Natural Dam Lake Cuejdel in the Stânişoarei Mountains, Eastern Carpathians

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A Limnogeographical Study

Springer

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ISBN 978-3-319-77212-7 ISBN 978-3-319-77213-4 (eBook)
https://doi.org/10.1007/978-3-319-77213-4

Library of Congress Control Number: 2018934431

Printed on acid-free paper

This Springer imprint is published by the registered company Springer International Publishing AG part of Springer Nature
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Foreword

In Romanian geographic literature, Limnology is a niche science. Limnology studies are artificially segregated by the two fields: Biology or Geography. Both schools avoid an interdisciplinary approach or teamwork. For this reason, the studies that can be highlighted are extremely rare. The same deficiencies are recorded for the study of wetlands, similarly to lakes. The current research direction of the Interdisciplinary Research Department—Field Science, University "Alexandru Ioan Cuza" of Iaşi—is interdisciplinary and transdisciplinary. The study elaborated by the author of this book also follows this direction.

Limnology, as a borderline science, has been avoided for a long time by disciplines designed to deal with understanding interdependent phenomena. Unfortunately, even internationally, the phenomena have not been controlled due to the lack of basic components: the studies are purely biological or purely geographical. Most biological studies take no count of physico-geographical factors. At the same time, geographical studies lack the biological component. We face the inability to fully understand the role of each component and its connections with the whole. In Limnology, there has always been a "missing link."

Specialty schools lead a fierce fight in order to impose their perspective in renowned specialties. How many biologists know what a hydrographic basin is or what its geological constitution comprises? How many specialists take into account the morpho-bathymetric phase as a layering unit for local conditions?

The lithologic substrate, emerged or submerged, represents the development support for communities on various evolution phases. Nevertheless, limnologists talk easily about water chemistry as if it were a gift from God. The fact is omitted that chemical parameters are given by the petrologic composition of hydrographic basin. Through physical and chemical erosion, the elements are detached, transported, and deposited in the lacustrine basin. The lake becomes a depositary for the components of the basin of influence, in this case, the hydrographic basin.

In the Romanian school, as in other European, Asian, or African schools, the lake surface is still confused with that of a wetland itself. Worldwide classifications are often unsatisfactory, and pride cannot be stopped. Fortunately, in science, bribery is not accepted!

The classifications based on wetlands delimitation, according to a series of parameters, have given satisfactory results. From this point of view, the American school defines wetlands based on hydrological, geomorphological, pedological, and biological parameters. The interdependence of the four parameters makes the ambiguity disappear. Nevertheless, the difficulty of delimitation, a long-time research and the high price of analyses interfere.

The link between wetlands and lacustrine basins is extremely strong. Due to this fact, the lake is confused with the typical wetland. Most morpho-hydrographic forms, such as wetlands, are just component parts of water basins or stagnant waters. The most important issue is linked to the interdependence between morpho-bathymetry and limno-ecological parameters existing in an aquatorium.

A mountain unit is highlighted by parameters related to altimetry. Each level of altitude determines a particular type of climate. Climatic parameters, in turn, determine the distribution of plants and animals. A lacustrine basin is the inverted image of a mountain unit. This time, each bathymetric stage corresponds to a number of hydrometric factors. In this case it is about the existence of bathymetric levels. Morpho-bathymetry represents the edifice on which secondary components are installed, exactly like a house waiting for its tenants.

Natural dam lakes from Romania were mainly studied by geographers and rarely by biologists. Most studies are dedicated to the formation process and intend to highlight the evolution in space and time of the water basin. Most of the natural dam lakes from Romania are located in the Eastern Carpathians, where high rainfall and the geological substrate allow landslides. Most landslides were caused by massive deforestation during the late nineteenth century and early twentieth century.

The limno-geographic literature until 2012 demonstrated that the Red Lake is the largest natural dam lake in Romania (12.01 ha). During 2012, topographic measurements were taken for the most important natural dam lakes from Eastern Carpathians and the largest one is actually Cuejdel Lake (13.95 ha). As far as depths are concerned, the same classification is applied: 16.45 m for Cuejdel Lake and 1.05 m for Red Lake. Among the largest natural dam lakes from Romania, the Red Lake is the oldest, formed in 1837. Cuejdel Lake is the youngest, with two formation phases: first, in 1978, when a small lake was formed and second, in 1991, when a massive landslide occurred and the landslide body blocked Cuejdel brook.

