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Seasonal Phytoplancton Variation and Cyanotoxins in a South American Reservoir

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Abstract

Excessive income of nutrients in water bodies is a process known as eutrophication and derives from the proliferation of organisms such as Cyanobacteria and several other microalgae, which are potentially hazardous to human health if they occur in a reservoir for drinking water. In this work, the case of a reservoir in the Argentine Republic, in South America, was studied. This reservoir provides drinking water to Cordoba, a city of about 1.5 million inhabitants. Together with the seasonal variation of phytoplankton diversity, also some Physico-chemical parameters were measured. The results show danger for human health, as far as eutrophication and levels of cyanotoxins are quite high.

Keywords: Eutrophication; Human health; Reservoirs; Water quality; Cyanobacteria.

1. Introduction

The provision of safe water and the management of its consumption comply with an important role in order to reduce the incidence of certain pathologies of water origin [1].

The increase in organic matter charges leads to the eutrophication process. This situation is when Cyanobacteria can become dominant, producing dense flourishings accompanied by the emission of unpleasant odors and cyanotoxins [2].

When the presence of these cyanotoxins occurs in areas close to water intakes for drinking water, the health of human populations involved is placed at risk. It is not likely that the concentration of cyanobacterial toxins reach levels as high as to originate acute intoxication cases, but they can produce subletal effects (such as diarrhea, vomiting, dizziness, digestive disorders, etc.) and become carcinogenic agents if the ingestion is chronic [3, 4].

The algal blooms are the result of multiplication events of microalgae in aquatic systems, and represent a significant increase in the biomass of one or few species, in very brief periods of few weeks.

Blooms of Cyanobacteria are favored by eutrophication due to the increase in nutrients, mainly nitrogen and phosphorus [5, 6].

They usually produce cyanotoxins, which can be peptides, alkaloids or lipopolysaccharides that can affect both the nervous or digestive system, with unpleasant skin effects. When they are in water bodies destined for human uses, they cause significant losses from both the sanitary and aesthetic point of view.

The hepatotoxin recorded more frequently is microcystine, which owes its name to the fact that was primarily identified in species of the genus *Microcystis.* This toxin directly affects the liver and is 100 times more powerful than cyanide. There is a strong correlation between primary liver cancer and cyanobacterial contamination of fresh water sources used by the population [1]. Such toxins do not suffer any degradation during standard potabilization processes. When they are present in reservoires for provision of drinking water, the health of the populations is placed at risk [7, 8].

The objective of this research was the monitoring of the upper mentioned reservoir in order to be able to give early alerts on the possible presence of cyanotoxins in water, and identify the different species of Cyanobacteria and other algae of interest.

2. Material and Methods

San Roque reservoir is the main drinking water reservoir of the city of Córdoba, with almost 1.5 millon inhabitans, and because it receives a high supply of nutrients mainly from anthropic activities, it constitutes a very favorable ecosystem for the development of algal communities, especially Cyanobacteria.

Samples were taken monthly from January 2019 to December 2020, in the wallon of the reservoir, which is in close vicinity to the place where the water intake is located. Physico-chemical parameters were recorded simultaneously with the identification of the most important taxa [9].

The population growth of phytoplactonic microorganisms is generally measured as a number of cells per unit of water volume or as a quantity of chlorophylls per unit, since chlorophylls are directly proportional to the biomass of photosytetizing organisms.

The samples were collected in 2-liter capacity bottles, washed several times with distilled water, taking a subsurface sample on the reservoir. After concentrated by decantation or centrifugation at low velocities, they were fixed in 3% formol for conservation purposes [10, 11].

The taxonomic study was carried out with identification keys and manuals [1, 12-16]. The count of the samples was made by direct counting under a photonic microscope [8, 17].

The phytoplanctonic biomass was estimated by measuring concentration of chlorophyll "a" in a spectrophotometer, extracted in methanol for 12 HR at -5 ° C, according to the methodology of Prosperi [3].

