INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ENVIRONMENT & GEOGRAPHY
www.kwpublications.com
ISSN: 2313-769X

Variations of The Physicochemical Parameters of Water in Lake Titan 2 and Non-Conforming Sanitation Practices in The Alexandru Ioan Cuza Park in Sector 3 of Bucharest

Felicia Benciu, Gabriela Taulescu, Elena Bogan, Liliana Bujor, Anca Apati, Dana Maria (Oprea) Constantin

To Link this Article: http://dx.doi.org/10.46886/IJAREG/v9-i1/7385 DOI: 10.46886/IJAREG/v9-i1/7385

Received: *27 December 2021*, ***Revised:*** *20* January 2022*,* ***Accepted:*** *0*8 February 2022

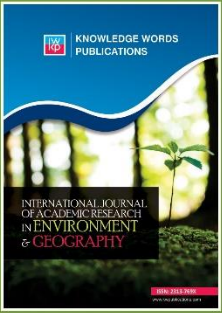
Published Online: *28* February 2022

In-Text Citation: (Benciu et al., 2022)

To Cite this Article: Benciu, F., Taulescu, G., Bogan, E., Bujor, L., Apati, A., & Constantin, D. M. (Oprea). (2022). Variations of The Physicochemical Parameters of Water in Lake Titan 2 and Non-Conforming Sanitation Practices in The Alexandru Ioan Cuza Park in Sector 3 of Bucharest. *International Journal of Academic Research in Enviornment & Geography*, *9*(1), 13–35.

Vol. 9, No. 1 (2022) Pg. 13 - 35

https://kwpublications.com/journals/journaldetail/IJAREG | **JOURNAL HOMEPAGE**



INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ENVIRONMENT & GEOGRAPHY
www.kwpublications.com
ISSN: 2313-769X

Variations of The Physicochemical Parameters of Water in Lake Titan 2 and Non-Conforming Sanitation Practices in The Alexandru Ioan Cuza Park in Sector 3 of Bucharest

Felicia Benciu[1], Gabriela Taulescu[1], Elena Bogan[2], Liliana Bujor[3], Anca Apati[1], Dana Maria (Oprea) Constantin[2]
[1]Ecological University of Bucharest, The Faculty of Ecology and Environment Protection, Romania, [2]University of Bucharest, Faculty of Geography, Romania, [3]Environmental consultant, external expert, Bucharest, Romania
Email: felidumitru@yahoo.com, elena.bogan@yahoo.com, lilianabujor@yahoo.com, danamartines@yahoo.com

Abstract
The variation of the physicochemical parameters of lake waters is a natural process occurring seasonally and annually. Depending on climate characteristics such as temperature and precipitation, aridity and drought may occur in summer. The chemical parameters of water may undergo changes due to evaporation. Anthropic activity may influence these natural variations with a largely negative impact. Changes in the water of Lake Titan 2 in the Alexandru Ioan Cuza Park were monitored over a three-and-a-half-year period, between 2017-2020. The changes in the physicochemical parameters were studied yearly and seasonally and their effect on the lake ecotope were observed. Conclusions were drawn which showed that the anthropic actions result in changes of water quality and impact the vegetation and fauna of the lacustrine environment of Lake Titan 2.

Keywords: Physicochemical Parameter Variation, Water Quality, Impact, Lake Titan, Anthropic Activity

Introduction

The new meaning of the term *geochemistry* goes beyond the boundaries imposed by the initial definition of geochemistry, being related to applied geochemistry and environmental chemistry. Together with its related disciplines, environmental geochemistry is also known as landscape geochemistry. In academic literature, the approach to *landscape geochemistry* nears the approach of *landscape ecology*, which is becoming more and more important in the development of environmental science. Current research predicts that landscape geochemistry is tending toward an integrative approach and may, in the next years, take the form of a global landscape geochemistry (Fortesque, 1990).

Since 2007, our country has fully adopted the European Union legislation regarding the environment. Consequently, water monitoring is done in accordance with the Water Framework Directive 2000/60/EC, implemented in national law by Law no. 310/2004 for the amendment and completion of Law no. 107/1996 regarding waters. Water quality is established by laws, rules and standards that stipulate for maximum permissible limits of the physicochemical parameters (Benciu, 2016). Pressures exerted on water quality are generated by anthropic activities such as: discharges of non-purified or incompletely purified waste water, urban agglomerations, nutrient and pesticide emissions from agriculture, hydrotechnical works for river and lake development (Breabăn and Breaban, 2020).

The analysis of monitoring parameters involves the analysis of chemical constants that outline geochemical deviations due to natural and anthropic processes in an ecosystem. Geochemical deviations occurring in the biosphere and resulting in their natural dispersion are associated to temporary states of chemical elements (Demetriades *et al.*, 2018). Relative to the reference system of the monitored environmental parameter, geochemical anomalies may be positive or negative. According to their origin, these are divided into natural geochemical anomalies and technogenic geochemical anomalies (Lungu and Dragomir, 2016).

Technogenic geochemical anomalies are related to anthropic activities directly impacting the environment. Depending on the affected geographical layer, these are subdivided in: atmospheric geochemical anomalies, pedological geochemical anomalies, hydrochemical and lithochemical, phytochemical and zoochemical anomalies (Demetriades *et al.*, 2018)

Study Area

Lake Titan 2 is managed by the Public Domain Administration of the municipal authority of sector 3 of the capital. The survey is aimed at monitoring the physicochemical changes occurred in the lacustrine environment over a three-and-a-half-year period. For the year 2020, the analysis of the chemical parameters of water was done in the first six months, comprising time intervals from the winter, spring and summer seasons. The research will follow the seasonal and yearly variation of the physicochemical parameters and will outline the impact of the aquatic and land sanitation practices applied by the park administration (Benciu, 2020).

The Alexandru Ioan Cuza Park, also known by its generic names Titan Park or IOR Park, is located in the eastern part of Bucharest, in the Balta Albă - Titan district of sector 3 of the capital (Figure 1).

Vol. 9, No. 1, 2022, E-ISSN: 2313-769X © 2022 KWP

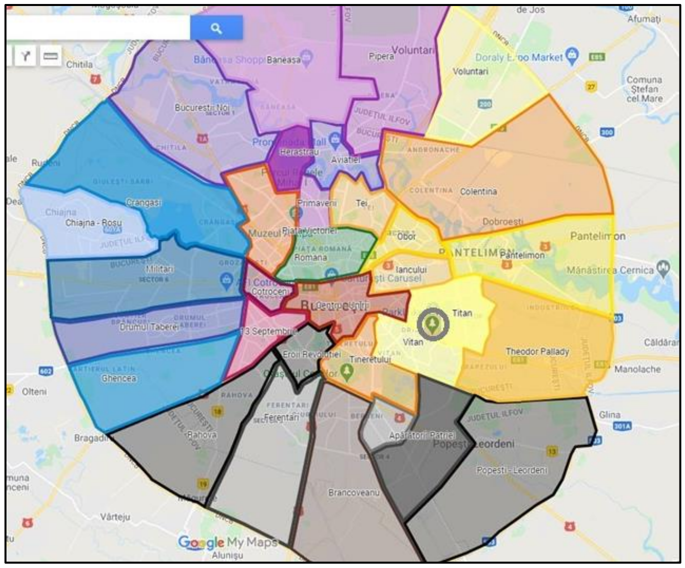


Figure1. Location of the Titan - Balta Albă district within the perimeter of Bucharest, 2021[1]

Archeological discoveries have revealed Neolithic Thraco-Dacian settlements in the Dudești, Cățelu and Glina areas, the first of them belonging to the Dudești culture and the more recent ones to the Boian culture. The subsequent historical periods attest to the continuous habitation of this part of the present-day Titan - Balta Albă district. The State Central Military and Historical Archive in Moscow contains a plan of Bucharest dating from 1770, drawn up by Russian officers. The plan shows that the city limits at that time were marked by the current artery roads: Mihai Bravu, Ștefan cel Mare, Plevnei street, Elefterie, Dealul Spirei, Dealul Filaret, Dealul Piscului and Dudești (Papazoglu, 2006). Hence one can draw the conclusion that, during the first half of the 18th century, the surveyed area wa.s enclosed in the capital, the Dudești area being located in its eastern part. Figure 2 shows the location of the Balta Albă area between 1806-1812.

