

OPINION

by **Prof. Eng. Ekaterina Ivanova Todorova, PhD**, University of Forestry, habilitated in the field of higher education **4. Natural Sciences, Mathematics and Informatics**, professional field **4.4. Earth Sciences**, scientific specialty "**Ecology and Ecosystem Conservation**" on the doctoral dissertation entitled "**Treatment of Mining Wastewater Using Microbial Electrolysis Cells**", submitted by **M.Eng. Maria Georgieva Georgieva** for the award of the educational and scientific degree **Doctor (PhD)** in the field of higher education **4. Natural Sciences, Mathematics and Informatics**, professional field **4.4. Earth Sciences**, scientific specialty "**Systems and Technologies for Environmental Protection**"

1. Brief Overview of the Doctoral Dissertation

The mining industry generates industrial wastewater that is, in most cases, characterized by elevated concentrations of sulfates, dissolved heavy metals, and low pH values. The doctoral dissertation, presented in an appropriate scope and well-structured format, investigates the potential for treating mining wastewater using microbial electrolysis cells. The research is fully consistent with the professional field and scientific specialty in which **M.Eng. Maria Georgieva** is applying for the award of the educational and scientific degree **Doctor (PhD)**.

The proposed technology is innovative, timely, and demonstrates considerable potential for industrial application, enabling the simultaneous removal of sulfates and heavy metals. It is based on the process of dissimilatory microbial sulfate reduction (DMSR) occurring in the anodic

2. Assessment of the Main Scientific Contributions

I accept **five of the six** stated scientific and scientific-applied contributions for the following reasons: they provide a realistic and reliable representation of the relationship between the conducted scientific research, the obtained results, and their practical applicability to the treatment of mining wastewater, while demonstrating a high degree of originality. The dissertation presents **four scientific contributions** related to new scientific knowledge and findings:

1. It has been demonstrated that the rate of dissimilatory microbial sulfate reduction (DMSR) in the anodic compartment of bioelectrochemical systems significantly exceeds the rate of sulfate ion migration through the anion-exchange membrane (from the cathodic to the anodic compartment), with the latter identified as the limiting factor of the process.
2. It has been demonstrated that increasing the surface area of the electrodes and the membrane substantially enhances the removal efficiency of sulfates and heavy metals, while also improving the electrochemical performance of the system.
3. It has been established that microbial electrolysis cells (MECs) exhibit higher efficiency than microbial fuel cells (MFCs) with respect to wastewater treatment performance and the reduction of metal ions.

4. It has been established that the competition between electrogenesis and sulfate reduction leads to a redistribution of electron flow; therefore, the degree of chemical oxygen demand (COD) removal does not directly correlate with the energy efficiency of bioelectrochemical systems.

The scientific-applied contribution, related to the practical implementation of the research results through the solution of specific engineering problems and the development of practical approaches, is as follows:

- Two- and three-chamber bioelectrochemical systems have been developed and validated for the efficient treatment of sulfate- and metal-containing waters, including acid mine drainage, enabling the simultaneous purification of wastewater and generation of electrical energy.

4. Publications and Dissemination of the Research Results

In accordance with the **Regulations for the Implementation of the Academic Staff Development Act of the Republic of Bulgaria** (*State Gazette, No. 75 of September 24, 2010, as last amended in State Gazette, No. 16 of February 10, 2026*), applicants for the educational and scientific degree **Doctor (PhD)** in Professional Field **4.4. Earth Sciences** are required to obtain a minimum of **30 publication points**. Under the same regulations, **up to 6 points** may be awarded for other publications published in peer-reviewed scientific journals or proceedings.

The candidate, **M.Eng. Maria Georgieva**, is the author of **five publications** in peer-reviewed scientific publications and fully satisfies the minimum requirement of **30 publication points**. These publications present individual research findings from the doctoral dissertation and make the results of the doctoral research accessible to the broader scientific community. They adequately reflect the research outcomes, as well as their analysis and interpretation.

The conducted research and the obtained results have also been disseminated through participation in **five scientific conferences**, including **three international conferences**, dedicated to mining engineering, environmental engineering, biotechnology, and wastewater treatment technologies. The corresponding papers have been published in the peer-reviewed conference proceedings of these scientific events.

The published research results are of both **scientific** and **scientific-applied** significance and contribute to the field of **environmental protection**.

5. Brief Critical Remarks

The following critical remarks do not diminish the quality of the dissertation or its contributions. Rather, they are intended to support the candidate's future scientific development and research activities.

One notable aspect is the relatively extensive literature review, which comprises **61 of the total 145 pages**, representing approximately **42%** of the dissertation. In future work, greater emphasis

should be placed on a more concise synthesis and critical analysis of the existing scientific literature, avoiding unnecessary detail.

The research is based on model aqueous solutions characterized by high concentrations of sulfate and copper ions, with the objective of evaluating the influence of design parameters on the rate of sulfate reduction and the efficiency of sulfate and Cu^{2+} removal. I recommend that future studies validate the obtained results using **real industrial wastewater**, both from the mining industry and from ore-processing facilities employing flotation technologies. In addition to energy efficiency, the **environmental efficiency** of the proposed treatment method could also be evaluated.

The results of future research should be appropriately structured and published in scientific journals indexed in internationally recognized databases, such as **Web of Science** or **Scopus**.

6. Conclusion

In light of the above assessment, I strongly support the awarding of the educational and scientific degree of **Doctor (PhD)** to **M.Eng. Maria Georgieva Georgieva** in Professional Field **4.4. Earth Sciences**, scientific specialty "**Systems and Technologies for Environmental Protection**", at the **University of Mining and Geology "St. Ivan Rilski"**.

Prepared by:

Prof. Eng. Ekaterina Ivanova Todorova, PhD

Date of submission of the opinion: **5 August 2026**