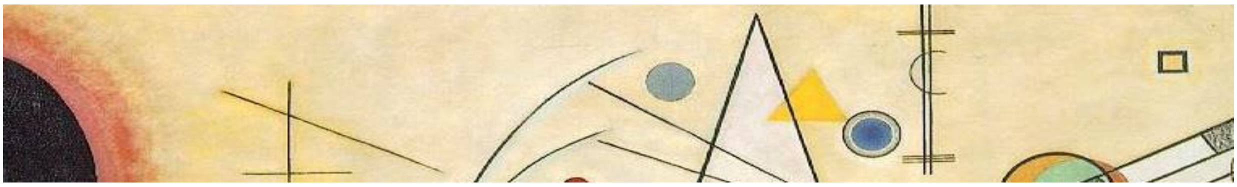


Contemporânea
Contemporary Journal
3(2): 933-954, 2023
ISSN: 2447-0961

Artigo

WATER QUALITY AND PLANKTONIC COMMUNITY OF IRACEMA BEACH, FORTALEZA/CE

QUALIDADE DA ÁGUA E COMUNIDADE PLANCTÔNICA DA PRAIA DE IRACEMA, FORTALEZA/CE

DOI: 10.56083/RCV3N2-017
Recebimento do original: 02/01/2022
Aceitação para publicação: 03/02/2023

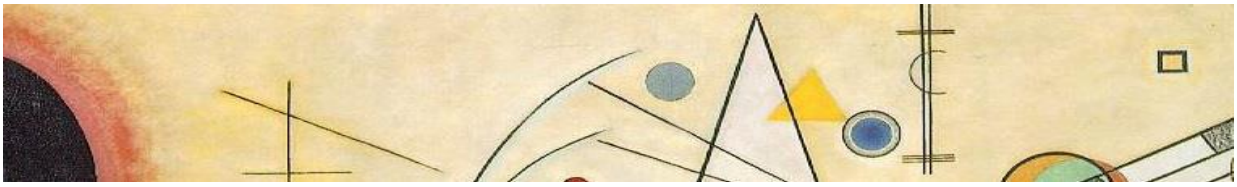
Aldeney Andrade Soares Filho
PhD in Fisheries Engineering
Institution: Universidade Federal do Ceará
Address: Avenida Mister Hull, S/Nº, Campus do Pici, CEP: 60455-970, Fortaleza - CE
E-mail: icthybr@yahoo.com.br

Winston Kleine Ramalho Viana
Master's student in the Graduate Program in Fisheries Engineering
Institution: Universidade Federal do Ceará
Address: Avenida Mister Hull, S/Nº, Campus do Pici, CEP: 60455-970, Fortaleza - CE
E-mail: winstonkleine@gmail.com

Marcos Luiz da Silva Apoliano
PhD student in the Graduate Program in Fisheries Engineering
Institution: Universidade Federal do Ceará
Address: Avenida Mister Hull, S/Nº, Campus do Pici, CEP: 60455-970, Fortaleza - CE
E-mail: marcosapoliano@gmail.com

Francisca Gleire Rodrigues de Menezes
Post-Doctorate in Fisheries Engineering
Institution: Universidade Federal do Ceará
Address: Avenida Mister Hull, S/Nº, Campus do Pici, CEP: 60455-970, Fortaleza - CE
E-mail: gleirerodrigues@gmail.com

Oscarina Viana de Sousa
PhD in Science
Institution: Universidade Federal do Ceará
Address: Avenida da Abolição, 3207, Meireles, CEP: 60165-081, Fortaleza - CE
E-mail: oscarinavs@ufc.br



Soraia Barreto Aguiar Fonteles
Post-Doctorate in Biological Sciences
Institution: Universidade Federal do Recôncavo da Bahia
Address: Rua Rui Barbosa, 710, Centro, CEP: 44380-000, Cruz das Almas - BA
E-mail: soraiafonteles@gmail.com

Rossi Lelis Muniz Souza
PhD in Tropical Marine Sciences
Institution: Universidade Federal do Ceará
Address: Avenida Mister Hull, S/Nº, Campus do Pici, CEP: 60455-970, Fortaleza - CE
E-mail: rossilelis@gmail.com

ABSTRACT: Aiming at analyzing the water quality at Iracema Beach, in Fortaleza/CE, as well as characterizing the planktonic community, monthly collections were carried out between February and November 2019, with 100 liters of water being filtered, concentrated to 10 mL and preserved in 4% formalin. In the laboratory, via microscopy, the plankton species were identified and then classified based on references relevant to the subject, as well as consultations with specialists and electronic addresses. Furthermore, data on water temperature, transparency, salinity, dissolved oxygen and pH were obtained *in situ*. Bimonthly, one liter of water was collected for microbiological analysis, in the laboratory. The parameters analyzed showed good quality water, with 17 phytoplankton species being recorded, distributed among the Classes Cyanophyceae, Bacillariophyceae, Euglenophyceae, Chlorophyceae, Mediophyceae, Coscinodiscophyceae and Zygnematophyceae. For zooplankton, there were five species included in the Rotifera, Cladocera and Crustacea Classes. Phytoplanktonic species diversity was high, the zooplanktonic was low; very high equability and low species richness in both communities. No species was considered a bioindicator of eutrophication or pollution, and the microbiological analysis showed minimum values of thermotolerant coliforms, and the waters of Iracema Beach can be classified as class one saline, intended for recreation and with a very good quality.

Keywords: Microbiological, Phytoplankton, Urban beach, Zooplankton.