The current Titan - Balta Albă district came into existence by the assimilation of the then Dudești - Cioplea township into Bucharest proper. The history of the district begins in 1813-1814, when Bucharest was struck by a bubonic plague epidemic that went on to be known as “Caragea’s plague”. Due to the high number of casualties and the impossibility of proper burial, the authorities at the time decided for their burial in the Dârstor mass grave. Historical documents record that Balta Albă was a large swampy area, where the bodies of the plague casualties were neutralized with quick lime and sand and were then covered with earth. Even in less than abundant rain, water stagnated over the closed grave and turned into a succession of whitish pools created by the quick lime, giving the landscape a grim note. In his letters to poet Vasile Alexandri, the politician Ion Ghica writes “In memory of those taken by the plague, the parish and, later, the district took the name of Balta Albă” (Papazoglu, 2006).

[1] https://i0.1616.ro/media/2/2621/33219/20006679/1/zone-bucuresti.jpg?height=581&width=700

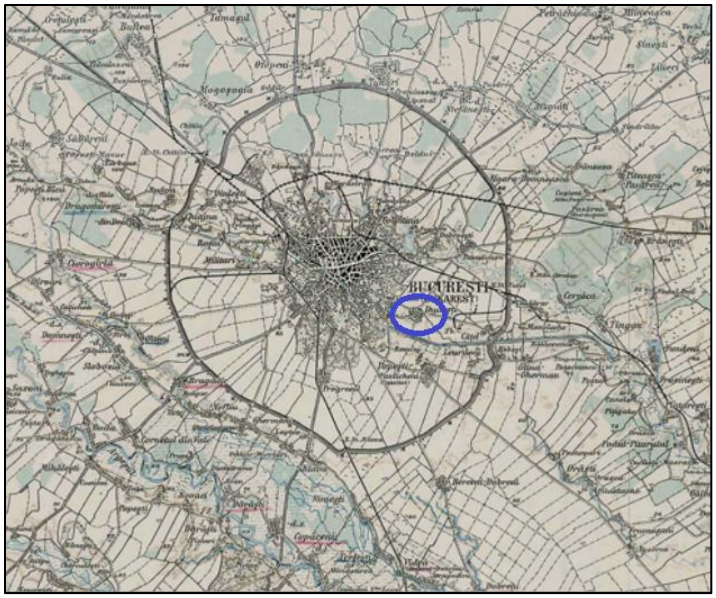


Figure 2. Location of the Titan Park between 1806-1812[2]

In 1845 the Dudești area hosted one of the six markets of Bucharest, named *the market on the Dudescului greenfield*. Although the city center is being modernized, the peripheral districts, still named slums, lacking infrastructure and utilities, remain deeply rural.

Most of the blocks of flats currently existing in the Titan - Balta Albă district were erected during the socialist-communist period. Between 1963 and 1964, the Titan Park is developed for the first time on the terrain where the former quick lime and sand pits used to be[3]. The Titan Park, later also known as the IOR Park (borrowing the acronym of Întreprinderea Optica Română, located very near the park) was developed in two stages: before 1989 in the sector between the Câmpia Libertății street, Baba Novac street, Constantin Brâncuși street, the Nicolae Grigorescu boulevard and the Liviu Rebreanu street to the bridge; and after 1990, beyond the bridge, in the sector previously known as Flax, extending between Liviu Rebreanu street and Lotrioara and Intrarea Odobești streets, towards the Camil Ressu boulevard. After 1990, the park's name is changed to Alexandru Ioan Cuza.

Currently, the park is managed by the Public Domain Administration of the municipal authority of sector 3, which is tasked with its development and maintenance. By area, the Alexandru Ioan Cuza Park is the largest park of sector 3 and the second largest in the capital, after the King Michael I of Romania Park (former Herăstrău Park).

The geographical characteristics of the Alexandru Ioan Cuza Park are given by its 85-hectare area, of which the water surface takes about 50 ha.

- The park contains two aquatic basins, Lake Titan 1 and Lake Titan 2, communicating via a lacustrine basin narrowing of about 5 m. The lake surface includes five small islands: Retirees'

[2] https://www.fotoshooting.ro/arhiva-foto-cu-vechiul-bucuresti-bucuresci-old-bucharest-photo-archive-partea-3/

[3] https://adevarul.ro/news/bucuresti/istoria-ciudata-cartierului-bucurestean-titan-groapa-carecadavrele-ciumatilor-erau-stropite-var-nestins-1_558abef3cfbe376e3591ce4d/index.html

Island ("Insula Pensionarilor") and Duck Island ("Insula Rațelor") on Lake Titan 1 and Art Island ("Insula Artelor"), Dog Island ("Insula Câinilor") and Fishermen's Island ("Insula Pescarilor") on Lake Titan 2, shown in Figure 3.

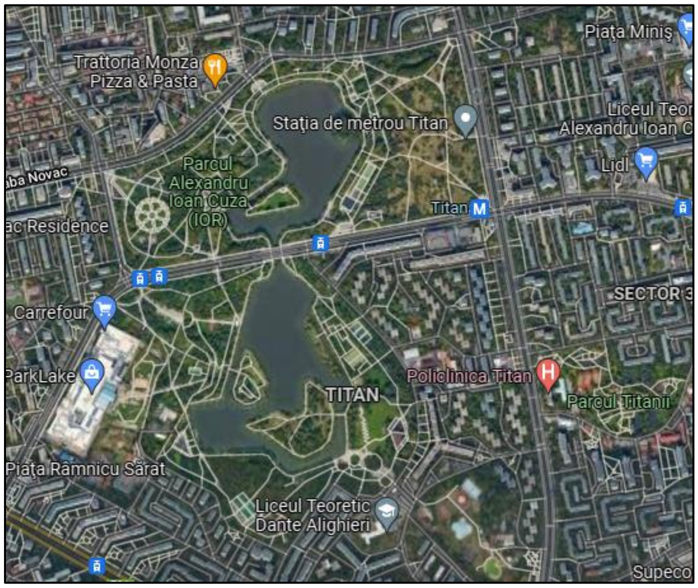


Figure 3. The Alexandru Ioan Cuza Park and Lake Titan, 2021
Source: https://www.google.ro/maps/

- The lake is located in a plain area - the Vlăsiei Plain, also known as Bucureștilor Plain, with an average elevation of 60 meters (above Black Sea level) and shallow slopes of 1-2°, has large intefluves and a low density of the hydrographic network. The park as a whole is shaped as a terraced basin with a level topographical surface in its central-northern part (Lake Titan 1) and hilly-undulated in its southern part (Lake Titan 2). Elevations do not exceed 20-22 m in the south-western part of the park (above the local lake level) (Taulescu, 2016).

- The climate is temperate-continental with aridity elements specific to the Romanian Plain. Winters are relatively mild, and periods of excessive frost, when temperatures drop below -10 to -15°C are limited to a few days a year. Summers are very hot, sometimes canicular. In recent years, the number of days with very high temperatures, above 35°C, has risen, which makes for a high annual temperature variation of about 50°C. Precipitation is around 500 mm/year, but its distribution is uneven in relation to the city center and its periphery (Ion Bordei and Taulescu, 2017). Also, in recent years, an increase in summer tempest frequency, precipitation torrentiality and wind intensity has been recorded in the peripheries. It is known that, due to atmospheric pollution, the Bucharest metropolitan area has developed its own local climate (Ion Bordei and Gogu, 2000).

- Ground and surface waters belong to the Argeș - Vedea hydrographic basin. According to the Argeș - Vedea Hydrographic Area Management Plan, updated for 2016-2020, the groundwater network is well represented by phreatic aquifers ROAG03 and by deep groundwater aquifers ROAG 11. The two aquifers partially overlap. The hydrographic network is represented by the regulated flows of Dâmbovița in the south and Colentina in the north, both located at a considerable distance from the park.

- Due to soils having been strongly changed by anthropic activity, types *erodisols* and *anthrosols* of the Anthrisol class predominate in the area covered by the capital. The soils in this class lack A and E horizons, which were removed by accelerated erosion or by anthropic decapitation. Erodisols originating from land stripping are called decosols; they have a low organic matter content and poor aero-hydric behavior. Anthrosols are largely present in areas where the initial soil was deeply changed (leveling and compaction works, areas where a water layer is maintained for long periods of time) (Scrădeanu, 2017).

- The natural steppe and sylvo-steppe vegetation has been completely replaced by urban plantations where ornamental species (tree, shrub and flower species) and urban pollution-resistant tree species were used.

- The water and land ecosystem of the park is made up of the vegetation and fauna specific to wetlands. For instance, Duck Island (Insula Rațelor), whose shore is dominated by natural vegetation, has become a little ecosystem permanently inhabited by dozens of animal species (*Cygnus olor* swans, *Anas platyrhynchos* wild ducks, *Trachemys scripta* and *T. s. elegans* turtles, *Natrix tessellata* aquatic snakes, Bucharest's *Larus michaellis* yellow-legged gulls, insects of the Hexapoda order). Duck Island is closed to visitors as it is a protected area.