Emphasis was placed on the determination of Cyanobacteria, but some other important taxa were included due to their interactions with them or their abundance, such as Euglenofites, Chlorofites, Bacillariofites and Dinofites [18].

3. Results

The number of taxa determined was 39 in total. *Microcystis aeruginosa* and *Anabaena spiroides*, (Cyanobacteria), two potentially toxic species, were the principal cause of blooms during the warm months, forming a greenish film on the water surface. Instead, during winter, Bacillariophyceae constituted the dominant group.

The complete list of genera is the following:

Cyanobacteria: *Anabaena, Anabaenopsis, Chroococcus, Merismopedia, Microcystis, Nostoc, Oscillatoria, Phormidium, Spirulina,*

Chlorophyceae: *Chlamidomonas, Coelastrum, Cosmarium, Eudorina, Kirchneriella, Oocistis, Pandorina, Pediastrum, Scenedesmus, Selenastrum, Volvox.*

Bacillariophyceae: *Amphora, Aulacoseira, Cocconeis Cyclotella, Cymbella, Diatoma, Fragillaria, Gomphonema, Gyrosigma, Melosira, Navicula, Nitzchia, Surirella.*

Euglenophyceae: *Euglena, Phacus, Trachelomonas.*

Dinophyceae: *Ceratium, Peridinium, Criptomonas.*

The results strongly suggest that the reservoir could be considered in an eutrophic state with a tendency to hypereutrophic in summer, since the water is characterized by abundant primary productivity, low transparency, greenish color and anoxic processes that generate odoriferous gases (figure 1).

According to the average number obtained for turbidity measured by means of a Secchi disk, and throughout the year, the characteristics of the reservoir considered as a whole corresponded to the eutrophic state, although with important variations according to the season of the year.

Regarding the concentration of chlorophyll "a", during spring and summer they were predominantly eutrophic, while during autumn and winter they were mesotrophic. Pierotto, *et al.* [19]. These data are coincident with the measurements of nitrogen compounds (see figures 2 and 3).

All these conditions are, of course, undesirable in an environment used for the provision of drinking water for a human population.

4. Discussion and Conclussions

It is noticeable that there is a variation in the trophic state of the reservoir that increases during the warm months (in the southern hemisphere they correspond approximately to the November-March period) due to higher temperatures and the highest duration of the photoperiod, which increases photosynthetic activity and facilitates algae growth. The opposite occurs in the coldest months (June-August).

Although chronic exposure to microcystins (toxins mainly produced by the Cyanobacteria *Mycrocystis aeruginosa*) has not been well studied, it can be assumed that it will leave to severe hepatocyte necrosis, loss of liver functionality and perhaps promote hepatic tumors or even death.

In our country, no uniform standards or criteria have yet been established for water quality, but several standards are available for australian consumption and some other countries (like Canada), which limit the concentration of toxic cyanobacteria to a maximum approximate of 15000 cel / ml, equivalent to approximately 5-10 (G / L of chlorophyll "a").

The provisional values guidelines of microcystine are ≤ 1 (g / l. for a low level of risk, or 10 g / l of chlorophyll "a" and 20000 cel / ml). In order to consider health risk, at least two aspects should be taken into account: first the toxin contained in the water represented by the number of scattered cells (depending on the cyanobacterial and cellular toxicity species) and second the development of foam on the surface. Moderate levels have a density of 100,000 cel / ml or 50 (g / l of chlorophyll "a".

According to the physico-chemical results, in general terms, the water quality of the environment was almost always within admissible limits. The risks of flourishings would decrease in months of lesser temperature, but is increasing in higher temperatures, becoming eutrophic to hypereutrophic.

The results of this study are a clear signal of attention to the progressive deterioration of water quality in these environments [20-22]. This fact claims for the implementation of urgent sanitation measures.

This sanitation must include the tertiary treatment of all sewage effluents that are poured into the environment, the control of diffuse organic contamination produced by agricultural-livestock activity in the affected basins, and the particular control of punctual contamination produced by various industries or diverse establishments [23, 24].

