OPEN JOURNAL SYSTEMS
ISSN: 2595-4431

Brazilian Journal of Environment, v.9, n.1. 113-130 (2021)

Brazilian Journal of Environment

Silva, Ferreira & Matos

Revista Brasileira de Meio Ambiente

Monitoring of physical-chemical aspects of water quality at Palmeiras Lagoon Beach (Brazil)

Júlia Pereira de Oliveira Silva [1], Gessé Pereira Ferreira [2], Jaqueline Borges de Matos [3]*

[1] *Master's student in Chemistry, Universidade do Estado do Rio de Janeiro, Brazil.*
[2] *Master's degree in Science Teaching, Professor at Instituto Federal de Educação, Ciência e Tecnologia Fluminense, Brazil.*
[3] *PhD in Physical Chemistry, Professor at Instituto Federal de Educação, Ciência e Tecnologia Fluminense, Brazil. (*Corresponding author: jborges@iff.edu.br)*

History: Submitted*: 21/05/2020* - Revised*: 22/08/2020* - Accepted*: 18/12/2020*

A B S T R A C T

Water bodies located in urban centers are continuously polluted by different sources. Even so, its waters are used for various human activities. Palmeiras Lagoon Beach, located in the city of Cabo Frio (RJ), is an aquatic environment that serves as diluent of wastewater from urban activities and, for this reason, it has become essential to attest its quality. The aim of this work was to measure the physicochemical parameters of that water. The inspections were carried out during the daytime, considering their seasonal variation from December 2018 to October 2019. Therefore, the waters that entered the beach, coming from the sea, and those from Araruama Lagoon were taken as the body of study. These analyses were performed by means of a multiparameter probe consisting of three sensors: DO/temperature, EC and pH /ORP. The results found were compared to CONAMA regulation nº 357/05, class I for saline water. The monitoring showed that the highest temperatures were observed in two places called points J and P. The pH has varied unduly at these points. Both sites are used for waste dumping in the lagoon. The data showed that EC, TDS and salinity reported direct proportional correlation, a result confirmed by Pearson's correlation. It was observed at point J that the DO values deviated from the parameter value. It was concluded that the monitoring carried out in this period made it possible both to trace the seasonal influence on the analyzed parameters and the interference of the residues released in these waters.
Keywords: Palmeiras Lagoon Beach, Seasonal monitoring, Water quality.

Monitoramento dos aspectos físico-químicos da qualidade da água na Praia Lagunar das Palmeiras (Rio de Janeiro)

R E S U M O

Os corpos hídricos localizados em centros urbanos são gradativamente poluídos por distintas fontes. Ainda assim, suas águas são utilizadas para diversas atividades humanas. A Praia Lagunar das Palmeiras, localizada na cidade de Cabo Frio (RJ), é um ambiente aquático que tem servido como diluente dos resíduos oriundos das atividades urbanas e, por essa razão, tornou-se essencial atestar a sua qualidade. Portanto, objetivou-se aferir parâmetros físico-químicos da referida água. As inspeções foram realizadas no período diurno, considerando a variação sazonal no período de dezembro de 2018 a outubro de 2019. Para tanto, tomou-se como corpo de estudo as águas que adentram a praia, advindas diretamente do mar, e as provenientes da Lagoa de Araruama. Essas análises foram realizadas por intermédio de uma sonda multiparâmetros, composta por três sensores diferentes: OD/temperatura, CE e pH/ORP. Os resultados encontrados foram confrontados com a regulamentação do CONAMA nº357/05, classe I para água salgada. Com o monitoramento observou-se a temperatura mais elevada em dois locais denominados como pontos, J e P. O pH sofreu uma variação indevida nesses pontos. Ambos os locais são utilizados para lançamento de resíduos na laguna. Os dados mostraram que CE, STD e salinidade apresentaram correlação diretamente proporcional, resultado confirmado pela correlação de Pearson. Observou-se no ponto J que os valores de OD se afastaram do valor parâmetro. Concluiu-se que o monitoramento realizado nesse período possibilitou tanto traçar a influência sazonal nos parâmetros analisados quanto à interferência dos resíduos lançados nessas águas.

Palavras-Chaves: Praia Lagunar das Palmeiras, Monitoramento sazonal, Qualidade da água.

1. Introduction

Water is a primordial substance for living beings' existence, being substantial in the life of man, animals, and vegetables. For these beings' subsistence, they use the water for several purposes (Souza et al., 2014). It is possible to list its applications in small and large crops, animal husbandry, power generation, culture, art, and leisure in society. Besides being essential to life, this substance is also the most expressive and fundamental component, quantitatively, in the human body's composition (Brito, Silva, and Porto, 2007).

Besides waters classified as sweet, there are also brackish and salt waters. Thus, the brackish waters are classified by the high content of dissolved substances, being their salinity superior to sweet and inferior to salt. The freshwaters have salinity lower than 0.5 parts per thousand. However, salty waters' composition for a high dissolved salt content gives them salinity equal or superior to 30 parts per thousand (BRAZIL, 2005).

Salted waters are of great importance for several peoples' social, economic, and cultural development, being a historical-cultural and natural heritage (Mendes, Souza e Silva, 2016). In the economic sphere, these waters generate income through tourism (Ahmad et al., 2018) and contribute to local aquaculture (Bertucci et al., 2016). Given the importance of water for maintaining life on earth, it is necessary to preserve its physical, chemical, and biological parameters (Silva, Angelis, and Machado, 2008).

The aquatic system, on which the current study focuses, is used to dilute effluents generated through anthropic activities. Its waters are intrinsically related to fishing activity, with small and medium boats. Besides, there are other essential characteristics of Araruama Lagoon, such as the collection of invertebrates in mangroves, shell extraction; salt extraction; recreation; sports; leisure, navigation, and tourism (Bidegain; Bizerril, 2002).

Water bodies in urban centers are the most vulnerable to anthropic activities. Historically, they are recipients of any waste through human activities. For this reason, they are sources of contamination and pollution of water resources (Archela et al., 2003). Studies to diagnose the quality of these urban waters are of utmost relevance. Thus, it is possible to verify the changes in these environments and promote actions to minimize the impacts generated in these aquatic ecosystems (Cordeiro et al., 2016).

Araruama Lagoon is a water system in an urban center. This ecosystem is a lagoon since it maintains restricted communication with the sea, and its waters are salty, hypersaline (Farion, 2007). Given the vulnerability of urban ecosystems, Araruama Lagoon was the study system chosen in this article. This waterbody on the east of the state of Rio de Janeiro/Brazil, in the Costa do Sol State Park (Bertucci et al., 2016), with 220 km2 (Kjerfve et al., 1996), is the lagoon has high salt content (Souza; Azevedo, 2020). Figure 1 represents the Araruama Lagoon and the six municipalities bathed by this water body: Saquarema, Arraial do Cabo, São Pedro da Aldeia, Iguaba Grande, Araruama, and Cabo Frio. Its body of water is an important tourist place, besides being responsible for a vast fishing activity (Bidegain; Bizerril, 2002).