RESUMO: Visando analisar a qualidade da água na Praia de Iracema, em Fortaleza/CE, bem como caracterizar a comunidade planctônica, foram realizadas coletas mensais, entre fevereiro e novembro de 2019, sendo filtrados 100 litros de água, concentrada para 10 mL e preservada em formol a 4%. Em laboratório, via microscopia, as espécies do plâncton foram identificadas e então classificadas com base em referências pertinentes ao assunto, bem como, consultas a especialistas e endereços eletrônicos. Ainda, foram obtidos *in situ* dados de temperatura da água, transparência, salinidade, oxigênio dissolvido e pH. Bimestralmente coletou-se um litro de água para análise microbiológica, em laboratório. Os parâmetros analisados mostraram uma água com boa qualidade, tendo sido registradas 17 espécies fitoplanctônicas, distribuídas entre as Classes Cyanophyceae, Bacillariophyceae, Euglenophyceae, Chlorophyceae, Mediophyceae, Coscinodiscophyceae e Zygnematophyceae. Para o zooplâncton ocorreram cinco espécies inseridas nas Classes Rotifera, Cladocera e Crustacea. A diversidade de espécies fitoplanctônicas foi alta, a zooplanctônica foi baixa; boa equabilidade e baixa riqueza de espécies em ambas comunidades. Nenhuma espécie foi considerada bioindicadora de eutrofização ou poluição e, a análise microbiológica mostrou valores mínimos de coliforme termotolerantes, podendo as águas da Praia de Iracema serem classificadas como salinas de classe um, destinadas a recreação e com uma qualidade muito boa.

PALAVRAS-CHAVE: Fitoplâncton, Microbiologia, Praia urbana, Zooplâncton.

1. Introduction

According to Odum (1988) a community or biocenosis is a set of living organisms that are part of an ecosystem and interact with each other and with other components, being able to present changes in its structure and in the processes of the community over time.

Due to the dynamics of the human population in its urbanization, there is a preference for housing close to places with an abundance of water, whether rivers, lakes and especially coastal areas close to beaches. Rego (2010) mentions that this dynamic has implications for these environments, changing their original biology.

In general, urban beaches are transition zones or ecotones between human and marine ecosystems, located on the coastal part of continents and subject to major environmental changes that will directly affect the structure of aquatic communities (Leão *et al.*, 2008).

Human-induced disturbance contributes to several impacts on planktonic communities by discharging pluviometric effluents directly into beach waters, which, together with wave action, cause vertical mixing due to natural turbulence, thereby retaining material transported in the water column in a manner that primary producers have access to more phosphorus and other nutrients. Such effects also contribute to changes in chemical levels and physical parameters and, therefore, in aquatic communities (Odum, 1988; Leão *et al*., 2008).

The term plankton was introduced by the German Viktor Hensen, in 1887, to designate several aquatic communities, as well as finely divided inorganic materials (particulates), which float in the water at the mercy of the currents, adrift (Esteves, 2011). Of these communities, phytoplankton is one of the most important, as it is the first link in the food web, the largest producer of oxygen, synthesizes organic matter through solar radiation, and its composition and structure being an important parameter for the assessment of water quality. On the other hand, zooplanktonic communities, the second link, is made up of organisms, most of which are heterotrophic, with a short life cycle and with rapid responses to states of eutrophication and/or pollution, climate change and other factors, being the main food for juveniles of almost all species fish, in addition to serving as exclusive food for some adult fish (Esteves, 2011; Klimova *et al*., 2018).

Therefore, the study of the composition of planktonic communities is an important tool to assess the state of the aquatic environment, generating information about its variability and abundance, as well as the ecological conditions of the aquatic ecosystem (Cervetto *et al*., 2002).

On the other hand, the analyses of environmental variables and of nutrient concentrations of an aquatic environment they can help in the diagnosis of ecological conditions, in the understanding of the dynamics of communities, as well as in the evaluation of their carrying capacity, measured by the ecosystem's ability to correct changes to internal and external, natural or anthropic stimuli (Bicudo & Menezes, 2006).

Also, the microbiological quality standard is very important and, being established in CONAMA Resolution nº. 357/2005 and its amendment and complementation given by CONAMA Resolution nº. 430/2011, which classifies water bodies and environmental guidelines for their framing, using thermotolerant coliforms (Brasil, 2005; Brasil, 2011).

Rego (2010) points out that the environmental quality of beaches is important for both environmental and public health reasons. Thus, the present work aimed to analyze the water quality, verifying physical and chemical parameters, the planktonic community and the microbiological conditions of the water of Iracema Beach, municipality of Fortaleza, State of Ceará.

2. Material and Methods

2.1 Study Place

The research was developed out at Iracema Beach, in the city of Fortaleza (03°43'03.1" S; 038°30'42.1" W), one of the eight administrative macro-regions of the State of Ceará, from February to November 2019.

Iracema Beach is one of the main beaches in the city of Fortaleza, located between Almirante Tamandaré and João Cordeiro streets. It underwent a spatial rethink after the construction of the hydraulic embankment. It hosts several events during the local festivities, the most famous being New Year's Eve, which attracts thousands of people, including residents and tourists, in addition to being constantly used by bathers.

2.2 Collects

Rainfall data for the study site were obtained from the website of the Ceará Meteorology and Water Resources Foundation – Funceme (Ceará, 2021).

Monthly collections were carried out to obtain data on physical, chemical and planktonic parameters, always at low tide. On the other hand, the microbiological were bimonthly.

In situ, water temperature they were obtained, measured with a mercury thermometer; water transparency, using a Secchi disk with a diameter of 20 cm; water salinity, with Red Sea® portable refractometer, accuracy of one practical salinity unit (ups); dissolved oxygen with a Milwaukee® SM600 oximeter, 0.1 mg L^{-1} accuracy and; pH with a pHMeter® portable pH meter, accuracy of 0.1.

Maximum nutrient limits and physical parameters were based on Boyd (1990), Schmittou (1999), Kubitza (2000) and Sipaúba-Tavares (1995), as well as those established in CONAMA Resolution N°. 357/2005 (Brasil, 2005). They were also submitted to the T-Student test, considering two samples (rainy and dry season) assuming different variances and a significance level of 0.05 (Pagano & Gauvreau, 2004).

The plankton were collected with a net, 25 µm mesh and 25 cm mouth opening diameter, and 100 L of water was filtered, which was concentrated to 10 mL and fixed with 4 % formaldehyde solution in a 1:1 ratio. On average, 10 samples of 0.1 mL were analyzed using a Callmex® microscope to identify organisms.

The systematic classification was based on Barsanti & Gualtieri (2006) and in the identification the works of, Alves-da-Silva *et al*. (2008); Verlecar & Desai (2004), Bicudo & Menezes (2006); Sant'Anna *et al*. (2006), Moresco & Bueno (2007) and as well as consultations the specialists in the area and electronic addresses.

The relative abundance was calculated, and based on the results the species were classified as: a) rare species, less than 10%; b) slightly abundant specie, between 10.1 and 25%; c) abundant specie, between 25.1 and 50% and; d) dominant specie, the one with relative abundance greater than 50%.