- Dog Island covers an area of 2,60 hectares and is the largest island in the Alexandru Ioan Cuza Park. In the spring of 2015, the island was developed as a special area for pets. It is important the natural wetland vegetation is preserved on the island: willows (Salix alba), pines (Pinus wallichiana), bald cypress or swamp cypress (Taxodium distichum) and European alder shrubs (Alnus glutinosa).

Factors that can impact the lake chemistry are of *natural origin*: abundant precipitation, aridity and droughts that can cause excessive evaporation of the lacustrine water and can modify the gas composition of the water, as well as water eutrophication. Factors of *anthropic origin*, such as pollution by chemicals derived from sodium and phosphates cause the nutrient enrichment of the water, further exacerbating the eutrophication process. Expert surveys regarding land and water pollution in the parks of Bucharest were also conducted in previous years. One example is the ample project in 2007, "Urban Environment Monitoring and Warning System (AIR-AWARE) - Structural and Functional Diversity of Anthropic Areas in Romania", with the topic *The Effect of Heavy Metals on Acarian Communities (Acari: Gamasina) in the urban parks of Romania*. The survey was conducted by the Institute of Biology and the Emil Racoviță Institute of Speleology of the Romanian Academy, both located in Bucharest, for three parks located in the center of the capital: Cișmigiu, Unirea and Izvor. For each park, water and soil samples were analyzed in three transects, after prior determination of pollution sources for each area (Manu *et al.*, 2018).

Water quality is defined by all the criteria for determining water quality, by quality indicators and parameters, as well as by their quality standardized values.

According to their nature, quality indicators are divided into: organoleptic indicators, physical indicators (pH, electrical conductivity, turbidity, color), chemical indicators and toxic chemical indicators, radioactive indicators, bacteriological and biological indicators.

According to their effect on water, the indicators can be classified as: general physicochemical indicators (t°C, pH), selective physicochemical indicators and specific (toxic) physicochemical indicators, oxygen indicators (OD, CBO_5, CCO_r and CCO_{Mn}), mineralization indicators and radioactivity indicators (Lungu and Dragomir, 2016).

Water quality is assessed mainly by physicochemical assays that would provide numerical values of parameters such as: overall mineral or organic compounds, dissolved gasses, suspended solids and suspended live organisms. By comparing the results to the water quality standards for Romania, the water quality (Lungu, 2016) in a predefined aquatic area can be determined (Benciu, 2019).

In this context, students and master students of the Faculty of Ecology and Environmental Protection under the guidance of scholars of the Faculty of Ecology and Environmental Protection within the Ecological University of Bucharest and of the Faculty of Geography within the University of Bucharest, decided to monitor de quality of the water of Lake Titan 2 in the Alexandru Ioan Cuza Park in sector 3 of the capital over a three-and-a-half-year period.

The survey of the water of Lake Titan 2 as an environmental factor approaches pollution from an ecological perspective by integrating the manner of treating and interpreting collected data into the analytical system applied in similar research to other Bucharest parks.

Methodology

The stages of water quality research for Lake Titan 2 were identified considering the aim pursued and based on known aspects:

- Stage 1 – Determining the aim of the research and preparing for the stage on site. The proposed aim was identifying the causes of the changes in the chemical parameters of the lake water over a three-and-a-half-year period.
- Stage 2 – Preparing the Plan for monitoring the physicochemical parameters of the water in Lake Titan 2 for the 2017-2020 period.
- Stage 3 – Data collection and graphical processing. The research comprised preliminary data collection, data consolidation and graphical modeling. Also, via comparison, changes in the values of chemical parameters of water were identified.
- Stage 4 – Results. Final results brought about the identification of the established scope (identification of the causes of the changes in physicochemical parameters of water in Lake Titan 2) that lay as the basis for formulating conclusions.
- Stage 5 – Conclusions and suggestions. Based on the conclusions obtained, several suggestions were formulated for limiting or mitigating the eutrophication of the lake water in summer.

The research proper adhered to the established work stages and to the established aims, as follows:

During the first stage the monitoring schedule, the observation and data collection points and the water sampling point at the of Lake Titan 2 were established, as shown in Figure 4.

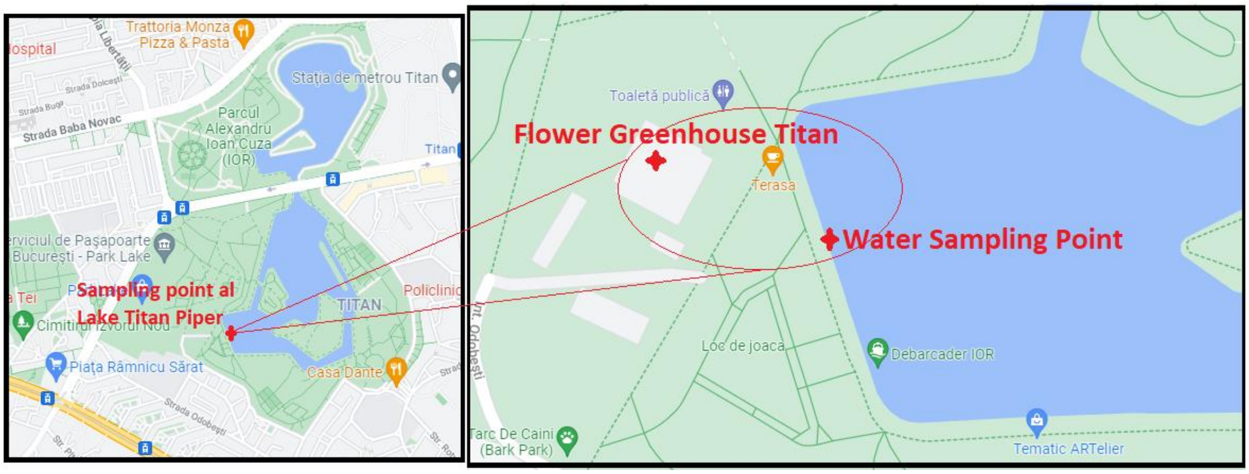


Figure 4. Map of the Alexandru Ioan Cuza Park and the water sampling point
Source: https://www.google.ro/maps/place/Alexandru+Ioan+Cuza+Park+(I.O.R.)/

When selecting the sampling point, the aim of the research was considered: establishing the seasonal and annual concentrations for 11 physicochemical parameters, of which two parameters were aimed at two heavy metals, nickel (Ni^+) and lead (Pb^+), and identifying the anthropic activities that cause or exacerbate variations in the physicochemical parameter of the lake water. Also, the sampling point was selected to be near the botanical garden - greenhouse area as, during the documentation period, the company managing the park was observed to constantly discharge the water surplus from the greenhouses into Lake Titan 2. This anthropic influence induces changes in the chemical parameters that reflect on their resulted annual values.

During the second stage the schedule for measuring the parameter values in various seasons over a three-and-a-half-year period (2017-2020) and emphasis was placed on measurements during the rainy season and the arid season. For 2020, measurements were taken in the first 6 months of the year, including parts of the cold season (fall-winter) and the warm season (spring-summer).

Following data processing, it was noted that the variation of physicochemical parameters is determined by the seasonal temperature (spring, summer, fall and winter), by the dissolved O_2 (DO) content which is especially important in spring, during the transition from a closed ecological system (winter) to an open ecological system (spring, summer and fall). Summer is characterized by carbon dioxide and dissolved oxygen exchanges, by nutrient enrichment (nitrites, nitrates and sulfates) which leads to lake water eutrophication and to plankton blooms (i.e. the excessive development of aquatic microorganisms). Towards the end of the fall, when temperatures drop, the dissolved oxygen content also drops and the decomposition of microorganisms occurs. This entails the discharging of carbon dioxide (CO_2), hydrogen sulfide (H_2S) and ammonium (NH_4^+), the whole process resulting in the proliferation of saprotrophs. Thus, *reduced chemical species* (carbon dioxide, ammonium, hydrogen sulfide etc.) are prevalent during the cold season, while *oxidized chemical species* (nitrites, nitrates, sulfates etc.) are prevalent during the warm season, when the dissolved oxygen content increases (Benciu, Palade and Olaru, 2006). Figure 5 shows the diagram of microorganism evolution at a seasonal level.

