Academy of Romanian Scientists
Annals Series on Biological Sciences

Volume 13, No. 2, 2024, pp. 7 - 18
Online ISSN 2285 – 4177
ORIGINAL PAPERS

SIUTGHIOL LAKE – CASE STUDY ON THE IMPACT FACTOR

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Abstract. *Located in close proximity to the Black Sea and surrounded by towns and tourist resorts, Lake Siutghiol offers a special situation. Included in the Natura 2000 Network as a bird protection area (ROSPA0057), Lake Siutghiol is currently subject to an intense eutrophication process, currently amplified by global climate warming. In the case of Lake Siutghiol, the state of preservation is also influenced by a series of impact factors, most of which are from the category of residential development and urbanization.*

Keywords: Siutghiol Lake, threats, pressures

DOI **10.56082/annalsarscibio.2024.2.7**

INTRODUCTION

Siutghiol Lake is located in the north of the city of Constanța and together with Tăbăcarie Lake forms a hydro morphological unit. Formerly a sea bay, Siutghiol Lake was formed at the end of the glacial period by the formation of a coastal belt that closed the sea bay that stretched between the area of Mamaia sat and the north of Constanta. The surface of Lake Siutghiol is 19 km^2, to which is added the 9.56 km^2 of Tăbăcarie Lake (Breier, 1976). The surface of the reception basin of Siutghiol Lake is 71.65 km2 (over 7100 hectares), extending to the north up to about 9 km and to the west up to about 2-4 km from the shore of the lake.

In the course of time, the area around Siutghiol Lake has largely changed its type of use, residential areas experiencing an explosive development after 1990 both on the coastline, in the Mamaia resort and north of it, in the Mamaia Sat area, in the north of the city Constanta as well as in the area of Palazu Mare and Ovidiu. Currently, the lake is almost completely surrounded by residential areas, only in the northern part there is still a narrow cordon covered with heavily anthropized natural vegetation. Currently, agricultural areas are located in the north, west and southwest of the lake, far from its shore. In the northern area, over a distance of 4.86 km, extends the eastern area of the Poarta Albă - Midia Năvodari Canal, separated from the lake by a land cordon whose width varies from 55 to 286 m.

The geological foundation of the lake is represented by green shale in the north and northwest, north of Ovidiu and by Sarmatian type limestone that allow the development of important aquifer systems (Breier, 1976; Mutihac et al, 2004).

Natura 2000 site (https://eunis.eea.europa.eu/sites/ROSPA0057). Siutghiol Lake is included in the network of protected areas of Community interest at European level, together with Tăbăcarie Lake forming ROSPA0057, through GEO 57/2007. The total protected area is exclusively the water surface, not including terrestrial areas, is 1858.8 ha (19 km^2) and includes exclusively the water surface and areas with reed agglomerations and excludes most of Ovidiu Island. During the migration periods, Siutghiol Lake can house flocks of waterfowl that exceed 20,000 specimens, for this reason it is eligible for its declaration as a RAMSAR site. Also, at the initiative of the Romanian Ornithological Society, Siutghiol Lake was declared an important area for birds (IBA) (https://datazone.birdlife.org/site/factsheet/lake-siutghiol-iba-romania on 15/11/2024).

Natural habitats. As for the shore of the lake, it is largely anthropized through the development of agriculture and residential areas. In terms of natural habitats, these are deeply degraded in the case of terrestrial habitats on the lakeshore. Areas with natural vegetation still exist only in the northwestern area of the lake, where a stretch of reeds is preserved in the Mamaia Sat area, along the land cordon that separates the lake from the Poarta Albă - Midia Năvodari Canal and in the area of Ovidiu Island. Reed beds can also be found in other areas of the lake, but they have a smaller extent. As types of natural habitats, habitat 3150 - Eutrophic natural lakes and habitat 3160 - Dystrophic lakes and ponds, with an unfavorable degree of conservation, can be found within the site.

The aquatic habitats have also undergone changes in the last 70 years, due to human intervention, so that today Siutghiol Lake no longer meets the conditions of a natural lake in a good state of conservation.