The following ecological indices were also analyzed: a) species diversity index, which relates the number of species and their relative abundance, being measured three indices: Shannon (H, in bits/individual), Simpson (1/D) and Berger -Parker (1/d); b) Margalef's species richness index, which assesses the number of species present and; c) Pielou's equability index (J), which analyzes the distribution of individuals between species, ranging from 0 to 1, and values closer to 1 indicate greater equability (Odum, 1988; Margalef, 1998; Magurran, 2007).

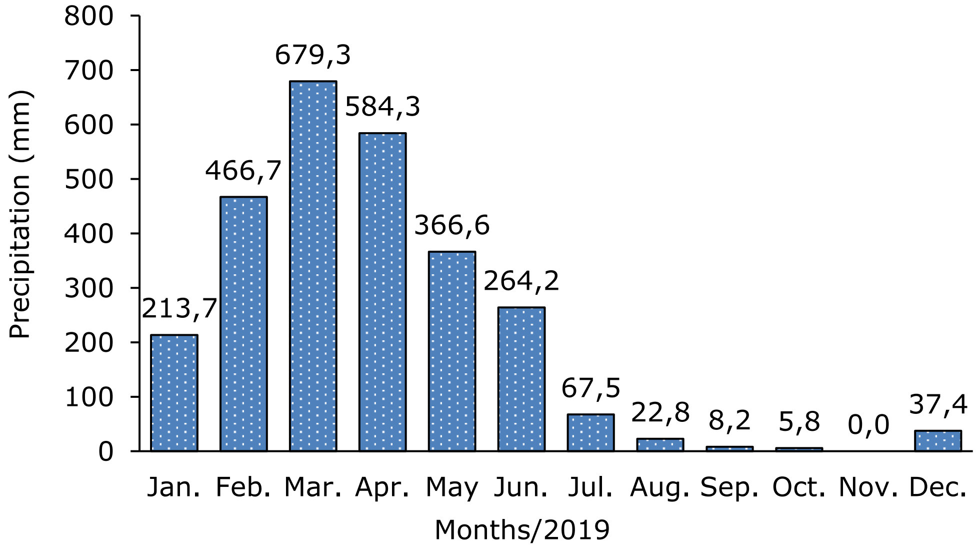
As for the microbiological analyses, these were carried out at the Laboratory of Environmental and Fish Microbiology - LAMAP, of the Instituto de Ciências do Mar - LABOMAR/UFC. The water sample collected was obtained at a depth of 50 cm, in one-liter amber bottles, previously sterilized. The sample was transported in an isothermal box, containing ice and, in the determination of the Most Probable Number (MPN) of Thermotolerant Coliforms, the technique of fermentation in multiple tubes was used, according to Feng *et al*. (2002).

The values obtained were compared with those of CONAMA Resolution nº. 357/2005 and its amendments and additions given by CONAMA Resolution nº. 430/2011, as well as CONAMA Resolution nº. 274/2000 (Brasil, 2005; Brasil, 2011).

3. Results

According to data obtained from the Funceme website (Ceará, 2021), Figure 1 shows the total monthly pluviometric in 2019 for the study site, with a seasonal cycle characterized by the rainy (January to June) and dry (July) periods to December), with a sharp peak of rain between the months of February and May, a period called winter season, with the highest rainfall in March (679.3 mm) followed by April (584.3 mm). In the dry period, there is a sharp drop in precipitation, culminating in a zero record in November.

Figure 1 - Variation pluviometric in 2019, at Iracema Beach, Fortaleza/CE.



3.1 Physical and Chemical Parameters of Water

Table I shows the variation of physical and chemical parameters at Iracema Beach, noting that the values recorded are within the acceptable range for good quality water (Schmittou, 1999; Kubitza, 2000; Brasil, 2005).

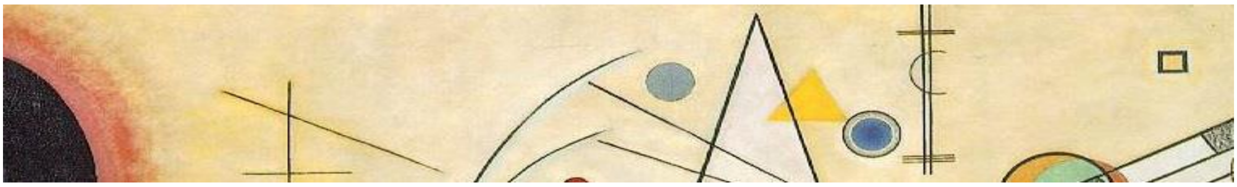


Table I - Physical and chemical parameters observed in the water of Iracema Beach/CE.

Parameters	Mín.	Máx.	Mean	Standard deviation
Salinity (ups)	30.0	35.0	32.3	2.2
Temperature (ºC)	27.0	29.0	28.1	0.7
Transparency (cm)	90.0	107.0	97.7	6.2
Dissolved oxygen (mg/L)	5.9	7.2	6.7	0.5
pH	7.9	8.2	8.1	0.1

All parameters showed a statistically significant difference between the rainy and dry seasons ($p \leq 0.05$), which corroborates the great influence of precipitation about the sames.

3.2 Phyto and Zooplanktonic Communities

Seventeen species of microalgae were identified, belonging to seven Classes, six Bacillariophyceae, four Chlorophyceae, two Cyanophyceae and Zygnematophyceae, and one species for Classes Euglenophyceae, Mediophyceae and Coscinodiscophyceae. Of the identified species, only *Spirulina* sp., *Scenedesmus quadricauda* were considered as Little Abundant and the others as Rare, both in the rainy and in the dry season (Table II).

Table II - Phytoplanktonic organisms observed in the waters of Iracema Beach/CE, in the rainy and dry season of 2019.

