

REVIEW

regarding the doctoral dissertation
„Treatment of Mining Wastewater Using Microbial Electrolysis Cells“,
by M.Sc. Eng. Mariya Georgieva Georgieva
for the award of the educational and scientific degree "Doctor"
in professional field 4.4. Earth Sciences,
doctoral program "Systems and Devices for Environmental Protection"

by Assoc. Prof. Dr. Petar Nikolov Gerginov

1. Relevance of the Problem Addressed in the Dissertation

The mining sector is associated with the continuous generation of waste products. This necessitates the introduction of radically new sustainable and environmentally friendly solutions for their treatment and processing. Among these products are mining wastewaters, which, upon release into the environment, pose risks of soil and natural water contamination. Conventional methods for treating acid mine drainage require substantial amounts of chemical reagents, generate hazardous secondary sludge, and are energy-intensive, thereby increasing the carbon footprint of the operations. In this context, the application of microbial electrolysis cells offers an innovative approach for pollutant degradation while simultaneously generating biofuels, leveraging the activity of specific microorganisms. This research has the potential to directly contribute to the development of zero-pollution wastewater treatment technologies, reduce operational costs in mining, and mitigate environmental pressure.

2. Overview of the Dissertation

The submitted dissertation comprises the following main sections: literature review, aim and objectives, materials and methods, results and discussion, conclusions and summary, contributions of the dissertation, publications on the dissertation topic, and references. The dissertation has a total volume of 145 pages, including 23 tables and 45 figures. The bibliography includes 157 references.

The dissertation is well-structured. The exposition is clear, with a strong correlation between the literature analysis, the stated objectives, the applied methodology, the obtained results, and the conclusions drawn. The abundant illustrative material and the use of specialized literature contribute to the convincing presentation of the research.

3. Main Contributions of the Dissertation

The dissertation formulates six scientific-applied and applied contributions. They relate to the investigation and optimization of bioelectrochemical systems for the efficient treatment of mining wastewater through the application of microbial sulfate reduction processes.

1. It has been demonstrated that the rate of dissimilatory microbial sulfate reduction (DMSR) in the anodic zone of the bioelectrochemical system (BES) significantly exceeds the rate of sulfate migration

through the anion-exchange membrane (from the cathodic to the anodic zone), which constitutes a limiting factor for the process.

2. It has been demonstrated that increasing the surface area of the electrodes and the membrane leads to a significant increase in the removal efficiency of sulfates and heavy metals, as well as to improved electrochemical performance.
3. Microbial electrolysis cells (MECs) have shown higher efficiency compared to microbial fuel cells (MFCs) in terms of treatment performance and reduction of metal ions.
4. The competition between electrogenesis and sulfate reduction redistributes the electron flow, which is why the removal of chemical oxygen demand (COD) does not directly correlate with the energy efficiency in the BES.
5. 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), with the capability for simultaneous treatment and electricity generation.
6. The applicability of real waste substrates (vinasse and distillery stillage) as effective electron donors has been demonstrated, and optimal operational parameters have been determined, ensuring a balance between efficient wastewater treatment and energy generation..

4. Description and Assessment of the Submitted Materials

In connection with the fulfillment of the requirements of the procedure, the following materials and documents have been submitted: Protocol from the preliminary defense, Order for enrollment, Order for withdrawal, Order for the composition of the scientific jury, Certificate of passed examinations, Diploma of higher education, Curriculum vitae, Dissertation, Abstracts, Contributions, List of publications related to the dissertation, Electronic media with materials related to the procedure.

The submitted materials fully meet the requirements of the Academic Staff Development Act of the Republic of Bulgaria (ASDA) and its implementing regulations at the University of Mining and Geology "St. Ivan Rilski," and the required number of points has been accumulated.

5. Personal Impressions of the Candidate

I did not know M.Sc. Mariya Georgieva Georgieva prior to this review and have no personal impressions of her.

6. Critical Notes and Recommendations.

The submitted dissertation presents an in-depth study concerning the treatment of mining wastewater using bioelectrochemical systems based on microbial fuel cells and microbial electrolysis cells. Through

the conducted experimental investigations, the possibilities for removing sulfates and heavy metals have been assessed, along with the influence of various design and operational parameters on process efficiency.

The dissertation is developed at a good scientific and methodological level and features a substantial experimental component. The notes made are primarily of an editorial, structural, and technical nature and do not affect the scientific value of the dissertation. It would be advisable for the formulated scientific-applied and applied contributions to be presented in a more synthesized manner, which would facilitate a clearer delineation of the original results of the conducted research.

The developed bioelectrochemical systems hold practical importance, which should be validated under real-world conditions. I hope that M.Sc. Georgieva will contribute to this in her future professional endeavors.

Conclusion

The dissertation "Treatment of Mining Wastewater Using Microbial Electrolysis Cells" outlines the application of novel technologies for the protection of natural environment components. The dissertation constitutes a complete work of scientific and practical significance, providing methodological guidelines for future research.

The procedure being conducted complies with the requirements of the Academic Staff Development Act of the Republic of Bulgaria and its implementing regulations at the University of Mining and Geology "St. Ivan Rilski."

Based on the submitted work and the professional qualities of the candidate, I give my **positive assessment** of the dissertation and propose to the esteemed scientific jury to award M.Sc. Mariya Georgieva Georgieva the educational and scientific degree "Doctor" in professional field 4.4. Earth Sciences, doctoral program "Systems and Devices for Environmental Protection."

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/ Assoc. Prof. Dr. Petar Gerginov /