Figure 1- Araruama Lagoon

The Itajuru Channel, Praia do Siqueira and Praia Lagunar das Palmeiras, located in the city of Cabo Frio, receive the waters originating from its water body. The Canal do Itajuru is the only propitiator of water exchange between the lagoon and the sea (Carvalho, Costa, and Rosa, 2018).

Although Palmeiras Beach's waters for bathing attract fishing boats in search, mainly of crab and shrimp (Pereira, 2007), many fishers use its waters for fishing, moving the city's economy. However, the Lagunar das Palmeiras beach is one of the points where one can observe the accumulation of algae and the foul smell from sewage disposal.

For the Araruama Lagoon's full extension, there is only one channel responsible for exchanging its waters, the Itajuru Channel. Thus, any pollution, punctual or not, becomes worrisome since any change can cause irreversible impacts throughout the ecosystem. Often, effluents' emission occurs clandestinely and worsens this water resource type (Ferreira, Lourdes, and Cunha, 2005).

Urban lagoons are of great importance for many people's economy, culture, and leisure (Sales, 2005). Anthropic activities daily influence these aquatic ecosystems since they are used mainly as receiving bodies for effluents generated by human activity. Cabo Frio is a tourist city that, in high season, more people circulate by the banks of the lagoon, contributing to the contamination of its waters, destining to water body the disposal of various debris in the environment, in addition to the excess generation of sewage (Bertucci et al., 2016).

Given the above, water quality monitoring is of great relevance since every lagoon's ecosystem is deteriorated with the emission of sewage, besides organic and inorganic sediments, pesticides, and heavy metals (Silva et al., 2003). These pollutants come from the rainfall systems that, in the long run, can cause irreversible damage to the whole ecosystem of the lagoon. Considering the urban growth in recent years and even creating a shopping mall on the shore of Palmeiras Lagoon Beach, it is necessary to continually evaluate the amount of dissolved oxygen (DO) (Lactec, 2009).

Some critical parameters to certify the quality of water are 1) dissolved oxygen (DO); 2) hydrogen potential (pH); 3) electrical conductivity (EC); 4) temperature; 5) total dissolved solids (TDS); 6) turbidity and 7) salinity (Alam et al., 2007). Through these parameters, it is possible to infer whether a particular water system complies with the legislation. In this case, the National (Brazil) Council of the Environment (CONAMA) dictates resolutions that govern environmental quality control standards, such as air quality and noise pollution, waste management and hazardous products, and water quality (Vargas et al., 2015).

Oxygen gas (O_2) - like the other gases present in the atmosphere - dissolves in water. DO allows aerobic species to survive in aquatic environments. Therefore, any change in the water that interferes with the DO concentration can negatively influence marine species' lives. Salinity and temperature are examples of properties that influence this parameter (Silva et al., 2017). They DO still control the oxidation and decomposition devices of organic matter. As this compound finishes, the oxidation process changes its rates (Spiro; Stigliani, 2009).

Electrical conductivity is intrinsically related to the number of dissolved solids in water, capable of conducting an electric current. Cruz reports that EC is related to the electrically charged particles dissolved in water and can vary according to temperature and pH (Cruz et al., 2007, apud Buzelli, G. M; Cunha-Santino, M. B, 2013).

Temperature is a parameter that directly influences the concentration of dissolved gases in water and regulates the chemical, physical, and biological characteristics of a water system. Moreover, it directly interferes with living species' survival in its interior (Manjare, Vhanalakar, and Muley, 2010). Ponds in urban areas are also diluents of effluents originating from anthropogenic actions, and, therefore, measuring temperature is essential to diagnose whether there is thermal pollution by these effluents (Pirabota et al., 2017).

CONAMA regulates typical values for pH, oxygen concentration, and turbidity for several classes of waters. In addition to the parameters mentioned above, several others are - by this council - made available to serve as a basis for attesting to the quality of water systems (Lucas, Folegatti, and Duarte, 2010).

Because of the above, it is of fundamental importance to monitor water's physical and chemical parameters to analyze its quality over time (Alves et al., 2008). For this, this work aims to point out the polluting influents of this water resource and then highlight the environmental impacts caused by human activity in the waters of the Palmeiras Lagoon Beach, to ascertain possible rates between the sampling positions at the collection site and the interference of seasonal variation in the region (Almeida, 2013).

2. Material and Methods

2.1 Multiparameter recording probe.

The laboratory benches research becomes more straightforward and dynamic with various sensors, which transform physical, biological, or chemical quantities into electrical quantities. The research analysis sensors can be individual or combined; thus, it is possible to inspect various parameters quickly and simultaneously (Sampaio et al., 2013). Besides, probes for static or dynamic monitoring can accompany or not by the analyst (Hermes et al., 2004).

Figure 2 shows the research instrument for classifying as a combined sensor; this classification comes from measuring several parameters simultaneously since it has three sensors, such as pH/ORP, DO/Temperature, electroconductivity (EC) (Nery et al., 2012). With this instrument, it is possible to perform measurements of pressure, temperature, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), salinity, pH, and oxireduction potential (ORP) (Bortoluzzi et al., 2019).

Figure 2 - Multiparameter meter for water analysis

Source: Hanna Instruments

The meter is easy to use, easy to calibrate, easy to handle, easy to transport, accessible to power, and waterproof. Apply the meter for water inspection in rivers, seas, and lakes. To obtain more precise and reliable results when using this instrument, frequent calibration, and maintenance of all the electrodes that compose it is essential. The probe's calibration is a fundamental part that precedes the verification procedure of the various water bodies' standards.

2.2 Palmeiras Lagoon Beach

Palmeiras Beach waters are saline, and the salinity, according to CONAMA, greater than or equal to 30 parts per trillion (ppt) (BRASIL, 2011). This salinity content is a result of the connection that the beach has with the sea through the Itajuru Channel, being possible to see it in Figure 3, highlighted by the yellow arrow.

Figure 3 - The connection of the Lagunar das Palmeiras Beach with the sea

Source: Google Maps (2019)

This hydric system is diluent of the waste generated by anthropic activities and the full extension of the Araruama Lagoon. It is notable, in Figure 4, various points along the Lagunar das Palmeiras Beach, where there are means of insertion of effluents originated from human activities.

Figure 4 - Waste disposal pipes

Source: Authors (2019)

The research works with fourteen points for the diagnosis of the parameters. We sought to analyze the fluid at predetermined distance intervals, from one point to another, along a straight line between Anjo Caído (point A) and Praia do Siqueira (point S), as shown in Figure 5. Executes the inspections from a point denominated as Z. Figure 5 highlights some of the points where the analyses took place for ten months.

Figure 5 - Points of analysis in Praia Lagunar das Palmeiras

Source: Adapted from Google Maps (2019)

2.3 Site selection and data collection

The point denominated as Z was the zero point for the data collection. The meeting point between the straight-line segments that have extremes the Praia do Siqueira and the Canal do Itajuru. In the Siqueira Beach (Figure 5 - point S in Table 1), on the right, there is the Itajuru Channel, represented by point A. At the bottom of the image is point J, where discharges part of the effluents from the city's water and sewage treatment concessionaire. Table 1 shows the coordinates of these points with their respective distances from Z.