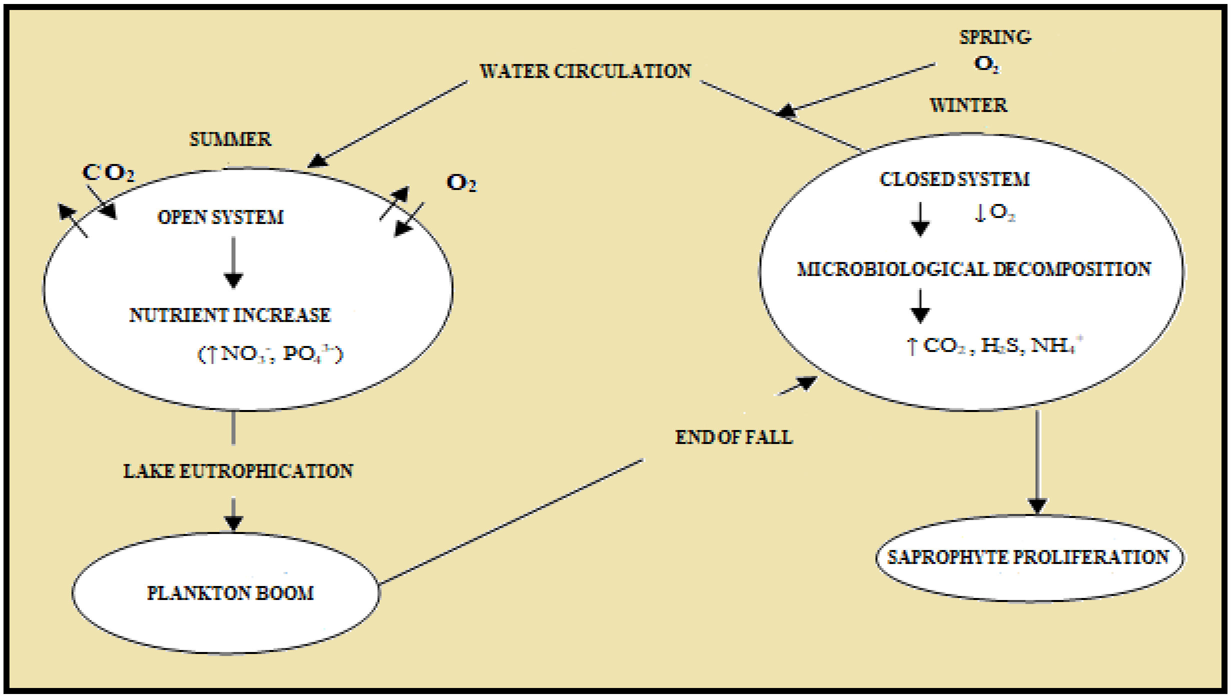


Figure 5. Seasonal variation of microorganisms due to chemicals present in the lake water

The blank assay. It was determined that should differences be found in the concentrations of the chemical parameters from year to year following the assay of the water samples from Lake Titan 2, these changes are to be attributed to the influence of the anthropic factor and the cause of the increase or decrease of the contribution of one or more of the water quality indicators is to be determined subsequently.

In order to perform a correct assessment of the anthropic impact, both domestic recreational activities and sanitation activities for the botanical garden - greenhouse area (which is managed by the park authority) were taken into consideration. Thus, it was established that there should be a single sampling point near the greenhouses and that the number of samples should be relevant to the research in order to eliminate potential deviations/errors.

For the *in situ* and laboratory assay of the physicochemical parameters, the following devices were used:

- A pH meter was used for measuring temperature, pH, conductivity and TDS (total dissolved solids).
- An oximeter was used for measuring DO (dissolved oxygen) and temperature.
- A turbidimeter is an instrument based on an optical system of light transmission via fiber optic. This was used for measuring water turbidity (NTU).
- A Cecil spectrophotometer is an instrument that can precisely measure the amount of photons (light intensity) absorbed upon passing through a sample (solution). Thus, the content (concentration) of substance in the water can be indirectly determined.

The results of the annual variation of the physicochemical parameters of the water in Lake Titan 2 from 2017 until 2020 are shown in Table 1.

Table 1. Annual variation of the physicochemical parameters, 2017-2020

Physicochemical parameter	Measurement unit	Year 2017	Year 2018	Year 2019	Year 2020
pH	-	8.35	8.25	8.15	8.45
Electrical conductivity χ	µSiemens/ cm	1041	1079	1150	1180
TDS	mg/l	666	765	860	870
Turbidity	NTU	0.81	2.35	4.05	4.10
$[O_2]$	mg/l	3.33	3.36	3.40	3.40
NH_4^+	mg/l	0.77	0.80	0.80	0.65
NO_3^-	mg/l	2.35	2.48	3.05	3.38
NO_2^-	mg/l	0.09	0.09	0.08	0.15
PO_4^{3-}	mg/l	0.10	0.15	0.15	0.15
Ni^{2+}	mg/l	0.31	0.29	0.30	0.30
Pb^{2+}	mg/l	0.060	0.058	0.060	0.058

For the seasonal variation, the results obtained from October 2019 until May 2020 are shown in Table 2.

Table 2. Seasonal variation of the physicochemical parameters, October 2019 - May 2020

Physicochemical parameter	Measurement unit	Oct 2019	Nov 2019	Dec 2019	Jan 2020	Mar 2020	May 2020
pH	-	8	9.18	9.05	8.84	8.54	8.24
Electrical conductivity χ	µSiemens/ cm	1055	1124	1155	1186	1188	1237
TDS	mg/l	675	720	739	759	763	765
Turbidity	NTU	4.35	2.62	1.58	1.10	1.96	3.28
$[O_2]$	mg/l	3.40	3.35	2.65	1.45	2.17	3.07
NH_4^+	mg/l	0.08	0.11	0.20	0.86	0.47	0.09
NO_3^-	mg/l	3.05	2.35	2.05	1.05	2.14	2.29
NO_2^-	mg/l	0.09	0.07	0.07	0.07	0.17	0.26
PO_4^{3-}	mg/l	0.31	0.11	0.10	0.09	0.18	0.29

For this interval, the concentration of heavy metals (Ni^+ and Pb^{2+}) was no longer assayed since it was found that the values of these parameters did not vary significantly during the 3 years of observation.

Results and Discussions

For a correct interpretation of the results, the Romanian standard for lake water was used (STAS 161/2006 - https://www.asro.ro/lista-standarde-calitatea-apei/), a standard developed by the National Standardization Authority and shown in Table 3, while for comparing the evolution of parameter values the results of surveys conducted in previous years 1994-1995 and included in expert documentation were used (Benciu *et al*., 2006).

According to maximum admissible limits specified by STAS 161/2006, concentration values for heavy metals Ni^+ and Pb^+ situate the lake water within quality class V. Any excesses are attributed to heavy traffic on Liviu Rebreanu Boulevard. This two-way road main with four lanes divided centrally by two tram lines follows the bridge connecting the two lacustrine basins Titan 1 and Titan 2. On the other hand, the park area surrounding Lake Titan 1 is delimited by four lane main roads Baba Novac and Constantin Brâncuși.

Table 3. Values of quality classes according to STAS 161/2006 for measured physicochemical parameters

Physicochemical parameter	Measurement unit	Quality class I	Quality class II	Quality class III	Quality class IV	Quality class V
pH	-	INTERVAL: 6.5 - 8.5				
Electrical conductivity (χ)	µS/ cm	INTERVAL: 1000 - 3000				
TDS	mg/l	500	750	1000	1300	>1300
Turbidity	NTU	INTERVAL: 5 - 10				
$[O_2]$	mg/l	9	7	5	4	<4
NH_4^+	mg/l	0.4	0.8	1.2	3.2	>3.2
NO_2^-	mg/l	1	3	5.6	11.2	>11.2
NO_3^-	mg/l	0.01	0.03	0.06	0.3	>0.3
PO_4^{3-}	mg/l	0.1	0.2	0.4	0.9	>0.9
Ni^{2+}	mg/l	0.01	0.025	0.05	0.1	>0.1
Pb^{2+}	mg/l	0005	0.01	0.025	0.05	>0.05

Source: STAS 161/2006 (excerpt)

Evaluation of Physicochemical Parameters. The comparison of the values of the nine physicochemical parameters shown in Table 3 was based on results of research undertaken over a two-year period (1994 and 1995) concerning these indicators. Measurements were taken during the rainy season of the fall of 1995 and the dry season of the summer of 1994. Their results are shown in Table 4:

Table 4. Seasonal variation of the physicochemical parameters of the water in Lake Titan 2 for the dry season (1994) and the rainy season (1995)

Physicochemical parameter	Measurement unit	Dry season/Summer (1994)	Rainy season/Fall (1995)
pH	-	8.30	8.28
Turbidity	NTU	1.15	1.10
$[O_2]$	mg/l	3.30	3.40
TDS	mg/l	937	930
PO_4^{3-}	mg/l	0.06	0.04
NH_4^+	mg/l	0.07	0.05
NO_3^-	mg/l	2.73	2.27

For 1994 and 1995, there are no data regarding the electrical conductivity (χ), the concentration of nitrite ions NO_2^- and the concentration of heavy metals Ni^+ and Pb^+.

