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 ORIGINAL PAPERS

Water Quality and Microbiological Contamination of Tabacarie Lake, Constanta City, Romania

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Abstract. *Urban lakes play a vital role in the sustainable development of urbanized areas. Tabacarie lake is an urban lake situated at the northern limit of the Constanta city, where anthropic impacts had affected the water quality and the microbial communities. The purpose of your research was to study the water quality and the bacterial contamination of Tabacarie lake, taking into account that the water bacterial abundance in the urban lakes is not well understood. So, we tried to identify possible sources of nutrients and bacteria in the lake. Our results showed that a possible source of nutrients and bacterial contamination is the water discharge from the Micro-Reservation channel (Natural Sciences Museum Complex) that communicates with Tabacarie lake.*

Keywords: Tabacarie lake, nitrates, phosphates, bacterial contamination

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1. Introduction

Urban lakes play a vital role in the sustainable development of urbanized areas. Tabacarie lake is an urban lake situated at the northern limit of the Constanta city, formed by the damming of a river valley; genetically, the lake is a fluvial-maritime creek [3].

Tabacarie lake together with Siutghiol lake, form a lake complex included in Natura 2000 protected areas, as ROSPA0057 Siutghiol Lake. Relatively isolated from natural sources (ground water is insufficient to balance losses), Tabacarie lake depends upon the influx of water from Siutghiol lake. Surface water flows southward from Siutghiol lake by a small channel into Tabacarie lake and then discharges through an outlet into the Black Sea [7].

Over the years, Tabacarie lake has undergone rapid eutrophication process, a fact that is demonstrated by the permanent algal blooms [11]. Wastewater discharges, rainwater and anthropogenic activities lead to continuous degradation of the quality of the aquatic environment which can have a devastating impact on the lake's biodiversity.

The research carried out revealed the contamination of the entire ecosystem (water, sediments, aquatic organisms' plants and animals), by accumulating Cd, Cr, Fe, Mn and Zn in all components of the ecosystem [4], [5], [6]. Wastewater discharges, the accumulation of large amounts of nutrients from different sources in conjunction with the increase in the temperature of the lake water in the warm season, almost annually cause the phenomena of eutrophication and consequently the death of fish [11].

Eutrophication, referring to nutrient enrichment of water bodies, causes changes in the physical, chemical, and biological characteristics of these ecosystems which are generally detrimental to the biota living in them and also decreases their esthetic and economic importance [9].

Anthropogenic activities have an impact also on the microbial communities, which are an important component of aquatic ecosystems. They play active roles in the biogeochemical cycles of organic matter and nutrients to maintain the health and stability of aquatic ecosystems [14]. In freshwater ecosystems as lakes, massive microbial communities can drive the recycling of nutrients and regulate the water quality [15].

Tabacarie lake is surrounded by a series of functional zones such as: Natural Sciences Museum Complex, Gravity Park, City Park Mall, Tabacarie Park, Holiday Village, Expositional Arena, Water Treatment Plant, and Residential Complex [13].

Within the Natural Sciences Museum Complex of Constanta, starting with 1985, a Micro-reservation entered the public circuit, which covers an area of about 12 ha, of which 2 ha represented a body of water with marshy vegetation. The heritage of this objective has aquatic avifauna (pelicans, swans, ducks and wild geese), terrestrial avifauna (peacocks, pheasants) and mammals (mouflons, deer). shovels, deer), which are found in the Danube Delta Biosphere Reserve and the Negureni Reserve [17].

The artificial lake inside the Micro-reservation communicates through a channel with Tabacarie lake. Animal shelters are located in the vicinity of the artificial lake in the Micro-Reservation causing its pollution, and through the communication channel, polluted waters are discharged directly into Tabacarie lake. So, the scope of the present research was to study the water quality of

Tabacarie lake and the bacterial contamination under the influence of the Micro-Reservation.

2.Materials and methods

To see the influence of Micro-Rservation input into Tabacarie lake, we established 5 stations for water collection, as follow: station 1- Tara Piticilor, Station 2- Sf. Mina Church, station 3- Micro-reservation, Station 4- Micro-Reservation channel, station 5 – Equestrum Complex (fig.1)

Fig. 1. Map of water collection stations from Lake Tabacarie (Google Maps)

Water samples were collected between 2022-2023 (March 2022, July 2022, November 2022 and January 2023), with a surface sampling device and transferred to sterile plastic bags (Whirl-Pak) and kept in a cooling chamber until

arrival at the laboratory, where they were filtered and subjected to processing procedures. On field the water oxygen and temperature were measured with Consort Z621 oxygenometer.