Table 1- Coordinates of the respective inspection points

Points	Distance from point Z	Latitude	Longitude	Depth
A (Anjo caído)	900 m	- 22,869307º	- 42,030647º	2,26 m
A1	600 m	- 22,869587º	- 42,033546º	0,59 m
A2	300 m	- 22,86992º	- 42,03646º	0,76 m
Z	0	- 22,870157º	- 42,03936º	1,06 m
S4	300 m	- 22, 870396º	- 42,042294º	1,16 m
S3	600 m	- 22, 87069º	- 42,04524º	1,11 m
S2	900 m	- 22,870956º	- 42,04815º	1,07 m
S1	1200 m	- 22,871292º	- 42,050983º	1,22 m
S(Praia do Siqueira)	1500 m	- 22,871628º	- 42,053886º	0,83 m
J3	122 m	- 22,871256º	- 42,03937º	0,89 m
J2	276 m	- 22,87265º	- 42,03926º	0,70 m
J1	432 m	- 22,874057º	- 42,039173º	0,39 m
J	575 m	- 22,875332º	- 42,038857º	0,80 m

P	---	-22,874064°	-42,037604°	---

Source: Adapted from Portal of National Classifications 2017

The probe allowed measurements of factors such as pH, EC, DO, salinity, and temperature through an intelligent multisensor with a microprocessor (Multiparameter Meter HI9828, 2013). They were executing the calibration for the monitoring with the probe before each set of analyses and for this purpose, using three solutions for the pH sensor calibration (4.0; 7.0 and 10.0), one explanation for the electrical conductivity sensor of 1413 µS/cm, one solution for OD zero, and one solution for ORP of 240 mV.

3. Research Results

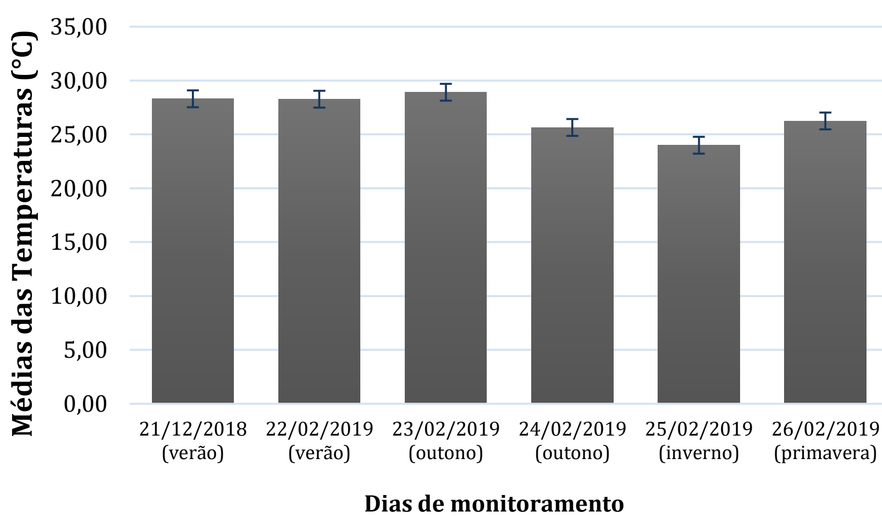
3.1 Physical parameters

- **Temperature**

Temperature is an essential parameter in determining water quality, as this variable influence other different measurements. During the four seasons of the year (summer, fall, winter, and spring), temperature monitoring shows that the seasons resulting from atmospheric temperature and climate change - interfered with this variable during each inspection.

Figure 6 shows the variation by the average temperature on each monitoring day, and it is possible to analyze that the lowest average temperature occurred in winter and detects one of the highest in summer.

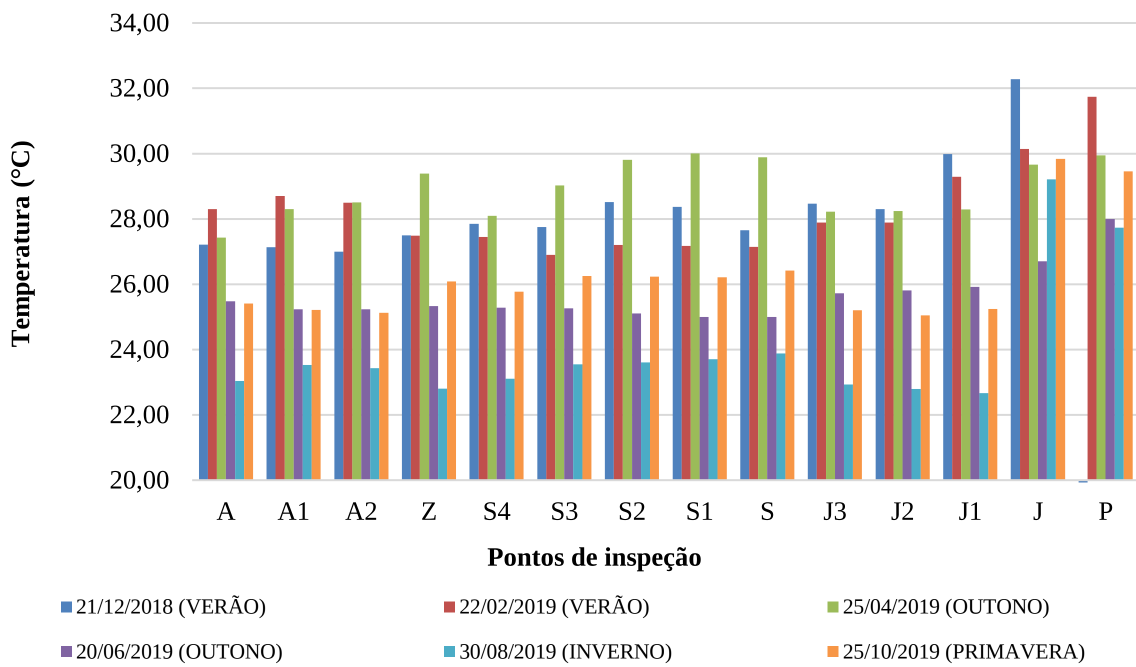
Figure 6 - Average variation of the temperature of the hydric system during the inspections



Source: Authors (2019)

Figure 7 shows the water temperature throughout the analyses. There is a greater volume of effluents into the ecosystem under anthropogenic activity analysis in points J and P. This waste input may influence the temperature rise since anthropogenic activities tend to present a higher temperature than those from the collecting sources (Percebon, Bittercourt, and Rosa Filho, 2005). The effluents discharged into the hydric systems contaminate the natural waters in several ways, one of which is the increase in the receiving bodies' temperature. Figure 8 shows the places where the highest average temperature values were detected, points P and J.

