Volume XXVII 2024
ISSUE no.2
MBNA Publishing House Constanta 2024

Scientific Bulletin of Naval Academy

SBNA PAPER • OPEN ACCESS

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To cite this article: Andra-Teodora Nedelcu, Gheorghe Samoilescu, Alecu Toma, Manuela Rossemary Apetroaei and Tiberiu Pazara, Scientific Bulletin of Naval Academy, Vol. XXVII 2024, pg. 88-96.

Submitted: 17.04.2024
Revised: 20.09.2024
Accepted: 07.10.2024

Available online at www.anmb.ro

ISSN: 2392-8956; ISSN-L: 1454-864X

doi: 10.21279/1454-864X-24-I2-008

Assessing freshwater pollution by CTD measurements: A holistic approach to water quality monitoring

Andra-Teodora NEDELCU[1], Gheorghe SAMOILESCU[1], Alecu TOMA[1], Manuela Rossemary APETROAEI[1], Tiberiu PAZARA[1]

[1]Mircea cel Batran Naval Academy, Faculty of Navigation and Naval Transport, 1 Fulgerului, RO-900218, Constanta, Romania
andra.nedelcu@anmb.ro

Abstract. This paper presents measurements of the MIDAS CTD instrument with Valeport profile, represented by conductivity, temperature and depth, which are fundamental in hydrographic research for any aquatic system, including freshwater lakes as Siutghiol Lake. Furthermore, these measurements provide invaluable insight into the physical and chemical properties of lake water, playing a crucial role in understanding hydrodynamics, ecology and potential environmental challenges that could be influenced by the dispersion, dilution, and transformation of pollutants. Also, due to its sensors (pH, pressure, turbidity, redox potential, florescence, dissolved oxygen, salinity, and speed of sound through water) CTD measurements provide critical data when combined with chemical and biological assessments, could give a comprehensive picture of water quality for protection and management purposes.

1. INTRODUCTION

Nowadays we are witnessing a permanent degradation of aquatic ecosystems because of the diversification of anthropogenic activities, especially to satisfy human needs. Overuse of land and water resources, population growth and unsustainable management practices have been identified as potential contributors to declining water quality, toxic pollution, eutrophication, acidification, and accumulation of suspended solids in water bodies [1], [2]. The main causal factors of this degradation are those of population growth and economic development which have led to the biodiversity loss [1], [3]. In addition, climate change, which has had an impact on the seasonal thermal stratification of the aquatic environment, cannot be neglected. [4], [5].

In this category of degradation of the aquatic ecosystem, the Siutghiol Lake is also included. In the last thirty years a very intense anthropic activity with a major negative impact on the lake habitat, especially on the associated flora and fauna, has been observed. This threat is mainly caused by the increase of human habitation in Mamaia resort, Mamaia village, the cities of Constanta, and Ovidiu. Also, considered are the heavy road traffic around the lake, water sports, fishing and mass tourism.

Surrounded by a picturesque landscape, Siutghiol Lake is a beacon of natural beauty and biodiversity. This freshwater jewel, however, is not immune to the harmful effects of man-induced pollution. As pressures from urban development, tourism, agriculture, industry and recreation increase, the lake's once clear waters are under constant threat, bringing them to the brink of ecological imbalance. That's why to prevent degradation of the lake's ecosystem, and for a real assessment of pollution, CTD measurements - a triad of conductivity, temperature, and depth analyses - emerge as critical tools in the arsenal of the remediation and monitoring program (fig 1).

