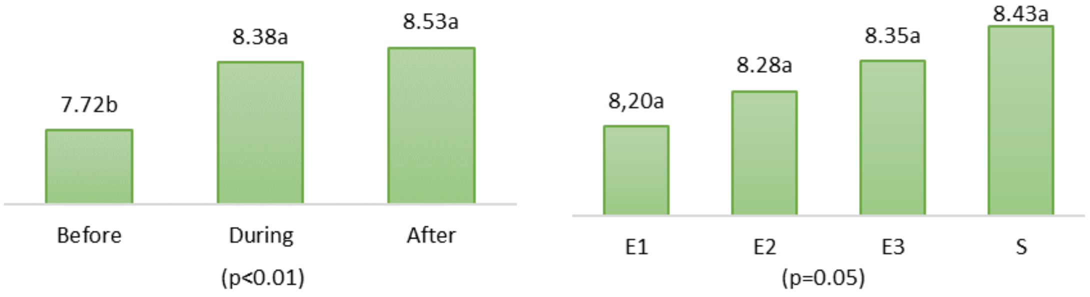
4.4 Suspended solids

The general mean of the suspended solids concentration throughout the evaluated period was 61,9 mg L^{-1}. There was no statistically significant difference for the analyzed factors and there was a low concentration of suspended solids compared to the means of total and dissolved solids. This can be explained by the fact that these are sections close to a reservoir, associating with the mean values of SS concentration found in the works by Belém (2019) and Guimarães (2019) at points close to dammed waters.

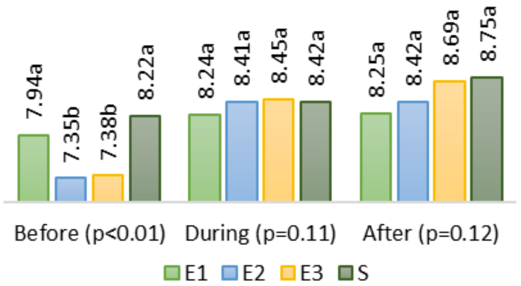
4.5 Hydrogenionic Potential

The pH results in the periods of desilting factor show that the mean increased after the beginning of the excavation. Comparing the mean before (7.72) with the mean found between the moments during and after (8.45), there was an increase of 9.5% (Figure 5a). As the means were greater than 7.0, it is understood that the water is alkaline (ANA, 2016).

Figure 5 - Means of hydrogenionic potential as a function of the PDes factor (a), the PO factor (b) and the interaction between the PRSxPO factors (c) (CV=3.54)


(a)
(b)

(c)



Means followed by the same letter do not differ at $p<0.05$
Source: Own authorship (2022)

No statistically significant differences were found for the points of monitoring in the isolated factor in the mean comparison test (Figure 5b), but the pH values recorded met the standard limit range provided by CONAMA Resolution No. 357 (BRASIL, 2005), which is from 6.0 to 9.0.

In the interaction factor between periods of silting and points of monitoring, it was verified that the mean pH increased in every point after the beginning of the excavation (Figure 5c), which can be explained by the growth of aquatic macrophytes in the sampling points that were observed. High pH values may be associated with the proliferation of plants, which cause the reduction of carbonic acid in the water and the consequent contribution to the environment becoming alkaline (VON SPERLING, 2014).

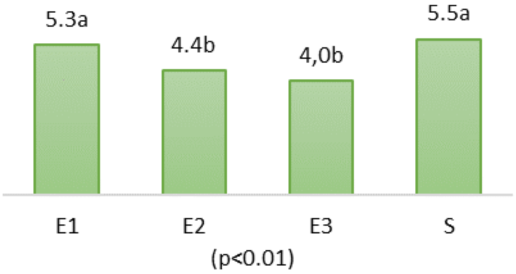
4.6 Dissolved oxygen

The concentration of DO, showed a statistically significant difference for the isolated points of monitoring factor and the mean of points E1 and S (5,3 mgL^{-1}) was 28.3% greater than the mean of E2 and E3 (4,18 mgL^{-1}) (Figure 6a). The greatest values indicated at points E1 and S are probably due to the greater flow of water that occurs in these places.

