REVIEW

by Prof. Rumyana Yankova, PhD, Department of Chemistry, Biochemistry, Biology and Microbiology, Medical Faculty, Burgas State University "Prof. Dr. Assen Zlatarov"

For awarding the educational and scientific degree "Doctor" in the area of higher education 4. Natural Sciences, Mathematics and Informatics, Professional sub-area 4.2 Chemical Sciences, the doctoral program: Ecology and Environmental Protection. The title of PhD dissertation is „Investigation and Analysis of Pollution Indicators in Marine and Coastal Ecosystems along the Southern Black Sea Coast", author Eng. Elena Yankova Mollova, Faculty of Natural Sciences, Shumen University, Department „Ecology and Environmental Protection".

By order No UD-229/26.06.2025 r. from the Rector of Burgas State University "Prof. Dr. Assen Zlatarov" I'm appointed as a member of the scientific jury. I have received all materials for the competition in electronic form.

1. Brief biographical data

Eng. Elena Yankova Mollova completed her higher education in 1997 at the "Prof. Dr. Assen Zlatarov" University in Burgas, specializing in "Water Technology," and was awarded the educational and professional degree of "Master Engineer." Between 1998 and 2001, she also earned a Master's degree in "Finance" from Burgas Free University.

Her professional career began as a technologist and insurance inspector, and from 2002 to 2008 she worked as a sales representative. Since 2009, she has focused her professional interests on chemistry and ecology, starting as a chemical technician at the Department of Ecology and Environmental Protection at "Prof. Dr. Assen Zlatarov" University, later also working as a quality specialist. Since 2016, she has again held the position of chemical technician in the same department, where she was a full-time doctoral student from 2021 to 2024. As of September 2024, she holds the position of Assistant Professor.

Her scientific interests lie in the fields of environmental monitoring, pollutants in the marine environment, microplastics, and sustainable management of aquatic ecosystems. She is a co-author of numerous scientific articles published in international journals with impact factors, including the *Journal of the Serbian Chemical Society*, *Journal of Environmental Protection and Ecology*, *Journal of Coatings Technology and Research*, among others.

Eng. Mollova has participated in numerous national scientific projects and programs related to the monitoring of microplastics, particulate matter, and the assessment of the ecological status of marine organisms. She has actively participated in scientific conferences and forums, as well as in the organization of annual student and school conferences on environmental topics.

She teaches courses such as "Fundamentals of Heat and Mass Transfer," "Food Ecology," and "Petroleum Products Ecology" in Bachelor's and Master's degree programs. She is proficient in applied analytical techniques such as ICP-MS, SEM-EDS, and methods for determining microplastic pollutants.

2. Presented materials

I have received a complete set of documents required by the Law for the development of the academic staff in the Republic of Bulgaria (LDASRB) and RALDASRB (Rules on the application of LDASRB), and according to the rules of Shumen University:

- the thesis;
- thesis abstract (54 pages);
- curriculum vitae of the applicant;
- list of applicant's scientific publications;
- a reference for the original scientific contributions of the thesis.

3. General description of the presented materials

According to the data presented in the submitted materials and the reference check with global databases (Web of Science (WOS), Scopus), the doctoral candidate's score (95 points) exceeds the required minimum number of points in accordance with the national minimum requirements for a doctoral degree in the field of higher education 4.2 Chemical Sciences: total required points – 80, of which 50 points must be from the dissertation work for acquiring the educational and scientific degree "Doctor" (Group A indicators) and 30 points from scientific publications (Group G indicators).

According to the submitted documents, the list of publications (WOS, Scopus) by which Elena Mollova is applying for the acquisition of the educational and scientific degree "Doctor" includes 3 publications. All three articles are published in the *Journal of Environmental Protection and Ecology*, which is in Q3 quartile, thus the number of points under Group G indicators is 45. In these publications, the doctoral candidate is the first author.

The submitted abstract objectively reflects the structure and content of the dissertation.

4. Dissertation thesis

Elena Mollova's dissertation addresses one of the most serious and growing environmental issues — the pollution of marine and coastal ecosystems, with a focus on the Southern Black Sea coast. The topic is highly relevant in the context of current EU environmental policies and the need for effective monitoring of emerging pollutants such as microplastics. The research aligns fully with strategies for the sustainable management of coastal zones and contributes to scientific knowledge through a multidisciplinary approach that combines chemical, physical, and biological indicators.

The main objective of the study is to investigate and analyze key pollution indicators in order to determine the current ecological status of marine and coastal ecosystems along the Southern Black Sea coast.