Natura 2000 species. The designation of Siutghiol Lake as a protected area of community interest was carried out for the protection and conservation, in particular, of the waterfowl populations that use the lake during migration, during the winter or for nesting. Although the shores of the lake are mostly residential areas, the water is clear enough for a number of waterfowl to find their refuge on the surface of the lake. The list of bird species protected on the surface of Siutghiol Lake and in its immediate vicinity includes 61 mostly freshwater and marine species, which use the lake as a food source or as a shelter during the migration period. Few species nest on the lake, precisely because of the lack of suitable habitats. In the area of the lake, four species of community interest constantly nest, for 25 species the lake is important during the migration period

and 6 species use the lake during the winter migration period (https://datazone.birdlife.org/site/factsheet/lake-siutghiol-iba-romania on 15/11/2024).

Apart from the bird species, there is a well-developed ichthyofauna in the lake, represented by species of fish that in the past were subject to intense aquaculture, now almost completely abandoned. Exotic fish species have also been introduced into the lake, which are listed as invasive species worldwide and have irreversibly affected the structure of the lake biocenosis.

Even if they are not included in the list of protected species (being an avifaunal protection area), it should be mentioned that there are some endemic species of macrophytic algae in the lake, as well as populations of endemic Ponto-Caspian crustaceans, the latter constituting the trophic base for some species of birds and especially for fish fauna.

Protected species of reptiles, mammals and insects are also found on the lakeshore - *Natrix tesselata, Dolichophis caspius, Emys orbicularis, Podarcis tauricus* (Reptilia), *Bufo viridis* (Amphibia), *Lutra lutra* (Mammalia), *Lycaena dispar* (Lepidoptera).

RESULTS

Impact factors - pressures and threats - in the context of climate change risks. Taking into account the position of the lake and the development of the inhabited areas on the shores, different kind of pressures and threats are present. The impact of these pressures and threats comes in the context of the fact that Siutghiol Lake is also a protected area for birds included in the Natura 2000 Network, which requires at least theoretically taking special measures for the conservation of its condition to ensure the basic objective of the area - namely the protection of waterfowl populations especially during migration and winter.

The list of pressures and threats developed by the European Environment Agency was used for the impact analysis. Due to the fact that this list has been updated in recent years, a comparative analysis of the pressures and threats mentioned in the standard data sheet of the protected area, in different previous studies and updated by field observations in February 2024 had to be carried out.

The situation in the field was analyzed with what is included in the analysis of the European Environment Agency for freshwater areas in the coastal area of Romania, overlapping with the Pontic area. In this case, on the EEA website, the main pressures and threats to coastal freshwater are from agriculture, forestry, development of structures related to residential and industrial areas, invasive species, pollution and human-induced changes in aquatic habitats. For the most part, these pressures and threats are also found in the case of Siutghiol Lake.

However, if we analyze the situation on the ground with what is reported, it is found that there are differences.

In the Natura 2000 standard form of ROSPA0057 Lake Siutghiol, 7 types of threats and pressures with high negative impact are mentioned - D01.02 Roads, highways, E01 Urbanized areas, human habitation (human dwellings), E02 Industrial or commercial areas, E03 Dewatering, G02 Sports and leisure complexes, and two types of threats and pressures with medium and low impact – E 03.03 Storage of inert materials (non-radioactive) and G 01.03 Motor vehicles.

An analysis on the ground, however, shows a completely different situation compared to the one in 2007. The Siutghiol lake area is characterized by a fairly wide range of impact factors, whose action in the short, medium and long term is transposed into a series of risks to the natural habitat. Although it is a protected natural area included in the European Natura 2000 network - ROSPA 0057, Lake Siutghiol has not benefited from a management plan that takes into account the requirements established by the network's objectives - those to ensure the conservation of avifaunistic biodiversity. The real estate projects that take place on the shore of the lake, the recreational activities that take place on the lake, the development of the hotel industry - have constantly ignored the desideratum of an international protection area. It should be mentioned that even at the level of the property type of the area, there are conflicts at the local level between the territorial administrative units (UAT) located in the Siutghiol Lake area - Constanta, Ovidiu and Năvodari - each with distinct economic interests. Without taking into account the fact that the lake is included as a public domain of the state or had a Natura 2000 protected area status, in 2019 one of these UATs tabulated the entire lake basin as a private domain.