Analysis of the annual variation of the physicochemical parameters (2017-2020). Values obtained over the three-and-a-half-year period for the physicochemical parameters *pH* and *electrical conductivity* show that these do not vary significantly, the lake water thus falls within in quality class I.

For both physicochemical parameters *total dissolved salts (TDS)* (Figure 6) and *turbidity* (Figure 7), a gradual increase is found over the 2017-2019 period. The increase in turbidity is significant for the first three years even though the recorded values situate the lake water in quality class II-III. The cause of these increases should be identified in order to stop that phenomenon as soon as possible.

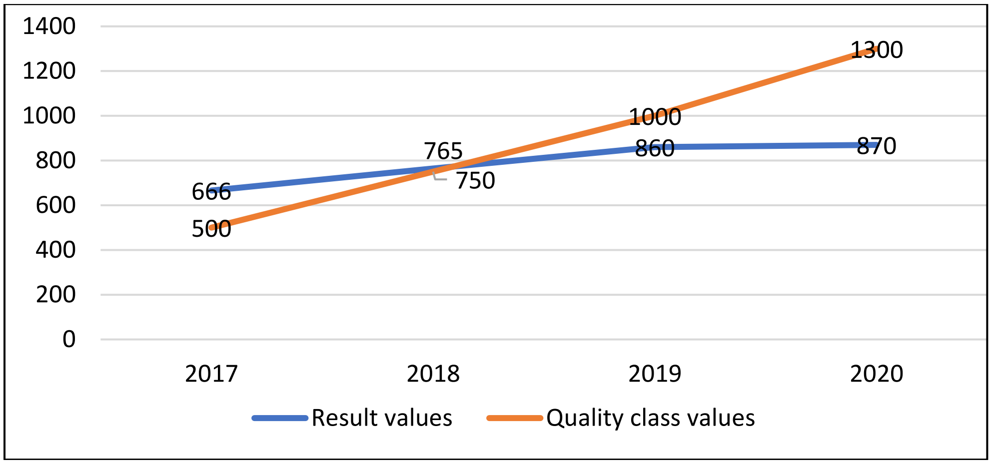


Figure 6. Annual variation of TDS, 2017-2020

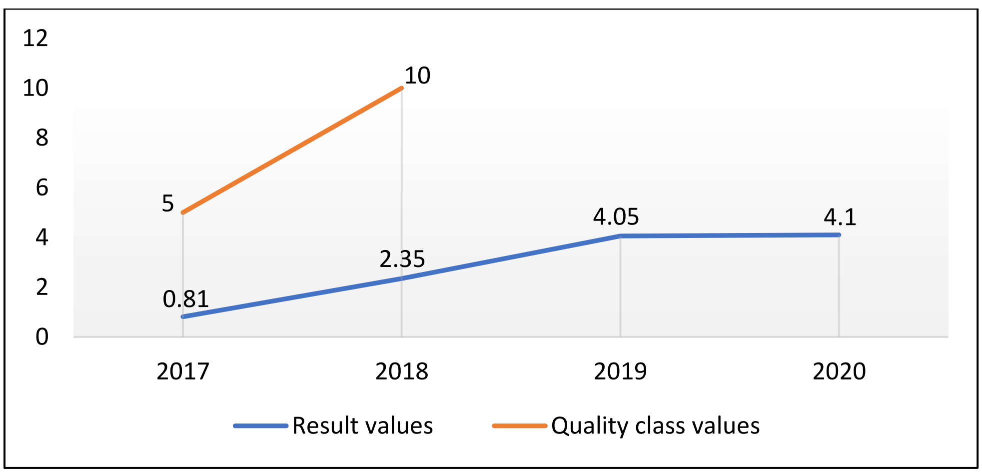


Figure 7. Annual variation of turbidity, 2017-2020

As far as turbidity is concerned, it is found that it greatly increases by 2-4 nephelometric units over a three-and-a-half-year period. This phenomenon can be correlated with the beginning of street dusting using portable blowers.

For *dissolved oxygen (DO)* in Figure 8, very low values are found, which demonstrates a weak water current aeration/circulation and high biochemical consumption. This results in excessive algal bloom and the start of the lake water eutrophication. The values of these parameters situate the water of Lake Titan 2 in quality class II-III.

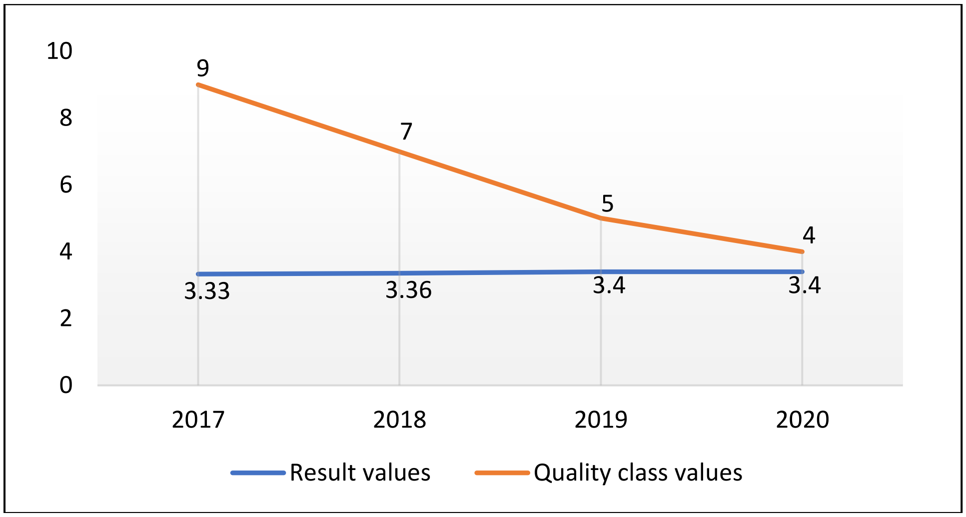


Figure 8. Annual variation of dissolved oxygen concentration, 2017-2020

If a correlation is made to the values of the *nitrogen-ammonium, nitrite and nitrate concentration* (Figure 9 and Figure 10), a great increase of those values is found. This increase can be correlated to water eutrophication, easily observable in summer, when temperatures are high, precipitation is low and the biochemical consumption of oxygen by organisms present in the water promote this process.