When analyzing the interaction between runoff periods and points of monitoring (Figure 6b), statistically significant difference was found in the period without surface runoff, with the greatest means being found at points E1 and S. The mean at these two points in relation to the mean of points E2 and E3, was 29.5% greater. The values found are in compliance with CONAMA Resolution No. 357 (BRASIL, 2005), which establishes a limit of 2 mgL^{-1} in the concentration of dissolved oxygen for class 4 fresh water.

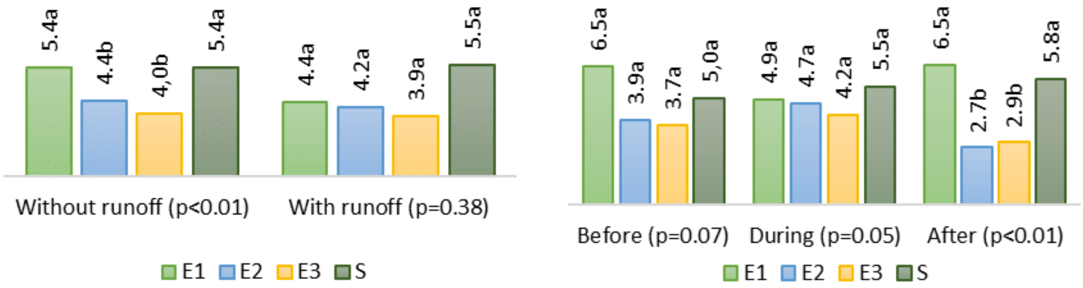
Figure 6 - Means of dissolved oxygen concentration (mgL^{-1}) as a function of the Po factor (a), the interaction between the PRunxPo factors (b) and the interaction between the PDesxPo factors (c) (CV=29.28)

(a)



(b)

(c)



Means followed by the same letter do not differ at p<0.05
Source: Own authorship (2022)

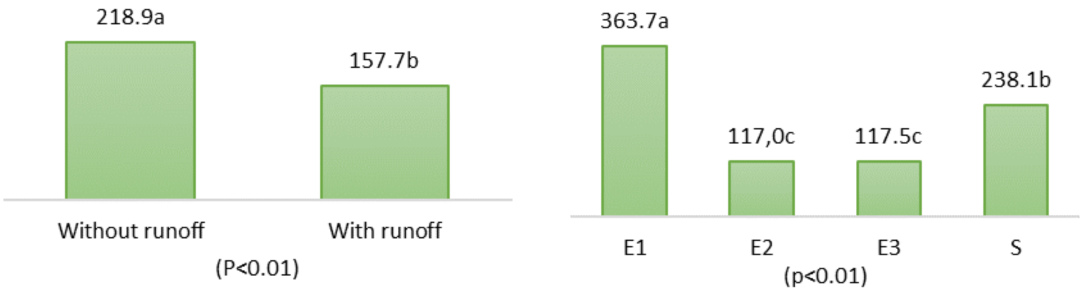
Within the same period, statistical significance was observed among the points only after the end of the excavation, with points E1 and S presenting the greatest means (Figure 6c). The low DO values found at points E2 and E3 affect aquatic organisms and may have been influenced by the organic matter present in these locations. As highlighted by Costa *et al.* (2021), lower means in DO concentration, may indicate that oxygen is being consumed in the process of decomposition of organic matter by the aquatic environment itself. While at points E1 and S, they have increased oxygenation from the greater movement of water.

4.7 Electric conductivity

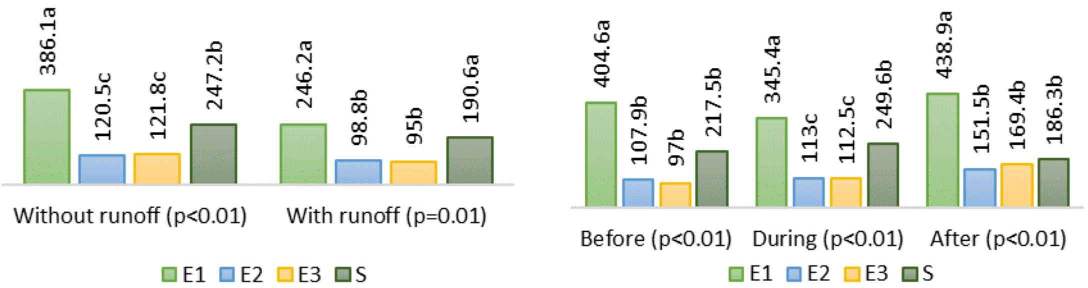
In the periods of the isolated runoff factor, the greatest EC mean was observed in the period when there was no runoff, being 38.8% greater than the mean of the period with surface runoff (Figure 7a). It is possible to verify that the precipitation affects the electrical conductivity, because, with the increase of the flows, which provoke the dilution of the polluting load, the means of the EC concentrations decrease.