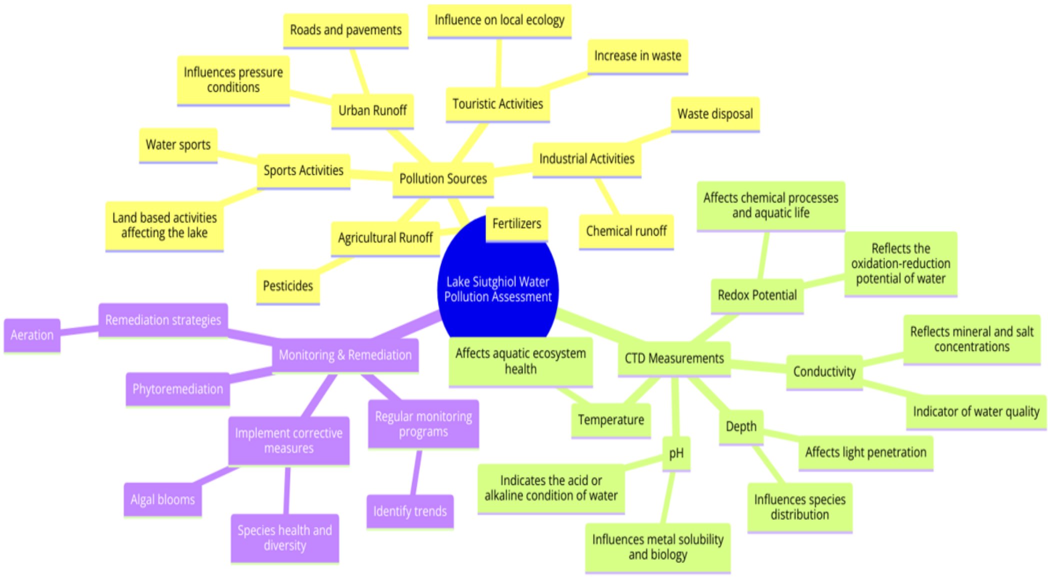

Fig. 1 CTD's role in assessing water pollution in Siutghiol Lake

Remediation and water quality monitoring programmes for Siutghiol Lake are in line with the new water management strategies and policies at European level. Thus by the Water Framework Directive (WFD) (2000), the harmonization of the development of the socio-economic system with the supporting capacities of the aquatic environment is ensured. [6]. In Romania the provisions of this Directive have been transposed into national legislation by Law 107/1996 amended and updated by Law 196/2015 [7].

Starting from the main objectives of the WFD on "prevention of deterioration, protection and improvement of the state of aquatic ecosystems due to permanent interactions between aquatic ecosystems and adjacent terrestrial ecosystems", our paper aims to highlight the importance of CTD analysis in assessing the environmental impact of different pollutants on the aquatic ecosystem of Siutghiol Lake from a physical-chemical point of view (fig. 1). According to WFD (2000), good surface water chemical status is defined as the chemical status achieved by a body of water at which concentrations of pollutants do not exceed environmental quality standards [6].

The primary goal of the EU biodiversity conservation plan is to save and preserve species and ecosystems that hold significance for the Community [8]. In May 2020, the European Union unveiled their latest biodiversity policy for the year 2030. This strategy, along with its corresponding action plan, embodies a thorough, ambitious, and enduring plan to safeguard nature and counteract the deterioration of the environment. This plan aligns with the purpose of the Water Framework Directive to achieve a favourable ecological condition by 2027 for all rivers, lakes, transitional regions, coastal waterways, and wetlands within the European Union [9].

The objective of this paper is to highlight the importance of using the Valport MIDAS CTD multiparameter, as it has the potential to provide a comprehensive examination of the state of Siutghiol Lake. These measurements are crucial in evaluating freshwater contamination, as they provide necessary data for determining various water quality indices and comprehending the mechanisms influencing the spread, dilution, and conversion of contaminants.

2. OVERVIEW ON THE SIUTGHIOL LAKE

Siutghiol Lake is situated near the Black Sea (fig. 2). It is a former lagoon, which is an ancient marine bay separated from the sea waters by a perisippus. The lake has a length of 7.57 km and a maximum width of 4.3 km in the northern region. It has a maximum depth of 17.15 m, with an average depth of

4.6 m. The overall contour of the lake is concave. The lake receives its water supply from subterranean springs, which effectively mitigate the risk of water salinization. The western half of Siutghiol Lake has a high shoreline, whereas the eastern area has a low shoreline reinforced with concrete. Siutghiol Lake has a position of 1.9 meters above sea level [10], [11]. It is part of the European Natura 2000 network of protected areas, ROSPA0057 Lake, Siutghiol Lake.