2.1. Analysis of nutrients

We analyzed the quantity of nitrates and phosphates with HACH spectrophotometer DR/24000. Prior to analysis, a check of the photometric performance was carried out, with the use of DR/Check Absorbance Standards in order to obtain the maximum performance capability of the instrument. The analysis of nitrates was performed by NitraVer 5 cadmium reduction method, the phosphates were determined by PhosVer 3 ascorbic acid method.

2.2 Microbiology

The samples were inoculated as such or diluted (10-1) on Petri dishes with nutritious agar. Incubation was performed at 28°C for 48 hours. Colonies developed on solidified medium were numbered and expressed in CFU (Colony Forming Units) / mL

3.Results and discussions

Regarding the temperature, this presented normal variations between seasons, with the lowest value recorded in January 2023 (5.1°C) and the highest temperature in July 2022 (26.4°C). Very low concentrations of dissolved oxygen were recorded in station 4 (Micro-Reservation channel), in both July 2022 and January 2023 (fig.2, fig.3, fig.4, fig.5).

In March 2022, the concentration of dissolved oxygen varied between 10.7 to 11.35 mg/L (fig. 2), in July 2022 dissolved oxygen varied between 3.57 to 8.91 mg/L (fig.3), in November 2022 between 6.04 to 9.5 mg/L (fig. 4), and in January 2023, between 6.72 to 7.59 mg/L (fig.5).

