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INFLUENCE OF TEMPERATURE AND TURBIDITY ON CYANOBACTERIAL BLOOMS FROM ARGES RIVER, ROMANIA

Ilie-Daniel RAICU[1,2], Ovidiu POPA[1], Miruna VADUVA[3], Veronica PANAIT[2], Florentina IARIM[2], Oana PAUN[2], Narcisa BABEANU[1]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, Bucharest, Romania, Phone: 00 40 737 282 003, Email: danielilie.raicu@yahoo.ro narcisa.babeanu@gmail.com, ovid_popa@yahoo.com
[2]SCA Laboratory, Apa Nova Bucharest Company, 53 Cartier Crivina Street, Bolintin-Vale, Romania, Email: panaitveronicaionela@gmail.com
[3]The World Bank in Romania, 31 Vasile Lascar St., Bucharest, Romania, Phone: 00 40 755 362 131, Email: vaduva.miruna@gmail.com

Corresponding author: ovid_popa@yahoo.com

Abstract

This article presents the evolution of cyanobacterial abundance represented by Microcystis sp. and Aphanizomenon sp., in the period 2009-2017, on the river Arges, in Romania, as well as correlations with the temperatures and turbidities of water, in order to identify the impact of the actual climatic trends on the frequency and concentration of cyanobacteria. During this time interval it could be observed a change in the cyanobacterial blooming period by its moving in autumn, also the growth of its duration, but in the same time, a slight decrease a cyanovbacteria production during the whole year. The duration of cyanobacterial blooms season was positive correlated (+0.74) with the average annual temperature, and negative correlated (-0.71), with the turbidity in the season. The maximum concentration achieved by cyanobacteria showed negative correlation (-0.62) along with the turbidity recorded at the beginning of the cyanobacterial blooms season. Although temperature is a very important factor in cyanobacterial development in the Arges river, flood-induced turbidity plays a key role both in favoring or inhibiting its growth but also in adjusting temperatures.

Key words**:** *cyanobacterial blooms, temperature, turbidity, correlation*

INTRODUCTION

The development of cyanobacteria in water sources that are suitable for potabilizartion, the high abundance and toxin production has forced international organizations to look out more strictly for this phenomenon [2, 5,6,11,12].
One of the most important factors that influences the growth rate of cyanobacteria is temperature [9,12], its overall trend being constant increase [8]. The impact of climate change on the growth of cyanobacteria in river waters is not yet well studied, with most research being done on lakes and reservoirs [1].
Global warming seems to lead to the enrichment of waters with various nutrients [4,10], which together with high temperatures seem to favor cyanobacterial blooms [13]. A rise in temperature is considered to be beneficial to the development of cyanobacteria due to the vertical stratification of water [3,9,10], while intense rain would lead to increased nutrient concentration, due to the washing of the slopes [10]. Changing climatic conditions, intense drought in alternation with floods may be the cause of cyanobacterial growth [9].
Phytoplankton biomass and some nutrients (nitrogen and phosphorus concentrations) express the degree of eutrophication of aquatic ecosystems [7].

MATERIALS AND METHODS

In order to be able to describe the impact of the latest climate changes on the frequency and abundance of cyanobacteria, the following parameters were monitored for a nine years period: temperature, turbidity, cyanobacterial abundance (*Aphanizomenon*

sp. and *Microcystis* sp.). Samples were taken from Arges river, Bolintin-Vale(B-V) area, having the following geographical coordinates: 44.427871, 25.778887.
The data was provided by SCA Laboratory of Apa Nova Bucharest Company.
The main method of determining correlations between data series was a Pearson correlation coefficient with the following standard formula:

$$r = \frac{\sum_{i=1}^{n}\left((x_i - \bar{x})(y_i - \bar{y})\right)}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

RESULTS AND DISCUSSIONS

The presence of *Aphanizomenon* sp. and *Microcystis* sp. was registered in the medium with an average of 92 days per year, except 2014, a year without cyanobacterial bloom. However, the general trend is one of growth (Fig.1), the highest values of the last nine years being recorded in 2017, with a 131-day season.

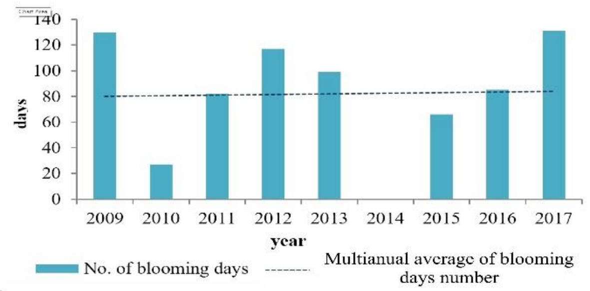

Fig.1. No. of days with cyanobacteria blooms, between 2009 – 2017, in Arges, B-V.
Source:SCA Laboratory database, Apa Nova Bucharest Company.