The results presented in Figure 7b show that there was a statistically significant difference when analyzing the isolated points factor, and the mean in point E1 was greater than the other points. According to Cetesb (2020b), EC concentrations between 200 and 500 µScm^{-1} suggest that this is a water body affected by polluting loads.

Figure 7 - Means of electrical conductivity concentration (µScm^{-1}) as a function of the PRun factor (a), the Po factor (b), the interaction between the PRunxPo factors (c) and the interaction between the PDesxPo factors (d) (CV=36.22)


(a) (b)

(c) (d)



Means followed by the same letter do not differ at p<0.05
Source: Own authorship (2022)

In the interaction between the runoff periods and points of monitoring factor, all points had greater EC values in the period without surface runoff (Figure 7c), with point E1 being greater than the other points. In the period with runoff, point E1 did not differ from point S. A greater EC value was obtained at point E1, since this has an extensive area of urbanization and exposed soil in its basin, as well as the clandestine release of sewage. The exposed soil contributes to directing solid particles to water courses, increasing electrical conductivity values (GUIMARÃES *et al.*, 2018).

Analyzing the interaction periods of desilting and points, statistical significance was observed in all periods (Figure 7d). The greatest mean was from point E1, being greater than the means of the other points in the three instants. After the end of excavation, the mean observed at point S did not differ from points E2 and E3. The high values of electrical conductivity indicate that the water body is being impacted by polluting loads.

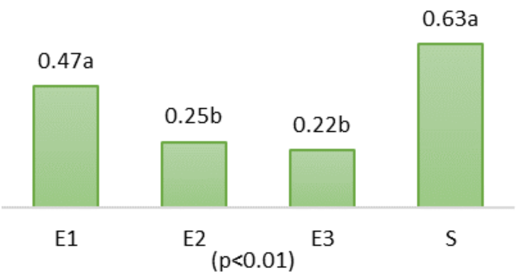
4.8 Ammonium

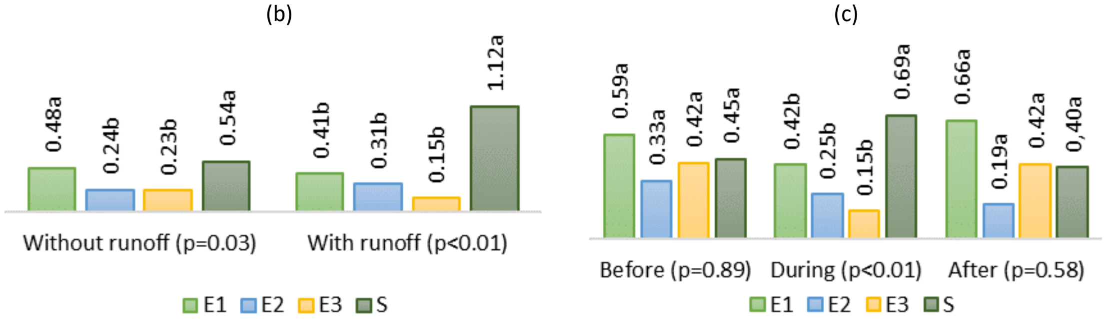
When analyzing the concentration of a NH_4^+ in the isolated points factor, the greatest means are found at points E1 and S. The mean between these two points (0,55 mgL^{-1}) is 133.2% greater than the mean of the points E2 and E3 (0.23 mgL-1) (Figure 8a).

Observing the unfolding of the points in the periods of runoff (Figure 8b), there was a statistically significant difference, and the point S presented the greatest mean in the period with runoff, but not differentiating from the point E1 in the period without runoff. The results obtained in the study by Sarmento (2019) did not show a statistically significant spatial and seasonal difference, but in the rainy season, the greatest concentrations of NH_4^+ were obtained, as well as in the works of Mitsuya (2014) and Silva (2013).