Figure 7 - Influence of the season on the variation of water temperature



Source: Authors (2019)

Figure 8 – Locations (points P and J) with highest average temperatures

Fonte: Autores (2019)

Since December 2018 (Table 2), the data obtained observes that the point P and J, the lowest standard deviation, as the temperature on each monitoring day presented relative values. The high standard deviation at the other points occurred as the individual temperature values showed increased data dispersion. These waters are urban waste and contribute to thermal pollution by discharging waste at temperatures higher than the natural system (Andrade; Felchak, 2009).

Table 2 – Values of water temperature at the points studied during the analysis.

Data	Temperature (°C) A	A1	A2	Z	S4	S3	S2	S1	S	J3	J2	J1	J	P
25/12/2018	27,21	27,13	27,00	27,50	27,85	27,75	28,52	28,37	27,65	28,47	28,30	29,99	32,28	a*
22/02/2019	28,30	28,70	28,50	27,49	27,45	26,90	27,20	27,17	27,14	27,89	27,89	29,29	30,14	31,74
25/04/2019	27,43	28,30	28,51	29,39	28,09	29,03	29,81	30,01	29,89	28,22	28,24	28,29	29,66	29,95
20/06/2019	25,48	25,23	25,23	25,33	25,28	25,26	25,11	25,00	25,00	25,72	25,81	25,92	26,70	28,00
30/08/2019	23,04	23,53	23,43	22,80	23,11	23,55	23,61	23,70	23,88	22,93	22,79	22,67	29,21	27,73
25/10/2019	25,41	25,21	25,13	26,09	25,77	26,25	26,23	26,21	26,42	25,20	25,05	25,24	29,84	29,46
Average	26,15	26,35	26,30	26,43	26,26	26,46	26,75	26,74	26,66	26,41	26,35	26,90	29,64	29,38
Maximum	28,30	28,70	28,51	29,39	28,09	29,03	29,81	30,01	29,89	28,47	28,30	29,99	32,28	31,74
Minimum	23,04	23,53	23,43	22,80	23,11	23,55	23,61	23,70	23,88	22,93	22,79	22,67	26,70	27,73
Standard Deviation	1,90	2,02	2,05	2,26	1,92	1,92	2,26	2,28	2,11	2,18	2,21	2,79	1,79	1,62

a* refers to the point at which no inspection occurred on the day of monitoring.

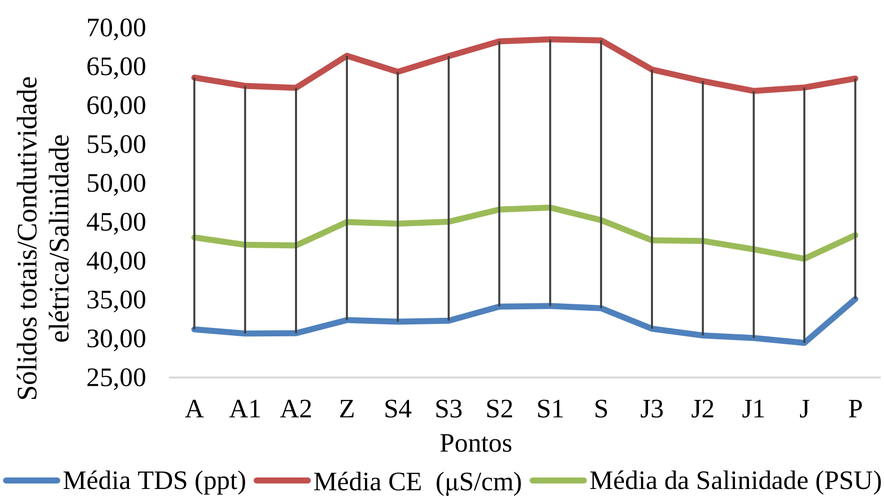
Source: Authors (2019)

- Conductivity

Conductivity is related to salinity and dissolved solids concentration, i.e., these factors interfere with each other. The salinity of this water body is high and, therefore, characterized as a hypersaline lagoon, according to CONAMA. Therefore, conductivity can relate to the number of dissolved salts in the system (Banna et al., 2013).

The high EC is closely related to high salinity and thus a high content of dissolved salts. Figure 9 outlines the relationship between conductivity, salinity, and TDS based on these variables' average at each point in the analyses. In this graph, it is possible to observe that each parameter's maximum and minimum points are correlated.

Figure 9 - Correlation between conductivity, salinity, and dissolved solids.



Source: Authors (2019)

Table 3 presents the data at each inspection site during the survey. Observes that the conductivity values at each point vary greatly from collection to collection, resulting in a high standard deviation. Values higher than the average conductivity may be associated with effluents' insertion into the water body, which may be of domestic, commercial, or industrial origin. However, by analyzing Table 3, it is impossible to infer the points that receive these effluents' contributions since there is no regularity in the measurements. Even so, the points at Praia do Siqueira presented higher averages than the others.

Table 3 – Variation of the electrical conductivity at the points understudy

	Conductivity (µS cm^{-1})													
Data	**A**	**A1**	**A2**	**Z**	**S4**	**S3**	**S2**	**S1**	**S**	**J3**	**J2**	**J1**	**J**	**P**
25/12/2018	66,16	63,55	63,52	70,33	70,20	70,50	72,12	74,34	67,50	70,34	69,90	65,16	63,90	a*
22/02/2019	62,09	63,07	63,31	61,28	61,88	58,77	60,18	60,59	58,25	59,00	59,16	60,73	59,92	62,65
25/04/2019	53,42	59,02	59,15	65,50	57,59	63,15	70,73	70,49	69,12	58,77	59,63	60,08	69,42	61,25
20/06/2019	68,48	65,49	65,00	68,12	69,76	69,44	72,00	71,00	71,26	69,60	67,14	64,82	63,04	65,80
30/08/2019	68,31	64,77	64,59	69,14	62,06	72,06	70,57	70,34	79,61	67,63	63,80	64,66	59,79	66,54
25/10/2019	62,98	59,25	57,93	64,09	64,37	64,12	63,90	64,29	64,35	62,26	59,15	55,75	57,90	61,11
Average	63,57	62,53	62,25	66,41	64,31	66,34	68,25	68,51	68,35	64,60	63,13	61,87	62,33	63,47
Maximum	68,48	65,49	65,00	70,33	70,20	72,06	72,12	74,34	79,61	70,34	69,90	65,16	69,42	66,54
Minimum	53,42	59,02	57,93	61,28	57,59	58,77	60,18	60,59	58,25	58,77	59,15	55,75	57,90	61,11
Standard Deviation	5,64	2,76	2,97	3,41	4,91	5,14	4,99	5,06	7,14	5,25	4,61	3,72	4,13	2,55

a* refers to the point at which no inspection occurred on the day of monitoring.