There is a strong positive correlation (0.74) between the extent of cyanobacterial season and the annual average temperature (Fig.2), but a moderate positive one with the temperature at the end of the mentioned season. The increase of the average water temperature resulted in an increase of the cyanobacteria blooms season. These correlation indicates that temperature is one of the most important factors that are influencing the growth of cyanobacterial populations in the Arges river.

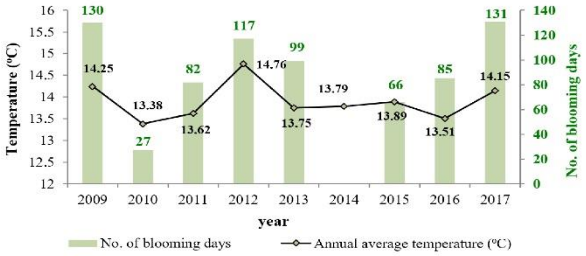

Fig.2. Number of days of cyanobacterial blooms and annual average temperature, Arges B-V, 2009-2017.
Source:SCA Laboratory database, Apa Nova Bucharest Company.

The average turbidity recorded during the cyanobacterial blooms season is 94.42 NTU, and the recorded peak is 50.91 NTU. The number of days recorded with cyanobacterial blooms is directly influenced by the level of turbidity of river water during the cyanobacterial blooms season. Thus, a strong negative correlation was obtained with the turbidity recorded during the season (-0.71), with the average annual turbidity (-0.69), with the turbidity at maximum cyanobacterial blooms period (-0.64), and the turbidity at the end of the season (-0.64).
Studying the connection between the length of blooms season with the average values of the cyanobacterial abundances (Fig.3) we obtained a positive correlation (+0.52), which is not a strong one due to the peak periods of the blooms, which maximum have a great influence on the average abundances.
The maximum cyanobacterial abundance shows a negative correlation (-0.44) to the length of the season cyanobacteria, consequently a greater richesse of cyanobacterial bloom will result in the shorter period of the season. Correlation tells us that strong blooms can consume some of the nutrients, diminishing conditions favorable to continued cyanobacterial blooms.
The correlation between maximum abundance and minimum temperature in the cyanobacterial season was +0.63. It was observed a slightly negative correlation (-0.62) between the maximum titre of cyanobacteria and the turbidity at the start of the cyanobacteria blooming period (Fig.4). One conclusion could be: the higher will be the turbidity at the beginning of the season,

the lower will be the maximum value of the concentration that year.

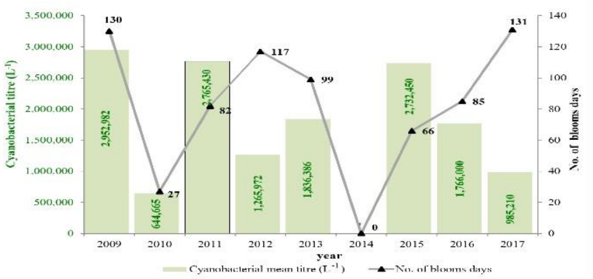

Fig. 3. The evolution of mean titre of cyanobacteria and the length of cyanobacterial blooms, in Arges river, B-V, between 2009-2017.
Source:SCA Laboratory database, Apa Nova Bucharest Company.

There is a positive correlation between cyanobacteria production, (titre × duration of cyanobacterial blooms season) and the turbidity values at the start of the cyanobacterial blooms season (+0.53). At the end of the mentioned period, cyanobacteria production was negatively correlated with NTU values. Production is also correlated positively with the temperature at maximum of cyanobacterial bloom (0.44) and the temperature at end of cyanobacterial bloom (0.41).

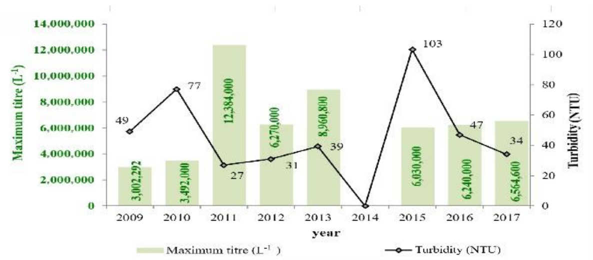

Fig. 4. Turbidity levels and cyanobacterial abundance registered in Arges river, B-V, between 2009-2017.
Source:SCA Laboratory database, Apa Nova Bucharest Company.