Class	Species	Rainy season	Dry season
		Classification	Classification
Cyanophyceae	*Spirulina* sp.	Little abundant	Little abundant
	Oscillatoria sp.	Rare	Rare
Bacillariophyceae	*Cyclotella* sp.	Rare	Rare
	Chaetoceros sp.	Rare	Rare
	Thalassiothrix sp.	Rare	Rare
	Amphora sp.	Rare	Rare
	Cymbella sp.	Rare	Rare
	Cocconeis sp.	Rare	Rare
Euglenophyceae	*Phacus longicauda*	Rare	Rare

Chlorophyceae	*Scenedesmus quadricauda*	Little abundant	Little abundant
	Scenedesmus acuminatus	Rare	Rare
	Eudorina elegans	Rare	Rare
	Eudorina sp.	Rare	Rare
Mediophyceae	*Thalassiosira* sp.	Rare	Rare
Coscinodiscophyceae	*Actinoptychus undulatus*	Rare	Rare
Zygnematophyceae	*Gonatozygon* sp.	Rare	Rare
	Closterium setaceum	Rare	Rare

The Chlorophyceae Class was the most significant with 34.62 % of occurrence, followed by Bacillariophyceae, with 31.77 % and Cyanophyceae, with 17.78 %, the others were less than 5 %.

As for the zooplanktonic community, five species were identified, distributed among the Rotifera Classes, with two species; Cladocera, with one species; and Crustacea, with two species *Brachionus sp*. was the Dominant species and the others were considered as Little Abundant in the rainy and dry seasons (Table III).

Table III - Planktonic organisms observed in the waters of Iracema Beach/CE, in the rainy and dry season of 2019.

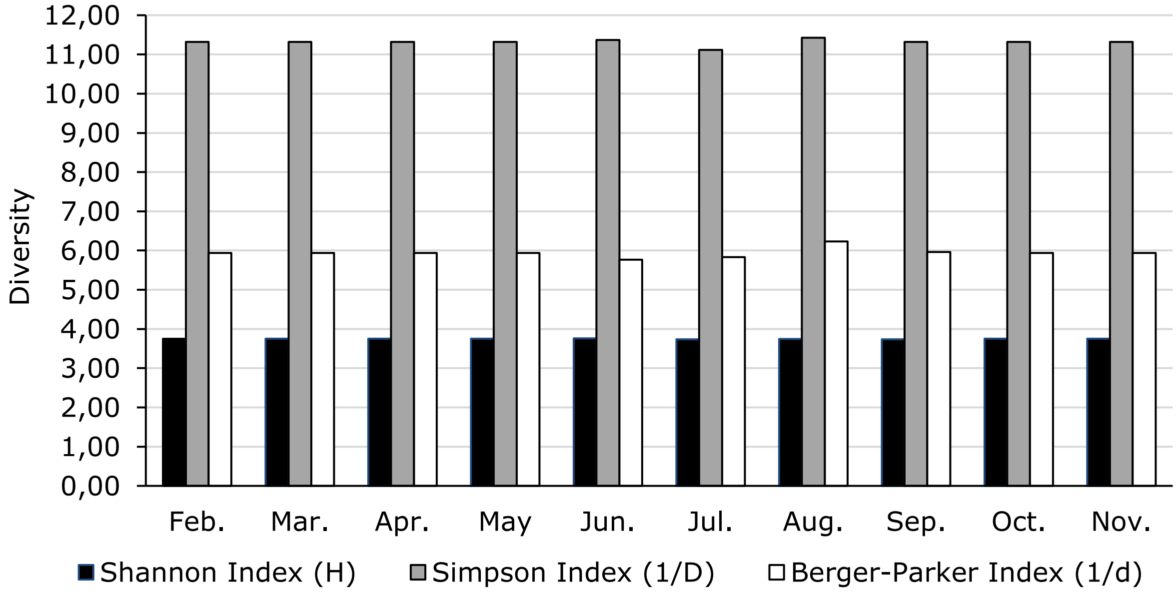
Class	**Species**	**Rainy period**	**Dry period**
		Classification	**Classification**
Rotifera	*Brachionus* sp.	Abundant	Abundant
	Keratella cochlearis	Little abundant	Little abundant
Cladocera	*Daphnia* sp.	Little abundant	Little abundant
Crustacea	Larvae of Cirrípedes	Little abundant	Little abundant
	Copepoda sp.	Little abundant	Little abundant

Overall, the Rotifera Class had a share of 51.27 %, Crustacea with 29.44 % and Cladocera with 19.29 %.

3.3 Ecological Indices

For the phytoplankton community, the diversity indexes analyzed were considered high, with Shannon's (H) presenting an average of 3.75 bits $ind.^{-1}$, Simpson's with 11.32 and Berger-Parker's (1/d) with 5.94. Pielou's evenness was significant (≥ 0.5) throughout the study, with a mean of 0.92. Species richness (d) was low, with an average of 1.25 (Figure 2).

Figure 2 - Diversity indices of the phytoplankton community of the waters of Iracema Beach/CE, in 2019.



For the zooplankton community, the diversity index was considered low, with Shannon's index presenting an average of 2.15 throughout the study, Simpson's, with an average of 3.99 and the Berger-Parker index, with an overall average of 2.69. Pielou's evenness was significant (≥ 0.5) with a mean of 0.93. As for wealth, it was low, with an average of 0.41 (Figure 3).