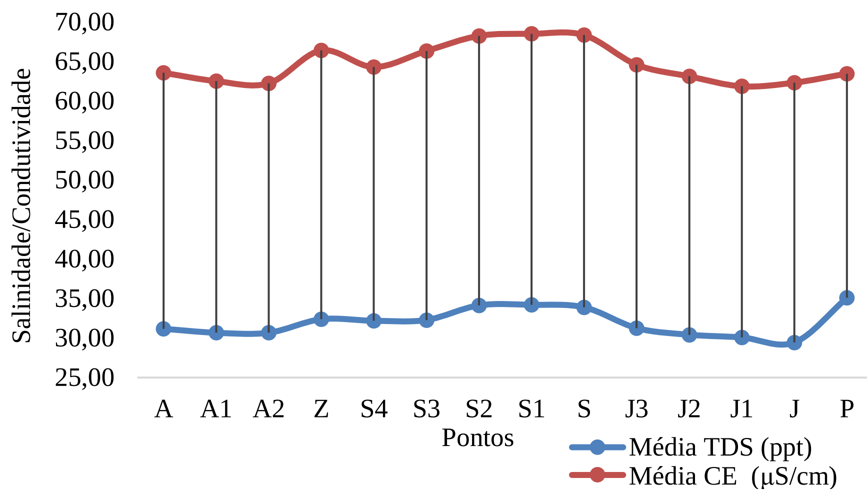
Source: Authors (2019)

- Total dissolved solids (TDS)

Evaluating the TDS parameter is important because due to the relationship with salinity and conductivity, suspended or dissolved solids interfere with the water's coloration, interfering with sunlight's penetration. The high concentration of dissolved solids can negatively influence water quality (Lougon et al., 2010).

The curves in Figure 10 show a direct relationship between conductivity and TDS. This relationship is concerning with the literature, which predicts that the amount of dissolved ion is proportional to the electrical conductivity (Limberger, Moraes, and Woiczekowski, 2017).

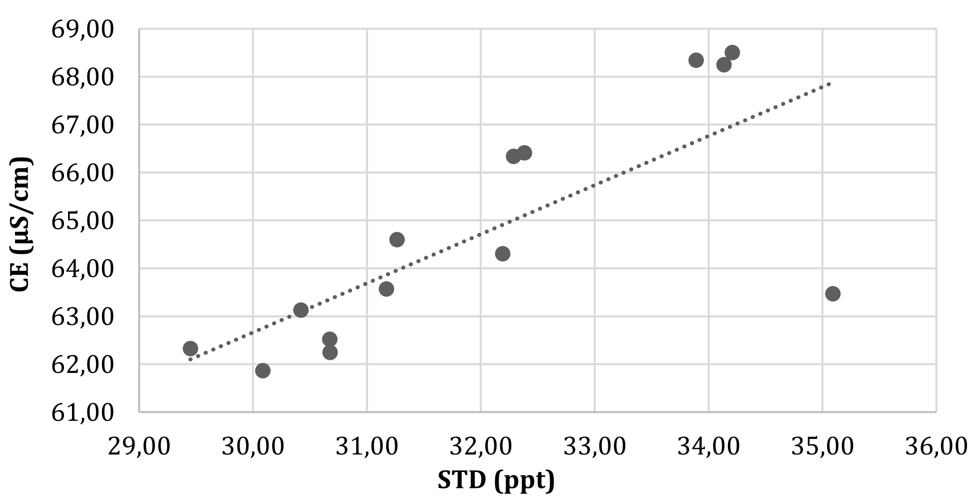
Figure 10 - The linear influence of conductivity and salinity



Source: Authors (2019)

Figure 11 illustrates the correlation between electrical conductivity and the amount of total dissolved solids. Obtains this result through Pearson's correlation test, and the correlation coefficient for this data was 0.746. This value indicates a strong correspondence, where these variables have a directly proportional correlation since the value is positive and more significant than 0.5 (Dalson Filho; Júnior, 2009).

Figure 11 - Relationship between EC and STD by Pearson's test



Source: Authors (2019)

- Salinity

Usually, it expresses the salinity in parts per trillion (ppt); however, it can represent PSU, which considers the water's electrical conductivity. Although the units are different, both (ppt and PSU) are equivalent (Souza, 2017); thus, it is possible to relate them directly. CONAMA, in Resolution No. 357/2005, specifies that, for the water class in this study, salinity should be equal to or greater than 30 ppt (Millero et al., 2008).

The data in Table 4 observes that all points monitored follow the legislation in force in the six different inspection days since they indicate salinities more significant than 30 PSU. The lower salinity at point J may be an indication of freshwater input. According to Schuindt, Daco, and Oliveira (2018), the discharge of freshwater effluents into aquatic ecosystems can reduce Palmeiras Lagoon Beach's salinity value.

Table 4 - Variation of the salinity parameter in the points of analysis

	Salinity (PSU)													
Data	**A**	**A1**	**A2**	**Z**	**S4**	**S3**	**S2**	**S1**	**S**	**J3**	**J2**	**J1**	**J**	**P**
25/12/2018	44,86	42,88	42,85	48,10	48,09	47,95	50,00	51,30	45,55	48,09	47,63	43,98	42,92	a*
22/02/2019	41,72	42,31	42,53	41,03	41,58	39,23	40,32	40,57	38,81	39,41	39,50	40,58	40,00	41,87
25/04/2019	35,18	39,31	39,94	43,61	38,35	42,91	48,24	48,11	47,04	39,20	39,84	40,11	38,35	43,80
20/06/2019	46,62	44,49	44,36	46,67	47,64	47,25	49,50	49,51	48,93	47,17	45,68	43,86	42,02	44,90
30/08/2019	47,35	43,88	43,71	47,32	49,60	49,60	48,41	48,23	47,63	40,13	43,20	43,98	39,91	45,12
25/10/2019	42,40	39,62	38,64	43,30	43,54	43,27	43,18	43,45	43,49	41,93	39,60	36,41	38,47	40,84
Average	43,02	42,08	42,01	45,01	44,80	45,04	46,61	46,86	45,24	42,66	42,58	41,49	40,28	43,31
Maximum	47,35	44,49	44,36	48,10	49,60	49,60	50,00	51,30	48,93	48,09	47,63	43,98	42,92	45,12
Minimum	35,18	39,31	38,64	41,03	38,35	39,23	40,32	40,57	38,81	39,20	39,50	36,41	38,35	40,84
Standard Deviation	4,44	2,17	2,24	2,77	4,37	3,89	3,93	4,03	3,66	3,98	3,50	3,05	1,86	1,89

a* refers to the point at which no inspection occurred on the day of monitoring.

Source: Authors (2019)

3.2 Chemical Parameters

- Dissolved oxygen (DO)

The oxygen probe is an oxygen gas-sensitive probe, termed as a probe because it is a complete electrochemical cell. It consists of an ion-selective electrode, a reference electrode, an electrolyte solution, and a membrane that separates the internal solution from the solution under analysis (Skoog et al., 2015).

Although on average (Table 5), all points (except two of the fourteen) are with DO concentration according to CONAMA regulation. Analyzing the dates shows that more points deviate from the established standard (6 ppm). This parameter's lowest value is in point J, equivalent to 1.94 ppm—understanding that it uses Points P and J for waste disposal in the lagoon. These sites are responsible for entering the Lagunar das Palmeiras beach with effluents from the shopping mall and the water and sewage concessionaire of Cabo Frio's city (RJ), respectively. In point J, possibly, there is the insertion of greater volume and diversity of organic matter, which could justify the difference in concentration of DO concerning point P because of utilization in aerobic decomposition and even for the oxidation of a more considerable amount of organic matter (Ram, A. et al., 2014).