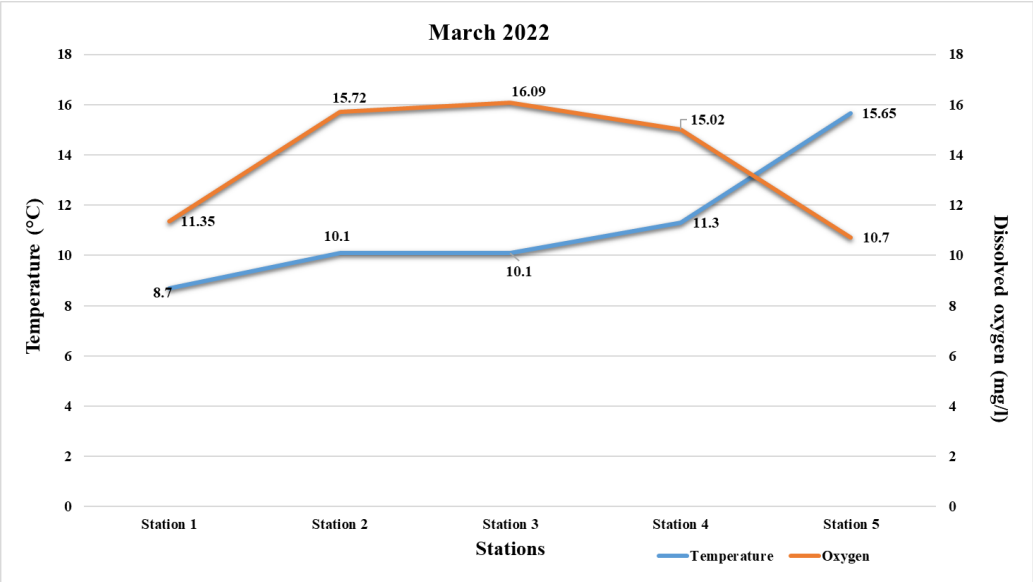

Fig.2. Temperature and dissolved oxygen correlation for March 2022

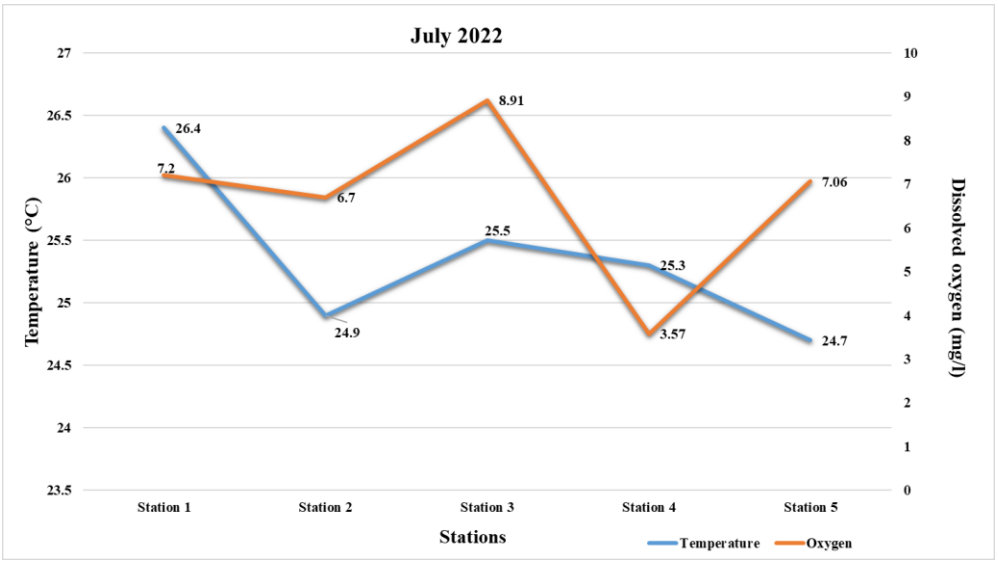

Fig.3. Temperature and dissolved oxygen correlation for July 2022

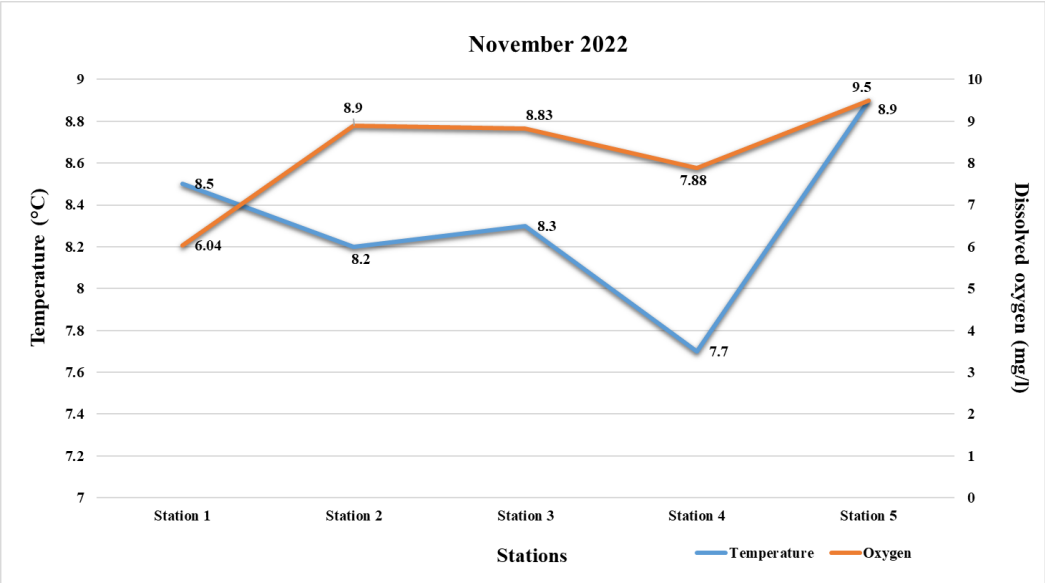

Fig.4. Temperature and dissolved oxygen correlation for November 2022

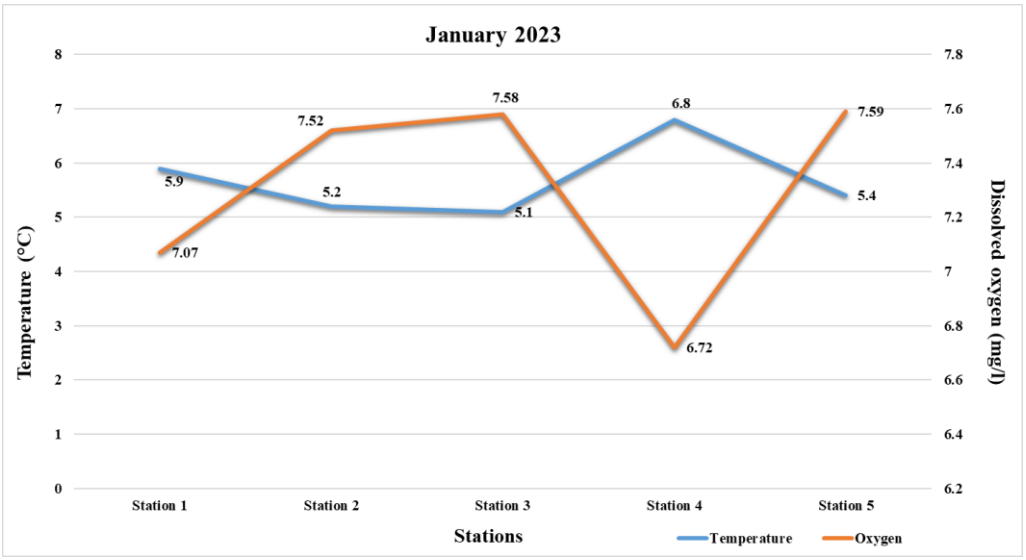

Fig.5. Temperature and dissolved oxygen correlation for January 2023

3.1.Nutrients results

In which concerns the variation of nitrates along seasons and stations (fig.6), in March 2022, the values of nitrates varied between 0.3 mg/L (station 5) and 0.7 mg/L (station 4). In July 2022, the nitrates were lower, with values ranging from 0.15 mg/L (station 5) to 0.6 mg/L (station 2). In November the nitrates concentrations were even lower with values ranging from 0.1 mg/L (station 2) to 0.25 mg/L (station 1 and 4). In winter (January 2023), the nitrates concentrations were among the highest, with values ranging from 0.35 mg/L (station 1) to 0.75 mg/L (station 4). All the values included the lake in Class I water quality, according to Order no. 161/2006 for the approval of the “Norms on quality classification of surface waters in order to establish the water bodies status" [16].

In which concerns the concentration of phosphates (fig.7), the values ranged between 0.01 mg/L to 0.06 mg/L, with the highest value in station 4, during the spring (March 2022). The concentration of nitrates continued to increase during summer (July 2022) up to values of 0.035 mg/L to 0.155 mg/L, with higher values station 4.

In November 2022, phosphates concentration increased again in all stations compared to previous months, in all stations, except station 5. The values ranged between 0.02 mg/L (station 5) to 0.15 mg/L (station 1 and station 4). In winter, the phosphates concentration continued to increase in station 3, 4, and 5, except station 1 and 2 were the phosphates concentration decreased compared to the last month. Once again, the highest concentration was recorded in station 4, 0.175 mg/l, which included the lake in Class II water quality, according to Order no. 161/2006 for the approval of the “Norms on quality classification of surface waters in order to establish the water bodies status" [16].