Figure 8 - Means of ammonium concentration (mgL^{-1}) as a function of the Po factor (a), the interaction between the PRunxPo factor (b) and the interaction between the PDesxPo factor (c) (CV=105.64)

(a)





(b) (c)

Means followed by the same letter do not differ at p<0.05
Source: Own authorship (2022)

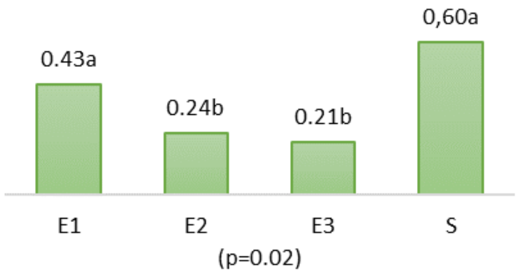
In the interaction of periods of desilting and points factor (Figure 8c), there was statistical significance only during excavation, and the greatest mean found was at point S (0,69 mgL^{-1}), equivalent to 154.1% greater than the mean among the upstream points (0,27 mgL^{1}). High concentrations of NH_4^+ can intervene in aquatic organisms, since at high pH, ammonium is transformed into ammonia (NH_3), becoming toxic to fish (KUBITZA, 2017).

4.9 Ammonia

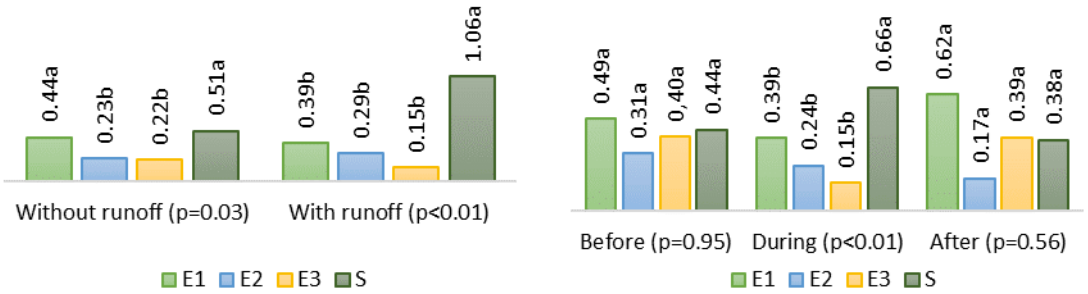
The results of the mean concentration of ammonia presented in Figure 9 are similar to those of ammonium indicated in the previous item. Analyzing the isolated points factor, the greatest means are found at points E1 and S. The mean between these two points (0,52 mgL^{-1}) is 129.7% greater than the mean of points E2 and E3 (0,22 mgL^{-1}) (Figure 9a). According to Kubitza (2017), ammonia is a very restrictive toxicant to the life of aquatic organisms, values above 0,20 mgL^{-1} are already enough to induce chronic toxicity and influence the growth of fish, as well as increase their probability of acquiring diseases.

Figure 9 - Means of ammonia concentration (mgL^{-1}) as a function of the Po factor (a), the interaction between the PRunxPo factor (b) and the interaction between the PDesxPo factor (c) (CV=104.57)

(a)



(b) (c)



Means followed by the same letter do not differ at p<0.05
Source: Own authorship (2022)

For the interaction between runoff periods and points of monitoring factor (Figure 9b), in the period without runoff, point S did not differ from point E1 and in the period with runoff, the downstream point (S) had a greater mean concentration than upstream points, being 285.5% greater. In natural environments, NH_3 can originate from rain, organic and inorganic material from the surroundings and from the fixation of molecular nitrogen within the lake itself (PEREIRA; MERCANTE, 2018).

When splitting the points into the periods of desilting, there was statistical significance at the time during excavation (Figure 9c), with the greatest mean concentration being at point S (0.66 mgL^{-1}), corresponding to 151.9% greater than the mean between the upstream points (0.26 mgL^{-1}). Determining the form that nitrogen is in the location can provide information about the stage of pollution of a water body. Recent pollution is characterized by concentration in the form of NH_3 (VON SPERLING, 2014).