Based on these data, for the particular case of Lake Siutghiol (excluding the Tăbăcarie Lake, which is part of the same Natura 2000 protected area), a special analysis was carried out, taking into account the reality on the ground (Table 1).

Table 1. Pressures and threats identified in the Siutghiol Lake area

Code	Pressures/threats	Impact	Impact type
PA	Agriculture related practices		
PA05	Abandonment of management/use of grasslands and other agricultural and agroforestry systems (e.g., cessation of grazing, mowing or traditional farming)	Present	Low risk
PA08	Extensive grazing or undergrazing by livestock	Present	Low risk
PA10	Livestock farming (without grazing)	Present	Low risk
PA11	Soil management practices in agriculture (e.g., ploughing)	Present	Low risk
PA12	Harvesting of crops and cutting of croplands	Present	Low risk

PA13	Application of natural or synthetic fertilisers on agricultural land	Significant	Substantial risk
PA14	Use of plant protection chemicals in agriculture	Significant	Substantial risk
PA15	Use of other pest control methods in agriculture (excluding tillage)	Present	Low risk
PA23	Physical alteration of water bodies (including dams, channels, etc.)	Present	Low risk
PB	Forestry related practices		
PB09	Clear-cutting, removal of all trees	Present	Low risk
PB10	Illegal logging	Present	Low risk
PC	Extraction of resources (minerals, peat, non-renewable energy resources)		
PD	Energy production processes and related infrastructure development		
PD05	Development and operation of energy production plants (including infrastructure)	Present	Low risk
PD06	Transmission of electricity and communications (cables)	Present	Low risk
PD07	Oil and gas pipelines	Present	Low risk
PD08	Energy production and transmission activities generating pollution to surface or ground waters	Present	Low risk
PE	Development and operation of transport systems		
PE01	Roads, paths, railroads and related infrastructure	Present	Low risk
PE02	Shipping lanes and ferry lanes transport operations	Present	Low risk
PE04	Flight paths of planes, helicopter and other non-leisure aircrafts	Present	Low risk
PE05	Land, water and air transport activities generating pollution to surface or ground waters	Significant	Substantial risk
PE08	Land, water and air transport activities generating noise, light and other forms of pollution	Present	Low risk
PF	Development, construction and use of residential, commercial, industrial and recreational infrastructure and areas		
PF01	Conversion from other land uses to built-up areas	Significant	Major impact
PF02	Construction or modification (e.g., of housing and settlements) in existing built-up areas	Significant	Major impact
PF03	Creation or development of sports, tourism and leisure infrastructure	Significant	Limited risk
PF04	Development and maintenance of beach areas for tourism and recreation	Present	Low risk
PF05	Sports, tourism and leisure activities	Present	Low risk

PF06	Deposition and treatment of waste/rubbish from built-up areas	Significant	Critical impact
PF07	Residential and commercial activities and structures generating pollution to surface or ground waters	Significant	Substantial risk
PF08	Industrial activities and structures generating pollution to surface or ground waters	Present	Low risk
PF09	Residential, commercial and industrial activities and structures generating air pollution	Present	Low risk
PF11	Residential, commercial and industrial activities and structures generating soil pollution	Present	Low risk
PF12	Residential, commercial and industrial activities and structures generating noise, light, heat or other forms of pollution	Present	Low risk
PF13	Drainage, land reclamation and conversion of wetlands, marshes, bogs, etc. for built-up areas	Significant	Limited risk
PF17	Active abstraction of water for built-up areas	Present	Low risk
PG	Extraction and cultivation of biological living resources (other than agriculture and forestry)		
PG06	Freshwater fish and shellfish harvesting (professional)	Present	Low risk
PG07	Freshwater fish and shellfish harvesting (recreational)	Present	Low risk
PG08	Hunting	Present	Low risk
PG11	Illegal shooting/killing	Present	Low risk
PG14	Poisoning of animals (excluding lead poisoning)	Present	Low risk
PG15	Use of lead ammunition or fishing weights	Present	Low risk
PG20	Freshwater aquaculture generating pollution to surface or ground waters (including marine)	Present	Low risk
PG21	Introduction and spread of new species in aquaculture (including GMOs)	Significant	Critical impact
PG22	Abandonment of aquaculture	Present	Low risk
PH	Military action, public safety measures, and other human intrusions		
PH04	Vandalism or arson (incl. human-introduced wild fire)	Present	Low risk
PH05	Tree surgery, felling/removal of roadside trees and vegetation for public safety	Present	Low risk
PH06	Closure or restricted access to site/habitat	Significant	Critical impact
PI	Alien and problematic species		
PI01	Invasive alien species of Union concern	Significant	Critical impact
PI02	Other invasive alien species (other than species of Union concern)	Present	Low risk

