

REVIEW

of a dissertation thesis on:

HYDROGRAPHIC CHARACTERISTICS OF THE LAKES IN RILA MOUNTAIN

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by Associate Professor Krasya Kolcheva, PhD, Centre for Hydrology and Water Management at the National Institute of Geophysics, Geodesy and Geography - Bulgarian Academy of Sciences.

1. BRIEF BIOGRAPHICAL DATA OF THE DOCTORAL STUDENT

Alexander Dimitrov Vassilev completed his higher education in the period 2007÷2013 at Sofia University St. Kliment Ohridski, acquiring a Bachelor's degree in Geology and a Master's degree in Regional geo-energy.

During the period 01.02. 2019 - 01.02.2023 he was a full-time doctoral student under the program „Land and Water Resources Hydrology.

In 2012 and 2013, Vassilev briefly carried out general archaeological work at the site "Tsari mali grad" near the village of Balchik. He has good computer skills, including in Geographic Information Systems (GIS) and language training in English.

2. GENERAL CHARACTERISTICS OF THE DISSERTATION WORK

The dissertation work, 169 pages in volume, has the following structure:

- *Introduction*, clarifying the relevance of the topic, the object of the study, the aims and objectives of the development and the limitations of the measurements (8,5 pages);
- *First chapter*, presenting the theoretical and methodological basics of the study (32 pages);
- *Second chapter*, which considers the general regularities in the distribution of lakes according to various characteristics (altitude, mountain sections etc.) and morphometric indicators (area, length and width of the water mirror, length of the coastline, maximum, average and relative depth, coast line development etc.) for the entire studied territory and the geographical distribution by sections in Rila mountain, the statistically significant relationships between individual morphometric indicators, and ends with conclusions (44.5 pages);
- *The third chapter* describes the morphometric characteristics of the lake groups and the lakes in North-West, Central, East and South-West Bulgaria with a description of their geographical features (geographic coordinates - GC, lake groups and lake systems, altitude, assigned new names) and morphometric measurements and calculations of nine statistically significant relationships between certain water mirror parameters. The Urdini lake group has been analyzed in detail and, more briefly - the lakes in the watersheds of the Iskar, Maritsa, Mesta and Struma rivers (64 pages);
- *Summary*, which, in conclusion, justifies the results in a synthesized way (2 pages);
- *Used sources (references) and appendix – 18 pages.*

The pages, indicated above, contain: 54 tables, 63 figures and 11 pages with a bibliography (132 cited sources - 45 in Bulgarian, 87 in English).

3. ASSESSMENT OF THE CONTENT OF THE DISSERTATION WORK

Relevance of the topic

After defining the concept of “lake” and emphasizing on the importance of the high-mountain and glacial lakes (a component of the cryosphere and the natural landscapes), the doctoral student justifies the need of developing the research, related to the lakes, taking into account both the achievements and the climatic changes and global warming.

In this regard, the importance of the River Basin Management Plans (RBMPs) can be added to the reasons for the topicality of the thesis, as they are the main instrument of the Directive 2000/60/EC of the European Parliament and the European Council of 23.10.2000, aimed at establishing a framework for Community actions in the field of water policy (the so-called Water Framework Directive - WFD) in order to protect and improve the status of all waters. In accordance with the requirements of the WFD for typology according to system "B", precisely on the basis of the well-studied morphological indicators and structure and composition of the lake bottom and shore, in the RBMP, surface water types of the category "lake" are defined (intra-territorial surface water body with standing waters) and passports for each type are drawn up. Every six years, which is the period of validity of the RBMP, the typology and the subsequent assessment of the ecological state of the surface water bodies in terms of biological, hydro-morphological (hydrological regime and morphological conditions) and physico-chemical elements are subject to updating.

Knowledge of the topic

It is possible to expand the study of the topic, given the updated typology and the assessment of the state of the surface water bodies of the "lake" category in the second RBMP (2016-2021) of the West Aegean River Basin (WARB).

In subsection 1.2.2. “Surface water typology update” under chapter one of the plan - "Description of the characteristics of the West Aegean River Basin management ", five lake types are defined, first of which alpine lakes (L1) with an altitude above 2000m and other factors, according to "Table No. 1.2.2.d “*Factors for defining the typology of lakes in the Republic of Bulgaria*”. The alpine lakes, as independent water bodies, also include the lakes of the West and South Rila groups. According to Appendix No. 1.2.2.a. *Passports of the types of lakes in the WARB*, for each lake type an information card (passport) has been prepared, containing data, characterizing the given type.