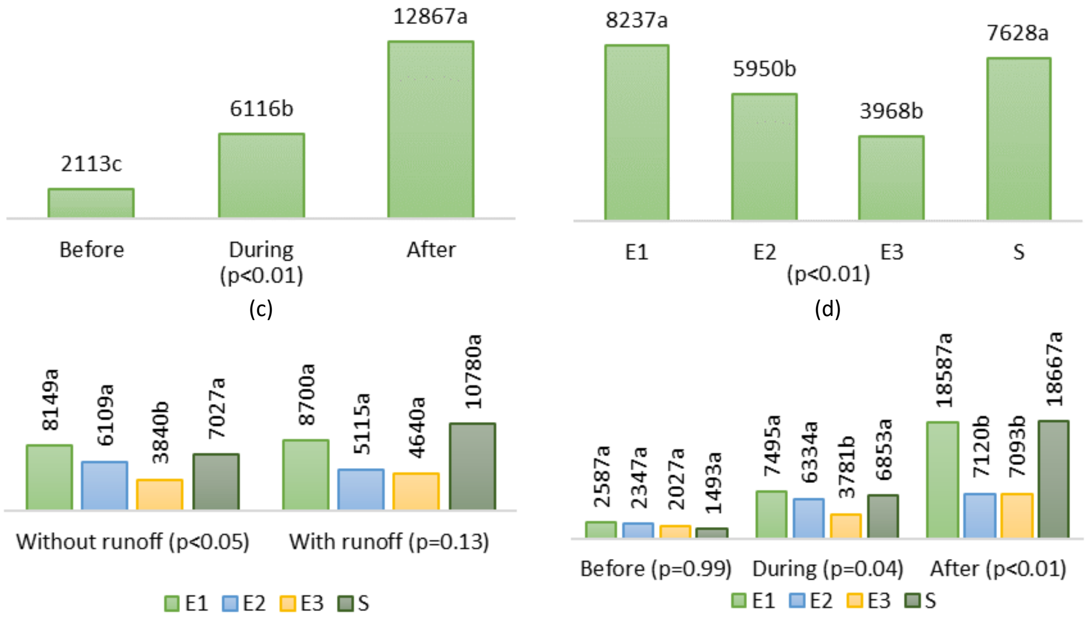
4.10 Total coliforms

The results of the mean concentration of TC in the periods of desilting show that the mean increased after the beginning of the work. Comparing the mean before with the means found during and after, there was an increase of 189.4% and 508.8%, respectively (Figure 10a). The significant increase after the beginning of the work may be related to the revolving of the material that was decanted by the machinery.

When comparing the results by the isolated points factor (Figure 10b), statistical significance was observed in which the greatest concentrations were found at points E1 and S, with their mean (7,932 CFU/100 mL) 60% greater than the mean between points E2 and E3 (4,959 CFU/100 mL). CONAMA Resolution No. 357 (BRASIL, 2005) does not have an established limit for total coliforms in class 4 water bodies.

Figure 10 - Mean concentration of total coliforms (CFU/100 mL) as a function of the PDes factor (a), the Po factor (b), the interaction between the PRunxPo factor (c) and the interaction between the PDesxPo factor (d) (CV=65.44)

(a) (b)



Means followed by the same letter do not differ at p<0.05
Source: Own authorship (2022)

When splitting the points into the runoff periods, it was found that the mean concentration of TC was less at point E3 in the period without runoff, being 46% less than the mean of the other points. In the runoff period, no statistically significant differences were observed (Figure 10c).

In the interaction between periods of silting and points factor (Figure 10d), statistically significant differences were observed, during and after the end of the excavation. After desiltation, the greatest mean concentrations were at points E1 and S, with the mean of these two points (18,627 CFU/100 mL) being 162.1% greater than the mean of points E2 and E3 (7,107 CFU/100 mL). At the time during desiltation, point E3 obtained the least mean (3,781 CFU/100 mL) among the points.