PI03	Problematic native species	Present	Low risk
PJ	Climate change		
PJ01	Temperature changes and extremes due to climate change	Significant	Critical impact
PJ03	Changes in precipitation regimes due to climate change	Significant	Critical impact
PJ05	Saline intrusion	Present	Low risk
PJ07	Cyclones, storms, or tornados due to climate change	Present	Low risk
PJ11	Desynchronization of biological / ecological processes due to climate change	Significant	Critical impact
PJ12	Decline or extinction of related species (e.g. food source / prey, predator / parasite, symbiote, etc.) due to climate change	Present	Low risk
PJ13	Change of species distribution (natural newcomers) due to climate change	Present	Low risk
PK	Mixed source pollution		
PK01	Mixed source pollution to surface and ground waters (limnic and terrestrial)	Significant	Critical impact
PK03	Mixed source air pollution, air-borne pollutants	Present	Low risk
PL	Human-induced changes in water regimes		
PL06	Physical alteration of water bodies (mixed or unknown drivers)	Significant	Substantial risk
PM	Geological events, natural processes and catastrophes		
PM01	Storm or cyclone	Present	Low risk
PM02	Flooding	Present	Low risk
PM05	Avalanches, landslides and collapse of terrain	Present	Low risk
PX	Unknown pressures, no pressures and pressures from outside the Member State		
PX01	Threats and pressures from outside the EU territory	Present	Low risk
PX02	Threats and pressures from outside the Member State	Present	Low risk

The observations resulted in a list of 63 pressures and threats from almost all categories, as follows (https://cdr.eionet.europa.eu/help/habitats_art17):

- PA Practices related to agriculture – 9 pressures and threats;
- PB Forestry-related practices - 2 pressures and threats;
- PD Energy production processes and related infrastructure development - 4 pressures and threats;
- PE Development and operation of transport systems - 5 pressures and threats;

- PF Development, construction and use of infrastructure and residential, commercial, industrial and agreement areas - 13 pressures and threats;
- PG Extraction and cultivation of living biological resources (other than agriculture and forestry) 9 pressures and threats;
- PH Military action, public safety measures and other human intrusions - 3 pressures and threats;
- PI Alien and problem species - 3 pressures and threats;
- PJ Climate change - 7 pressures and threats;
- PK Mixed sources of pollution - 2 pressures and threats;
- PL Human-induced changes in water regimes - 1 pressures and threats;
- PM Geological events, natural processes and disasters - 3 pressures and threats;
- PX Unknown pressures, no pressures and pressures from outside the Member State - 2 pressures and threats;

Of these, 17 pressures and threats are of greater relevance, most of which are in the field of development, construction and use of infrastructure and residential, commercial, industrial and agreement areas:

AP Agriculture-related practices: PA13 Application of natural or synthetic fertilizers on agricultural land, PA14 Use of plant protection chemicals in agriculture;

PE Development and operation of transport systems: PE05 Land, water and air transport activities generating pollution to surface or ground water;

PF Development, construction and use of infrastructure and residential, commercial, industrial and agreement areas, PF01 Conversion from other land uses to built-up areas, PF02 Construction or modification, PF03 Creation or development of sports, tourism and leisure infrastructure, PF06 Deposit and treatment of waste/garbage within the built-up area, PF07 Residential and commercial activities and structures generating pollution of surface water or groundwater, PF13 Drainage, land reclamation and conversion of wetlands, marshes, bogs, etc. for built-up areas;

PG Extraction and cultivation of living biological resources: PG21 Introduction and spread of new species in aquaculture;

PH Military action, public safety measures and other human intrusions: PH06 Closure or restricted access to site/habitat.