2.1. Geographical and ecological significance

The formation of the Siutghiol Lake depression, a marine mini-lagoon, can be attributed to the Capidava-Ovidiu fault. This fault serves as a boundary between the Jurassic limes and the Cretaceous limes and is influenced by karst processes. The karst processes have resulted in the emergence of a substantial underground water supply from submerged springs, which has influenced the water balance structure. Typically, the water in this area is abundant and fresh. According to Telteu&Zaharia (2012) study, Siutghiol Lake, formerly a bay, underwent a process of deepening and subsequent silt deposition by the Black Sea, resulting in its closure [10].

A coastal band composed of fine sands, measuring 300 to 600 m in width and around 15 km in length, separates the lake from the Black Sea. The barrier is located between Constanţa City and Mamaia (village), where the Mamaia resort has been established (Fig. 2). The Siutghiol Lake, with an area of 19.6 km2 and a maximum depth of 17.15 meters, is located within a karst doline that is predominantly flat, with an average depth of 4.6 meters. Ovidiu Island is located in the lake area, near the town of the same name. The abrasion witness, composed of Jurassic limestone, encompasses a total area of 2.6 hectares, with reaches reaching a maximum height of 5 meters [11]. As per to the study of Gâştescu et al., (2016) the quantitative values of the water balance component show that the water of Siutghiol Lake was and remained fresh water (PSU < 1‰), and the degree of mineralization of the water is mainly given by the sodium-magnesium bicarbonate type components at the expense of the magnesium chloride one. These values confirm the dominant influence of fresh groundwater on the hydrochemical structure of the lake [11].

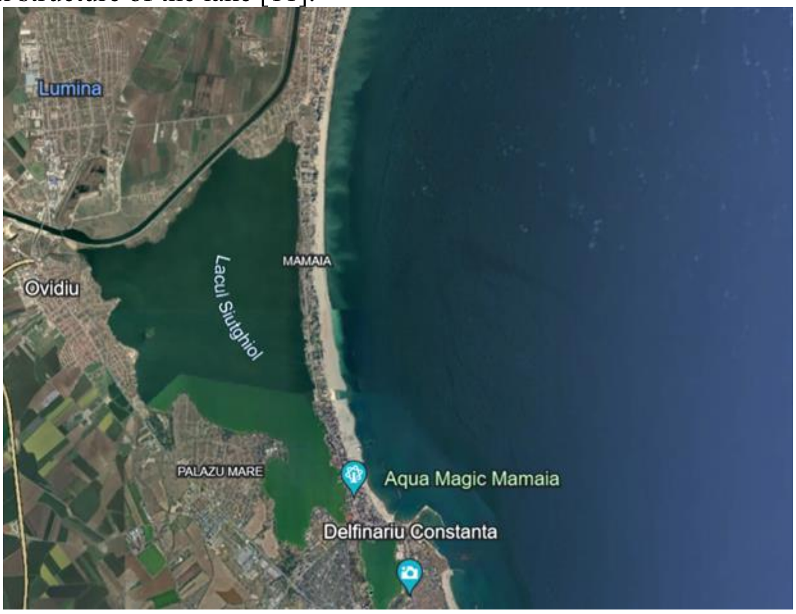

Fig. 2 Siutghiol Lake map [12]

2.2. Biodiversity and endemic species

The benthic domain of Siutghiol Lake can be an efficient barometer in assessing the pollution degree of the aquatic ecosystem. Thus, the representative benthic samples for this site were sediment, rock and submerged vegetation, macrofauna and meiofauna substrate. Overall, mesophilic, hygrophytic and hygro-halophilic plant associations are present in the lake area [13]. In the waters of Siutghiol Lake can be found the following species of fish: the crucian carp, the flounder, the roach, the frogfish, the rudd, or the perch [14].

3. POLLUTION FACTORS OF THE SIUTGHIOL LAKE

According to study of Avram et al., (2021), Siutghiol Lake is in a state of semi-degradation in terms of pollution [3]. This classification is due to its location within the large urban centres (the cities of Constanta, Ovidiu and Mamaia resort), industrial units and the influence of anthropic activities in the area on its underground springs.

In this assessment of the quality of the aquatic ecosystem, the following factors have been considered:

- the influence of human settlements as well as the processing capacity of wastewater,
- agricultural activities due to the existence of agricultural land, which uses chemical fertilizers in its exploitation,
- the location near the catchment area of the E87 European road, the A4 motorway, and several other national and local roads,
- tourism in this area, known as an important consumer of space, natural and anthropic resources.