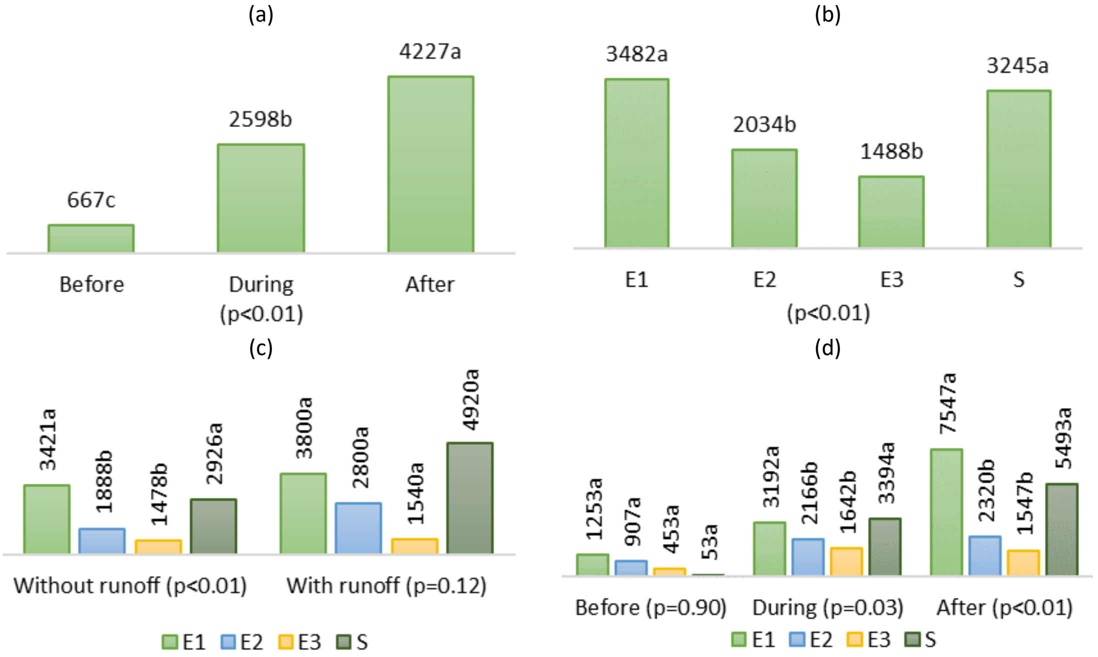
At every point sampled, evidence of contamination was found, as evidenced by the high concentration of TC sampled. At point E1 there is a large contribution of waste load due to the storm drainage of the urban area, in addition to having clandestine discharge of sewage and the presence of animals such as horses and cattle. While the E2 point has a diffusion of loads of residues from the rural area, for the most part, it also has animals on its banks, which use these points to quench their thirst. The urbanized area in the basin of point E3 contributes to its contamination and point S receives the propagation of pollution from all points together.

4.11 Thermotolerant bacteria (*E. coli*)

Following the same characteristics of the results presented for total coliforms, there was statistical significance for the concentration of *E. coli* in the isolated periods of desilting factor (Figure 11a), and the mean increased after the beginning of the work. Comparing the mean concentration before with those found during and after the work, there was an increase of 289.8% and 534.0%, respectively.

Observing the results of the isolated points factor, the greatest means were found at points E1 and S, their mean (3,363 CFU/100 mL) being 91% greater than the mean between points E2 and E3 (1,761 CFU/100 mL) (Figure 11b). As for total coliforms, current legislation does not have an established limit for the maximum concentration of *E. coli* in class 4 water bodies (BRASIL, 2005), but the values found are considered high.

Figure 11 - Mean concentration of thermotolerant bacteria (CFU/100 mL) as a function of the PDes factor (a), the Po factor (b), the interaction between the PRunxPo factor (c) and the interaction between the PDesxPo factor (d) (CV=79.54)



Means followed by the same letter do not differ at p<0.05
Source: Own authorship (2022)

For the interaction between runoff periods and points factor, a statistically significant difference was observed in the period without surface runoff, where the mean of points E1 and S (3,173 CFU/100 mL) was greater than the mean of points E2 and E3 (1,683 CFU/ 100 mL) by 88.6% (Figure 11c).

In the breakdown of the points within the periods of desilting, there was statistical significance during and after the end of the excavation, in which the means of points E1 and S were greater (Figure 11d). During excavation, the mean concentration of these two points in relation to the mean between E2 and E3 was 72.9% greater and, in the period after excavation, 237.2% greater.