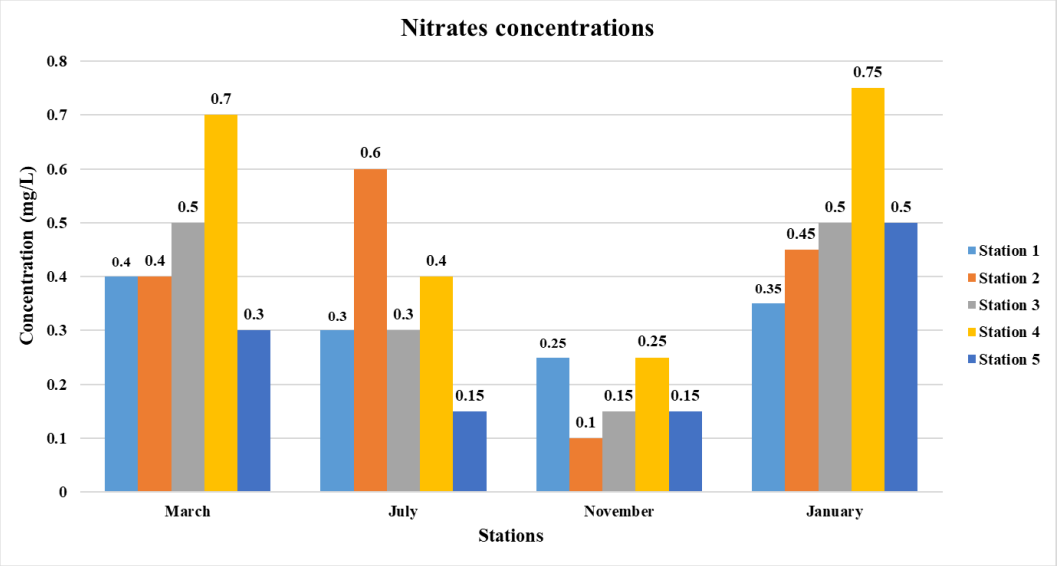

Fig.6. Variation of nitrates concentrations among seasons and stations

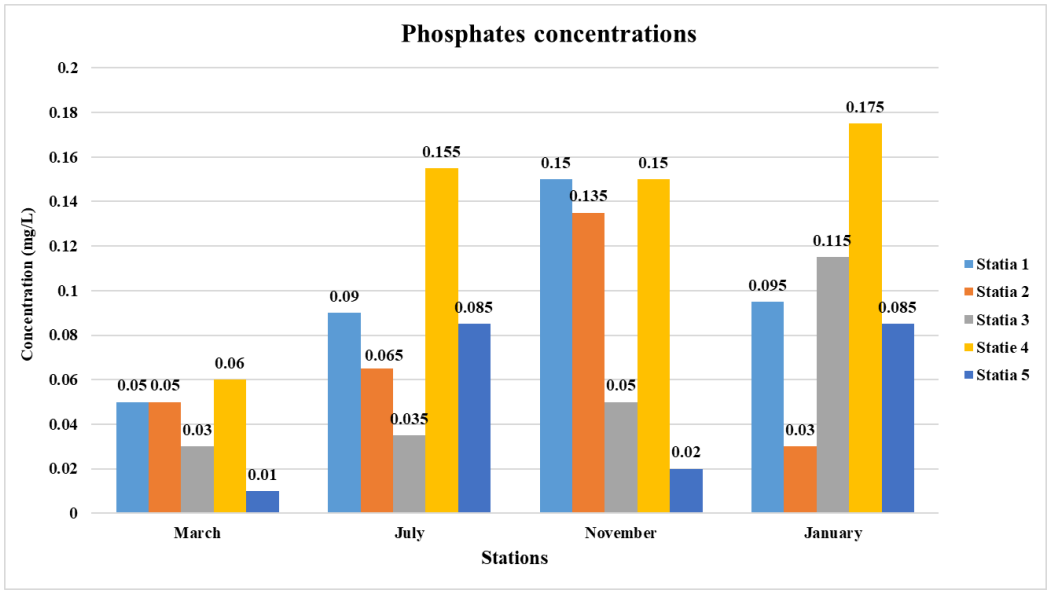

Fig.7. Variation of phosphates concentrations among seasons and stations

3.2. Microbiology results

In which concerns the seasonal variation of bacteria (fig.8) in March 2022, the average value of heterotrophic bacteria was 316 CFU mL, with the highest values recorded in station 3 (450 CFU/mL) and station 4 (430 CFU/mL). With increase of temperature, in summer, the density of heterotrophic bacteria increased, with an average value of 3.180 CFU/ml, with the highest value recorded in station 4 (17.000 CFU/mL).

In autumn (November 2022), we recorded the highest bacterial contamination of all seasons, with an average value of 22860 CFU/mL, once again station 4 recording the highest value of CFU/mL (32000 CFU/mL). In winter (January 2023) the bacterial contamination was still high, with an average value of 21.300 CFU/mL, but this time the highest values was recorded in station 1 (31.200 CFU/mL).

Due to the fact that the highest bacterial contamination was observed in autumn and winter, the dynamic of heterotrophic bacteria is not controlled only by the temperature, but also by the oscillation of organic nutrients or the influx of use water.

High concentration of bacteria in autumn and winter, compared to the rest of the months, can be explained also by the study of [2] were a massive bloom of heterotrophic bacteria occurred during winter, because carbon rather than temperature was the limiting factor for bacterial growth.