The traffic in the areas adjacent to Siutghiol Lake causes the release of various emissions into the atmosphere (NOx, COx, SOx, VOC, heavy metals, particulate matter, etc.). Besides these, particulates resulting from friction, ageing or wear of both roads and car tyres should also be taken into account. On the other hand, the atmosphere is washed by rain and as a result these pollutants are transferred into the lake water.

Another environmental concern is the overdevelopment of mass tourism in the area. In addition, water sports also have a negative impact on the environment, due to noise pollution in particular.

4. CTD ANALYSES SPECIFIC TO SIUTGHIOL LAKE

CTD instruments typically consist of sensors for conductivity, temperature, and pressure (depth), integrated into a single probe that is lowered into the water column either from a stationary platform or a moving research vessel [15]. Using CTD devices we are able to collect valuable information about physical and chemical properties of aquatic environments, supporting various research activities, with a focus on ocean circulation studies, climate research, ecosystem monitoring, and habitat assessment. [16].

CTD conductivity sensors typically use electrodes to measure the electrical conductivity of the water. The sensor's electrodes are in direct contact with the water, and the conductivity measurement is based on the electrical resistance encountered by the current as it passes through the water. This resistance is inversely proportional to the conductivity of the water. Conductivity measurements obtained from CTD sensors are often used in conjunction with temperature and depth measurements to provide a comprehensive understanding of the physical and chemical properties of the water column. [17]. It is primarily influenced by the concentration of dissolved ions in the water, such as salts. Conductivity measurements are crucial for determining water salinity. The salinity affects the density and buoyancy of water masses, as well as the distribution of marine organisms. Salinity is a measure of the amount of halides dissolved in water. It is normally defined as the total amount of dissolved solids (chlorides, bromides, iodides) in seawater, expressed in parts per thousand (ppt or ‰) by weight. Salinity, in practice in not possible to be determined directly. It is calculated using the total amount of chlorides in water, electrical conductivity, reflective index of other properties [18]. The rate of change of sound velocity is about 1.3 m/s for a 1 ‰ change in salinity [17].

Using the CTD to provide information about temperature, is realized on the thermal structure of the water column [17]. Temperature affects various physical and biological processes in aquatic ecosystems. Also, temperature affects water density, solubility of gases, metabolic rates of organisms, and species distribution. Monitoring temperature gradients over time helps researchers understand seasonal variations and long-term trends in water temperature. Through the water column, temperature behaviour is also complex. Take into consideration this unpredictability requires an careful analysis of the sound speed distribution, both in time and space, in order to maintain an accurate sound speed value for the area of the rise. Depth measurements are quite sensitive to variations in the sound speed profile: a 1°C change in temperature corresponds to a change in sound speed of about 4.5 m/s.

Depth measurement, also known as pressure or hydrostatic pressure of CTD instrument indicates using the vertical position within the water column [17]. Depth measurements is very important because using this information received, is helpful for constructing bathymetric profiles of lakes and oceans, identifying thermoclines and haloclines. Furthermore, is important in understanding vertical mixing processes such as upwelling and downwelling. Depth data are often used in combination with temperature and conductivity measurements to characterize water column structure and circulation patterns. Pressure also has a large impact on the variation of the speed of sound in water. The rate at which the speed of sound changes with pressure is about 1.6 m/s at 10 atmospheres.

5. CTD ROLE'S IN THE MEASUREMENTS FOR POLLUTION ASSESSMENT

In order to understand the role of CTD in assessing the ecological status of Siutghiol Lake, our research started from the hydrodynamic analysis of the lake's status. Thus, the lakes are characterized by a low mean current velocity of 10-3 to 10-2 m s-1, which makes it necessary to consider residence times in the quantification of water mass movements. The currents present in lakes exhibit a multidirectional nature. Numerous lakes exhibit alternating phases of stratification and vertical mixing, with the frequency of these processes being influenced by climatic factors and the depth of the lake [19].