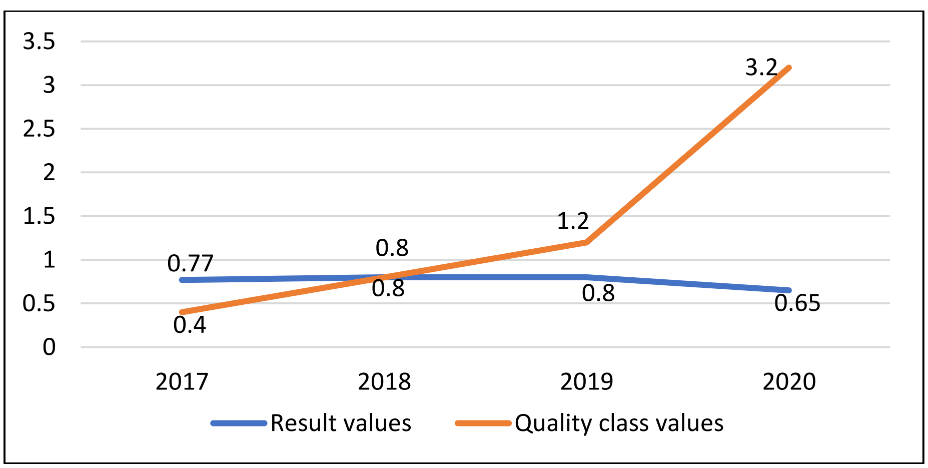


Figure 9. Annual variation of the ammonium ion NH_4^+ concentration, 2017-2020

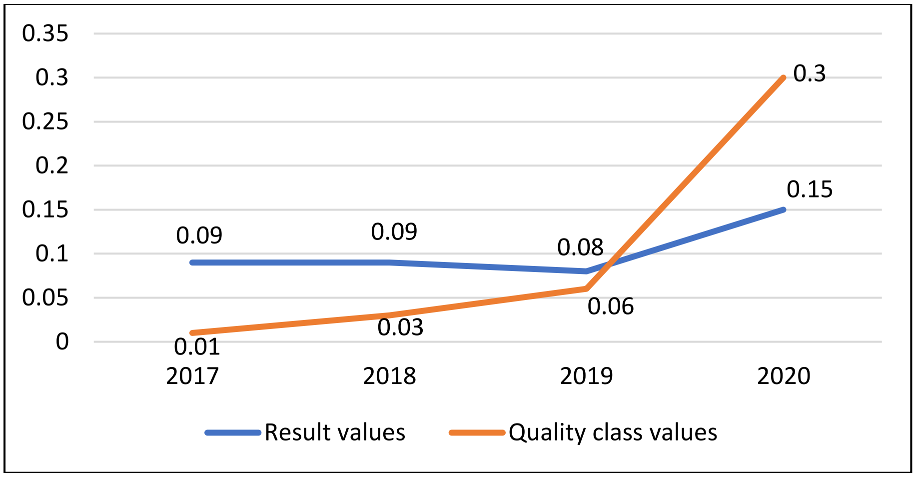


Figure 10. Annual variation of the nitrite ion NO_2 concentration, 2017-2020

Over the first two years of observation (2017 and 2018), nitrogen content parameter values fell within water quality class I, while over the next one and a half year, 2019-2020, the nitrate ion concentration increased steadily, situating water quality within class II, as can be seen in Figure 11 below.

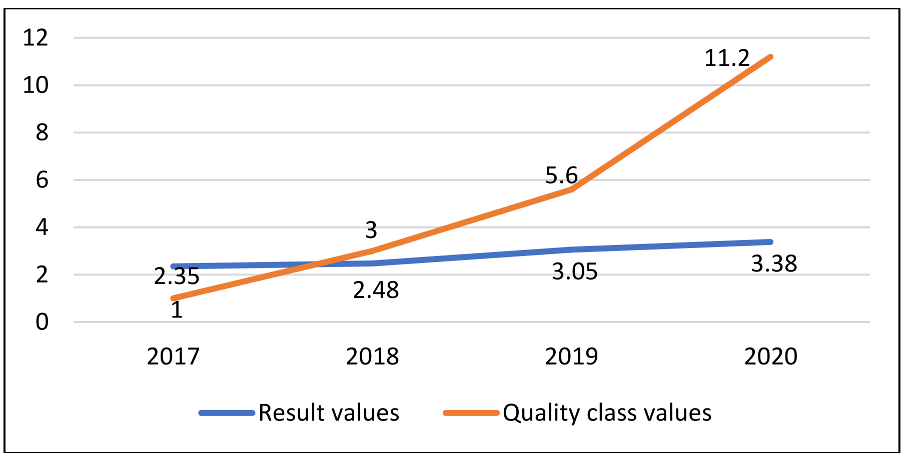


Figure 11. Annual variation of the nitrate ion NO_3^- concentration, 2017-2020

The interpretation of the nutrient increase in the water of Lake Titan 2 can be correlated to the non-conforming procedure of discharging the excess water from the greenhouse area in 2018, when they were set up. Taking into account that the lake waters falls within quality class II/III, the presence of excess nutrients in water becomes directly responsible for the rapid development of lacustrine microorganisms and organisms. This will result in a gradual increase of the biochemical oxygen consumption and, in the end, will cause the eutrophication of the lake water.

Analysis of the seasonal variation of the physicochemical parameters. For the comparison of seasonal variations over the 2017-2020 period, the reference systems will consist of results of research conducted in 1994 and 1995, shown in Table 4 above (Benciu and Palade, 2006). By comparative analysis of the data, an increase or decrease of the values of the analyzed chemical parameters could be found which in turn will allow for conclusive results to be obtained regarding the quality of the water in Lake Titan over a 25-year period.

By analyzing *pH* and *electrical conductivity* values shown by graph in Figure 12, it can be found that the pH varies slightly, by only 0.02 units, between the rainy fall season and the dry summer season (1994-1995). For the fall-winter (2019-2020) fluctuation, the variation is greater, with a difference of 0.30 units. Overall, pH variation over the 25-year period is relatively small (8.28-8.45), therefore this parameter situates the water of Lake Titan 2 within quality class I.

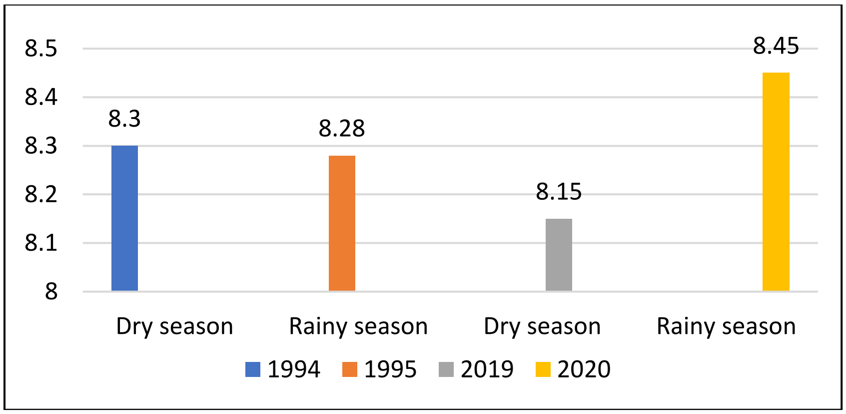


Figure 12. Seasonal variation of pH, 1994-1995 and 2019-2020

For *turbidity,* over a 25-year period, it is found that values increase greatly by 3 NTUs (nephelometric turbidity units), as shown by the graph in Figure 13. This phenomenon can be correlated to the daily use of portable leaf blowers for cleaning the park alleys.

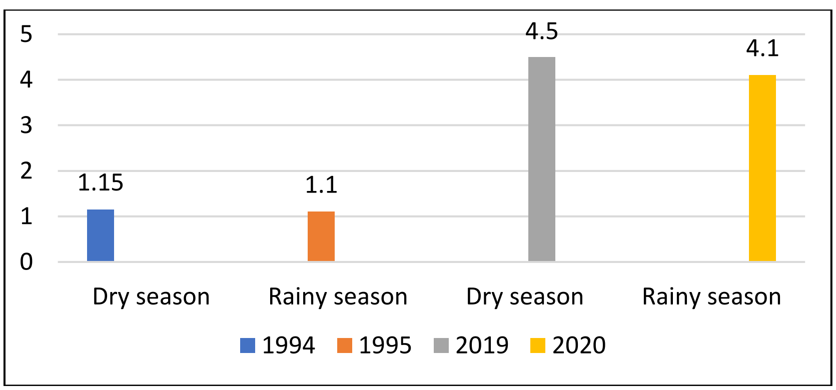


Figure 13. Seasonal variation of turbidity, 1994-1995 and 2019-2020

By analyzing summer-fall (1994-1995) and fall-winter (2019-2020) seasonal variations, a correlation is found between the concentration values for the nitrate ion NO_3^- and of the phosphate ion PO_4^{3-}, shown by the graphs in Figure 14 and Figure 15. It is determined that an increase of the values of the oxidized species (nitrates, phosphates) occurs during the dry/warm season, accompanied by a decrease of the oxygen content in water. At the macro level, the incipient eutrophication of the lake water due to the increase in the chemical and biochemical oxygen consumption by the aquatic microorganisms and fauna was observed.

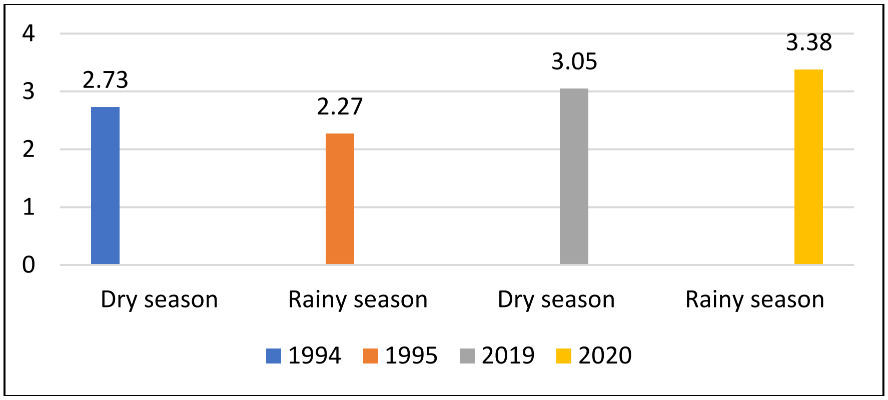


Figure 14. Seasonal variation of the nitrate ion NO_3^- concentration, 1994-1995 and 2019-2020