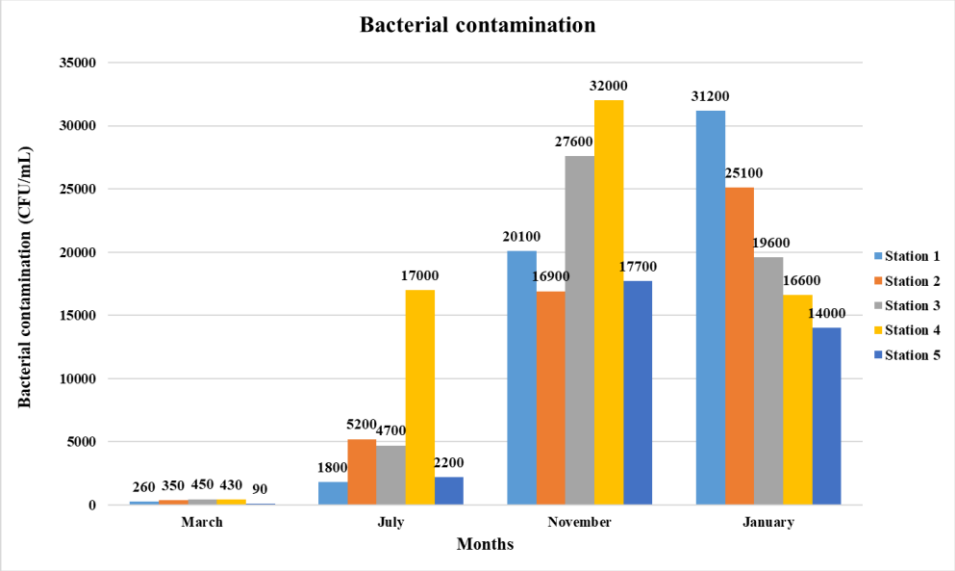

Fig.8. Seasonal variation of heterotrophic bacteria

As seen in figure 8, one of the main causes of high bacterial contamination in lake Tabacarie, can be the discharge of waters from the artificial lake inside the Micro-Reservation through the channel that communicates with lake Tabacarie.

The microbial community in fecal samples of zoo animal is very diverse (fig.9), with bacterial species like *Bacterioides, Escherichia, Bacillus, Clostridium* [12].

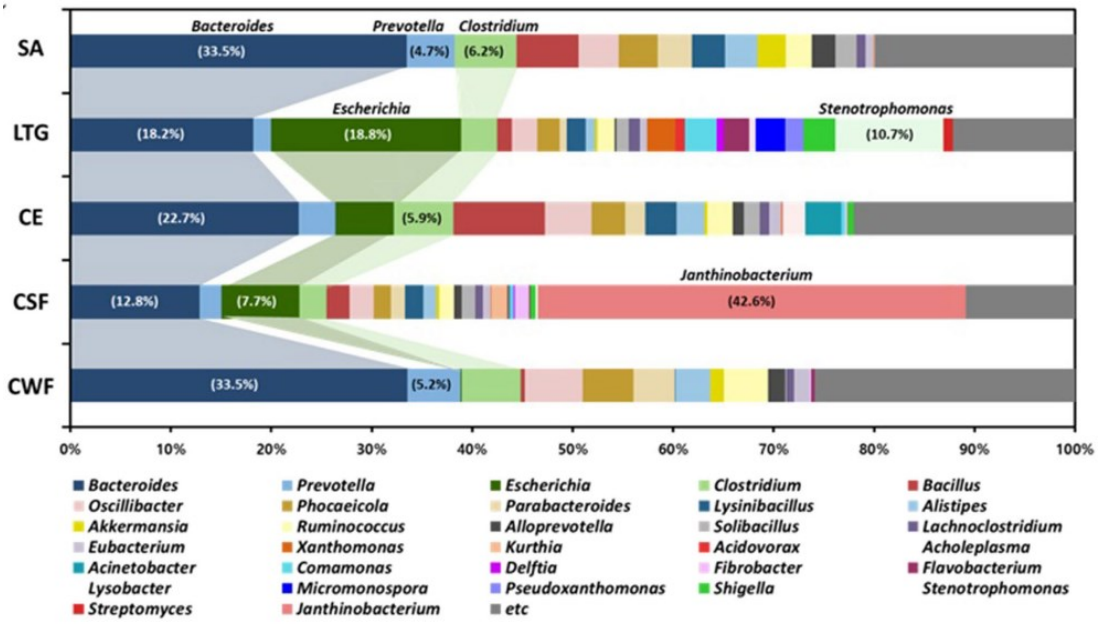

Fig.9. Species diversity and microbial community distribution in the five feces at the genus level (sable antilope (SA), long -tailed goral (LTG), common elan (CE), omposited summer feces (CSF), winter feces (CWF) [12]

Heterotrophic bacteria account for a large portion of total uptake of both phosphate (60% median) and ammonium (30% median) in freshwaters and marine environments [10].