To protect the future of Siutghiol Lake, the CTD measurements are not just a technical exercise, but a clear call for knowledgeable action. They respond to the urgency for sustainable practices, strict monitoring, and collective commitment to preserve the ecological integrity of a lake that reflects the delicate balance of life itself.

CTD measurements, encompassing conductivity, temperature, and depth, provide an extensive framework for comprehending the physical characteristics of various water bodies, such as oceans, seas, lakes, and rivers [17], [20]. The aforementioned measurements are of utmost importance in evaluating the freshwater contamination within the Siutghiol Lake catchment area. They offer crucial information that may be utilised to deduce different water quality indices and comprehend the mechanisms influencing the dispersion, dilution, and conversion of pollutants.

Conductivity is a parameter that quantifies the capacity of water to facilitate the flow of electric current. It is commonly used as an indicator of the existence of dissolved salts, which can provide insights into different contaminants and the general ionic nature of the water. Elevated conductivity levels in freshwater systems frequently serve as indicators of the existence of contaminants, including salts, heavy metals, and other dissolved solids originating from agricultural runoff, industrial effluents, and urban wastewater [21]. Monitoring fluctuations in conductivity can facilitate the identification of pollution origins and the quantification of their effects on the quality of water. The conductivity of water, which serves as an indicator of ion concentration, can be affected by the ionic products resulting from alterations in pH and redox processes. For example, the introduction of metal ions into water due to acidic circumstances (low pH) or reductive reactions can potentially lead to an increase in conductivity. On the other hand, in the event that conditions become more alkaline or oxidative, certain ions may undergo precipitation, which might potentially result in a reduction in conductivity [22].

The solubility and reactivity of chemicals are influenced by water temperature, hence impacting the behaviour of contaminants. In certain instances, elevated temperatures have the ability to enhance the solubility of specific chemicals, hence influencing their concentration and possible toxicity. The significance of temperature in biological processes is of utmost importance, as it has a significant impact on the metabolism of aquatic organisms and the degradation of organic contaminants. The prediction of ecological repercussions of pollution can be facilitated by the comprehension of temperature profiles. According to literature data [11], [23], the average water temperature in Siutghiol Lake is 12 °C and any major deviation from this value can be an alarm signal. Water temperature can exert an influence on the chemistry of reactions involving pollutants. Consequently, elevated temperatures have the potential to enhance the rate of chemical reactions, thereby facilitating expedited conversions of pollutants. On the other hand, reduced temperatures have the potential to stabilize specific types of pollutants present in water [24]. Another parameter influenced by temperature is the pH of the water. This characteristic affects the solubility and dissociation rate of carbon dioxide (CO2) in water. Warmer water tends to retain less CO2, which can cause a slight increase in pH due to decreased carbonic acid formation [25]. If the CTD temperature data indicate seasonal warning tendencies in Siutghiol Lake, one should anticipate modest and slight variations in pH, which usually increasing with increasing temperatures. It is imperative to acknowledge that temperature plays and represent a critical role in influencing and impact aquatic life, serving as both a fundamental physical parameter and an indicator of chemical reaction rates and the likelihood of detrimental algal blooms. Temperature parameter also affects redox reactions. Reaction rates are often positively correlated with higher temperatures parameter. This phenomenon should have an impact on the redox state of various components in the lake, which could result in the oxidation of organic material or the reduction of metals. The temperature variations can lead to variations in oxygen reduction potential (ORP). Also, as higher temperatures exist can accelerate the oxidation process [26].