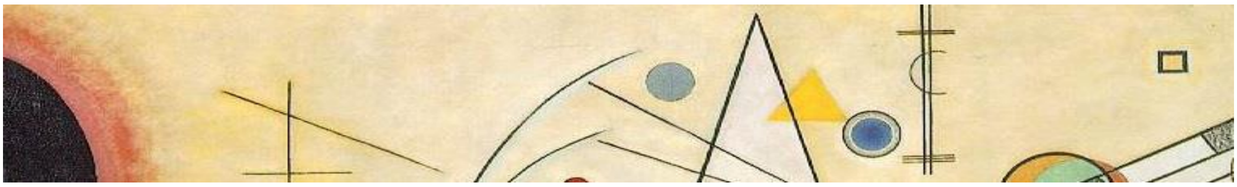
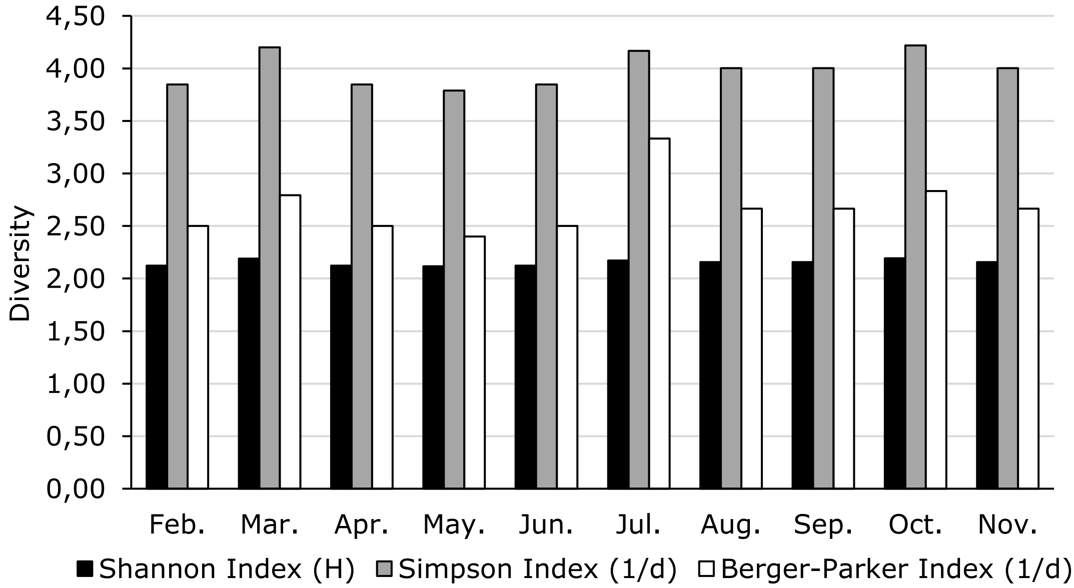


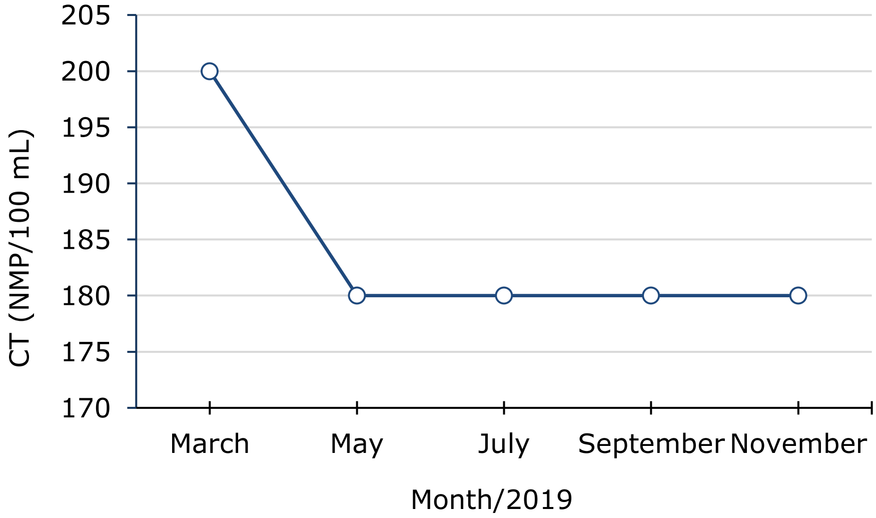
Figure 3 - Species diversity index of the zooplankton community of the waters of Iracema Beach/CE, in 2019.



4. Microbiology

Figure 4 shows the variation of thermotolerant coliforms for the waters of Iracema Beach during the study period, which presented an average of 184.0 ± 8.9 NMP 100 mL^{-1}.

Figure 4 - Thermotolerant Coliforms (CT), in Most Likely Number (NMP), observed in the waters of Iracema Beach/CE, in 2019.



5. Discussion

The variations in precipitations in the State of Ceará are related to the sunspot cycle, the Pacific Decadal Oscillation (PDO), with the occurrence of El Niño Southern Oscillation (ENSO) and the seasonality itself throughout the year (Silva *et al*., 2013).

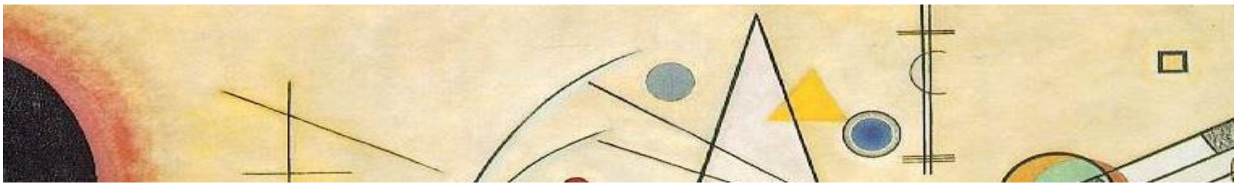
In general, rainfall indices differ along the coastline, with a decrease in annual totals in the West-East direction, ranging from 1,250 to 1,500 mm near the border with Piauí, to 500 – 750 mm near the of Rio Grande do Norte, with the capital of Ceará presenting a Rain Anomaly Index (IAC) around -0.01 characteristic of a dry zone (Ceará, 1989; Costa & Da Silva, 2017).

Precipitation is a factor that should always be analyzed, Once the volume accentuated of drainage rainwater can mainly change salinity, in addition to pH and other aquatic environmental parameters (Alencar *et al*., 2019).

The salinity in the sea along the coast of Ceará is directly influenced by rainfall, and the values obtained are within the standards for surface waters of the sea along the coast of the Northeast, which according to Nunes *et al*. (2003), can vary from 28 to 40 ups.

Water temperature is an extremely important parameter in the assessment of aquatic ecosystem dynamics, directly influencing vital oxidative metabolic processes, such as respiration, decomposition of organic matter and the solubility of gases, such as oxygen, fundamental for the balance of the ecosystem and support of aquatic life. In addition, the seasonal variations observed in most tropical waters are due to winds and precipitation on a scale rarely observed outside the tropics (Lowe-Mcconnell, 1999).

As for water transparency, several factors can cause interference from land drainage, dissolved particulate materials to phytoplankton density, therefore, it has a great influence on the amount of chlorophyll-*a*,



phytoplankton biomass, salinity of the sea surface and chemical factors, being widely used as an indicator of marine environmental quality (Zhou *et al*., 2021). Iracema Beach is a place that can be considered with waters in the mesotrophic belt (transparency between 80 and 200 cm) according to Schmittou (1999), as the pier mitigates the effect of turning the bottom, the main cause of reduced transparency in the marine zone, in addition, the coastal currents that carry sediments are parallel to the beach (Vasconcelos, 2018).