Table 5 - Variation of dissolved oxygen concentration from the April collection

	Dissolved oxygen (ppm)													
Data	**A**	**A1**	**A2**	**Z**	**S4**	**S3**	**S2**	**S1**	**S**	**J3**	**J2**	**J1**	**J**	**P**
25/04/2019	6,38	a*	6,08	5,01	5,94	6,12	5,91	6,48	6,76	5,83	6,24	6,52	1,94	a*
20/06/2019	6,62	7,00	6,92	6,47	6,37	6,12	7,03	7,23	7,78	6,49	7,80	8,00	2,90	8,16

30/08/2019	6,68	6,84	7,12	6,25	6,79	6,69	6,66	7,18	7,18	6,37	6,52	6,97	8,75	7,03
25/10/2019	5,71	5,50	5,32	7,55	6,97	7,56	7,53	7,94	7,98	4,63	4,26	3,34	5,03	8,64
Average	6,35	6,45	6,36	6,32	6,52	6,62	6,78	7,21	7,43	5,83	6,21	6,21	4,66	7,94
Maximum	6,68	7,00	7,12	7,55	6,97	7,56	7,53	7,94	7,98	6,49	7,80	8,00	8,75	8,64
Minimum	5,71	5,50	5,32	5,01	5,94	6,12	5,91	6,48	6,76	4,63	4,26	3,34	1,94	7,03
Standard Deviation	0,44	0,82	0,83	1,04	0,46	0,68	0,68	0,60	0,56	0,85	1,46	2,01	3,02	0,83

a* refers to the point at which no inspection occurred on the day of monitoring.

Source: Authors (2019)

- Hydrogenic potential (pH)

The verification of this parameter is fundamental, as it directly or indirectly influences aquatic species' lives. The pH interferes in organic and inorganic materials' solubility in the precipitation of various ions and heavy metals. Values outside the acceptable range (6.5 to 8.5) can be lethal for fish living in this environment (Vieira, 2015). Table 6 observes that this parameter showed values lower than the regulated at no point or inspection day. However, at point J, the pH value exceeded the permitted value, giving this system a high alkaline condition and a significant deviation from the standard value. CONAMA also states that this parameter cannot vary by 0.2 units. Thus, when analyzing points Z, S4, S3, S2, J2, and, especially, points J and P, these points deviated considerably from the allowed variation value.

Table 6 - Variation of the pH parameter

	pH													
Data	**A**	**A1**	**A2**	**Z**	**S4**	**S3**	**S2**	**S1**	**S**	**J3**	**J2**	**J1**	**J**	**P**
25/12/2018	8,19	8,17	8,16	8,18	8,20	8,24	8,33	8,30	8,29	8,28	8,25	8,17	8,08	a*
22/02/2019	8,17	8,20	8,18	8,16	8,17	8,20	8,27	8,29	8,23	8,25	8,24	8,35	7,95	7,95
25/04/2019	8,10	8,10	8,11	8,12	8,12	8,14	8,15	8,17	8,19	8,12	8,14	8,15	7,91	7,83
20/06/2019	8,17	8,20	8,18	8,16	8,17	8,20	8,27	8,29	8,23	8,25	8,24	8,35	7,95	7,95
30/08/2019	8,22	8,19	8,19	8,20	8,25	8,28	8,29	8,28	8,29	8,18	8,17	8,24	8,65	8,36
25/10/2019	8,31	8,23	8,29	8,34	8,34	8,34	8,35	8,36	8,38	8,29	8,26	8,21	8,18	8,36
Average	8,19	8,18	8,19	8,19	8,21	8,23	8,28	8,28	8,27	8,23	8,22	8,25	8,12	8,09
Maximum	8,31	8,23	8,29	8,34	8,34	8,34	8,35	8,36	8,38	8,29	8,26	8,35	8,65	8,36
Minimum	8,10	8,10	8,11	8,12	8,12	8,14	8,15	8,17	8,19	8,12	8,14	8,15	7,91	7,83
Standard Deviation	0,07	0,04	0,06	0,08	0,08	0,07	0,07	0,06	0,07	0,07	0,05	0,09	0,28	0,25

a* refers to the point at which no inspection occurred on the day of monitoring.

Source: Authors (2019)

4. Conclusion

Through this study, it was possible to analyze, through six days of monitoring, between December 2018 and October 2019, how the seasonal changes and effluents' contributions interfered with the Lagunar das' water quality Palmeiras Beach. The monitoring also allowed diagnosing how the waters originating from the Canal do Itajuru and Praia do Siqueira are concerning CONAMA regulations.

When monitoring the temperature, it is possible to verify that J and P presented the highest averages and the data set's highest values. Both points are places where urban effluents are discharged into the Laguna das Palmeiras beach. Thus, thermal pollution occurs in these regions, which can directly impact this ecosystem's life. Observes in winter the lowest mean temperature and the highest mean temperature in the fall. In summer, the temperature values were close to the average in the autumn month.

According to data analysis, the electrical conductivity with the number of dissolved solids and the water salinity has a relationship. During the monitoring, Praia's waters presented higher electrical conductivities concerning the other inspection points and "point P." This parameter, associated with total dissolved solids, gives these waters a probable location of effluents, which directly interfere with the number of solids. Therefore, the Palmeiras Lagoon Beach has served as a diluent for urban waters.

CONAMA, in the resolution used as a basis for this work, does not determine a reference temperature for this water class. There is no value as a parameter for conductivity and total dissolved solids. However, it determines that this water body salinity should be equal to or greater than 30 PSU, observing all inspection points. Besides, it brings as a parameter that the DO should not be lower than six ppm. However, two points (J3 and J) were below the minimum predetermined value when analyzing the average.

The pH is another parameter addressed by the resolution and should be between 6.5 and 8.5, not exceeding a variation of 0.2 units. The points Z, S4, S3, S2, J2, J, and P are outside the reference value by observing each point separately because they presented a variation more significant than two-tenths of a unit.

The water entering Praia Lagunar das Palmeiras, from "Praia do Siqueira," presented during the inspections, higher electrical conductivity values, and dissolved oxygen concentration lower than the parameter value (6 ppm), relatively higher temperatures, pH, salinity, and quantities of dissolved solids considerably higher.

It is noteworthy that the parameters' inspections were carried out for ten months, permeating all seasons of the year. Thus, it was possible to verify the seasons' influence, the effluents discharged into the water body, and the waters from both Praia do Siqueira and Canal do Itajuru on this water quality.

5. Acknowledgements

The authors thank the IF Fluminense - Federal Institute of Education, Science, and Technology, for the possibility of developing this work through technological and logistical support and CNPq, which supported the study financially. We thank the boat instructors, Mr. Josias and Mr. Brito, who helped us with the data collection.