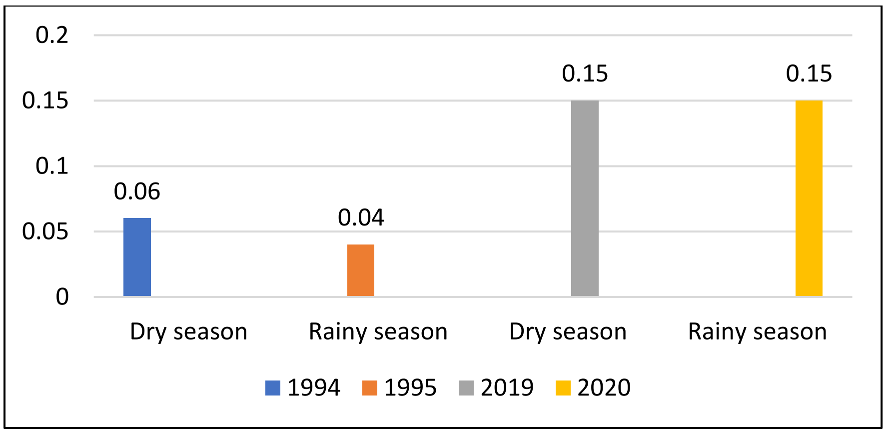


Figure 15. Seasonal variation of the phosphate ion PO_4^{3-} concentration, 1994-1995 and 2019-2020

At the same time, it was found that the drop in temperatures results in a decrease of the concentration of dissolved oxygen in water and that during the fall-winter season an increase of reduced chemical parameters (ammonium and phosphate ions).

Lakes formed by the natural or artificial damming of a water course show changes in the quality indicators in comparison to the main tributary due to water stagnating in the lake for a certain time, to thermal variations (strong insolation that causes high evaporation), to water stratification phenomena in summer and winter and water destratification in spring and fall and also to the mineral composition of the water.

In the case of shallow lakes, the lack of vertical mixing currents leads to lake water stagnation and the natural sedimentation of suspended matter, clear water being less sensitive to external physicochemical reactions. In the case of deeper lakes, thermal stratification is associated with mineral stratification and leads to the almost complete exclusion of the vertical circulation of water, especially during the warm time of summer-fall. This entails the decrease of the dissolved oxygen content in the pelagic (bottom) area and leads to the occurrence of anaerobic oxidation processes, resulting in an increase of the organic matter, nitrate and phosphate salt content and can sometimes lead to the occurrence of hydrogen sulfide in the deepest portion of the lake.

The thermal and mineral destratification occurring in spring and summer brings about a mixing movement and a quality uniformization of the lake water quality, resulting in its organic matter and nutrient enrichment. In summer, the increase in organic matter and nutrient content, combined with strong solar radiation, results in the growth of considerable phyto- and zooplanktonic biomass.

The water quality changes entailed by changes in the physicochemical parameters lead to changes in the pH, and the increase in nutrient and plankton biomass content can be highlighted by water analysis or can be physically sensed at the organoleptic level by changes in the water smell, taste, color and turbidity.

The results obtained for the *annual and seasonal variation of the physicochemical parameters over the 2017-2020 period* were compared to permissible limit values specified in STAS 161/2006.

According to this regulatory document, the physicochemical parameters annually monitored for the water in Lake Titan 2 fall within the following quality classes:

- Quality class I:
- pH, according to Table 2, in November and December of 2019; and January and March of 2020, water pH exceeded 8.5, which *reflects an increase in water basicity (alkalinity).*
- Electrical conductivity (χ),
- Turbidity, in the 2017-2020 interval. While the turbidity value was found to have increased over the four years of measuring, it does not reach the threshold required by STAS 161/2006.
- Quality class II:
- Total dissolved salts (TDS) for 2017-2018,
- Nitrate-ammonium concentration,
- Nitrite ion NO_2, for 2017-2020,
- Quality class III:
- Total dissolved salts (TDS) for 2019-2020,
- Nitrate ion NO_3, for 2017-2018 and 2019,
- Quality class IV:
- Nitrate ion NO_3, for 2020,
- Quality class V:
- Dissolved oxygen O_2, with a value below the permissible lower limit according to STAS 161/2006, upon measurements conducted in 2017-2020.
- Concentration of heavy metals Ni^+ and Pb^+,

According to STAS 161/2006, the physicochemical parameters seasonally monitored for the water in Lake Titan 2 fall within the following quality classes:

- Quality class I:
- pH,
- Turbidity for 2019-2020,
- Phosphate ion PO_4^{3-} concentration for 2019-2020,
- Electrical conductivity for 2019-2020,
- Total dissolved salts (TDS) for October, November and December of 2019,
- NH_4^+ for October, November and December of 2019 and March-May of 2020,

- NO_3^- for November of 2019 through May of 2020,
- PO_4^{3-} for November-December of 2019 and January and March of 2020,

- Quality class II:
  - Nitrate ion NO_3^- concentration for 2019-2020,
  - Total dissolved salts (TDS) for January, March and May of 2020,
  - NH_4^+ for January of 2020,
  - NO_3^- for October of 2019,
- Quality class III:
  - NO_2^- for October, November and December of 2019 and January, March and May of 2020;
  - PO_4^{3-} for October of 2019 and May of 2020,
- Quality class IV:
  - NO_2^- for March of 2020,
- Quality class V:
  - Dissolved oxygen O_2, with a value below the permissible lower limit according to STAS 161/2006, upon measurements conducted in 2019-2020.
  - Concentration of heavy metals Ni^+ and Pb^+.

Table 5 shows the consolidated view of the physicochemical parameters by quality class, annually and seasonally for 2017-2020:

Table 5. Consolidated view of the physicochemical parameters for 2017-2020:

PHYSICOCHEMICAL PARAMETER	QUALITY CLASS				
	I	II	III	IV	V
ANNUAL VARIATIONS					
pH	x				
Electrical cond. (χ)	x				
Total dissolved salts (TDS)		x	x		
Turbidity	x				
$[O_2]$					x
NH_4^+		x			
NO_3^-			x	x	
NO_2^-		x			
PO_4^{3-}	-	-	-	-	-
Ni^+					x
Pb^+					x
TOTAL	3	3	2	1	3
SEASONAL VARIATIONS					
pH	x				
Electrical cond. (χ)	x				
Total dissolved salts (TDS)		x			

Turbidity	x				
$[O_2]$					x
NH_4^+	x	x			
NO_3^-	x	x			
NO_2^-			x	x	
PO_4^{3-}	x		x		
Ni^+					x
Pb^+					x
TOTAL	6	3	2	1	3

The interpretation reveals a difference by quality class between annual and seasonal variations of the number of physicochemical parameters as follows:

- *For quality class I,* annual variations are represented by three indicators, while seasonal variations, the number of indicators doubles. Common parameters for both intervals are: pH, electrical conductivity and turbidity.

- *For quality class II,* both annual and seasonal variations are represented by three physicochemical parameters. Common parameters for both intervals are: total dissolved salts (TDS) and ammonium ion NH_4^+ concentration. Nitrite ion NO_2^- is present in annual variations, but it is absent in seasonal variations, while for the nitrate ion NO_3^-, the situation is reversed: it is absent in annual variations, but it is present in seasonal variations.

- *For quality class III,* different parameters were recorded for both time intervals. Thus, annual variations are assigned: TDS and nitrate ion NO_3^- concentration, while seasonal variations are assigned: nitrite ion NO_2^- concentration and phosphate ion PO_4^{3-} concentration. It is found that in this quality class no parameter is common to annual and seasonal variations.

- *Quality class IV* is found to be represented solely by nitrogen components: nitrate ion NO_3^- for annual variations and nitrite ion NO_2^- for seasonal variations.

- *Quality class V* is found to be represented by the dissolved oxygen DO and heavy metals Ni^+ and Pb^+ concentrations for both time intervals (annual and seasonal).

The dissolution of suspended particulate matter and the gradual sedimentation process can explain the significant increase in water turbidity, from 0.80 NTU in 2017 to 4.10 NTU in 2020. The same factor was considered responsible for the increase in water nutrient content in Lake Titan 2 over that same time.