According to Sipaúba-Tavares (1995), dissolved oxygen is the most important compound for aquatic organisms, once it plays it plays an important role in the oxidation of nutrients that release energy necessary for the maintenance of aquatic life optimal range and always above 5.0 at Iracema Beach.

As for pH, it is an important parameter, because according to Sipaúba-Tavares (1995), it exerts a great influence on the distribution of aquatic organisms, in which acidification can reduce primary production, limit the growth of zooplanktonic species and cause the disappearance of several species of fish. The observed values are within the range of variation for seawater along the coast, which is 7.8 to 8.2 (Viana *et al*., 2021).

Boyd (1990) mentions that temperature, water transparency, dissolved oxygen, pH, in addition to electrical conductivity and the contents of inorganic and phosphate compounds can interfere in water quality and, consequently, in the dynamics of aquatic populations. Viana *et al*. (2021) emphasize that the most important characteristic of the surface waters of the oceans is the variation of environmental factors that can undergo major changes in a short time.

The presence of Cyanophyceae in relation to other classes is due to the physiology of their organisms, which have different adaptive strategies which make it possible to maintain them in normal and extreme environmental conditions, such as: the ability to fix atmospheric nitrogen, exclusive to this class; their aerotopes (gas vesicles) in the cells, which allow them to migrate vertically in the water column, being able to use light more efficiently; the presence of additional pigments that allow capturing a wider spectrum of solar radiation; among others (Sant'anna *et al*., 2006).

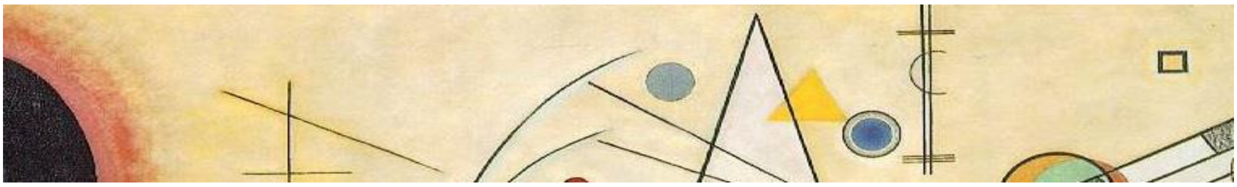
Silva *et al.* (2016) mention that a high number of low-intensity rainfall may favor phytoplankton due to the entry of nutrients, especially blooms. The distribution of nutrients in the water column is stratified, but with the entry of water by rain, a destratification begins, making all the nutrients available in the water column.

According to Costa Rodrigues *et al*. (2015), the quantitative characteristics of phytoplankton vary over time, which may be a result of changes in hydrological parameters, following the temporal gradient between the rainy and dry seasons, so that phytoplankton density is related to fluctuations of water input by the hydrological cycle.

Zooplankton are influenced by biotic and abiotic factors in the environment, relating to other trophic levels (Gibson *et al*., 2000). Some of these are: the predation, competition for nutrients, temperature, pH and salinity. Many researchers claim that competition, temperature, and availability of nutrients are the variables that most influence the diversification of these organisms.

The availability of nutrients, such as nitrogen and phosphorus, alter the diversification of the phytoplankton community, which in turn also interfere with that of zooplankton. For example, in the rainy season, there may be an increase in rotifer density due to the greater availability of nutrients from allochthonous material carried by the silting process (Landa *et al*., 2002).

In general, in the waters of Iracema Beach, both the phytoplankton and the zooplankton community showed higher density in the rainy season, with no species being considered as a bioindicator of eutrophication and/or pollution, according to CONAMA Resolution nº 357 (Brasil, 2005).



According to Magurran (2007) and Odum (1988), while the Shannon index assigns greater weight to rare species and Simpson's index to common species, the Berger-Parker index is based on the maximum abundance observed between species and the abundance total, thus expressing, the proportional abundance of the most abundant species, being considered among the available indices, the one that most satisfactorily measures diversity. In this research, the high indexes reflect the instability of the environment due to climatic and environmental conditions during most of the year, which does not allow the dominance of a single species, also reflecting the species richness that has always been below 1.3. The equability, on the other hand, always presented values higher than nine, evidencing the good distribution of the species in the phytoplankton community.

Shannon diversity values below 2.5 are considered low (Margalef, 1978), which was observed throughout the research, the same being observed for Simpson and Berger-Parker, below 4.5 and 3.5, respectively, a consequence of the instability of the environment, associated with the low richness of phytoplankton species during the studies (“d” was less than 0.5).

The low zooplankton diversity observed at Iracema Beach is in line with Margalef (1998) who mention that in coast this variable is lower than in the oceanic zone. On the other hand, there was no drop in equability, that is, in the distribution of species in the environment, which, as in the phytoplankton community, was always high and above nine.

Therefore, very low levels in the concentration of planktonic biomass in Iracema Beach is a direct consequence of the mesotrophic conditions of its waters and, mainly, because no nutrient inputs of anthropic origin have been observed at the site.

Rainwater in its natural form of purification through the hydrological cycle, when it precipitates, comes into contact with the atmosphere and, in urban centers, with natural and artificial structures (Tundisi, 2003). As water is a universal solvent, when passing through these places, it adds several chemical and organic compounds, carrying microorganisms, bacteria, among others, which cause its contamination and, consequently, its biological instability.

Moreno *et al*. (2019), when analyzing the microbiological conditions of the waters of urban beaches on the coast of Colombia, found a high level of contamination of fecal origin, from irregular sewers, which represents a serious risk factor to the health of bathers, different from that observed in **Iracema Beach**, whose surroundings do not have a sewage outlet.

The State Environmental Superintendence - Semace carries out analyzes of the water quality of the beaches of Fortaleza, and during the years from 1990 to 1993 it sent to the National Institute of Metrology, Quality and Technology - Inmetro, a federal autarchy, statistical data on the average of coliforms from the analyzed beaches. During this period, the waters of Iracema Beach presented an average of 100 MPN/100 mL (Brasil, 1998), showing that for almost three decades microbiological contamination continues to present low values, as observed in the present study.