Understanding the vertical dispersion of contaminants in Siutghiol Lake's aquatic environments depends on the acquisition of CTD depth data. Sediments are part of the contaminants which tend to accumulate approximately the bottom of the water column, when other contaminants are distributed equally throughout [19]. Consider the way that different layers emerge in bodies of water due to variations in density and temperature at different depths, this process named stratification. Stratification is the term for this phenomenon. These stratification greatly impact the vertical transmission and mixing of contaminants. For example, depth measurements made with a CTD can be very helpful in determining the distribution of heavy metals in a body of water. Heavy metals can be deposited in lake bottom sediments. Therefore, deeper areas may have higher concentrations of these metals due to sediment accumulation. Heavy metals are known pollutants with major negative impacts on water quality due to their inability to break down, long persistence, bioaccumulation and biomagnification in the food chain [27]. The significance of particle matter within the distribution of the water column should not be ignored. The presence of particulate matter (PM) has a significant role in the assessment of water quality through its influence on the mechanisms of adsorption and desorption. The primary factors contributing to the temporal variations in dissolved and particulate matter levels in aquatic settings are the complex interactions between hydrodynamic variability, mineral solubility, PM characteristics, and the nature and intensity of biological activity [19], [28]. The presence of stratification in water bodies, as observed in the temperature and conductivity profiles in the CTD data, suggests the existence of layering where pollutants are likely to be concentrated. For instance, water that is heavier and colder tends to descend to the bottom, which can potentially transport dissolved metals along with it. This can result in a greater concentration of metals in deeper layers, especially in sediments [21]. pH parameter can be influenced by depth as a result of distinct biological processes occurring at different depths. For example, when we speak about ample light penetration, the photosynthetic activity by phytoplankton is typically more pronounced at the upper layers. As a result, CO2 gases are consumed, and the pH parameter rises. Conversely, water at lower depths might have a lower pH, which would lead to less photosynthetic activity and higher respiration rates, which would produce CO2 gases [29].

Using the CTD instrument, is very important for predicting the dispersion of pollutants and evaluating the dangers for aquatic life at different depths. Also, the depth measurement, the pd parameters and the pressure can be correlated and determinate the lake stratification, in order to realise the levels and distribution of living organisms in water column.

6. MONITORING AND REMEDIATION STRATEGIES

In order to prevent water pollution, it is essential to continuously monitor conductivity, temperature and depth of water using the CTD sensors. Furthermore, it is necessary to monitor pH and redox to help track changes in water chemistry.

Researchers can enhance their comprehension of pollutant distribution patterns and probable sources of contamination in freshwater ecosystems by establishing a correlation between CTD data (in situ) and water samples that have been analysed in lab for heavy metals. This data are important for develop different strategies and procedures to effectively manage and attenuates the consequences and effects of pollution.

It can be useful to monitor CTD data on regular, frequent and various period of time to detect and identify changes in water quality and potential pollution events. Sudden changes in conductivity or temperature profiles could signal new inputs of pollutants.

An examination of the influence of tourism on the natural, economic, and social environment, taking into account both the positive and negative consequences, is crucial as it should result in the growth of tourism in the coastal area while maintaining ecological equilibrium.

In order to establish a strong correlation between these factors, it would be necessary to gather data from various sample sessions conducted at different seasons and depths. The application of statistical analysis techniques, such as correlation coefficients or multivariate regression models, can be utilised to get insights into the temporal and spatial interactions of various variables within Siutghiol Lake.

7. CONCLUSIONS

In conclusion, these CTD characteristics (Conductivity, Depth and Temperature) construct an intricate scenario for the well-being of Siutghiol Lake. Alterations in conductivity can serve as indicators of the influx of urban or agricultural runoff, which carries a substantial amount of nutrients that have the potential to contribute to eutrophication. Temperature fluctuations can be attributed to the influence of industrial effluents or the changing climate patterns. The utilization of depth profiles can facilitate the identification of regions within the lake that are primarily impacted by sedimentation or diminished light penetration, hence influencing several aspects such as photosynthesis and fish habitats.

An analysis of the impact of tourism on the environmental, economic, and social environment, considering both the favourable and unfavourable outcomes, is essential in order to foster tourism development in coastal regions while preserving ecological balance.

Acknowledgements: This research was supported by European project –EMFAF-2023-PIA-FLAGSHIP-Black Sea SIERRA-Harnessing complementary curricular preparedness via sustainable management in response to civil and military pollution on the coastline, tributaries and lagoons in Black Sea's North, West, South zone.

References

[1] Millennium Ecosystem Assessment, "ECOSYSTEMS AND HUMAN WELL-BEING: WETLANDS AND WATER Synthesis," World Resources Institute. [Online]. Available: https://www.millenniumassessment.org/documents/document.358.aspx.pdf

[2] A. R. dos Santos, R. C. F. da Silva, L. C. de Assis, and F. F. Mauad, "Defining environmental conservation levels considering anthropic activity in the Uberaba River Basin protected area," *Ambient. e Agua - An Interdiscip. J. Appl. Sci.*, vol. 14, no. 1, p. 1, Jan. 2019, doi: 10.4136/ambi-agua.2279.