As a result of its relative isolation, Cuejdel Lake caught rather late the attention of interdisciplinary research. The lack of modern ways of access leads to its isolation. The entry of Cuejdel Lake into the national and international tourist circuit will be delayed. Unfortunately, most studies focused only on the lacustrine basin and geological substrate and less on the analysis of physical–chemical parameters and water dynamics. Cuejdel Lake is a tourist attraction only for the local population.

This study tries to emphasize the role of morpho-bathymetry in the distribution of sediments and areas of wetlands. At the same time, physical–chemical characteristics and water dynamics are highlighted being directly related to other physico-geographical factors. Thus, the first chapter about natural dam lakes and

their position within limnological studies creates an interesting overview about the state of knowledge in the field, both internationally and nationally.

The best represented category on the territory of Romania is one of the natural dam lakes formed due to subsidence and gravitational landslide processes. The author emphasizes that the most favorable conditions for the formation of natural dam lakes are found in the Eastern Carpathians, the Curvature Subcarpathians, and the Moldavian Subcarpathians. These conditions may also occur separately in the Moldavian Plateau. The highest susceptibility is found in the Carpathian flysch area where the formation of lacustrine accumulations behind diluvia is frequent.

The next chapters are focused on methodology and monitoring techniques of Cuejdel Lake. The most modern tools were used in order to take samples, scan the basin, and for integrated analysis. For the first time in Romanian research, the noninvasive technique of bathymetric mapping (GPR) was used. In this regard, as far as the approach and unexpected results are concerned, Chaps. 3, 4, and 5 are distinguished. It is very important that research was conducted based on two aspects: quantity and quality. A meritorious scientific contribution is given by the map of sediment thickness distribution. According to the results, Cuejdel Lake will become clogged in approximately 250 years.

Biotic conditions aimed at describing physico-chemical parameters, water quality index, and trophic level determined based on chemistry and nutrients. In situ measurements were taken seasonally using a Hach Lange multiparameter with real-time display. Laboratory investigations followed standard methods of water analysis. In terms of temperature, Cuejdel Lake behaves like a dimictic aquatorium, with direct thermal stratification in the summer and inverted during winter. The amount of dissolved oxygen decreases inversely proportional to the standard conductivity of water, indicating an euxinic stratification, induced by the lack of vertical currents. The pH value follows the same pattern, with a slightly alkaline environment, specific to mountain waters.

Cuejdel Lake presents a productive environment only in the epilimnion area. The water quality determined based on nutrients, phosphates, and ammonium ions concentration, to which were added to the formula when making calculations the amount of dissolved oxygen, the biochemical demand of oxygen and the pH, indicates a score of 86%. This value is equivalent to first-class quality. Based on the nutrients determined in laboratory samples, Cuejdel Lake belongs to mesotrophic aquatory category. Trophic conditions are similar to those from Lake Sfânta Ana or from Brădișor and Izvorul Muntelui anthropic accumulations.

The trophic level of Cuejdel aquatic limno-system was achieved based on ecological bio-indices determined in the water mass. The following categories were identified: algal communities, vertebrate and invertebrate aquatic fauna, of which we mention insects, zoo-planktonic, and benthic macroinvertebrates communities. Based on ecological bio-indices from the water mass, Cuejdel Lake is defined as an oligotrophic aquatic ecosystem with mesotrophic tendencies during warm season.

At the same time, 11 aquatic and palustrine phytocoenoses were identified which provide favorable habitats for already existing species as well as other new ones. There were reported nine species of birds, one species of amphibians, and one

reptile species listed in the Habitats Directive (92/43/CEE) and Birds Directive (79/409/CEE). In this case, having the status of Protected Area (IUCN IV.40 Cuejdel Lake) is not enough for protecting them. Cuejdel Lake area meets all legal conditions to establish a Site of Community Importance (SCI), a Special Area of Conservation (SAC), and/or a Special Protection Area (SPA) according to Natura 2000 methodology.

The entire work is unique as a way of approaching a limnology subject in an interdisciplinary context of European geography. The content of this paper was designed as a novelty in Romanian literature. The author used the latest generation devices, and the interpretation and the results are extremely interesting. Such work brings new data in the analysis of the natural environment and the development of human society in relation to water, the most important resource on Earth.