None of the values obtained exceeded the minimum limit proposed by Brazilian legislation, i.e 250 NMP 100 mL^{-1}. Therefore, according to CONAMA Resolution 357/2005 and 274/2000, the waters of **Iracema Beach** are classified as class 1 saline, intended for primary contact recreation, and considered of excellent quality (Brasil, 2005).

6. Conclusions

In general, the waters of Iracema Beach showed good physical and chemical patterns, typical of coastal waters, with high phytoplankton diversity, low zooplankton diversity; good equability and low species richness in both communities. Noting that no species was considered a bioindicator of eutrophic or polluted waters and, in terms of thermotolerant coliforms, the waters can be considered suitable for bathing (primary contact recreation), and can be classified as an environment with very good quality water.

References

Alencar, V.; Rocha, E.J.P.; Souza Júnior, T.J.A. & 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*, Recife, v. 12, n. 2, p. 661-680, 2019. https://doi.org/10.26848/rbgf.v12.2.p661-680

Alves-da-Silva, S.M.; Juliano, V.B. & Ferraz, G.C. Euglenophyceae pigmentadas em lagoa ácida rasa, Parque Estadual de Itapuã, Sul do Brasil. *IHERINGIA: Série Botânica,* Porto Alegre, v. 63, n. 1, p. 15-36, 2008.

Barsanti, L. & Gualtieri, P. *Algae***:** anatomy, biochemistry, and biotechnology. New York: Taylor & Francis Group, 2006. 320 p.

Bicudo, C.E.M. & Menezes, M. *Gêneros de Algas de Águas Continentais do Brasil:* chave para identificação e descrições*.* São Carlos: Rima, 2006. 554 p.

Boyd, C.E. *Walter quality in ponds for aquaculture. Birmingham*. Alabama: Birmingham Publishing, 1990. 482 p.

Brasil. Instituto Nacional de Metrologia, Qualidade e Tecnologia – INMETRO. *Balneabilidade*. Brasília: Inmetro, 1998.

Brasil. Ministério do Meio Ambiente. Conselho Nacional do Meio Ambiente – CONAMA. Resoluções e outros atos. *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.

Brasil. Ministério do Meio Ambiente. Conselho Nacional do Meio Ambiente – CONAMA. Resoluções e outros atos. *CONAMA nº 430*, de 13 de maio de 2011. Dispõe sobre as condições e padrões de lançamento de efluentes, complementa e altera a Resolução nº 357, de 17 de março de 2005, do Conselho Nacional do Meio Ambiente - CONAMA.

Ceará. Fundação Cearense de Meteorologia e Recursos Hídricos - Funceme. *Mapeamento, levantamento e caracterização de áreas potenciais para implantação de projetos de carcinicultura no Norte e Nordeste do Brasil*. Fortaleza: Secretaria de Recursos Hídricos, 1989.

Ceará. Fundação Cearense de Meteorologia e Recursos Hídricos - Funceme. *Monitoramento*: postos pluviométricos. 2021. Available in: <http://www.funceme.br/?page_id=2694>. Accessed in February 2021.

Cervetto, G.; Mesones, C. & Calliari, D. Phytoplankton biomass and its relationship to environmental variables in a disturbed coastal area of the Río de la Plata, Uruguay, before the new sewage collector system. *Atlântica*, Rio Grande, v. 24, p.45-54, 2002. https://doi.org/10.5088/atl.2002.6

Costa, J.A. & Da Silva, D.J. Distribuição espaço-temporal do Índice de anomalia de chuva para o Estado do Ceará. *Revista Brasileira de Geografia Física*, v. 10, n. 04, p. 1002-1013, 2017.

Costa Rodrigues, E.H.; Barreto, L.; Correia, M.M.F. & Silva, M.R.C. Variação temporal do fitoplâncton em um rio tropical pré-amazônico (Rio Pindaré, Maranhão, Brasil). *Ciência e Natura*, v. 37, n. 2, p. 241-25, 2015.

Esteves, F.A. *Fundamentos de limnologia*. 3 ed. Rio de Janeiro: Interciência, 2011. 826 p.

Feng, P.; Weagant, S.D. & Grant, M.A. Enumeration of Escherichia coli and the coliform bacteria, Silver Spring, v. 13, n. 9, p. 1-13, 2002.

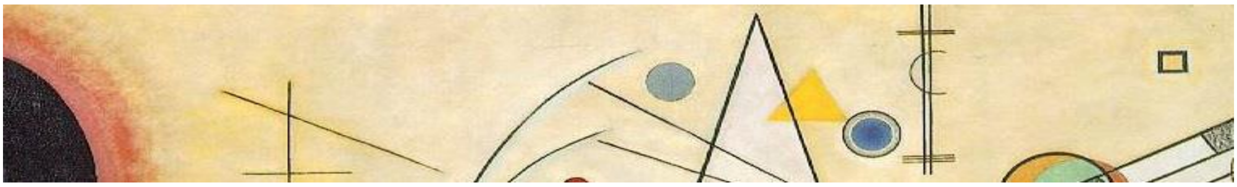
Gibson, G.R.; Bowman, M.L.; Gerritsen, J. & Snyder, B.D. *Estuarine and coastal marine waters:* bioassessment and biocriteria technical guidance. Washington: Environmental Protection Agency (EPA), 2000. 68 p.

Klimova, T.; Vdodovich, I. & Zagorodnyaya, Y.U. State of the Ichthyoplankton Community along the Crimean Peninsula in August 2011. *Journal of Ichthyology*, Birmingham, n. 58. p.382-388, 2018. https://doi.org/10.1134/S0032945218020078

Kubitza, F. *Qualidade da água, planejamento da produção e manejo alimentar em piscicultura*. Jundiaí: Cursos Avançados em Piscicultura. 2000. 72 p.

Landa, G.G.; Del Aguila, L.M.R. & Pinto-Coelho, R.M. Distribuição espacial e temporal de *Kellicottia bostoniensis* (Rousselet, 1908) (Rotifera) em um grande reservatório tropical (reservatório de Furnas), Estado de Minas Gerais, Brasil. *Acta Scientiarum. Biological Sciences,* Maringá, v. 24, p. 313-319. 2002.