From the assessments, made in Section 4. “Monitoring and assessment of the state of the surface water, groundwater and the protection zones”, it becomes clear that the surface water bodies of lake type (L1): BG4ST600L1007 - group of lakes "Eastern/(Western Rila – the Black Lake) and BG4ST600L1018 - group of lakes "South Rila"(Redzhep Lake) are in excellent ecological condition in terms of biological and physico-chemical indicators and in good chemical condition. The assessments are tabulated in Appendix 4.1.3.b. *General assessment of the ecological status/potential and chemical state of the surface water bodies in the WARB*.

Aims, objectives, territorial scope and limitations of the study

In order to achieve the aim of the research - "Morphometric description of the lakes and establishment of dependencies between morphometric indicators, identification of lake systems", four objectives have been formulated, reflecting the work done on the dissertation. The scope and limitations of the research are clearly expressed by specifying the appropriate season, device and the impossibility to fully characterize the lakes, located in hard-to-reach places.

Chapter one: "Theoretical basis and research methods", structured in two main subsections, contains an in-depth description of the lakes, considering their classification according to several characteristics and the possible research methods.

Subsection 1.1. "Theoretical basis of the study", in seven items describes the lakes

based on the available scientific research, distinguishing between the morphogenetic, hydrographic, hydrological, hydro-physical, hydro-chemical, hydrodynamic and hydrobiological description. The content is comprehensive with an emphasis on the thematically important morphometric features - measured (area, volume, maximum depth, length and width of the water mirror, coastline length) and calculated (relative depth, average width, coastline development). The main hydrological characteristics of the lakes - water volume in the lake cup, water balance and regime - are presented in sufficient volume, including by empirical formulas. Hutchinson (1957), offering the most detailed division of lakes by the origin of their lake basin, is missing from the bibliography. In subsection 1.2. "Research methods", for the purposes of the research, the doctoral student has suggested and well justified the combination of a method for field observations and measurements using appropriate devices and the Google Earth program, a classification method and statistical methods (descriptive statistics, correlation and cluster analysis) and a method for division of the studied lakes into lake groups. The correlation analysis applied to study the relationships and dependencies between some of the measured and calculated morphometric parameters has been properly based on Pearson's linear correlation.

In conclusion, chapter one contains important and well-defined theoretical concepts and appropriate research methods for solving the tasks set in the dissertation, with the doctoral student referring to established scientists and correctly interpreting them. The conclusions emphasize first the importance of studying the lakes as dynamic limno-systems with examining their morphometric characteristics (reflecting the specifics in the development of the lake basin and the processes taking place in the water mass) and their influence on the lake thermal regimes and hydrodynamics. The morphometric indicators for the description of the lakes are up-to-date, and the proposed analytical expressions for their determination are stable over time and successfully applied in practice. The morphometric analysis based on GIS, satellite images, orthophoto images and software products for rapid calculations allow the maintenance of up-to-date information on lakes. The indicated analysis and classification of lakes according to morphometric indicators is important also for sustainable water management and, in particular, for the planning process. The assessment of this chapter is generally positive.

Chapter two: "General characteristics of lakes in Rila", structured in three main subsections, deals with the geographical and morphological description of 173 lakes on the territory of Rila (mostly cirque glacial lakes, located in trough valleys either individually, or in lake systems or lake groups) and the inferred empirical relationships between morphometric indicators. Subsection 2.1. "Geographic description of the lakes in Rila mountain" analyzes and evaluates (including in tabular and graphical form) the location and distribution of the lakes in Rila by geographical coordinates and altitude and the established 41 lake groups, 22 lake systems and 20 single lakes. However, it should be clarified for Figures 11 and 13 that they present a percentage distribution. In subsection 2.1. "Morphometric description of the lakes" the data from the descriptive statistics for the area, length, width and oblongity of the lakes and the length and coefficient of development of the coastline, are analyzed and summarized in tables for Rila as a whole and by mountain sections as well. The estimates for the distribution of the lakes in Rila according to the indicated parameters and mountain sections (in tabular and graphical form) are well founded, including their distinguishing in five classes according to the maximum depth and width. The distribution by a combination of two indicators has also been investigated, such as the undetermined close relationship between the maximum depth and the area of the water mirror of the lakes and the logical relationship between the length of the coastline and the area. To the entry "Table 10 - *Descriptive statistics of lakes in Rila by width*" should also be added "*by mountain sections*". The studies of the lakes in Rila in subsection 2.3. "Empirical relationships between morphometric metrics" are extended by establishing a correlation between different morphometric parameters and the corresponding analytical expressions for the resulting relationships. Based on various analyzes and statistic procedures, a matrix has been obtained, placing

in one cluster the area, the length, the maximum and average width, and the coastline length. Thoroughly analyzed (in graphical form) are the regression models of the relationships between: the area and latitude, the area and length of the shoreline, the longitude and latitude and the length of the lakes and their shoreline for the studied lakes in Rila.