PI Alien and problem species: PI01 Invasive alien species of Union concern.

PJ Climate change: PJ01 Changes in temperature and extremes due to climate change, PJ03 Changes in rainfall patterns due to climate change, PJ11 Desynchronization of biological/ecological processes due to climate change.

PK Mixed source of pollution: PK01 Mixed source of pollution of surface and groundwater (limnic and terrestrial).

PL Human-induced changes in water regimes: PL06 Physical alteration of water bodies.

If we refer to the severity of the risk that these pressures and threats pose to the ecosystem of Lake Siutghiol, we have the following situation:

- Major impact - PF01 Conversion from other land uses to built-up areas, PF02 Construction or modification (e.g. housing and settlements) in existing built-up areas.

- With critical impact - PF06 Deposit and treatment of waste/garbage in the countryside, PG21 Introduction and spread of new species in aquaculture, PH06 Site/habitat closure or restricted access, PI01 Invasive alien species of Union concern, PJ01 Temperature changes and extremes due to climate change, PJ03 Changes in rainfall patterns due to climate change, PJ11 De-synchronization of biological/ecological processes due to climate change, PK01 Mixed source of surface and groundwater pollution.

- With substantial risk - PA13 Application of natural or synthetic fertilizers on agricultural land, PA14 Use of plant protection chemicals in agriculture, PE05 Land, water and air transport activities generating pollution to surface or ground waters, PF07 Residential and commercial activities and structures generating pollution of surface water or groundwater, PL06 Physical alteration of water bodies;

- With limited risk - PF03 Creation or development of sports, tourist and agreement infrastructure, PF04 Development and maintenance of beach areas, PH13 Drainage, land reclamation and conversion of wetlands, marshes, bogs, etc. for built-up areas;

Climate change is a current phenomenon that no longer needs to be demonstrated and has led to measures being taken at EU level. Lake Siutghiol is located in an area sensitive to climate risk, primarily because of the high degree of eutrophication that makes it particularly sensitive to climate change. On the other hand, the explosive development of the real estate sector on the shores of the lake increases anthropic pressure and implicitly the risks of eutrophication due to sewage spills.

Under these conditions, taking into account the data presented in the report of the European Environment Agency (EEA Report 01/2024), a number of issues have been identified for Lake Siutghiol related both to the impact of climate change on freshwater systems and its impact on coastal marine ecosystems.

As a freshwater lake, resulting from the transformation of a marine bay, Lake Siutghiol is under the influence of factors that affect small, medium and large bodies of water as a result of climate warming. Its position and depth make it vulnerable to the following factors:

- Rising temperatures favor the growth of cyanobacteria, causing algal blooms with socio-economic impacts and decreased recreational value.

- Increasing temperature also influences the length of the ice-free period in winter, leading to changes in water stratification with direct effects on biodiversity;

- Changes in precipitation levels (i.e. lack of precipitation or very high precipitation over short time intervals) have multiple ecological impacts

- Climate change causes not only eutrophication but also increased nutrient loading which causes a loop effect.

- Rising temperatures lead to a longer stratification period and to a deeper shift of thermocline, as well as to increased productivity and organic carbon but also to oxygen depletion. All these factors combined limit suitable habitats for cold-water stenoterms and oxyphiles.

- Changes in lake structure can trigger the recycling of nutrients accumulated in sediments, which exacerbates eutrophication problems.

Lake Siutghiol, being extremely close to the sea, is also influenced by a number of aspects related to climate change in the coastal environment, which affect not only marine waters. From this point of view, the lake is under the influence of the following factors:

- Thermal stress, leading to changes in life cycles, physiological rates, phenology and species distribution. Thermal stress has a cascading effect on ecosystem functioning, including the uptake of pollutants by organisms which can have an impact on mortality rates.

- Increased stratification and altered water circulation, which can lead to hypoxia resulting from warming. Increased stratification leads to eutrophication - the emergence and enhancement of algal blooms and pathogen growth.

- Habitat degradation due to human activities, overfishing, introduction of alien species and pollution are also factors to be taken into account, which are present on the surface and around the lake.

In fact, in the case of Lake Siutghiol, the two categories of factors identified in the EEA report overlap, generating in fact an increased risk of eutrophication, stratification and changing habitat conditions.