Leão, B.M.; Passavante, J.Z.O.; Silva-Cunha, M.G.G. & Santiago, M.F. Ecologia do microfitoplâncton do estuário do Rio Igarassu, PE, Brasil. *Acta.*



Bot. Bras, Alta Floresta, v. 22, n. 3, p. 711-722, 2008. https://doi.org/10.1590/S0102-33062008000300009

Lowe-McConnell, R.H. *Estudos ecológicos de comunidades de peixes tropicais.* Tradução de Anna Emília A. de M. Vazzoler, Ângelo Antônio Agostinho e Patrícia T. M. São Paulo: Editora da Universidade de São Paulo, 1999. 536 p.

Magurran, A.E. *Measuring biological diversity*. Oxford: Blackwell Publishing, 2007. 248 p.

Margalef, R. *Ecología.* 8 ed. Barcelona: Omega S.A., 1998. 968 p.

Margalef, R. Les types biologiques de phytoplankton consideres comme des alternatives de survie dan sum millieu instable. *Oceanologica Acta*, v. 1, n. 4, p. 493-509, 1978.

Moresco, C. & Bueno, N.C. Scenedesmaceae (Chlorophyceae – Chlorococcales) de um lago artificial urbano: *Desmodesmus* e *Scenedesmus*. *Acta Scientiarum. Biological Sciences,* Maringá, v. 29, n. 3, p. 289-296, 2007. https://doi.org/10.4025/actascibiolsci.v29i3.483

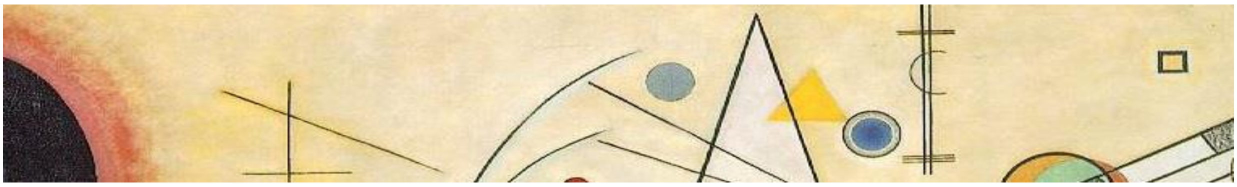
Moreno, H.S.; Bolívar-Anillo, H.J.; Soto-Varela, Z.E.; Aranguren, Y.; Gonzaléz, C.P.; Daza, D.A.V. & Anfuso, G. Microbiological water quality and sources of contamination along the coast of the Department of Atlántico (Caribbean Sea of Colombia). Preliminary results. *Marine Pollution Bulletin*, Hong Kong, v. 142, n. 3030-308, 2019. https://doi.org/10.1016/j.marpolbul.2019.03.054

Nunes, A.S.; Silva, R.P. & Esquivel, M.S. *Diagnóstico oceanográfico e proposição de disciplinamento de usos da faixa marinha do litoral Norte do Estado da Bahia*. Salvador: Governo da Bahia/CRA, 2013. 134 p.

Odum, E.P. *Ecologia.* Rio de Janeiro: Guanabara Koogan S. A., 1988. 446 p.

Pagano, M. & Gauvreau, K. *Princípios de Bioestatística.* 2 ed., São Paulo: Thomson. 2004. 222 p.

Rego, J.C.V. *Qualidade sanitária de água e areia de praias da Baía de Guanabara*, Dissertação, Dissertação, Ciências na área da Saúde Pública, Escola Nacional de Saúde Pública Sergio Arouca, 132 p., Rio de Janeiro, 2010.



Sant'anna, C.L.; Azevedo, M.T.P.; Agujaro, L.F.; Carvalho, M.C.; Carvalho, L.R. & Souza, R.C.R. *Manual Ilustrado para identificação e contagem de cianobactérias planctônicas de águas continentais brasileiras*. Rio de Janeiro: Interciência Ltda., 2006. 58 p.

Schmittou, H.R. *Produção de peixes em alta densidade em tanques-rede de pequeno volume*. São Paulo: Associação Americana de Soja, 1999. 78 p.

Silva, D.F.; Costa, I.M.; Mateus, A.E. & Sousa, A.B. Previsão Climática e de Ciclos Climáticos para o Estado do Ceará. *Revista Brasileira de Geografia Física,* Recife, v. 6, n. 959-977, 2013. https://doi.org/10.26848/rbgf.v6i4.233088

Silva, T.F.G.; Vinçon-Leite, B.; Alessandra Giani, A.; Figueredo, C.C.; Petrucci, G.; Lemaire, B.; Von Sperling, E.; Tassin, B.; Seidl, S.; Khac, V.T.; Viana, P.S.; Viana, V.F.L.; Toscano, R.A.; Rodrigues, B.H.M. & Nascimento, N.O*.* Modelagem da Lagoa da Pampulha**:** uma ferramenta para avaliar o impacto da bacia hidrográfica na dinâmica do fitoplâncton*. Engenharia Sanitária e Ambiental***,** v. 21, n. 01, p. 95-108, 2016.

Sipaúba-Tavares, L.H. *Limnologia aplicada à aquicultura.* Jaboticabal: FUNEP, 1995. 72 p.

Tundisi, J.G. Ciclo hidrológico e gerenciamento integrado. *Cienc. Cult*., São Paulo, v. 55, n. 4, p. 31-33, 2003.

Vasconcelos, F.P. *Dinâmica costeira do litoral de Fortaleza e os impactos da construção dos aterros das praias de Meireles (beira mar) e Iracema sobre o litoral de Caucaia*. Fortaleza: IEPRO/UECE, 2018. 110 p.

Verlecar, X.N. & Desai, S.R. *Phytoplankton Identification Manual*. New Delhi: National Institute of Oceanography, 2004. 40 p.

Viana, D.L.; Oliveira, J.E.L. & Hazin, F.H.V.; Souza, M.A.C. *Oceano, Clima, Ambientes e Conservação*. Recife: Via Design Publicações, 2021. 512 p.

Zhou, Y.; Yu, D.; Yang, Q.; Pan, S.; Gai, Y.; Cheng, W.; Liu, X. & Tang, S. Variations of water transparency and impact factors in the Bohai and Yellow Seas from satellite observations. *Remote Sensing*, Basileia, v. 13, n. 514, p. 2-19, 2021. https://doi.org/10.3390/rs13030514