The tasks include the selection of representative ecosystems, sampling and analysis of toxic metals, metalloids, and microplastics, as well as the application of physicochemical methods for water assessment. The structure and execution of these tasks demonstrate a well-planned and successfully implemented study.

The dissertation is clearly structured and includes:

- **Introduction (pp. 4-5)**

The author clearly articulates the relevance of the topic and outlines the main objective of the dissertation. The scientific and practical significance of the research, as well as the expected outcomes, are well presented. The structure of the introduction is logical and includes well-founded arguments justifying the choice of the research problem.

- **Literature Review (pp. 6-41)**

The literature review in the dissertation outlines the evolution of scientific and public awareness regarding plastic pollution in marine ecosystems. As early as the 1970s and 1980s, the main impacts of plastic waste were identified, leading to regulatory initiatives such as MARPOL Annex V. It has been established that the majority of pollution originates from land-based, diffuse sources that are difficult to control. In the early 21st century, microplastics were recognized as a ubiquitous marine pollutant with measurable impacts on ecosystems and human health. Pollution from microplastics, heavy metals, and metalloids has been documented in seas, rivers, and coastal

areas around the world, including the Black Sea, as a result of intense anthropogenic pressure and climatic factors.

The review emphasizes the need for new analytical approaches, effective regulations, and educational measures. The study conducted in the Burgas Bay area is timely and necessary for assessing pollution levels and supporting regional monitoring and management programs.

- **Experimental Section (pp. 42-52)**

The experimental section of the dissertation presents in detail the methodology used to assess pollution in the coastal waters of the Burgas Bay. Field studies are described, including the sampling of seawater and sediment from selected sites with varying degrees of anthropogenic pressure. In situ measurements of key parameters such as temperature, pH, salinity, and conductivity were conducted to provide an initial assessment of the physicochemical state of the environment.

In the laboratory, established analytical methods were applied for the quantitative determination of heavy metals and metalloids using ICP-MS. The samples were pre-filtered, mineralized, and calibrated with reference standards. In parallel, an analysis of microplastic pollutants was carried out using a combined methodology—density separation, microscopy, and SEM-EDS spectroscopy—to confirm the morphology and chemical composition of the polymer fragments.

The results from this stage of the study reveal the presence of both inorganic pollutants (Pb, Cd, Cr, and others) and microplastic particles of various origins, with concentrations varying across the sampling sites. A quantitative comparison between the samples was made, along with a preliminary evaluation of the relationships between the identified pollutants and the physicochemical conditions of the environment. This section lays the foundation for the subsequent analysis of correlations and ecological interpretations presented in the following chapters.

- **Results and Discussion (pp. 53-144)**

The results and discussion section constitutes the most substantial and comprehensive part of the dissertation and is built upon an in-depth analysis of the experimental data obtained during the field and laboratory studies. The author demonstrates a high level of analytical thinking and an interdisciplinary approach in interpreting the findings.

The presentation of the results is systematically organized by type of pollutants (heavy metals, metalloids, microplastics) and by study areas, with a clear distinction made between the different sampling sites based on their geographic location and level of anthropogenic impact. A wide range of graphs, tables, and micrographs is used to effectively visualize trends and compare values.

Elena Mollova traces the concentrations of key elements such as Pb, Cd, Cr, Cu, and Zn in various samples and identifies statistically significant differences between different zones. These data are interpreted in the context of current regulatory standards and threshold concentrations, allowing for a categorization of the pollution levels. Potential sources of pollution—industrial activity, port infrastructure, and tourism pressure—are correctly identified.

The discussion on microplastics is also well-argued and thorough. Observations are presented regarding particle morphology and distribution—by color, size, shape, and likely origin. It is noted that fragments of polyethylene and polypropylene dominate, which is consistent with global trends. The connection of local results with data from other European and Black Sea studies is semantically and logically sound, highlighting the compatibility and validity of the observed phenomena.

A strong aspect of the discussion is Mollova's attempt to analyze the interrelationships between the physicochemical characteristics of the environment and the degree of pollution. Correlation analyses were performed, revealing dependencies between salinity, pH, temperature, and the concentration of microplastics and metals. This enables the formulation of broader conclusions about the mechanisms of pollutant accumulation and transfer in coastal ecosystems.

Particularly noteworthy is the doctoral candidate's ability to propose interpretations that go beyond the mere presentation of results—through ecological hypotheses, risk assessments, and suggestions for future monitoring. This section clearly demonstrates the independence of the research approach and the maturity of the scientific interpretation.