According to CETESB (2020b), environmental conditions influence *E. coli* values and high concentrations indicate recent fecal contamination, which is possibly due to the presence of animals at the sampling points, which use the water for drinking, as well as the release of clandestine sewage effluents at point E1.

5 CONCLUSION

The excavation operation for desilting the water reservoir in Fernandópolis/SP had negative impacts on ammonium (NH_4^+) and ammonia (NH_3) water variables. Before starting the work, the mean of the NH_4^+ and the NH_3 concentrations at point S were 0.2% and 9.5%, respectively, greater than the mean between points E1, E2 and E3. With the work in progress, there was a mean increase of 154.1% in the NH_4^+ concentration and 151.9% in the NH_3 concentration at the downstream point, compared to the mean of the upstream points.

The other qualitative water variables analyzed (T, TS, DS, SS, pH, DO, EC, TC and *E. coli*) were influenced by interference from use and occupation around the monitored points and/or climatic factors, not indicating a relationship with the work of desiltation.

In order to minimize new future problems of silting up in the reservoir, it is recommended the restoration of the upstream permanent preservation areas (PPAs), improvement of public sweeping to reduce the transport of various solid wastes to the water course, control of cattle and horse breeding in the PPAs, containment of occasional clandestine waste releases and promotion of continuous environmental education of the population in the neighborhoods located in the watershed in order to raise awareness.

6 REFERENCES

ALENCAR, V. E. S. A.; DA ROCHA, E. P.; JÚNIOR, J. A. S.; CARNEIRO, B. S. Análise de Parâmetros de Qualidade da Água em Decorrência de Efeitos da Precipitação na Baia de Guajará – Belém – PA. **Revista Brasileira de Geografia Física**, v. 12, n. 2, p. 661–680, 2019. Available at: <https://periodicos.ufpe.br/revistas/rbgfe/article/view/238413> Accessed on: 09 jul. 2022.

ALVES, A. R.; MANSANO, C. F. M.; VANZELA, L. S.; FRIAS, D. F. R.; AMÉRICO-PINHEIRO, J. H. P. Water quality in the Tietê River watershed, São Paulo State, Brazil. **International Journal of Development Research**, v. 11, n. 2, p. 44566–44570, 2021.

ANA. **Sistemas de Informação na gestão de águas:** conhecer para decidir. v. 8. Brasília: Agência Nacional de Águas (Brasil), 2016. Disponível em: <https://capacitacao2.ana.gov.br/conhecerh/handle/ana/260> Accessed on: 09 jul. 2022.

BELÉM, F. L. **Influência das variáveis ambientais na qualidade das águas do reservatório da Usina Hidrelétrica da Ferreira Gomes – Amapá**. 2019. 252f. Tese (Doutorado em Geografia). Programa de Pós-Graduação em Geografia, Universidade Federal de Goiás, Goiânia, 2019.

BRASIL. **Resolução n° 357, de 17 de março de 2005.** Dispõe sobre a classificação dos corpos de água e diretrizes ambientais para o seu enquadramento, bem como estabelece as condições e padrões de lançamento de efluentes, e dá outras providências. Diário Oficial da República Federativa do Brasil, 2005. Available at: <http://www.mma.gov.br/port/conama/res/res05/res35705.pdf> Accessed on: 03 jul. 2022.
BUOSI, G. G. P. **Relatório Técnico Pró-Atividade US:** Processos eeodinâmicos e desassoreamento da Represa Municipal De Fernandópolis - SP. Fernandópolis: Secretaria Municipal de Meio Ambiente - Prefeitura Municipal de Fernandópolis, 2021.

CARVALHO, N. DE O. **Hidrossedimentologia Prática**. 2. ed. Rio de Janeiro: Editora Interciência, 2008.

CETESB. **Autorização CETESB nº 44663/2020**. CETESB/CFJ - Agência Ambiental de Jales, 2020a.

CETESB. **Qualidade das águas interiores no estado de São Paulo 2019**. São Paulo: Companhia Ambiental do Estado de São Paulo, 2020b. Available at: <https://cetesb.sp.gov.br/aguas-interiores/wp-content/uploads/sites/12/2021/09/Relatorio-Qualidade-das-Aguas-Interiores-no-Estado-de-Sao-Paulo-2020.pdf>. Accessed on: 03 jul. 2022.