6. References

Ahmad, A., Khalid, S. A. A., Ismall, N. R., Ahmadi, N. A., Abidin, P. N. S. Z., & Azmi, N. A. S. (2018). Salt Water Tourism Development in Peninsular Malaysia: A General Review. **Journal of Postgraduate Current Business Research**, 1(1), 6-12.

Alam, M. J. B., Islam, M. R., Muyen, Z., Mamun, M., & Islam, S. (2007). Water quality parameters along rivers. **International Journal of Environmental Science & Technology**, 4(1), 159–167.

Almeida, J.S.M. (2013). **Condições de oxigenação e desoxigenação de um trecho do Rio Uberabinha no município de Uberlândia**. Dissertação de Mestrado em Engenharia Química, Universidade Federal de Uberlândia, Uberlândia, 80, Brasil.

Alves, E. C., Silva, C. F. D. A., Cossich, E. S., Tavares, C. R. G., Souza Filho, E. E. D., & CarnieL, A. (2008). Avaliação da qualidade da água da bacia do rio Pirapó – Maringá, Estado do Paraná, por meio de parâmetros físicos, químicos e microbiológicos. **Acta Scientiarum Technology**, 30(10), 39-48.

Andrade, A. R.., & Felchak, I. M. (2009). A poluição urbana e o impacto na qualidade da água do rio das antas - IRATI/PR. **Revista eletrônica do curso de Geografia**, 12, 1-25.

Archela, E., Carraro, A., FernandeS, F., Barros, O. N. F., & Archela, R. S. (2003). Considerações sobre a geração de efluentes líquidos em centros urbanos. **Geografia**, 12(1).

Banna, M. H., Najjaran, H., Sadiq, R., Imran, S. A., Rodriguez, M. J., & Hoorfar, M. (2014). Miniaturized water quality monitoring pH and conductivity sensors. **Sensors and Actuators B: Chemical**, 193, 434–441.

Bertucci, T. C. P., Silva, E. P., Júnior. A. N. M., & Neto, C. M. (2016). Turismo e urbanização: os problemas ambientais da lagoa de Araruama - Rio de Janeiro. **Ambiente e sociedade**, 19(4), 43-64.

Bidegain, P. S. P., & Bizerril, C. R. F. (2002). **Lagoa de Araruama: perfil ambiental do maior ecossistema lagunar hipersalino do mundo**. Rio de Janeiro: SEMADS.

Bortoluzzi, P. C., Prata, A. R., Brito, T. C., Hora, A. B., & Marques, M. N. (2019). Avaliação da qualidade de água de consumo em comunidade vulnerável no estado de Sergipe. congresso brasileiro de engenharia química em iniciação científica. **Anais do XIII Congresso Brasileiro de Engenharia Química em Iniciação Científica,** Uberlândia, MG, Brasil, 6.

BRASIL. Ministério do Meio Ambiente. (2005). **Resolução CONAMA nº. 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 União. Brasília, DF: Imprensa Oficial. Disponível em: http://www2.mma.gov.br/port/conama/legiabre.cfm?codlegi=459. Acesso em novembro/2019.

BRASIL. Ministério do Meio Ambiente. (2011). **Resolução CONAMA nº. 430, de 13 de maio de 2011. Dispõe sobre as condições e padrões de lançamento de efluentes, complementa e altera a resolução n.357, de 17 de março de 2005, Conselho Nacional do Meio Ambiente – CONAMA**. Diário Oficial da União. Brasília, DF: Imprensa Oficial. Disponível em: http://www2.mma.gov.br/port/conama/legiabre.cfm?codlegi=646. Acesso em novembro/2019.

Brito, L. T., Silva, A. S., & Porto, E. R. (2007). **Disponibilidade de água e a gestão dos recursos hídricos**. Embrapa Semiárido.

Buzelli, G. M., & Cunha-Santino, M. B. (2013). Análise e diagnóstico da qualidade da água e estado trófico do reservatório de Barra Bonita (SP). **Ambi-Agua**, 8(1), 186-205.

Carvalho, A. P. A. M., Costa, R. S., & Rosa, J. C. L. (2018). Eutrofização e introdução de espécies exóticas em estuário hipersalino: Lagoa de Araruama, Rio de Janeiro, Brasil. **IV Seminário regional sobre gestão de recursos hídricos**, Campos dos Goytacazes, RJ, Brasil, 13.

Cordeiro, G. G., Guedes, N. M., Kisaka, T. B., & Nardoto, G. B. (2016). Avaliação rápida da integridade ecológica em riachos urbanos na bacia do rio Corumbá no Centro-Oeste do Brasil. **Revista ambiente e água**. 11(3), 702-710.

Dalson, Filho, B. F., & Júnior, J. A. S. (2009) Desvendando os mistérios do coeficiente de correlação de Pearson (r). **Revista Política Hoje**, 18(1).

Farion, S. R. L. (2007). Litoral do Rio Grande do Sul: rio, lago, lagoa, laguna. **Revista do departamento de história e geografia**, 13(1), 167-186.

Ferreira, A. P., De Lourdes, C., & Da Cunha, N. (2005). Anthropic pollution in aquatic environment: Development of a caffeine indicator. **International Journal of Environmental Health Research**, 15(4), 303–311.

Google. **Google Maps**. 2019. Disponível em: < https://www.google.com.br/maps/place/Lagoa+De+araruama/@-22.8729002,-42.0545846,14z/data=!4m5!3m4!1s0x9704b787e4a61d:0xde7c608137a36fe2!8m2!3d-22.8749572!4d-42.016304> Acesso em: 23 jul. 2019.

Hanna Intruments. **Medidor de pH, ISE, EC, OD, e turvação com opção de GPS**. Disponível em: < https://www.hanna.pt/produto/hi9829>. Acesso em: 24 nov. 2020.

INSTITUTO DE TECNOLOGIA PARA O DESENVOLVIMENTO (LACTEC). (2009). **Modelagem matemática para a qualidade da água para UHE Mauá**. Curitiba.

Kjerfve, B., Schettini, C. A. F., Knoppers, B., Lessa, G., & Ferreira, H. O. (1996). Hydrology and Salt Balance in a Large, Hypersaline Coastal Lagoon: Lagoa de Araruama, Brazil. **Estuarine, Coastal and Shelf Science**, 42(6), 701–725.

Limberger, D., Moraes, J. D., & Woiczekowski, N. R. (2017). A qualidade dos córregos urbanos em pequenos municípios: parâmetros físicos e químicos da sanga das charqueadas, Tapes/RS, Brasil. **VII congresso brasileiro de gestão ambiental Campo Grande/MS – 27 a 30/11/2017. IBEAS – Instituto Brasileiro de Estudos Ambientais**, Campo Grande, MS, Brasil, 4.

Lougon, M. S., Rocha. S. A., Guimarães, H. F., Louzada, F. L. R. O., & Garcia, G. O. (2010). Caracterização dos sólidos totais, fixos e voláteis nas águas residuais geradas pela lavagem dos frutos do cafeeiro. **XIII Encontro Latino Americano de Iniciação Científica e IX Encontro Latino Americano de Pós-Graduação – Universidade do Vale do Paraíba**, Espírito Santo, ES, Brasil, 3.