In the Arges river cyanobacterial blooms starts between June 5 to July 27, with a migration trend towards mid-July.
The peak of the cyanobacteria titre was in the period July 10 - September 26, with a migration trend from June, as recorded in the first four years (2009-2012) towards the end of September, as seen during 2013-2017 period. In 2014 there were no cyanobacterial blooms (Fig.5).

The end period of cyanobacterial blooms respects the general trend, migrating between 5 and 13 days towards the end of October, from 11,12 October in 2009, 2010, on 17, 25 October 2016 and 2017.

Fig. 5. Start, peak and end blooms values for cyanobacteria, registered in Arges river, B-V, in 2009-2017 period.
Source:SCA Laboratory database, Apa Nova Bucharest Company.

The general trends of cyanobacterial bloom migration are a result of changes in temperatures and the rainfall regime of turbidity.
During cyanobacterial blooms periods we obtained a multiannual average temperature of 22.21 °C; 24.61 °C values were recorded at the beginning of the season, respectively 27.66 °C at the peak of season. The start and maximum values of temperatures are recorded in the optimal growth range of cyanobacteria in temperate zones, described by Reynolds (2006) [10], ranging from 25 to 35 ° C.
In general, the end of the cyanobacterial blooms season is characterized by a low persistence of Microcystis caused by low temperatures, the multiannual minimum temperature being of 15,18 °C.

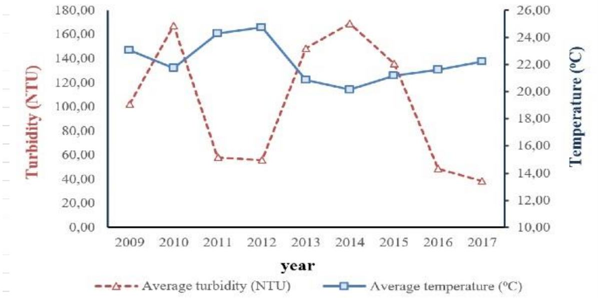

Fig. 6. The evolution of temperature and turbidity levels recorded in the cyanobacterial blooms seasons, between 2009-2017, Arges river, B-V.
Source:SCA Laboratory database, Apa Nova Bucharest Company.

Analyzing the correlations between temperature and turbidity values, we obtained the following strong correlation indices: -0.67 between the average values and -0.79 between the maximum values. This is explained by the marked tendency of temperature drops with increasing turbidity in water (Fig.6 and Fig.7).

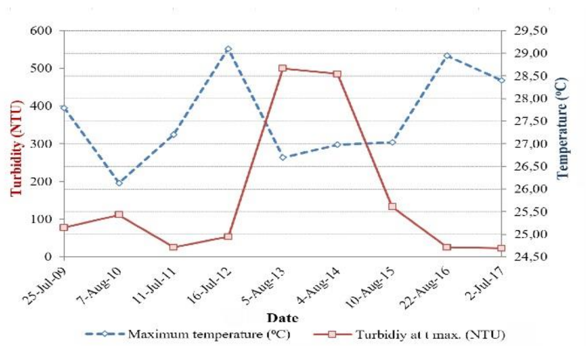

Fig. 7. The evolution of maximum temperature and turbidity between 2000-2017, Arges river, B-V.
Source:SCA Laboratory database, Apa Nova Bucharest Company.

CONCLUSIONS

The analysis of the recordings made on the Arges river, during 2009–2017 period, it was observed that the cyanobacterial blooms season tends to migrate to the autumn and its dimensions tend to extend to 131 days.

The annual number of days in which Cyanobacteria is present in the Arges river is strongly correlated (0.74) with the average annual temperature.

Turbidity has an important role in the starting process, maintaining, and reaching high levels of cyanobacterial, thus showing a strong negative correlation (-0.71) with the number of bloom days. This strong correlation can lead us to the conclusion that a warming of the environment can result to a direct incensement of the number of days with cyanobacterial blooms.

The increase in turbidity also negatively influences the water temperature, and between these parameters a strong negative correlation (-0.79) is established.

Temperature is one of the most important factors influencing the development of cyanobacterial populations in the Arges river (B-V) and turbidity plays a key role both in favoring or inhibiting the growth of *Microcystis* and *Aphanizomenon* populations and in adjusting Arges river temperature.

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