[3] S. Avram *et al.*, "GIS-Based Multi-Criteria Analysis Method for Assessment of Lake Ecosystems Degradation—Case Study in Romania," *Int. J. Environ. Res. Public Health*, vol. 18, no. 11, p. 5915, May 2021, doi: 10.3390/ijerph18115915.

[4] G. Woodward, D. M. Perkins, and L. E. Brown, "Climate change and freshwater ecosystems:

impacts across multiple levels of organization," *Philos. Trans. R. Soc. B Biol. Sci.*, vol. 365, no. 1549, pp. 2093–2106, Jul. 2010, doi: 10.1098/rstb.2010.0055.

[5] M. Edlund *et al.*, "Effects of Climate Change on Lake Thermal Structure and Biotic Response in Northern Wilderness Lakes," *Water*, vol. 9, no. 9, p. 678, Sep. 2017, doi: 10.3390/w9090678.

[6] European Environment Agency, "Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy," Off. J. L 2000. [Online]. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0060:en:NOT

[7] Romanian Parliament, "Law no. 196/2015 for the Amendment and Completion of Law no. 107/1996," Official Gazette of Romania: Bucharest, vol 522. [Online]. Available: https://monitoruloficial.ro/publicare-acte-normative/

[8] ECE - European Commission Environment, "Natura 2000 and Forests. Part III - Case Studies," Publications Office of the European Union, Luxembourg. [Online]. Available: https://circabc.europa.eu/sd/a/41f417db-d69d-4f37-9870-6eb5dc0f1577/20150508 Guide N2000 Forests Part I-II-Annexes.pdf

[9] E. Commission, "EU Biodiversity Strategy for 2030 Bringing Nature back into Our Lives," Directorate-General for Environment: Brussels. [Online]. Available: https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

[10] C.-E. Telteu and L. Zaharia, "Morphometrical and Dynamical Features of the South Dobrogea Lakes, Romania," *Procedia Environ. Sci.*, vol. 14, pp. 164–176, 2012, doi: 10.1016/j.proenv.2012.03.016.

[11] D. T. P GÂŞTESCU, P BREŢCAN, "THE LAKES OF THE ROMANIAN BLACK SEA COAST. MAN-INDUCED CHANGES, WATER REGIME, PRESENT STATE," *Rom. J. Geogr.*, vol. 60, no. 1, pp. 27–42, 2016.

[12] "Map." [Online]. Available: https://earth.google.com/web/search/romania+black+sea+coast%5Csiutghiol/@44.25927398,28.66152549,5.80779826a,22859.41875912d,35y,-0h,0t,0r/data=CigiJgokCQFysl0pHUZAEQSKmFtJGUZAGQjpzTdYsDxAIZYr9IG4mDxAOgMKATA

[13] Z. T. Boicenco L., Abaza V., Anton E., Bișinicu E,. Buga L., Coatu V., Damir N,. Diaconeasa D., Dumitrache C., Filimon A., Galațchi M., Golumbeanu M., Harcotă G., Lazăr L., Marin O., Mateescu R., Maximov V., Mihailov E., Nenciu M., Nicolaev S., Niță V., Oros A., "Studiu privind elaborarea raportului privind starea ecologică a ecosistemului marin Marea Neagră conform cerinţelor art. 17 ale Directivei Cadru Strategia pentru mediul marin (2008/56/EC)," Constanta, 2018. [Online]. Available: https://www.mmediu.ro/app/webroot/uploads/files/STUDIU MSFD V1.9.pdf

[14] M. Niţă, Victor, Nenciu, Magda & Galatchi, *FISH SPECIES OF THE ROMANIAN COAST. UPDATED ATLAS*. 2022.

[15] D. . Baker, "Ocean instruments and experiment design," in *Evolution of Physical Oceanography*, B. A. W. and C. Wunsch, Ed., The MIT Press., 1981, pp. 396–433.