Nutrient, particularly phosphorus, is a limiting factor for bacterial growth and utilization of organic carbon, abundance of bacteria being enhanced by phosphate [8].

The composition of microbial communities varied widely among lakes with different trophic states. The heterotrophic bacterial community is mainly involved in the recycling of organic matter and its transformation into mineral nutrients. The process is influenced both by the concentration of organic matter existing at a given time, by temperature or other physico-chemical parameters, as well as by internal factors (metabolic state of cells) [14].

Taking into consideration the average annual value of nutrients and bacterial abundance (fig.10, fig.11, fig. 12), we can conclude that the discharge from the Micro- Reservation channel is a source of nitrates, phosphates and bacteria in Tabacarie lake.

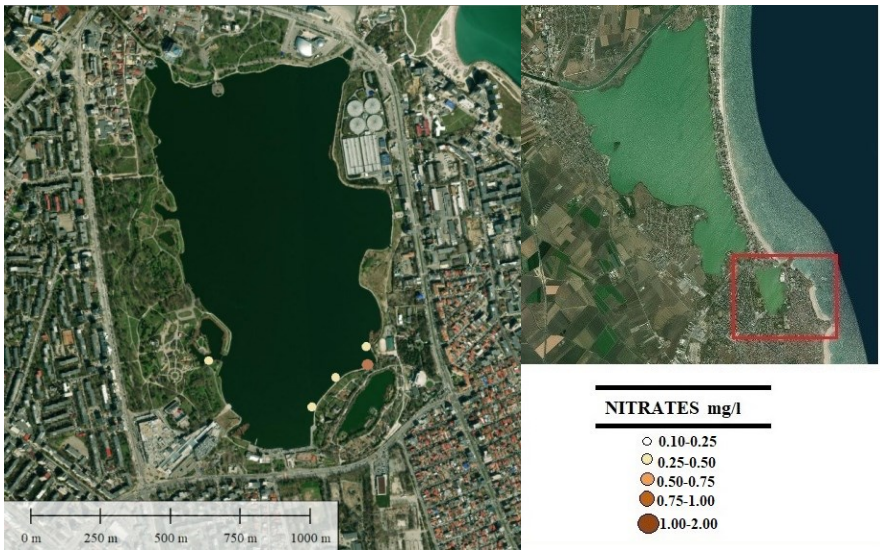

Fig.10. Variation of average nitrates concentrations (mg/L) among the stations

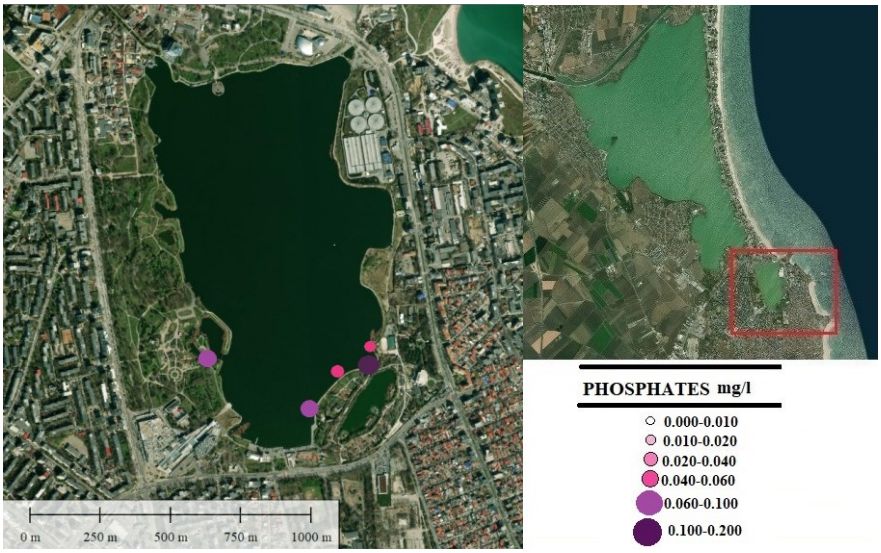

Fig. 11. Variation of average phosphate concentrations (mg/L) among the stations

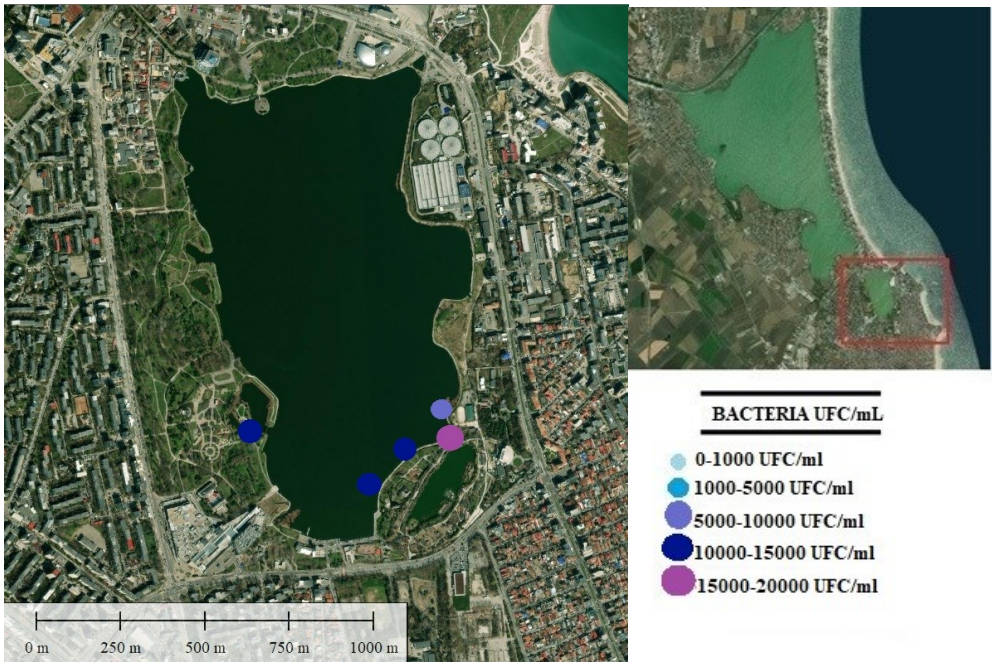

Fig. 12. Variation of average bacterial contamination (CFU/mL) among the stations

In 2008, a study of bacterial contamination in Tabacarie lake (unpublished data) during IRES project, using chemiluminescence, showed that the input into Tabacarie lake from Siutghiol lake is 18.561 RLU/ml while the output from lake Tabacarie into Black Sea is 227.311 RLU/ml, which indicates Tabacarie lake as a possible source of bacterial contamination.