CIIAGRO. **Portal Agrometeorológico e Hidrológico do Estado de São Paulo**. Available at: <http://www.ciiagro.org.br/diario/cperiodo>. Accessed on: 24 abr. 2022.

COSTA, K. A.; COSTA, A. D.; VENTURA, A. C. T.; GUMY, M. N.; WEINERT, P. L.; SCHEFFER, E. W. DE O. Influência Das Atividades Antrópicas Sobre a Qualidade Da Água Em Lagos Urbanos: Um Estudo De Caso. **Brazilian Journal of Development**, v. 7, n. 2, p. 19889–19907, 2021.

GIUDICE, S. L.; M., J. A. R.; MOREIRA, J. B.; MENDES, A. DA S. **Aspectos operacionais do desassoreamento do Rio Tietê em São Paulo, Brasil**. Anais do XXVIII Congreso Latinoamericano de Hidráulica. **Anais**...Buenos Aires, Argentina: Asociación Internacional de Ingeniería e Investigaciones Hidro-Ambientales, 2018.

GUIMARÃES, A. G.; DO PRADO, F. S.; SANTOS, G. O.; DINIZ, R. G.; MARASCA, I.; MAIA, C. H. Qualidade Da Água E Potencial De Assoreamento Em Represas Com Influência De Diferentes Usos Do Solo. **Científic@ - Multidisciplinary Journal**, v. 5, n. 3, p. 125–139, 2018. Available at: <http://periodicos.unievangelica.edu.br/index.php/cientifica/article/view/3109> Accessed on: 09 jul. 2022.

GUIMARÃES, T. T. **Utilização de imagens de satélite para predição de clorofila-a e sólidos suspensos em corpos d'água: estudo de caso da Represa do Lobo/SP**. 2019. 118f. Dissertação (Mestrado em Ciências da Engenharia Ambiental). Escola de Engenharia de São Carlos, Universidade de São Paulo, São Carlos, 2019.

KUBITZA, F. A água na aquicultura - parte 3. **Panorama da AQÜICULTURA**, v. 27, n. 164, p. 14–27, 2017.

LEE, F. Z.; LAI, J. S.; SUMI, T. Reservir Sediment Management and Downstream River Impacts for Sustainable Water Resources—Case Study of Shihmen Reservoir. **Water**, v. 14, n. 479, 2022.

MITSUYA, M. **Variação sazonal na composição química da água no leito principal do Rio Amazonas em frente à Cidade de Óbidos – PA**. 2014. Dissertação (Mestrado em Recursos Naturais da Amazônia). Universidade Federal do Oeste do Pará, Santarém, 2014.

PEREIRA, L. P. F.; MERCANTE, C. T. J. Ammonia in Fish Breeding Systems and Its Effects on the Water Quality – a Review. **Boletim do Instituto de Pesca**, v. 31, n. 1, p. 81–88, 2018.

SÃO PAULO. **Decree No. 10,755, of November 22, 1977.** Provides for the classification of receiving water bodies in the classification provided for in Decree No. 8,468 (1), of September 8, 1976, and provides related measures. Government of the State of São Paulo, Brazil, 1977.

SARMENTO, I. C. C. **Dinâmica do Nitrato, Amônio e Nitrogênio Total Dissolvido no estuário Guajarino**. 2019. Trabalho de Conclusão de Curso (Graduação em Engenharia Ambiental e Energias Renováveis). Universidade Federal Rural da Amazônia, Belém, 2019.

SCOTT, A. J.; KNOTT, M. A Cluster Analysis Method for Grouping Means in the Analysis of Variance. **Biometrics**, v. 30, n. 3, p. 507–512, 1974.

SILVA, M. DO S. R. DA. **Bacia Hidrográfica do Rio Amazonas:** contribuição para enquadramento e preservação. 2013. Tese (Doutorado em Química). Universidade Federal do Amazonas, Manaus, 2013.

VON SPERLING, M. **Introdução à qualidade das águas e ao tratamento de esgotos:** princípios do Tratamento Biológico de Águas Residuárias. Belo Horizonte: Departamento de Engenharia Sanitária e Ambiental/UFMG, 2014.