[16] George L. Pickard; William J. Emery, *Descriptive Physical Oceanography, An introduction*, 5th ed. Elsevier, 1982. doi: 10.1016/C2013-0-10174-2.

[17] VALEPORT LIMITED, "MIDAS CTD Profiler Hardware Manual, Document Version D." [Online]. Available: https://www.valeport.co.uk/content/uploads/2020/03/MIDAS-CTD-Operating-Manual-0606803d.pdf

[18] V. I. Rich and R. M. Maier, "Aquatic Environments," in *Environmental Microbiology*, Elsevier, 2015, pp. 111–138. doi: 10.1016/B978-0-12-394626-3.00006-5.

[19] D. Chapman, *Water Quality Assessments*. London: CRC Press, 2021. doi: 10.1201/9781003062103.

[20] S. J. Painting *et al.*, "St Helena Marine Water Quality: Background Conditions and Development of Assessment Levels for Coastal Pollutants," *Front. Mar. Sci.*, vol. 8, Jun. 2021, doi: 10.3389/fmars.2021.655321.

[21] R. Bhateria and D. Jain, "Water quality assessment of lake water: a review," *Sustain. Water Resour. Manag.*, vol. 2, no. 2, pp. 161–173, Jun. 2016, doi: 10.1007/s40899-015-0014-7.

[22] M. Rodríguez-Rodríguez, A. Fernández-Ayuso, M. Hayashi, and F. Moral-Martos, "Using Water Temperature, Electrical Conductivity, and pH to Characterize Surface–Groundwater Relations in a Shallow Ponds System (Doñana National Park, SW Spain)," *Water*, vol. 10, no. 10, p. 1406, Oct. 2018, doi: 10.3390/w10101406.

[23] C.-E. Telteu, "HYDROCHEMICAL FEATURES OF THE SOUTH DOBROGEA'S LAKES AND IMPACT OF THE CLIMATIC CONDITIONS ON THESE FEATURES," in *Water resources and wetlands*, 2012, pp. 163–168. [Online]. Available: https://www.semanticscholar.org/paper/HYDROCHEMICAL-FEATURES-OF-THE-SOUTH-DOBROGEA%27S-AND-Camelia/5fe87c85dea5fcc06306071a2af9651ff2842b2a

[24] H. Y. Li, J. Xu, and R. Q. Xu, "The Effect of Temperature on the Water Quality of Lake," *Adv. Mater. Res.*, vol. 821–822, pp. 1001–1004, Sep. 2013, doi: 10.4028/www.scientific.net/AMR.821-822.1001.

[25] Ž. Brkić, "Increasing water temperature of the largest freshwater lake on the Mediterranean islands as an indicator of global warming," *Heliyon*, vol. 9, no. 8, p. e19248, Aug. 2023, doi: 10.1016/j.heliyon.2023.e19248.

[26] E. Santofimia, E. González-Toril, E. López-Pamo, M. Gomariz, R. Amils, and Á. Aguilera, "Microbial Diversity and Its Relationship to Physicochemical Characteristics of the Water in Two Extreme Acidic Pit Lakes from the Iberian Pyrite Belt (SW Spain)," *PLoS One*, vol. 8, no. 6, p. e66746, Jun. 2013, doi: 10.1371/journal.pone.0066746.

[27] M. Tuzen, "Toxic and essential trace elemental contents in fish species from the Black Sea, Turkey," *Food Chem. Toxicol.*, vol. 47, no. 8, pp. 1785–1790, Aug. 2009, doi: 10.1016/j.fct.2009.04.029.

[28] L. Brodský, V. Vilímek, M. Šobr, and T. Kroczek, "The Effect of Suspended Particulate Matter on the Supraglacial Lake Depth Retrieval from Optical Data," *Remote Sens.*, vol. 14, no. 23, p. 5988, Nov. 2022, doi: 10.3390/rs14235988.

[29] P. O. Brown, B. Bowerman, H. E. Varmus, and J. M. Bishop, "Retroviral integration: Structure of the initial covalent product and its precursor, and a role for the viral IN protein," *Proc. Natl. Acad. Sci. U. S. A.*, vol. 86, no. 8, pp. 2525–2529, Apr. 1989, doi: 10.1073/pnas.86.8.2525.