The study of [1] regarding the bacteria screening of Mamaia beaches, showed that a number of 560 bacteria species are present both in sand and water, species like *Escherichia coli, Proteus sp., Klebsiella sp., Pseudomonas sp., Enterobacter, Citrobacter, Serratia sp., Enterococcus sp. Staphylococcus aureus*.

From quantitative point of view, total coliforms isolated in the sea water had normal concentration (< 100 CFU/mL) in all samples harvested from Mamaia beach, except the ones obtained from the area near the site of communication with Tabacarie lake, where higher proportion of fecal coliforms flora (sea water - 160 CFU/mL; dry and wet sand - 350 CFU/g) were identified.

All these studies confirm our results of existing a bacterial contamination source in Tabacarie lake.

Conclusions

Our results showed that the discharge from the Micro-Reservation channel is a source of nitrates, phosphates and bacteria in Tabacarie lake. Annual average nitrates concentrations varied between 0.275 to 0.525 mg/L, with the highest value in station 4, while phosphates annual average concentrations varied between 0.05 and 0.135 mg/L, the highest concentration being recorded in station 4 (Micro-Reservation channel).

Overall, the highest bacterial concentration was in station 4, with an average value of 16507 CFU/mL, compared with the other stations. Information on the seasonal abundance of bacterial communities in Tabacarie lake is still far from complete, so more year-round studies are needed, especially for this urban lake, where many bacterial sources can be found.

Tabacarie lake can be a possible source of bacterial contamination of the Black Sea waters.

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