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Acknowledgements

This work was partially supported by the strategic grant POSDRU/159/1.5/S/133391, Project: *Doctoral and Post-doctoral programs of excellence for highly qualified human resources training for research in the field of Life sciences, Environment and Earth Science*, co-financed by the European Social Fund within the Sectorial Operational Program Human Resources Development 2007–2013.

All the equipment used during the data collection process belong to the Geoarchaeology Laboratory within the Faculty of Geography and Geology, University "Alexandru Ioan Cuza" of Iaşi (Manager—Prof. Dr. Gheorghe Romanescu). In this sense, the author thanks Prof. Dr. Victor Spinei, corresponding Member of the Romanian Academy, the director of this research platform, and Conf. Dr. Vasile Cotiugă, the administrative manager of the Interdisciplinary Research Platform ARHEOINVEST.

The author also thanks the scientific coordinator Gheorghe Romanescu, Prof. Dr. at Faculty of Geography and Geology, University "Alexandru Ioan Cuza" of Iaşi, and referents of Ph.D. thesis, who contributed significantly to the consolidation of this scientific endeavor: Senior Researcher Petre Gâştescu at Geography Institute of Romanian Academy and President of Romanian Association of Limnogeography; Prof. Dr. Victor Sorocovschi at Faculty of Geography, University "Babeş-Bolyai" of Cluj-Napoca; Prof. Dr. Florian Stătescu, Dean of the Faculty of Hydrotechnical Engineering, Land Measurement and Environmental Engineering, "Gheorghe Asachi" Technical University of Iaşi.

The commitment of Conf. Dr. Cristian Constantin Stoleriu, during field expeditions and data processing, is highly acknowledged. Also, many thanks to my colleagues from the Faculty of Biology, Geography and Geology and Interdisciplinary Research Department—Field Science, University "Alexandru Ioan Cuza" of Iaşi. Last but not least, I dedicate this work to my family who was worried every time "I disappeared" in the Eastern Carpathians.

Contents

About the Author

Alin Mihu-Pintilie is a Researcher, Dr., at the Interdisciplinary Research Department—Field Science, "Alexandru Ioan Cuza" University of Iaşi (UAIC), Romania. He completed his Ph.D. in Physical Geography, with the Distinction Excellent for his thesis, at the same university in 2015. During his Ph.D. research, he taught university courses in geography, hydrology, and geosciences, an activity that he still undertakes today. Additionally, he has been part of seven national research projects in academic and political institutions in Romania. His main research interests include advanced spatial analysis using GIS software, remote sensing, and geophysics techniques for bathymetric and terrestrial mapping, geoarchaeology, underwater archaeology, and alluvial paleolandscapes. He is the author/co-author of 35 scientific papers and attended 70 scientific presentations and conferences. He is a specialist in continental and oceanic sea diving since 2008 (NAUI Worldwide Patent). In addition, he is a member of national and international scientific societies such as EGEA, ARLG, SOR, SystemIS, GeoDA, and AGR and has also participated in numerous geographical and archaeological expeditions in different parts of Eurasia and the North Atlantic Ocean.

Abbreviations

A	Inferior mesosaprobic area
α–p	Inferior transition meso-polysaprobic area
α_{Global}	Global water flow coefficient
B	Superior mesosaprobic area
β–α	Superior–inferior transition mesosaprobic area
ε_{ave}	Relative permittivity (average)
$Ø_{med}$	Grain size (median)
ABA	Siret Water Basin Administration—Romania
AD	Anno Domini
AGR	Romanian Association of Geomorphologists
Aq	Aquitanian (Oligocene–Miocene)
ARHEOINVEST	Interdisciplinary Research in Archaeology—Romania
ARLG	Romanian Association of Limnogeography
ASCE	American Society of Civil Engineers
AT	Anthrosols
BC	Bern Convention, 1979
Bd	Burdigalian (Early Miocene)
BD	Birds Directive
BDO_5	Biochemical Oxygen Demand
C	Critically endangered plants list (sozological category)
C 1…4	Gravity core
Ca^{2+}	Calcium
CDC 401	Standard electrical conductivity of water
Cl^-	Chlorine
CM	Cambisols
CNCSIS	Romanian Council for Research in Higher Education
CS	Cross section
CV	Cumulative lake volume
DEM	Digital elevation model
DF	Dual frequency