As a palliative measure of the flourishings, aeration is recommended in its different possibilities of implementation. There are several aeration mechanisms for rivers and lakes, all more or less efficient according to the characteristics of the environment that seek to be treated and according to a cost and benefit ratio that must be evaluated in each particular case [25, 26].

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Illustrations

Fig-1. View of San Roque Lake. The greenish color at the bottom is due to Cyanobacteria

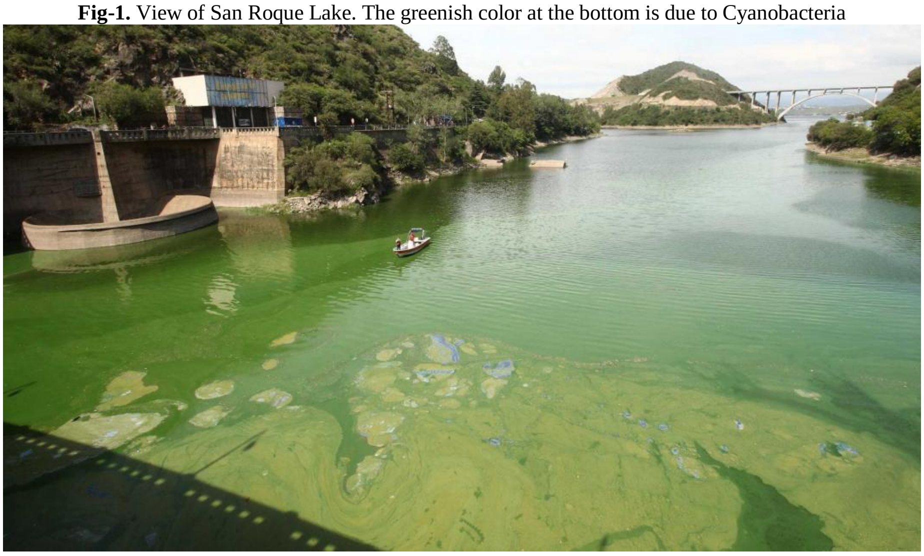

Fig-2. Monthly chlorophyll "a" variation during 2019 and 2020

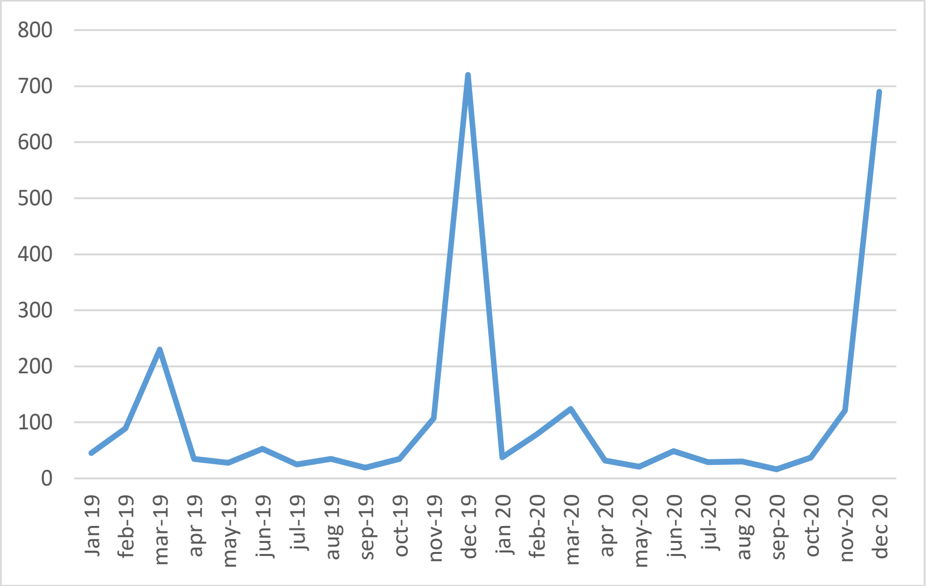

Fig-3. Monthly nitrogen variation during 2019 and 2020