In conclusion, the results and discussion section are comprehensive, well-structured, and presented with the necessary scientific depth. It significantly contributes to achieving the objectives of the dissertation and forms the foundation for its scientific and practical contributions.

- **Scientific contributions (pp. 145,146).**

The conclusions formulated at the end of the dissertation clearly, thoroughly, and convincingly reflect the results of the conducted research. They demonstrate the doctoral candidate's strong analytical skills and interdisciplinary approach, while also confirming the achievement of the main goal and specific objectives of the study.

First and foremost, the dissertation makes a notable contribution to the field of microplastic pollution by conducting a primary, field-supported, and quantitative study in three representative coastal ecosystems along the Southern Black Sea coast. The second conclusion stands out for its originality and scientific contribution, as it presents, for the first time, a comprehensive assessment of microplastic contamination in both water and sediment, followed by analysis by year, polymer type, and spatial distribution. The reported values are well substantiated and supported by hypotheses explaining the observed dynamics, taking into account hydrological and atmospheric factors.

The conclusions regarding the identified polymer compositions in 2022 and 2023 show in-depth data processing and interpretation, highlighting changes in dominant polymers and linking them to possible new sources of pollution. Particular attention is given to the dynamics in sediment samples, where the author suggests a possible relationship between polymer density and persistence and their accumulation levels.

The fourth conclusion summarizes the findings on toxic metal and metalloid contamination in two main water bodies—Lake Burgas and the Kitenska River. The evaluation is scientifically sound, identifying both primary and secondary pollutants, seasonal fluctuations, and potential sources. Factors such as industrial activity, vehicular traffic, and hydro-meteorological conditions are logically associated with the observed concentrations.

The final, overarching conclusion appropriately frames pollution within the context of sustained and diffuse anthropogenic pressure. The author demonstrates an understanding of the systemic nature of the issue, recognizing that local pollution cannot be viewed in isolation but must be analyzed within a broader regional and climatic context.

Overall, the conclusions reflect a high level of scientific validity, logical coherence, and analytical depth. They are directly derived from the presented experimental results, avoiding unnecessary generalizations or unsupported claims, and provide a well-founded and appropriate conclusion to the dissertation.

- **Scientific and Applied Contributions (pp. 147)**

Scientific Contributions:

1. For the first time, a systematic study of microplastic pollution and their qualitative identification has been conducted in Burgas Bay, Lake Burgas (Vaya), and the mouth of the Kitenska River (Karaagach).

2. The main pollutants from toxic metals and metalloids in Lake Burgas (Vaya) and the mouth of the Kitenska River (Karaagach) have been confirmed as indicators of pollution in marine and coastal ecosystems along the Southern Black Sea coast.

3. The study and identification of the types of microplastics, toxic metals, and metalloids make an important contribution to the localization of pollution sources in the investigated ecosystems.

Applied Scientific Contributions:

1. The methodology developed in the dissertation for the extraction and analysis of micro-polymers from a matrix (water or sediment) is an important element in the development of a standardized method, which is currently lacking in the global scientific literature.

2. The knowledge gained from the investigation and analysis of the presence of microplastics as indicators of pollution in the studied marine and coastal ecosystems along the Southern Black Sea coast provides a potential foundation for the development and implementation of monitoring programs. These programs are essential for assessing environmental status, proposing measures to reduce pollutants, organizing information campaigns, and formulating educational policies aimed at preventing the entry of such pollutants into aquatic ecosystems.

5. Critical comments and recommendations:

The dissertation is written in a sound scientific style. In some graphs and tables, visual readability could be improved by standardizing legends and labels.

The discussion section could benefit from a more detailed comparative analysis with data from other Black Sea countries or international studies.

I recommend that the conclusions and the empirical experience gained from the study be adapted to support local environmental management authorities by contributing to the development of regional ecological programs and sustainable development plans for coastal communities.

These remarks do not diminish the scientific value and contributions of the research.

CONCLUSION

The dissertation of Eng. Elena Yankova Mollova represents a comprehensive, in-depth, and scientifically well-grounded study on a current environmental issue. The topic, structure, methodology, and results fully comply with the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria and its implementing regulations.

I recommend the scientific jury to award **Eng. Elena Yankova Mollova** the educational and scientific degree "**Doctor**" in the field of higher education 4. Natural Sciences, Mathematics, and Informatics, professional field 4.2. Chemical Sciences, doctoral program "Ecology and Environmental Protection".

30.07.2025 г. Reviewer: Подпис заличен Чл.2 от ЗЗЛД

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