Siutghiol Lake is currently affected by eutrophication, historical pollution with nutrients from agriculture and domestic runoff leading to changes in water quality over time. Being a lake surrounded by residential areas and having industrial enterprises in the immediate vicinity, the Siutghiol Lake has undergone a series of transformations in the last 100 years, both in terms of the water body itself and in terms of the surrounding areas. Currently, the development of real estate projects on the shores of the lake only contributes to the maintenance of the eutrophication phenomenon not only through the discharge of household water but also through the modification of the microclimate conditions, such as the alteration of the wind regime due to the large number of high-rise buildings built on the coastline that produce wind fence effect.

Another aspect that contributes to the alteration of the natural habitat and that directly interferes with the protected area is the development of real estate development projects beyond the limit of the protected area. Thus, both in the Mamaia area and in the Ovidiu area, a large number of piers have been built, and the

properties are delimited by fences that prohibit access to the lake mall. In the Mamaia area, an aquatic park was built, occupying an area of 8.5 hectares of water, and in the area of the city of Ovidiu, an entire housing complex was built on an area of over 4 hectares inside the protected area.

The freshwater cyanobacteria *Mycrocystis aeruginosa* constantly develops in the phytoplankton of the lake, which reaches extremely high densities all year round. The development of these populations is directly influenced by the degree of eutrophication of the lake as well as the level of average annual temperatures. A large part of the nutrients that reached the lake came from the irrigation system that served the areas of the lake's reception area and which currently occupies only about 4000 ha. Currently, the irrigation system is decommissioned, and the use of fertilizers, insecticides and pesticides decreased after 1990. The water of the lake, at first marine and then brackish, sweetened with the closure of the coastal belt, the fauna of the lake changing accordingly. In the post-war period, along with the socio-economic development of the area, a series of water intakes were built through which the water from the lake was used in agriculture or industry. In the 1970s, a number of 20 water intakes were functional on the perimeter of the lake (Breier, 1976), most of them being located in the north and northwest of the lake. Also, in the area of the reception surface of the lake, two boreholes were working that reach the level of the groundwater table located under the limestone layer, active boreholes even today and through which the groundwater is used for domestic use. A part of this water returns to the lake either directly or through underground drains.

CONCLUSIONS

Drawing some final conclusions, from the point of view of the current situation generated by climate change, the position of Lake Siutghiol makes it vulnerable both to the complex of factors that influence freshwater bodies and to factors that impact coastal marine waters in the immediate vicinity of the coastline.

The increase in the trophic level of the lake water has led over time to changes in the structure of bacterioplankton, phytoplankton and zooplankton, which has led to cascading effects that have affected the structure of the communities of plant and animal organisms living in the lake. Eutrophication is an obvious phenomenon in Lake Siutghiol, with cyanobacterial populations having conditions to develop all year round, including during the winter.

The fact that the lake only freezes for short periods of time or does not freeze at all during the winter makes it attractive for a number of migratory species that use it either as a temporary shelter or as a feeding ground, and the large populations of ichthyophagous birds indicate a well-developed fish population, which is no longer exploited as in the past.

Changing the land use around the lake and restricting natural habitats or land for irrigated agriculture generates another type of impact. The entrainment of nutrients

into the lake water continues today, even if at a different level compared to the 1960-1970s. The change in the rainfall regime, with prolonged summer droughts punctuated by torrential rains, also contributes to the maintenance of the eutrophication phenomenon. On the other hand, the infiltration water input from the Poarta Alba - Midia Navodari Canal, located in the immediate vicinity of the lake, cannot be excluded.

The construction of apartment buildings around the lake in combination with the effect of climate warming produces a wide range of secondary effects that lead to changes in the quality of the water body and thus to the alteration of the lake's protected area status.

ACKNOWLEDGEMENT

The data for this paper represent part of the activities carried out within the complex RDI Project - PNRR-III-C9-2022 – I5 - Competence Center for Climate Change Digital Twin for Earth Forecasts and societal redressment: DTEClimate. Active Measures for Restoring Sweet-Water Lakes and Coastal Areas affected by Eutrophication addressing the Enhancement of Resilience to Climate Change and Biodiversity – Act4D-Eutrophication

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