Chapter two ends with clearly formulated and logically sustained conclusions, which specify for the geographical description: the reported small difference in the geographical coordinates, the formation of lake groups and systems due to the origin, the altitude of the lakes as an indirect indicator of their young age and thermal peculiarities etc. As for the studied morphometric characteristics of the lakes in Rila, important generalizations have been made for them, such as: 65.3% of the studied 173 lake reservoirs have an area of up to 1.0 ha, the average length of the water mirror is 155m with a large difference between the measured extreme values, the width of the lakes fluctuates within narrower limits around the average value of 95.9 m relative to the length, etc. Finally, the results of the conducted statistical tests and non-linear and linear regressions prove the lake water surface area as the main factor for the rest of the measured and calculated morphometric indicators.

Chapter three: "Hydrographic description of the lakes in Rila by mountain sections and river basins" in two main subsections makes a hydrographic description of the lakes in Rila by mountain sections - Northwestern (including the lake group Urdini lakes), Central, Eastern and Southwestern Rila and the catchment basins of the Iskar, Maritsa, Struma and Mesta rivers. The study of the lakes, located in the four mountain sections, is based on general characterization, geographical description with GC and analysis and evaluation of the main morphometric indicators and drawing up empirical dependencies between them. The studied empirical dependencies and general conclusions for each mountain section prove the existence of a relationship between: the area and the length of the lake, the area and the width, the length of the coastline and the length of the water mirror, and insignificantly between the perimeter and the maximum width in North-Western Rila; a close relationship between the area of the water mirrors and the length of the coastline, as well as between the area and the width in Central Rila; between the perimeter and the length of the lakes, and also between the area and the length and the area and the average width in Eastern Rila. The characteristics and analyzes for the indicated river basins are relevant for the updated RBMPs of the Danube Region, the East Aegean River Basin, and the West Aegean River Basin.

The summary, ending the dissertation, draws conclusions, corresponding to the entire exposition.

Author's abstract: The structure of the abstract meets the requirements and both accurately and in a synthesized form reflects the content of the dissertation work. However, the scientific contributions are indicated only in the abstract.

Contributions: Differentiated in a theoretical and applied aspect, the contributions are well formulated and prove that the present dissertation has scientific value in the development of lake research and practical value for the adequacy of the planning process. The importance of updating the typology and information maps of the alpine type of lakes, defined in the RBMP, can be added to the applied contributions.

4. PUBLICATION ACTIVITY

According to the attached reference, the author of the dissertation has submitted three publications, related to the subject and object of the dissertation. The two independent articles (one in Bulgarian and one in English) have been published in the Proceedings (scientifically peer-reviewed with ISSN: 2683-0558) from the first and third scientific conferences on the topic: "Climate, atmosphere and water resources in the conditions of climate change", 2019 and 2021, organized by the Climate, Atmosphere and Water Research Institute at the Bulgarian Academy of Sciences. The third one, in Bulgarian, and co-authored with the scientific supervisor, with the doctoral student as the lead author, has been published in the Yearbook of the Sofia University "St. Kliment Ohridski", Faculty of Geology and Geography, Book 2 -

Geography, volume 114. The articles present important parts of the dissertation in an appropriate way.

5. CONCLUSION

Given the review and the evaluation of the provided documentation, I believe that the dissertation work on the topic: "Hydrographic characteristics of the lakes in Rila Mountain" achieves the set goals by building on the previous studies of the lakes in Rila and that the doctoral student has both the qualities and the competence to conduct independent scientific research. In this regard, I propose to the respected members of the Scientific Jury to vote "YES" to award Alexander Dimitrov Vassilev the educational and scientific degree "Doctor of Philosophy - PhD" in the professional field 4.4. Earth Sciences, scientific specialty "Land and Water Resources Hydrology".

Sofia, 22.03. 2023

Reviewer:
(Assoc. Prof. Krasya Kolcheva, PhD)