Lucas, A. A. T., Folegatti, M. V., & Duarte, S. N. (2010). Qualidade da água em uma microbacia hidrográfica do Rio Piracicaba, SP. **Revista Brasileira de Engenharia Agrícola e Ambiental**, 14(9), 937–943.

Manjare, S. A., Vhanalakar, S. A., & Muley, D. V. (2010). Analysis of water quality using physico-chemical parameters tamdalge tank in kolhapur district, maharashtra. **International Journal of Advanced Biotechnology and Research**, 1, 115-119.

Mendes, A. B., Souza, R. C. C. L., & Silva, E. P. E. (2016). Percepção de alunos sobre a problemática ambiental da Lagoa de Araruama, Cabo Frio, Rio de Janeiro, Brasil. **REMEA- Revista eletrônica do mestrado em educação ambiental**, 185-212.

Millero, F. J., Feistel, R., Wright, D. G., & Mcdougall, T. J. (2008). The composition of Standard Seawater and the definition of the Reference-Composition Salinity Scale. **Deep Sea Research Part I: Oceanographic Research Papers**, 55(1), 50–72.

MULTIPARAMETER METER HI9828. (2013). **Instruction Manual**. Hanna Instruments. Woonsocket (USA): Printed in Romania, 98 p.

Nery, J. R. C., Moura, H. P., Santos, A. L. L., & Reis, A. A. B. (2012). Estudo físico-químico de águas subterrâneas na área do bairro zerão, Macapá (AP). **XVIII Congresso Brasileiro de Águas Subterrâneas**, Macapá, AP, Brasil, 8.

Percebon, C. M., Bittencourt, A. V. L., & Rosa Filho, E. F. (2005). Diagnóstico da temperatura das águas dos principais rios de blumenau, SC. **Boletim Paranaense de Geociências**, 56.

Pereira, L.F.M. (2007). A gestão participativa no caso do saneamento da região dos lagos, Rio de Janeiro. **Revista Discente Expressões Geográficas**, (3), 10-41.

Pirabota, A. R. A., Ribeiro, H. M., Morales, G. P, & Gonçalves, W. G. (2017). Caracterização de parâmetros de qualidade da água na área portuária de Barcarena, PA, Brasil. **Rev. Ambient. Água**, 12(3), 435-456.

Portal de classificações nacionais. 2017. **Cálculo de distâncias com coordenadas geográficas**. Disponível em: < http://nacionais2017.fpcolumbofilia.pt/Distancia>. Acesso em: 24 de nov. 2020.

Ragassi, B., Américo-Pineiro, J. H. P., & Junior, S. O. P. (2017). Monitoramento do oxigênio dissolvido no Córrego das Marrecas – SP como principal parâmetro de qualidade da água. **Fórum ambiental da alta paulista**, 13(5), 17-23.

Ram, A., Jaiswar, J. R. M., Rokade, M. A., Bharti, S., Vishwasrao, C., Majithiya, D. (2014). Nutrients, hypoxia and Mass Fishkill events in Tapi Estuary, India. **Estuarine, Coastal and Shelf Science**, 148, 48-58.

Sales, V. C. (2005). Lagoas costeiras na cultura urbana da cidade de Fortaleza, Ceará. **Revista da ANPEGE**, 2(2), 89-96.

Sampaio, F. G., Losekann, M. E., Luiz, A. J. B., Neves, M. C., Scorvo, C. D. F., & Rodrigues, G. S. (2013). Monitoramento e gestão ambiental da piscicultura em tanques-rede em reservatórios. **Informe agropecuário**, 34(272), 1-11.

Schuindt, R. M. A., Daco, R. S., Oliveira, M. M. (2018). Impactos na Lagoa de Araruama e percepção ambiental da comunidade da praia do Siqueira, Cabo Frio (RJ). **Revbea**, 13(1), 309-331.

Silva, A. E. P., Angelis, C. F., Machado, L. A. T., & Waichaman, A. V. (2008). Influência da precipitação na qualidade da água do Rio Purus. **Acta Amazonica**, 38(4), 733–742.

Silva, L. A., Carvalho, L. S., Lopes, W. A., Pereira, P. A. P., & Andrade, J. B. (2017). Solubilidade e reatividade de gases. **Química nova,** 40(7), 824-832.

Silva, L.H.S., Senra, M. C. E., Lespa, A. A. C., CarvalhaL, S. B. V., Alves, S. A. P. M. N., Damazio, C. M.., Shimizu, V. T. A.., Faruolo, T. C. M.., & Santos, R. C. (2003). Estudo das cianobactérias psâmicas na lagoa de Araruama, Rio de Janeiro, Brasil. *In*: **Congresso Sobre Planejamento e Gestão das Zonas dos Países de Expansão Portuguesa, XI Congresso da Associação Brasileira de Estudos do Quaternáiro, II Congresso Quaternário dos Países de Língua Iberica, 2**. Recife, Brasil, 3.

Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2015). **Fundamentos de química analítica**. (9 ed.). São Paulo: Cengage Learning.

Souza, C. M. M. A. (2017). **Comparação de modelos numéricos bidimensional e tridimensional para a avaliação de mudanças ambientais, aplicado à região costeira de Santos**. Tese de doutorado, Engenharia Civil na área de Recursos Hídricos, Energéticos e Ambientais, Universidade Estadual de Campinas, Campinas, São Paulo, 175, Brasil.

Souza, F. P., Azevedo, J. P. S. (2020). Panorama das lagoas urbanas no Rio de Janeiro: aspectos relevantes na gestão das Lagoas Rodrigo de Freitas, Araruama e Complexo Lagunar de Jacarepaguá. **Engenharia Sanitária e Ambiental**, 25 (1), 197-204.

Souza, J. R., Moraes, M. E. B., Sonoda, S. L., & Santos, H. C. R. G. (2014). A Importância da Qualidade da Água e os seus Múltiplos Usos: Caso Rio Almada, Sul da Bahia, Brasil. **REDE - Revista Eletrônica do Prodema**, 8(1), 26-45.

Spiro, T. G., & StiglianI, W. (2009). **Química Ambiental**. (2. ed.). São Paulo: Pearson Prentice Hall.

Vargas, R. R., Saad, A. R., Dalmas, F. B., Rosa, A., Arruda, R. O. M., Mesquita, M. V., & Andrade, M. R. M. (2015). Water Quality Assessment in the Córrego Taquara do Reino Hydrographic Basin, Guarulhos Municipality (São Paulo State - Brazil): Effects of Environmental Degradation. **Anuário do Instituto de Geociências – UFRJ**, 38(2), 137-144.

Vieira, M. R. (2015). **Os principais parâmetros monitorados pelas sondas multiparâmetros são: pH, condutividade, temperatura, turbidez, clorofila ou cianobactérias e oxigênio dissolvido. Agencia nacional das águas** – ANA, 3.