The values obtained for total dissolved salts and turbidity show that the lake water is not fit for human consumption, but that it has an adequate quality for sustaining the aquatic or terrestrial flora and fauna. This is made clear by the presence of a large number of animals (insects, amphibians, avian fauna) inhabiting the islands of the lakes Titan 1 and Titan 2. The species present in large numbers include the red-eared terrapin *Trachemys scripta elegans*, indigenous birds (ducks and gulls) and transitory or migratory species, present only in spring and summer: the little bittern (*Ixobrychus minutus*), the mute swan *(Cygnus olor),* the mallard *(Anas platyrhynchos),* the gadwall *(Anas/Mareca strepera)*, the pintail (*Anas acuta),* the Eurasian wigeon (*Anas/Mareca penelope),* the garganey (*Anas/Spatula querquedula),* the common pochard *(Aythya ferina),* the Eurasian hobby (*Falco subbuteo),* the common coot (*Fulica atra),* the common gull (*Larus canus)*, the black-headed gull *(Larus/Chroicocephalus ridibundus)*, the Eurasian wryneck *(Jynx torquilla)* and others.

Conclusions

Data interpretation reveals that within the space of 25 years an excessive increase in the nutrient values of the lake water has occurred. This can be explained by the discharge of water from the greenhouses of the botanical garden near Lake Titan 2. At the same time, high values of nutrients are observed that can be directly correlated to the dissolved salts content (TDS), to the increase of turbidity, which leads to the eutrophication of the lake in summer. Another factor that may promote an excessive increase of the nutrient content in the water of Lake Titan 2 pertains to the public's non-conforming practices of feeding the local fauna with bakery products specific to human diet. Also, the water quality of lakes Titan 1 and Titan 2 is permanently and constantly affected by exceeding concentrations of heavy metals Ni^{+} and Pb^{+}. These were identified during all annual measurements conducted over the three and a half years of observation.

Consequently, although the physicochemical parameters situating the water in the quality classes I and II are the most numerous (7 out of 9 monitored items), the water in Lake Titan 2 cannot be used for recreational activities/swimming since the temperature increase in summer amplifies the eutrophication of the lake water. As a permanent feature in summer, towards the end of July and during the first half of August, the excessive proliferation of aquatic flora and the appearance of dead fish on the lake surface can be observed.

Suggestions and recommendations. The park administration manages the consistent removal of leaves, fallen branches, algae and waste packages such as PET bottles discarded by the public etc. However, due to incorrect practices of cleaning the park alleys and green areas with portable blowers, the water is negatively impacted. The cumulation of anthropic non-conforming actions results in an increase of the lake water nutrient content. These practices can be stopped by discontinuing the following actions:

Discharging the excess water from the park greenhouses directly into the lake, which brings surplus nutrients into the lake. By eliminating this action, the nutrient content can be reduced.

Cleaning the park alleys with portable blowers and small electric vehicles in the absence of pavement moistening. Blown air drives plant matter particles and dust which settles in significant amounts on the lake surface, leading to the nutrient enrichment of the lake water.

The conservation of the water quality of Lake Titan can be ensured by applying rules of good practice such as:

Involving schools in the Titan-Baltă Albă district in student education and awareness campaigns with a view to maintaining clean streets and public spaces.

Involving the security and control service of the Alexandru Ioan Cuza Park administration in disciplining infringers of rules regarding the maintenance of public space cleanliness.

Special Thanks: The study was conducted with the support of the Park Public Administration of Sector 3 - the Alexandru Ioan Cuza Park, who provided us with bibliographical and documentation resources whenever it was necessary over the three and a half years of research. Also, we would like to thank the administration of the Faculty of Ecology and Environmental Protection for making available to us the Chemistry Lab and the working instrumentation in situ and in the field, without which the research would not have been possible.

References

Benciu, F., Palade, Gh., Olaru, F. (2006). A biochemical study of lakes in Bucharest correlated with polluted phenomenon*. Fifth Symposium of Environmental Geochemistry, Session "Mineral Deposits and Environment*", 20-23 September, Albac, Romania, Geological Institute of Romania, vol. .82, pp. 106-110, http://publicatio.bibl.u-szeged.hu/8586/1/Szak%C3%A1ll%20et%20al_2006.pdf

Benciu, F. (2016). *Biogeochemical circuits. University course,* Faculty of Ecology and Environmental Protection within the Ecological University of Bucharest.

Benciu, F. (2016). *Environmental chemistry. Curs universitar,* Faculty of Ecology and Environmental Protection within the Ecological University of Bucharest.

Bogan, E. (2018). Promoting the Health and Social Inclusion of the Urban Population by endowing and improving the Quality of Leisure Facilities in the Parks in Bucharest, *Quality-Access to Success Journal*, vol. 19, no. 166, October 2018, pp. 80–86.

Breabăn, G. I., and Breabăn, I. A. (2020). Causes and Effects of Water Pollution in Romania. *Water Resources Management in Romania*, pp. 57-131. https://www.researchgate.net/publication/337000928_Causes_and_Effects_of_Water_Pollution_in_Romania

Demetriades, A., Jonson, C. C., & Birke, M. (2018). Urban geochemical mapping: The EuroGeoSurveys Geochemistry Expert Group's URGE project. *Journal of Geochemical Exploration*, Volume 187, pp 1-5. https://doi.org/10.1016/j.gexplo.2017.10.024

Fortesque, J. A. C. (1990). Landscape geochemistry: retrospect and prospect – 1990. *ELSEVIER Applied Geoghemistry,* vol. 7, Issue 1, January 1992, pp. 1-53.

Ion Bordei, E., and Gogu, S. (2000). The aerosynoptic that determined the abundant rains in the south of Romania, between September 2-5, 1999. *Scientific Bulletin of the Faculty of Ecology and Environmental Protection*, Ecological University of Bucharest, no.2/200, pp.148-159.

Ion Bordei, E., and Taulescu, G. (2017*). Meteorology and climatology issues for ecology*. Ecological University of Bucharest*,* Publishing House Printech, Bucharest.

Lungu, E., and Dragomir, M. C. (2016). *Water quality indicators*. "Dunărea de Jos" University of Galați, Cross-border Faculty of Humanities, Economics and Engineering, Cahul, Republic of Moldova.

Manu, M., Onete, M., Ioana, R., & Băncilă, R. (2018). The effect of heavy metals on mite communities (Acari: Gamasina) from urban parks – Bucharest, Romania. *Environmental Engineering and Management Journal*, 17(9), pp. 2071-2081.

Papazoglu, D. (2006). *The history of the founding of the city of Bucharest,* https://upload.wikimedia.org/wikisource/ro/2/21/Istoria_fondarei_orasului_Bucuresti.pdf

Scrădeanu, D. (2017). *Soil impact assessment. Course support,* Faculty of Ecology and Environmental Protection, Ecological University of Bucharest.

Taulescu, G. (2016). *Geography of Romania. Course notes* Faculty of Ecology and Environmental Protection, Ecological University of Bucharest, Publishing house Printech, Bucharest.

****, Updated Management Plan of the Argeș-Vedea Hydrographic Area*, 2016-2020, Ministry of Waters and Forests, Argeș-Vedea Water Basin Administration http://www.rowater.ro/dajiu/Documente%20Repository/Directive%20Europene/Anexa%209.1_Jiuf

****, Sector 3 Sustenable Development Strategy for the period 2021-2017*, Local Council of Sector 3 Bucharest https://www.primarie3.ro/images/uploads/consiliu_local/Strategia_de_Dezvoltare_Durabila_a_Sectorului_3_perioada_2021_-2027_-_publicat_28.04.2021.pdf

Websites

https://sd4doteu.wordpress.com/2013/05/29/comuna-dudesti-cioplea-vechiul-bucuresti/
https://adevarul.ro/news/bucuresti/istoria-ciudata-cartierului-bucurestean-titan-groapa-carecadavrele-ciumatilor-erau-stropite-var-nestins-1_558abef3cfbe376e3591ce4d/index.html
https://ro.wikipedia.org/wiki/Parcul_Alexandru_Ioan_Cuza
http://www.topfiltreapa.ro/ape-naturale-%E2%80%93-proprietati
http://despretoate.com/turism/mica-insula-virgina-din-bucuresti-insula-ratelor-a-devenit-un-mic-ecosistem/
https://www.momondo.ro/descopera/articol/lucruri-gratis-de-facut-in-bucuresti
https://centrulcomercialauchan.ro/auchan-titan/articole/povestea-parcului-ior
https://i0.1616.ro/media/2/2621/33219/20006679/1/zone-bucuresti.jpg?height=581&width=700
https://www.fotoshooting.ro/arhiva-foto-cu-vechiul-bucuresti-bucuresci-old-bucharest-photo-archive-partea-3/
https://www.google.ro/maps/@44.4225994,26.1585921,1936m/data=!3m1!1e3?hl=en
https://adevarul.ro/news/bucuresti/concediu-1_51926f3f053c7dd83f9a4935/index.html
https://www.asro.ro/lista-standarde-calitatea-apei/