DO_2	Dissolved oxygen
E	Endemic plants list (sozological category)
E	Endangered bird species (phenological categories)
E_s	Specific erosion
EGEA	European Geography Association
Eq	Equation
ER	Endemic plant species in Romania
ESRI	Environmental Systems Research Institute
FL	Fluvisols
(g)	Saprobic weight
GeoDA	Geo-speleology Association in Romania
GIS	Geographic information system
GL	Gleysols
GPR	Ground-penetrating radar
GPS	Global positioning system
GSA	Geological Society of America Bulletin
HCO_3^-	Bicarbonate
HD	Habitats Directive
$I_{n\%}$	Average intensity of rain with the probability of n%
ISL	International Symposium on Landslides
IUCN	International Union for Conservation of Nature
$KmnO_4$	Organic matter
LDO 101	Luminescent dissolved oxygen in water
lt-ch	Latorfian–Chattian (Oligocene)
LS	Longitudinal section
LV	Luvisols
NASH	North Atlantic subtropical high
Natura 2000	European Network of Protected Areas
ne-al	Neocomian–Albian (Lower Cretaceous)
Mg^{2+}	Magnesium
mi	Miocene
MN	Minister Order—Romania
MP	Management plan
NH_4^+	Ammonium ions
NO_3^-	Nitrates
NO_2^-	Nitrites
nt	Unthreatening plants (sozological category)
ntR	Unthreatening plant species in Romania
o	Oligosaprobic area
O'_s	Static conductivity
OUG	Government Emergency Ordinance—Romania
p	Polymesosaprobic area
p–α	Inferior polymesosaprobic area
P	Total phosphorus
Pb	Passage bird species (phenological categories)

P 1…7	Water samples
PASP	Specific Alluvial Soil Production
PGA	Peak ground acceleration (seismic activity)
Pg1-lt	Lutetian-Ypresian (Paleocene–Eocene)
PH	Phaeozems
ph	ph of water
Pm	Partially migratory bird species (phenological categories)
PO_4^{3-}	Phosphates
PP-q-E	Rainfall–runoff–erosion equation
pr	Priabonian (Upper Eocene)
Q_{max}	Maximum flow
Q_{avg}	Average flow
Q_{min}	Minimum flow
Q_i	Sub-index calculated for each parameter of water quality
$Q_{n\%}$	Probability of exceeding the maximum discharge (n%)
qh2	Holocene
qp3/3	Upper Pleistocene
qp1/2	Middle Pleistocene
R	Red plants list (sozological category)
RA	Relative lake area
RG	Regosols
ROMSILVA	National Forest Administrations—Romania
ROSCI	Sites of Community Importance Code—Romania
ROSPA	Special Protection Area Code—Romania
RR	Rare plant species in Romania
RRL	Romania Red Lists of bird species
(s)	Saprobic classes
(S)	Saprobic score
S	Sedentary bird species (phenological categories)
Sb	Summer bird species (phenological categories)
SAC	Special Areas of Conservation
SCI	Sites of Community Importance
SGAN	Water Management System of Neamț County
SIL	International Society of Limnology
SystemIS	Association SystemIS Group in Romania
sn-Pg1	Senonian (Upper Cretaceous–Paleocene)
SOR	Romanian Ornithological Society
SPA	Special Protection Area
SOVROLEMN	Romanian-Soviet Society for forest exploitation
STEREO 70	Stereographic Projections for Romania 1970
SO_4^{2-}	Sulfates
T_c	Time of runoff concentration
T°C	Temperature in °Celsius
TDS	Total dissolved salts
TOC	Total organic carbon

USDA	United States Department of Agriculture
USLE	Universal Soil Loss Equation
WQI	Water quality index
UP	Forest Production Units
V	Vulnerable plants list (sozological category)
V	Vulnerable bird species (phenological categories)
vr-tu	Vraconian–Turonian (Cretaceous)
W	Wintering bird species (phenological categories)
W_i	Weight associated for each parameter of water quality
Wr	Wintering rare bird species (phenological categories)
x–α	Xeno-mesosaprobic area